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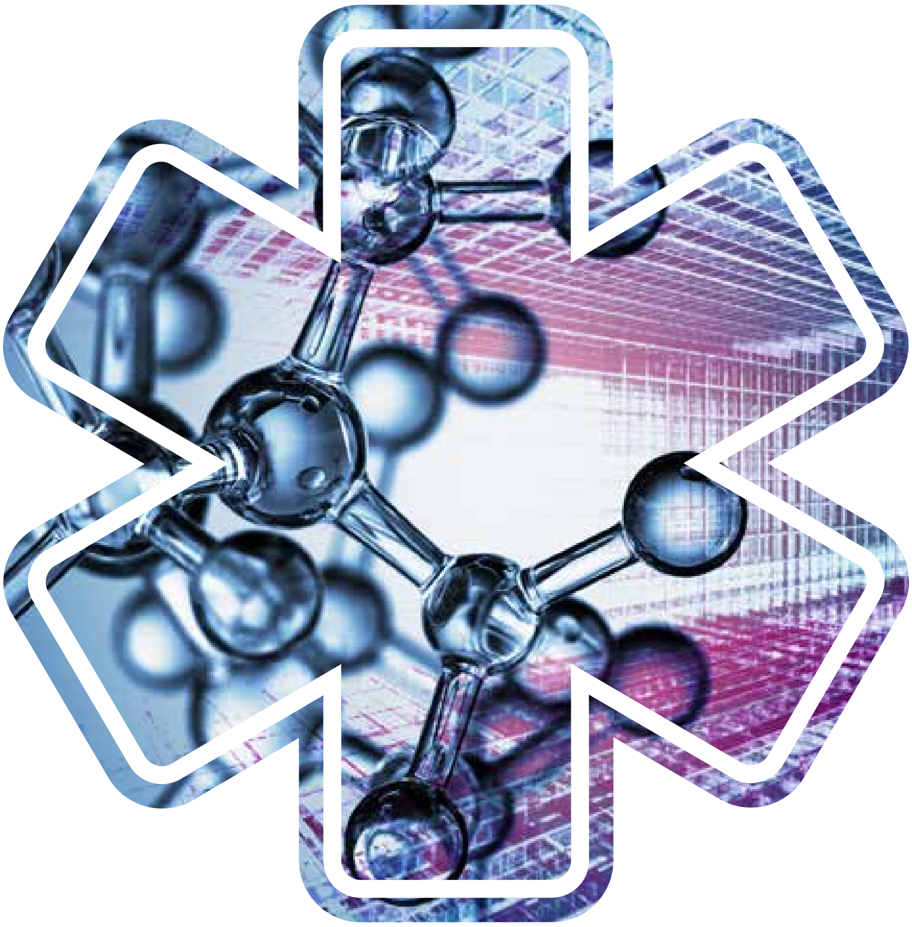
GLOBAL INNOVATION INDEX 2019

Creating Healthy Lives—The Future of Medical Innovation



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Confederation of Indian Industry

DASSAULT SYSTEMES

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Brazilian Micro and Small Business Support Service

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Creating Healthy Lives—The Future of Medical Innovation

12TH EDITION

Soumitra Dutta, Bruno Lanvin, and **Sacha Wunsch-Vincent**
Editors

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PREFACE

RELEASING THE GLOBAL INNOVATION INDEX 2019: CREATING HEALTHY LIVES—THE FUTURE OF MEDICAL INNOVATION

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We are pleased to present the 12th edition of the Global Innovation Index (GII). The special theme for this edition is *Creating Healthy Lives—The Future of Medical Innovation*.

Over the last two centuries, improvements in healthcare have prompted a sustained increase in life expectancy and in the quality of life, resulting in substantial contributions to economic growth. Medical innovation has largely contributed to this progress.

As we look into the future, new technologies and non-technological innovations will likely continue to enrich the provision of healthcare at a rapid pace. Artificial intelligence, genomics, stem cell research, big data, and mobile health applications will open doors to improved health. Likewise, novelties such as the delivery of medicines via drones have potential for rural and low-resource contexts in developing countries.

Focusing on the next two decades, the GII 2019 will shed light on the role of medical innovation as it shapes the future of healthcare. The insights shared within the report show that we have an exciting opportunity ahead of us. In addition to the theme, and as every year, the GII report analyzes global innovation trends and the performance of approximately 130 economies.

For more than a decade, the GII has fostered national innovation strategies and international debates on innovation in three main ways. First, the GII helps place innovation firmly on the map for countries, in particular for low- and middle-income economies. Second, the GII allows countries to assess the relative performance of their national innovation system. A significant number of countries work hard to "unpack their GII innovation ranking" and to analyze their innovation strengths and weaknesses. These findings then inform innovation policies and actions. Third, the GII provides a strong impetus for countries to collect fitting innovation metrics.

With this in mind, however, the GII is only as good as its data ingredients. The current state of innovation metrics is improving. Yet, despite this progress, the figures available to assess innovation outputs and impacts—a topic of critical importance—remain poor. Similarly, sound metrics on key components of innovation systems, such as the state of entrepreneurship, the availability of venture capital, the nature of innovation linkages, or the degree to which innovations are successfully commercialized, are lacking.

To improve the state of innovation metrics, the GII will continue to be a laboratory for measuring and analyzing emerging innovation data. Trial and error will be required to provide the most accurate assessment of perpetually changing innovation contexts. We appreciate the feedback we continue to receive from innovation experts and decision-makers, whose insights contribute to how we refine the GII methodology.

For this GII edition, we thank our Knowledge Partners; the Confederation of Indian Industry (CII); Dassault Systèmes, The 3DEXPERIENCE Company; the National Confederation of Industry Brazil (CNI); and the Brazilian Service of Support to Micro and Small Enterprises (SEBRAE) for their support. Likewise, we recognize the contributions of the GII's prominent Advisory Board members.

Finally, we express our sincere appreciation for the annual audits and technical assistance provided by the Competence Centre on Composite Indicators and Scoreboards (COIN) of the Joint Research Centre at the European Commission.

Soumitra Dutta
Professor of Management and Former Founding Dean
SC Johnson College of Business
Cornell University

Francis Gurry
Director General,
World Intellectual Property Organization (WIPO)

Bruno Lanvin
Executive Director for Global Indices,
INSEAD

FOREWORD

INNOVATING FOR A HEALTHY NATION

Healthcare is a sector of critical importance in India, encompassing an array of areas including hospitals, medicines, medical devices, clinical trials, outsourcing, telemedicine, medical tourism, health insurance, and medical equipment. The sector holds enormous opportunity for public and private stakeholders to develop innovative processes that democratize healthcare and increase affordability.

Last year, the Government of India introduced breakthrough initiatives for improving coverage of immunization and reducing mortality and morbidity for all citizens, particularly the deprived and vulnerable sections of society. Since India's innovative healthcare delivery initiatives must function across a wide spectrum of geographical, agro-climatic, socio-economic, and cultural diversity, the initiatives are adaptable and easy to replicate in India or any other country.

Private healthcare service providers are also investing in innovative products and the latest technology. At the same time, the Confederation of Indian Industry (CII) has been creating awareness to improve the quality of healthcare processes. The CII is actively involved in the development and dissemination of healthcare standards and practices.

These efforts are lifting India's Global Innovation Index (GII) rank, which improved to 66 in 2016, 60 in 2017, and 57 in 2018. Honorable Prime Minister Narendra Modi has envisioned India as one of the top 25 globally innovative nations—which has led to a series of enabling policies and practices for the country.

The theme of this year's Global Innovation Index, Creating Healthy Lives—The Future of Medical Innovation, is quite relevant as technology advances in the healthcare sector. The applications of artificial intelligence, robotics, remote diagnosis, genomics, big data, mobile health, stem cell research, regenerative medicine, biomarkers, and nano-technology will pave the way for healthy living.

CII is happy to be a 12-year partner in the GII, supporting its goal to capture the multi-dimensional facets of innovation across countries and assisting in tailoring GII policies to promote long-term growth, improved productivity, and job creation. I wholeheartedly thank the GII team for their passionate stewardship and in-depth research in bringing out the 2019 report.

Chandrajit Banerjee
Director General
Confederation of Indian Industry

FOREWORD

HEALTH IN THE AGE OF EXPERIENCE

Healthcare is at the core of the *Industry Renaissance* that is emerging worldwide with new ways of inventing, learning, producing, trading, and treating. We must no longer think of industry as a set of means of production, but instead as a vision of the world and a process of value creation that embraces all sectors in the economy and society. Today, we see new categories of innovators creating new categories of solutions for new categories of customers, citizens, and patients.

As we enter the age of the experience economy—in which value is in the usage rather than the product—innovation is driven by consumer and patient experience. Today, society seeks personalized health and tailored patient experiences while ensuring optimum industrial security. Improving global health requires a holistic approach that includes cities, food, and education. It also implies a shift from reactive medicine to predictive and preventive approaches.

To achieve this multiscale purpose, we must connect people, ideas, data, and solutions. Healthcare today calls for a fresh and collaborative approach to innovation, which cuts across scientific disciplines and breaks down silos to allow education, research, big firms, retailers, and patients to collaborate in real time.

Collaborative experience platforms are the infrastructure of this change. They provide a continuum of transformational disciplines to imagine, create, produce, and operate experiences from end to end. This is one of the primary functions of Dassault Systèmes' **3D**EXPERIENCE platform. In addition to cross-disciplinary collaboration, the platform empowers teams to conduct in silico 3D experiments, produce multiscale and multidisciplinary digital models, simulate healthcare scenarios, and turn big data into smart data. It connects biology, material sciences, multiscale and multiphysics simulation with model data and communities. This translates into continuous improvements in industrial processes, enhanced and customized treatments, and the development of new services from the lab to the hospital and beyond. For example, a city platform like *Virtual Singapore* is useful not only in city management but also in healthcare management. In parallel, 3D printing is already changing how prosthetics are designed. In the not too distant future, we will be able to create the virtual twin of the human body—not just any body, but each individual's own body. We will also see more data brokers marketing health data to private firms, insurance companies, and others.

The time has come for the healthcare sector—governments, businesses, researchers, and patients—to leverage the tremendous power of the virtual world. Virtual environments are pushing the bounds of possibility to transform research, science, the pharmaceutical industry, and medicine. These virtual environments will also empower the workforce of the future with knowledge and know-how, while eliminating the gap between experimentation and learning—both globally and locally. Virtual worlds are revolutionizing our relationship with knowledge, just as the printing press did in the 15th century. The new book is the virtual experience.

Bernard Charlès
Vice-Chairman and Chief Executive Officer
Dassault Systèmes

FOREWORD

INNOVATION IN HEALTH AND MEDICINE: NEW POSSIBILITIES FOR BRAZIL

Brazil could be a significant player in the international market for health care. A majority of the population—approximately 210 million people—is covered by the public health system. The country spends over 9% of its GDP on health and, with an aging population, this percentage is expected to increase. In addition to science and technology policies, the country has developed health policies, such as the National Policy for Innovation in Health, which encourages using public procurement to foster innovation in the sector. Brazil is currently pursuing innovation in several areas, including biopharmaceuticals and the use of digital technologies to improve health care.

Today, innovating in health means a great deal more than just developing new medicines. It means creating equipment capable of assisting in the diagnosis of diseases, developing medical devices for health monitoring and treatment, and conceiving customized treatments and protocols for each patient. Innovation goes beyond technological innovation—taking multiple forms that improve medicines, vaccines, and medical devices and that consider prevention, treatment, and the broader healthcare delivery and organization.

This broad view of innovation in health and medicine drives the National Confederation of Industry–Brazil (CNI), Social Service of Industry (SESI), National Service for Industrial Training (SENAI), Euvaldo Lodi Institute (IEL), Brazilian Micro and Small Business Support Service (SEBRAE), and the Entrepreneurial Mobilization for Innovation (MEI). MEI is comprised of Brazilian business leaders, including leaders of industries that serve the health and medicine sector, who have been promoting innovation as the center of strong business strategy and aiming to increase the strength and efficiency of innovation policies in Brazil. CNI, SESI, SENAI, IEL, SEBRAE, and MEI are confident that the emergence of intelligent, interconnected devices, sensors, and mobile trackers are essential for the country to develop telemedicine, which is one of the emerging technologies in this field. Artificial intelligence (AI) is another promising technology in health that is gaining momentum due to the expansion of information processing capacity and data availability. AI can be used, among other things, to reduce medical errors. In countries like Brazil, where it is difficult for doctors to reach all regions of the country, telemedicine and AI could prove helpful in advancing medical care.

CNI, SESI, SENAI, IEL, and SEBRAE strive to stimulate research and innovation and to promote the competitiveness of the Brazilian industry and economy. From academic studies to working in collaboration with legislative and executive branches in Brazil to advocate broad and well-informed innovation policies, CNI, SESI, SENAI, IEL, and SEBRAE have made important contributions to building a dynamic ecosystem for innovation in health and medicine in Brazil. The Global Innovation Index (GII) has played an influential role in this effort by sharing data and insights that guide countries on how to build a more innovative economy.

Robson Braga de Andrade
President; CNI; Director, SESI; President; SENAI's National Council

Carlos Melles
President, SEBRAE

KEY FINDINGS

FIGURE A

Global leaders in innovation in 2019

Every year, the Global Innovation Index ranks the innovation performance of nearly 130 economies around the world.

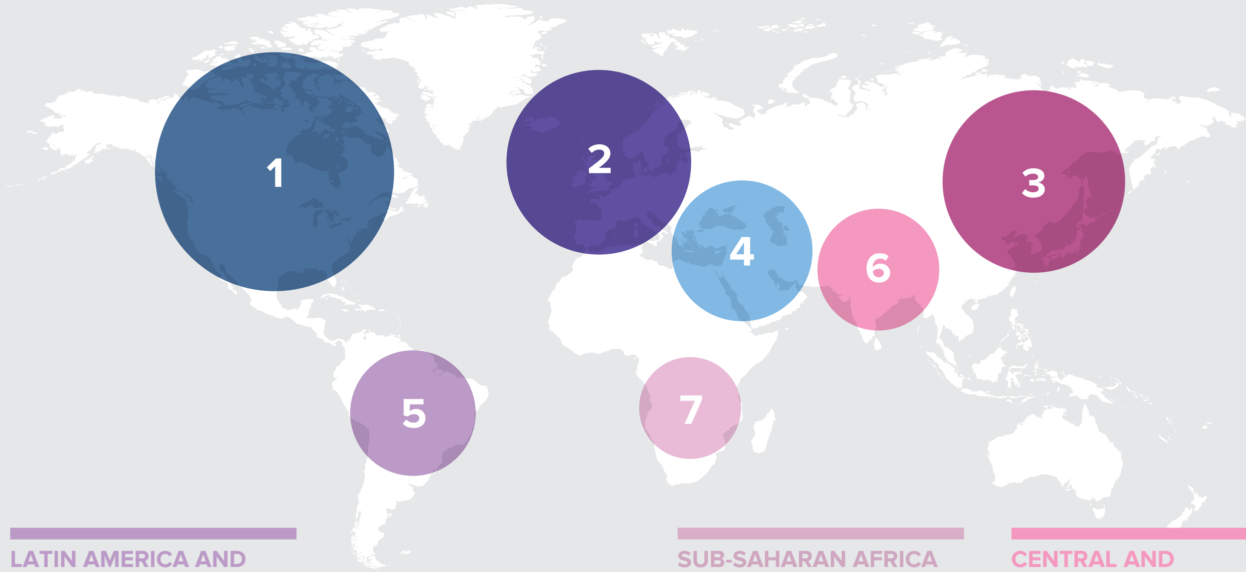
Top 3 innovation economies by region

NORTHERN AMERICA
1. U.S.
2. Canada

EUROPE
1. Switzerland
2. Sweden ↑
3. Netherlands ↓

NORTHERN AFRICA AND WESTERN ASIA
1. Israel
2. Cyprus
3. United Arab Emirates

SOUTH EAST ASIA, EAST ASIA, AND OCEANIA
1. Singapore
2. Republic of Korea
3. Hong Kong, China ★



LATIN AMERICA AND THE CARIBBEAN
1. Chile
2. Costa Rica
3. Mexico

SUB-SAHARAN AFRICA
1. South Africa
2. Kenya ↑
3. Mauritius ↓

CENTRAL AND SOUTHERN ASIA
1. India
2. Iran
3. Kazakhstan

↑↓ indicates the movement of rank within the top 3 relative to 2018, and ★ indicates a new entrant into the top 3 in 2019.

Top 3 innovation economies by income group

HIGH INCOME
1. Switzerland
2. Sweden ↑
3. U.S. ★

UPPER-MIDDLE INCOME
1. China
2. Malaysia
3. Bulgaria

LOWER-MIDDLE INCOME
1. Viet Nam ↑
2. Ukraine ↓
3. Georgia ★

LOW INCOME
1. Rwanda ↑
2. Senegal ↑
3. Tanzania ↓

Source: Figure 1.4 in Chapter 1.

KEY FINDINGS 2019

The main messages of the Global Innovation Index 2019 can be summarized in seven key findings.

1: Amid economic slowdown, innovation is blossoming around the world; but new obstacles pose risks to global innovation

Global economic growth appears to be losing momentum relative to last year. Productivity growth is at a record low. Trade battles are brewing. Economic uncertainty is high.

Despite this gloomy perspective, innovation is blossoming around the world. In developed and developing economies alike, formal innovation—as measured by research and development (R&D) and patents—and less formal modes of innovation are thriving.

Today, developed and developing economies of all types promote innovation to achieve economic and social development. It is now also better understood that innovation is taking place in all realms of the economy, not only in high-tech companies and technology sectors. As a result, economies are firmly centering their attention on the creation and upkeep of sound and dynamic innovation ecosystems and networks.

The world witnessed an increase in innovation investments over recent years, as measured by the average investments of economies across all levels of development. The use of intellectual property (IP) reached record highs in 2017 and 2018.

Global R&D expenditures have been growing faster than the global economy, more than doubling between 1996 and 2016. In 2017, global government expenditures in R&D (GERD) grew by about 5% while business R&D expenditures grew by 6.7%, the largest increase since 2011 (Figure B and C). Never in history have so many scientists worldwide labored at solving the most pressing global scientific challenges.

What can we expect in terms of innovation efforts in the years to come?

Despite economic uncertainty, innovation expenditures have been growing and seem resilient in light of the current economic cycle.

As global economic growth declines in 2019, the question is whether this trend will continue. Two concerns stand out:

First, the GII 2019 shows that public R&D expenditures—in particular, in some high-income economies responsible for driving the technology frontier—are growing slowly or not at all. Waning public support for R&D in high-income economies is concerning given its central role in funding basic R&D and other blue sky research, which are key to future innovations—including for health innovation, this year's GII theme.

Second, increased protectionism—in particular, protectionism that impacts technology-intensive sectors and knowledge flows—poses risks to global innovation networks and innovation diffusion. If left uncontained, these new obstacles to international trade, investment, and workforce mobility will lead to a slowdown of growth in innovation productivity and diffusion across the globe.

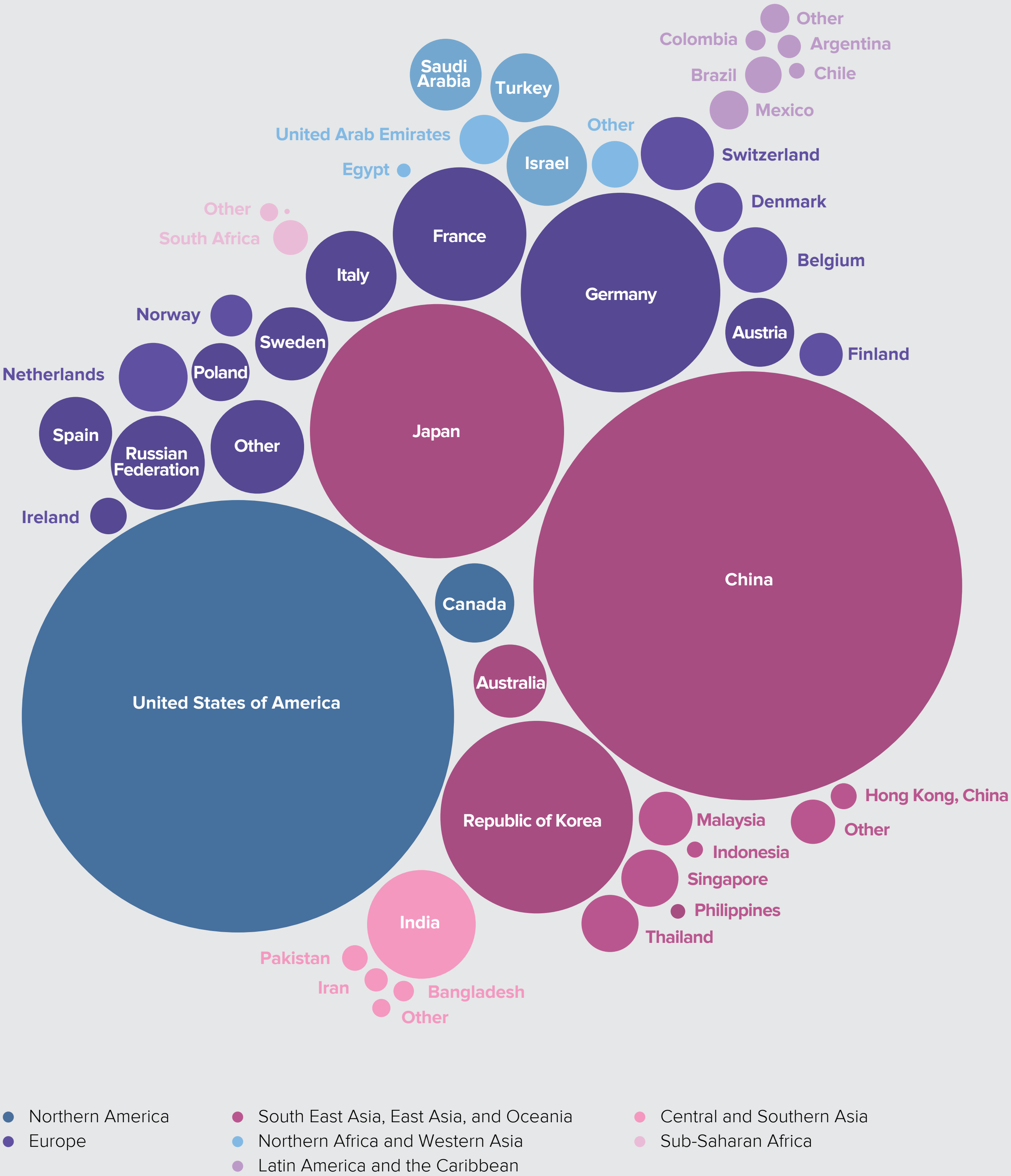
FIGURE B

R&D expenditure growth, 2000-2017

Source: Figure 1.3 in Chapter 1.

FIGURE C

Regional and economy shares in world business expenditures, 2017



Source: Figure 1.2 in Chapter 1.

2: Shifts in the global innovation landscape are materializing; some middle-income economies are on the rise

This year, again, the geography of innovation is changing.

In the top echelon, Switzerland, Sweden, and the United States of America (U.S.) lead the innovation rankings, with the latter two moving up in GII 2019. Other European nations, such as the Netherlands and Germany, along with Singapore in Asia, remain consistent members of the GII top 10. This year, Israel moves up to the 10th position, marking the first time an economy from the Northern Africa and Western Asia region cracks the top 10 rankings.

In the top 20, the Republic of Korea edges closer to the top 10. China, continues its upward rise, moving to 14th (from 17th in 2018), and thus firmly establishing itself in the group of leading innovative nations. China remains the only middle-income economy in the top 30. China's innovation strengths become evident in numerous areas; it maintains top ranks in Patents by origin, Industrial designs, and Trademarks by origin as well as High-tech net exports and Creative goods exports.

Notable moves in GII rankings this year include the United Arab Emirates (36th); Viet Nam (42nd), and Thailand (43rd) getting closer to the top 40; India (52nd) getting closer to the top 50; the Philippines (54th) breaking into the top 55; and the Islamic Republic of Iran (61st) getting closer to the top 60.

The performance improvement of India is particularly noteworthy. India continues to be the most innovative economy in Central & Southern Asia—a distinction held since 2011 (Figure A)—improving its global rank to 52nd in 2019. India is consistently among the top in the world in innovation drivers such as ICT services exports, Graduates in science & engineering, the quality of universities, Gross capital formation—a measure of economy-wide investments—and Creative goods exports. India also stands out in the GII ranking of the world's top science and technology clusters (Key Finding #6), with Bengaluru, Mumbai, and New Delhi featuring prominently among the global top 100 clusters. Given its size—and if progress is upheld—India will make a true impact on global innovation in the years to come.

As always, it must be noted that for year-on-year comparisons of the above type, GII ranks are influenced by various factors, such as changes in metrics and data availability.

When comparing levels of innovation to the level of economic development, India, Viet Nam, Kenya, and the Republic of Moldova stand out for outperforming on innovation relative to GDP for the ninth consecutive year—a record.

Other economies also outperform in innovation relative to their GDP, catching-up with innovation leaders more quickly than their peers (Table A). Middle-income economies outperforming on innovation relative to their level of development include, for example, Costa Rica—the only country in Latin America and the Caribbean—South Africa, Thailand, Georgia, and the Philippines. Burundi, Malawi, Mozambique, and Rwanda stand out as thriving economies within the low-income group.

As in previous years, Africa shines in terms of innovation relative to level of development. Out of the 18 innovation achievers identified in the GII 2019, six (the most from any one region) are from the Sub-Saharan African region. Importantly, Kenya, Rwanda, Mozambique, Malawi, and Madagascar stand out for being innovation achievers at least three times in the previous eight years.

3: Innovation inputs and outputs are still concentrated in very few economies; a global innovation divide persists

The geography of innovation is shifting from high-income to middle-income economies. Nonetheless, innovation expenditures remain concentrated in a few economies and regions. Moving from a successful middle-income economy with innovation potential into an innovation powerhouse remains hard; an impermeable innovation glass ceiling exists that divides middle- and high-income economies. Most of the drive to break through that ceiling comes from China and to some extent India, Brazil, and the Russian Federation.

In terms of innovation scores and ranks, the innovation divide is evident across the GII—existing between income groups and across all GII pillars, from Institutions to Creative outputs (Figure E).

On a regional level, continuous innovation performance improvements are primarily happening in Asia. Other world regions struggle to catch up with Northern America, Europe, and South East Asia, East Asia, and Oceania.

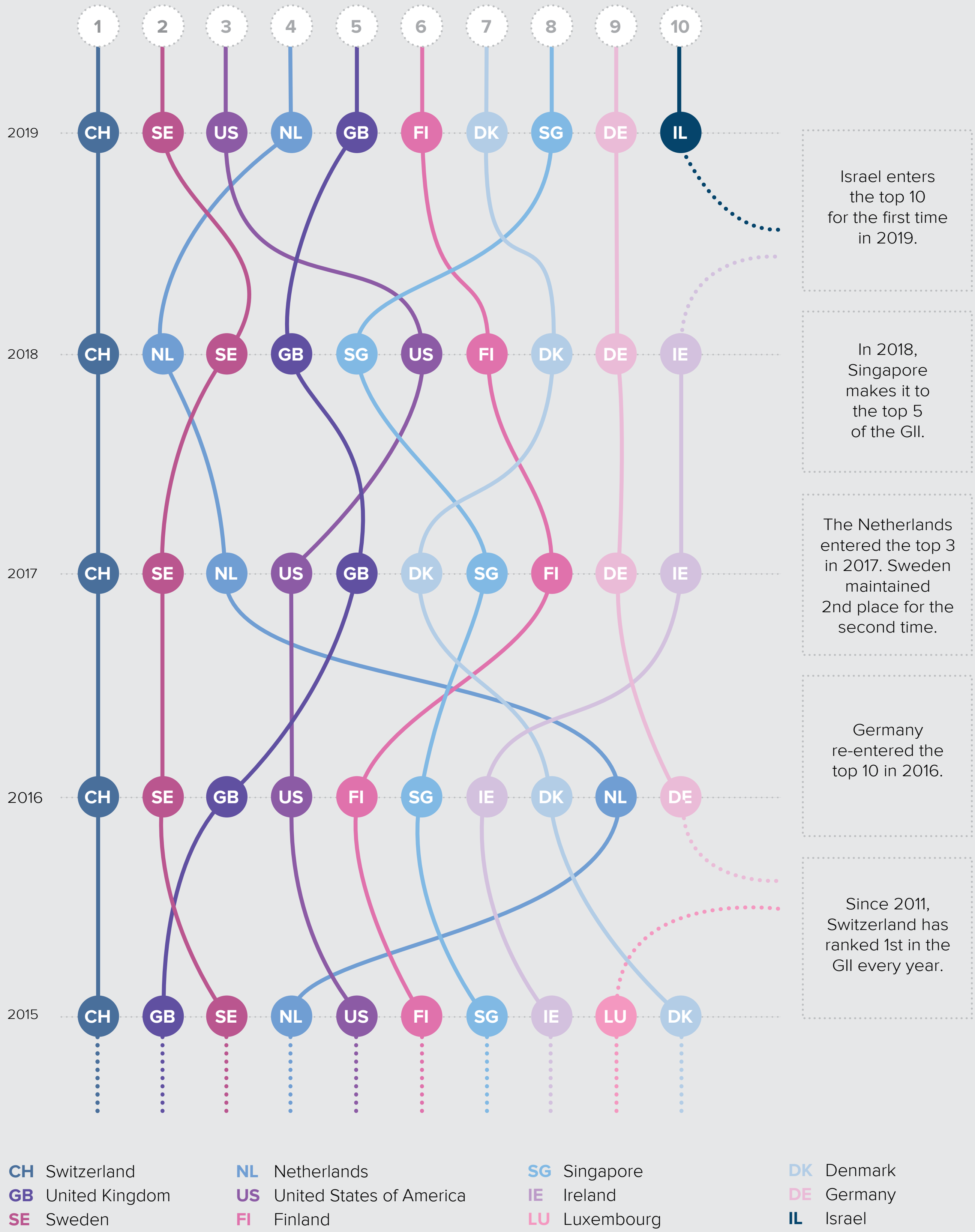
It will take time and persistence, perhaps over decades, for the innovation policy ambitions of economies at all levels to influence the global innovation landscape.

4: Some economies get more return on their innovation investments than others

A divide also exists in how effective economies are in translating innovation inputs into innovation outputs (Figure F); some economies simply achieve more with less. This discrepancy exists even among high-income economies: while Switzerland, the Netherlands, and Sweden effectively translate their innovation inputs into a higher level of outputs, Singapore (8th) and the United Arab Emirates (36th), for example, produce lower levels of output relative to their innovation inputs.

FIGURE D

Movement in the GII, top 10, 2019



Source: Figure 1.5 in Chapter 1.

TABLE A

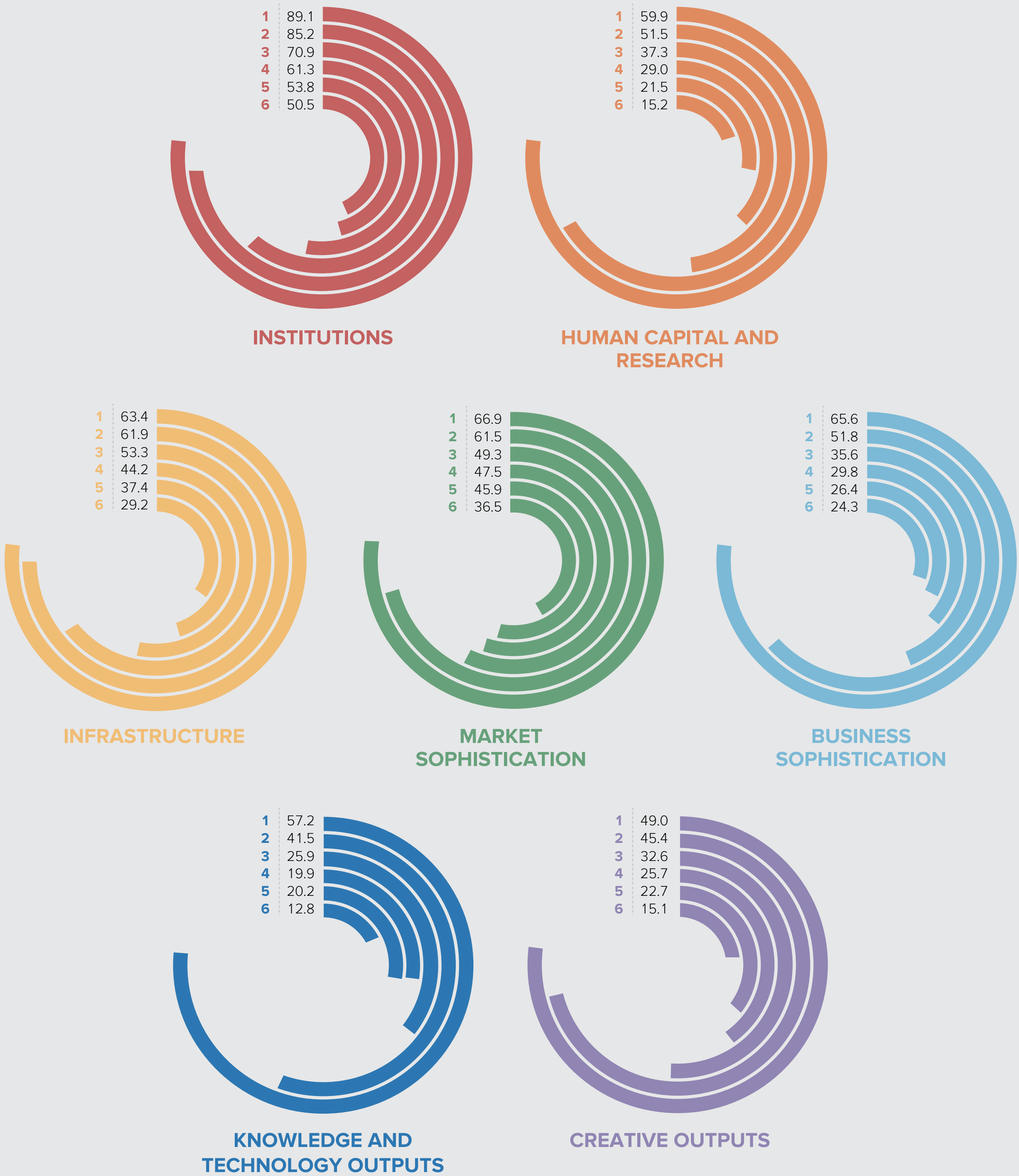
Innovation performance at different income levels, 2019

	High Income	Upper-middle Income	Lower-middle Income	Low Income
Above expectations for level of development	Denmark Finland Netherlands Singapore Sweden Switzerland United Kingdom United States of America Germany Israel Republic of Korea Ireland Hong Kong, China Japan France	Armenia China Costa Rica Montenegro North Macedonia South Africa Thailand	Georgia India Kenya Mongolia Philippines Republic of Moldova Ukraine Viet Nam	Burundi Malawi Mozambique Rwanda
In line with expectations for level of development	Canada Luxembourg Norway Iceland Austria Australia Belgium Estonia New Zealand Czech Republic Malta Cyprus Spain Italy Slovenia Portugal Hungary Latvia Slovakia Poland Greece Croatia Chile Uruguay Argentina	Malaysia Bulgaria Romania Mexico Serbia Iran (Islamic Republic of) Brazil Colombia Peru Belarus Bosnia and Herzegovina Jamaica Albania Azerbaijan Jordan Lebanon	Tunisia Morocco Indonesia Sri Lanka Kyrgyzstan Egypt Cambodia Côte d'Ivoire Honduras Cameroon	Senegal United Republic of Tanzania Tajikistan Uganda Nepal Ethiopia Mali Burkina Faso Madagascar Zimbabwe Niger
Below expectations for level of development	United Arab Emirates Lithuania Kuwait Qatar Saudi Arabia Brunei Darussalam Panama Bahrain Oman Trinidad and Tobago	Russian Federation Turkey Kazakhstan Mauritius Dominican Republic Botswana Paraguay Ecuador Namibia Guatemala Algeria	Pakistan Ghana El Salvador Bolivia (Plurinational State of) Nigeria Bangladesh Nicaragua Zambia	Benin Guinea Togo Yemen

Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.

FIGURE E

Innovation divide across income groups, 2019

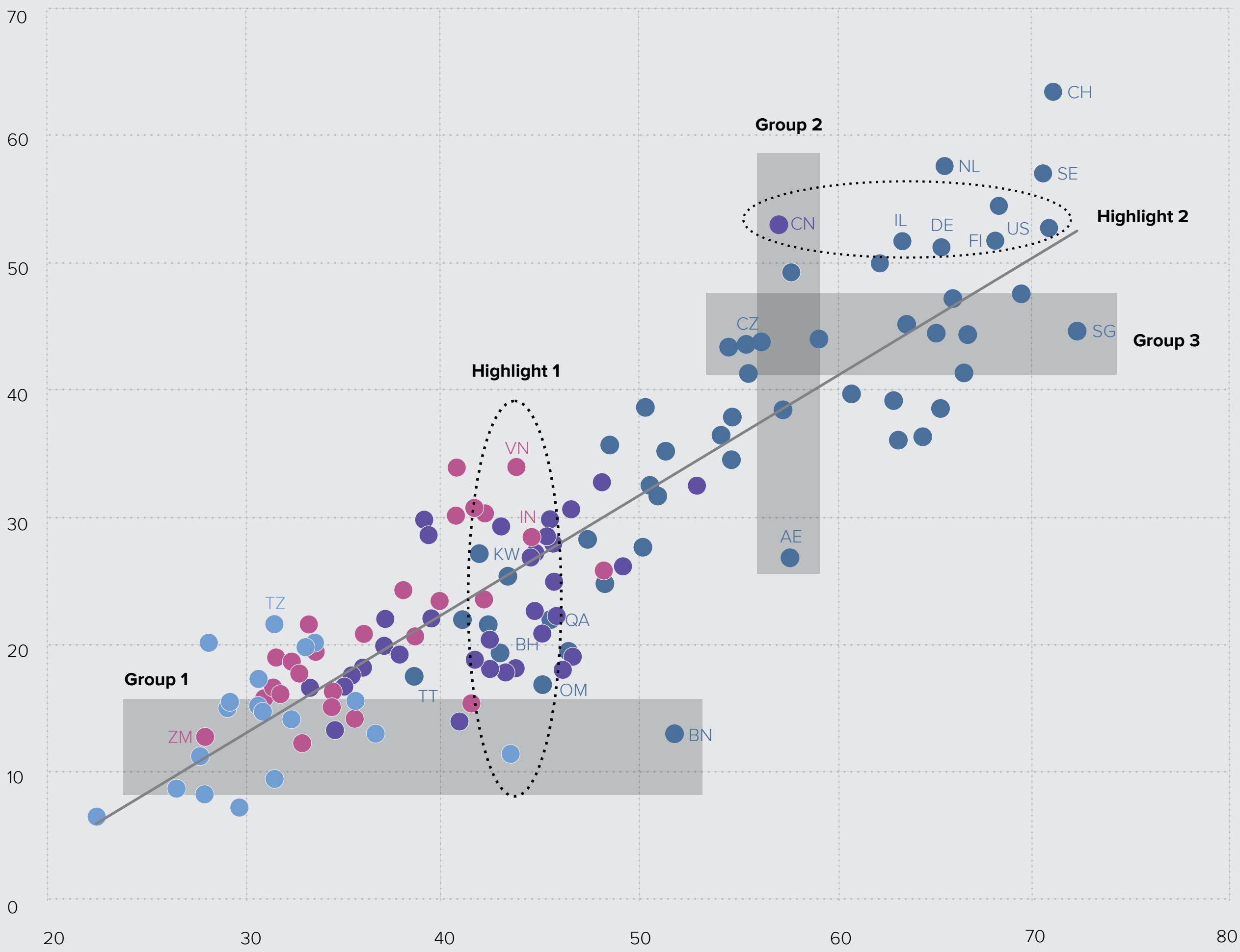


1 Top 10 high income
2 11 to 25 high and upper-middle income
3 Other high income
4 Other upper-middle income
5 Lower-middle income
6 Low income

Source: Box 2, Figure 1 in Chapter 1.

FIGURE F

Innovation input/output performance by income group, 2019



▲ Output score
▶ Input score

● High income
● Upper-middle income

● Lower-middle income
● Low income

— Fitted values

AE	United Arab Emirates
BH	Bahrain
BN	Brunei Darussalam
CH	Switzerland
CN	China
CZ	Czech Republic
DE	Germany
FI	Finland
IL	Israel
IN	India
KW	Kuwait
NL	Netherlands
OM	Oman
QA	Qatar
SE	Sweden
SG	Singapore
TT	Trinidad and Tobago
TZ	United Republic of Tanzania
US	United States of America
VN	Viet Nam
ZM	Zambia

Source: Figure 1.8 in Chapter 1.

China (CN), Malaysia, and Bulgaria are the only middle-income economies that perform as well on most GII innovation input and output measures as the high-income group. China stands out for producing innovation output that is equivalent to Germany (DE), the U.K., Finland (FI), Israel (IL), and the United States of America (US)—but with considerably lower levels of input.

Among lower middle-income economies, Viet Nam (VN) and India (IN) are among a small group of countries that achieve high impact for their innovation efforts. In the low-income group, the United Republic of Tanzania (TZ) achieves the same (Figure F).

5: Shifting focus from innovation quantity to innovation quality remains a priority

Assessing the quality, rather than only the quantity, of innovation inputs and outputs has become an overarching concern to the innovation policy community.

The GII makes a modest attempt at measuring innovation quality by looking at 1) the quality of local universities (QS university ranking); 2) the internationalization of patented inventions (Patent families 2+ offices); and 3) the quality of scientific publications (Citable documents H-index).

Among the high-income economies, the U.S. regains the top rank—moving ahead of Japan, which moves down to 3rd this year (Figure G). For the first time, Germany has moved up to 2nd.

The ranking of middle-income economies in these innovation quality indicators remains steady, with China, India, and the Russian Federation in the top 3 positions. Positioned 15th globally, China is the only middle-income economy that is closing the gap with the high-income group in all three indicators. India ranks 2nd among the middle-income economies, with top positions in quality of universities and in quality of scientific publications.

With regards to the quality of universities, the U.S. and the U.K. occupy the top 2 positions in the GII 2019, followed by China, which takes the 3rd spot this year (moving up from the 5th position in 2018). In the middle-income group, China is followed by Malaysia and India, thanks to the high scores for their top universities. The Russian Federation, Mexico, and Brazil also appear in the top 10, due largely to the quality of their universities (Table B).

Regarding the quality of publications, rankings are rather stable with the U.S., the U.K., and Germany leading the GII rankings. Among middle-income economies, China takes the top position, followed by India.

Regarding international patents, European countries take seven of the top 10 positions—with the three remaining spots going to Israel, Japan, and the Republic of Korea. Among the middle-income economies, China and South Africa take the top two positions, with India and Turkey registering improvements in this indicator.

TABLE B

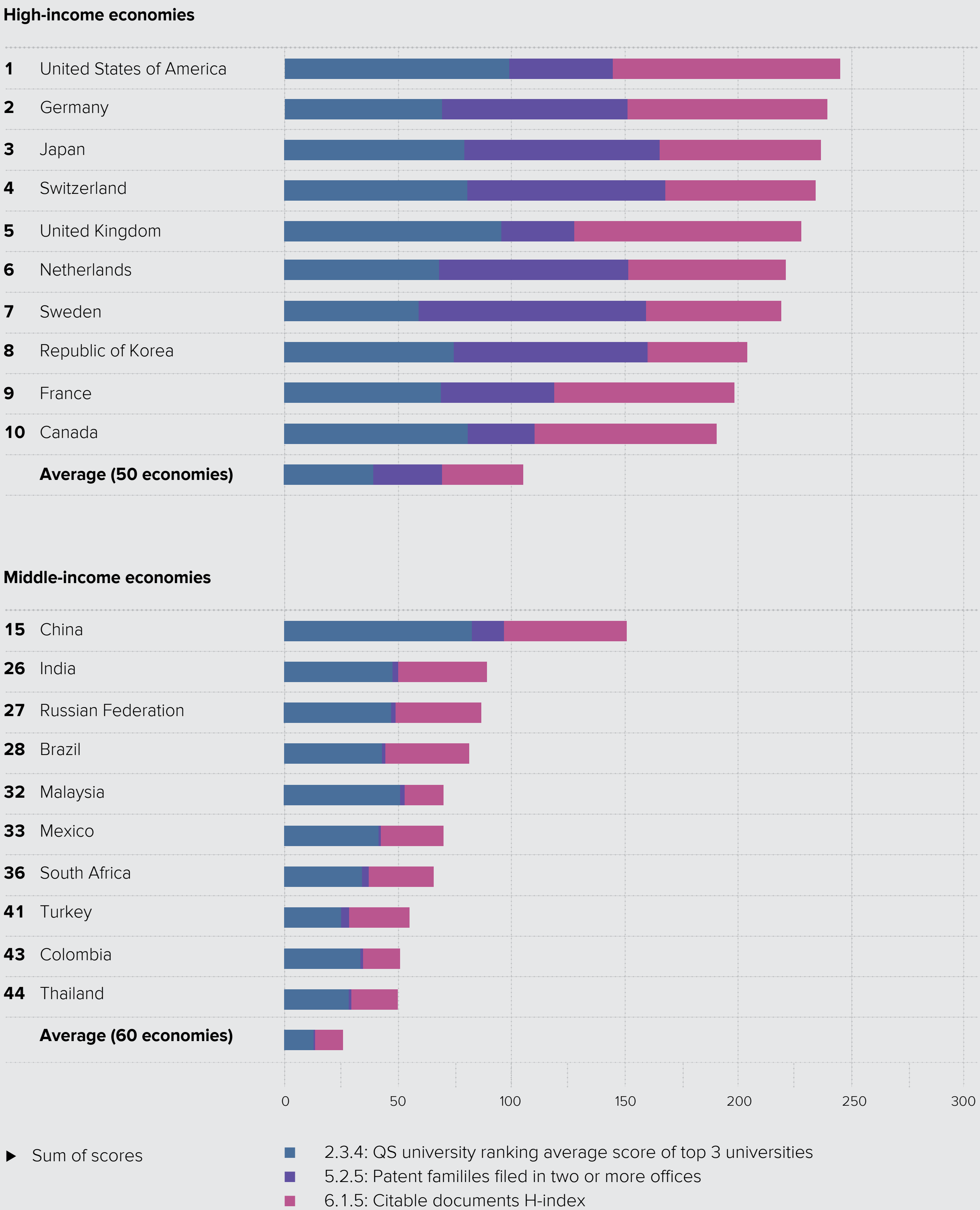
Top 10 universities in middle-income economies

Location	University	Score
China	Tsinghua University	87.2
China	Peking University	82.6
China	Fudan University	77.6
Malaysia	Universiti Malaya (UM)	62.6
Russian Federation	Lomonosov Moscow State University	62.3
Mexico	Universidad Nacional Autónoma de México (UNAM)	56.8
Brazil	Universidade de São Paulo (USP)	55.5
India	Indian Institute of Technology Bombay (IITB)	48.2
India	Indian Institute of Science (IISC) Bengaluru	47.1
India	Indian Institute of Technology Delhi (IITD)	46.6

Source: Table 1.3 in Chapter 1.

FIGURE G

Metrics for quality of innovation: top 10 high- and middle-income economies, 2019



Source: Figure 1.7 in Chapter 1.

6: Most top science and technology clusters are in the U.S., China, and Germany; Brazil, India, Iran, the Russian Federation, and Turkey also make the top 100 list

As in the previous two years, the GII 2019 includes a Special Section, which presents the latest ranking of the world's largest science and technology (S&T) clusters.

The top 10 clusters are the same as last year (Table C). Tokyo–Yokohama tops this ranking, followed by Shenzhen–Hong Kong. Figure H shows the concentration of top science and technology clusters worldwide. The U.S. continues to host the largest number of clusters (26), followed by China (18, two more than in 2018), Germany (10), France (5), the U.K. (4), and Canada (4). Australia, India, Japan, the Republic of Korea, and Switzerland all hosted three clusters each. In addition, there are clusters from five middle-income economies in the top 100—Brazil, India, the Islamic Republic of Iran, the Russian Federation, and Turkey.

TABLE C

Top cluster of economies or cross-border regions within the top 50, 2019

Rank	Cluster name	Economy(ies)
1	Tokyo-Yokohama	JP
2	Shenzhen-Hong Kong	CN/HK
3	Seoul	KR
4	Beijing	CN
5	San Jose-San Francisco, CA	US
9	Paris	FR
15	London	GB
18	Amsterdam-Rotterdam	NL
20	Cologne	DE
23	Tel Aviv-Jerusalem	IL
28	Singapore	SG
31	Eindhoven	BE/NL
32	Stockholm	SE
33	Moscow	RU
35	Melbourne	AU
39	Toronto, ON	CA
40	Brussels	BE
42	Madrid	ES
46	Tehran	IR
48	Milan	IT
50	Zürich	CH/DE

Source: Special Section: Identifying and ranking the world's largest science and technology clusters (Cluster Rankings).

Compared to last year, almost all Chinese clusters moved up the ranks.

Also, compared to last year, there is a notable shift in the distribution of top patenting fields. Coinciding with this year's GII theme, medical technology is now the most frequent patenting field—present in 19 clusters. Pharmaceuticals dropped to second place.

Beijing is the top collaborating cluster for scientific co-authorships, followed by Washington, DC–Baltimore, MD; New York City, NY; Boston–Cambridge, MA; and Cologne, Germany. San Jose–San Francisco, CA is the most frequent top co-inventing cluster, followed by Beijing; Shenzhen–Hong Kong; and New York City, NY. The Chinese Academy of Sciences was the top academic entity for all of Beijing's collaborations. Entities that also drove their clusters' collaborations were Johns Hopkins University (8, Washington, DC–Baltimore, MD), Columbia University (7, New York City, NY), and Harvard University (6, Boston–Cambridge, MA).

7: Creating healthy lives through medical innovation requires more investment in innovation and increased diffusion efforts

The 2019 GII theme is *Creating Healthy Lives—The Future of Medical Innovation*, which explores the role of medical innovation as it shapes the future of healthcare. In the years to come, medical innovations such as artificial intelligence (AI), genomics, and mobile health applications will transform the delivery of healthcare in both developed and emerging nations.

The key questions addressed in this edition of the GII include:

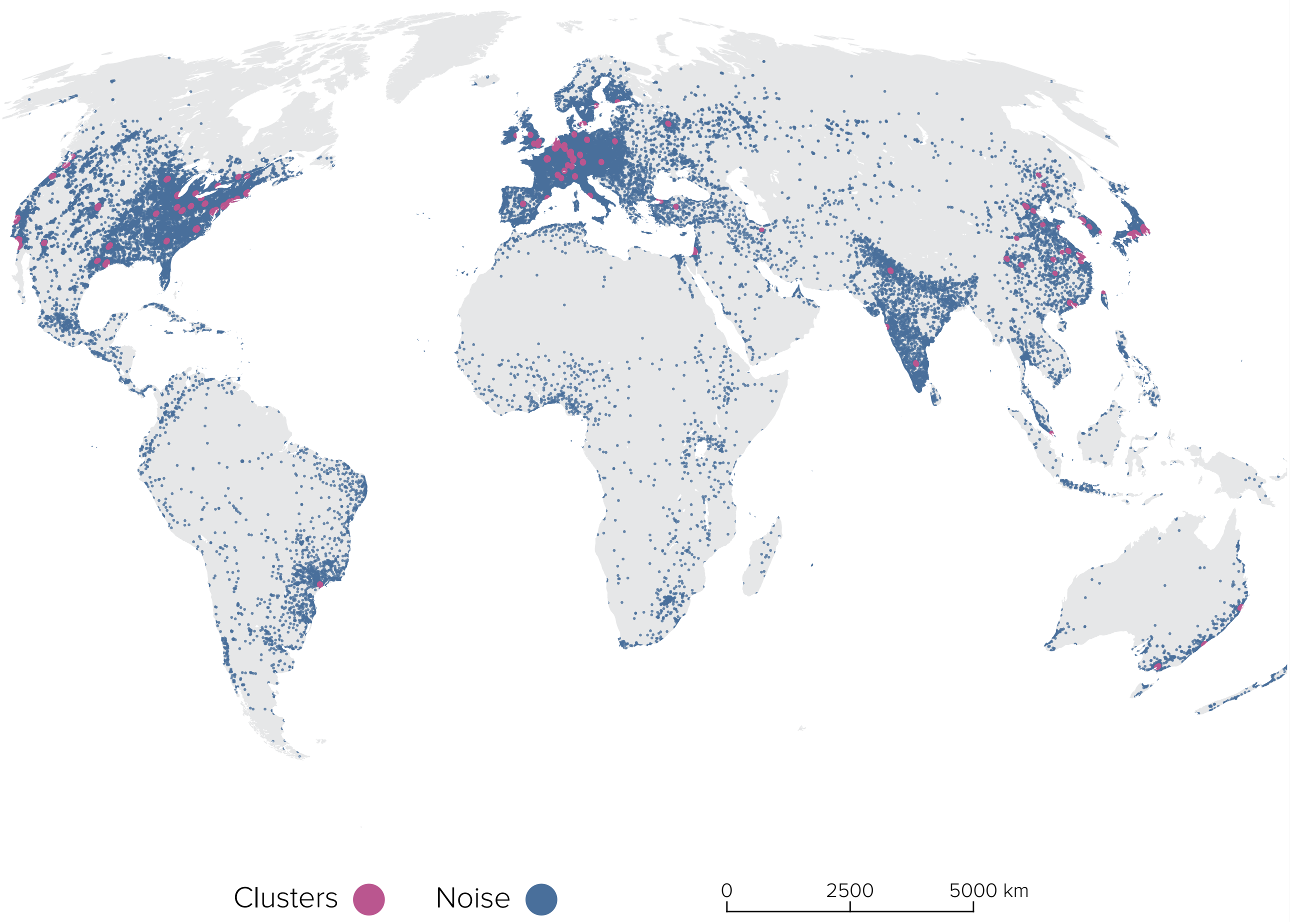
- What is the potential impact of medical innovation on society and economic growth, and what obstacles must be overcome to reach that potential?
- How is the global landscape for R&D and medical innovation changing?
- What health challenges do future innovations need to address and what types of breakthroughs are on the horizon?
- What are the main opportunities and obstacles to future medical innovation and what role might new policies play?

The following six learnings emerge:

- High quality and affordable healthcare for all is important for sustainable economic growth and the overall quality of life of citizens. While significant progress has been achieved across many dimensions over the last decades, significant gaps in access to quality healthcare for large parts of the global population remain.

FIGURE H

Top science and technology clusters worldwide, 2019



Source: Special Section: Cluster Rankings

- Medical innovations are critical for closing the gaps in global healthcare provision. Yet, nowadays, there are obstacles to health innovation and its diffusion which urgently need to be overcome. First, in the recent past, productivity in healthcare R&D has slowed; the identification of new cures for new diseases is painstakingly long. As a result, many acute and chronic conditions, such as cancer, depression, or Alzheimer's, have not yet been matched with breakthrough cures. Second, innovations in healthcare generally diffuse more slowly relative to other sectors. Moving medical innovations from "bench to bedside" is a long process, sometimes over decades. This is due to the complexity of the health innovation ecosystem and the diverging incentives of healthcare actors at play.

- Thankfully, a resurgence of health R&D and health innovation is taking place, possibly helping to overcome the innovation productivity decline of the pharmaceutical industry in the past decades. These innovations are happening across multiple dimensions, including core sciences, drug development, care delivery, and organizational and business models. Figure I shows the most promising fields for medical innovation in the years to come. In particular, medical technology related innovations are blossoming, with medical technology patents more numerous and growing at a faster path than pharmaceutical patents for the last decade (Figure J).

- The convergence of digital and biological technologies is disrupting healthcare and increasing the importance of data integration and management across the healthcare ecosystem. Innovation in the field of health now massively evolves around big data, the internet of things and artificial intelligence, entailing huge power shifts within and away from the health sector. This phenomenon will also drive future health-related innovation into non-technological fields, such as business model reorganization and new processes, rather than new technologies alone.

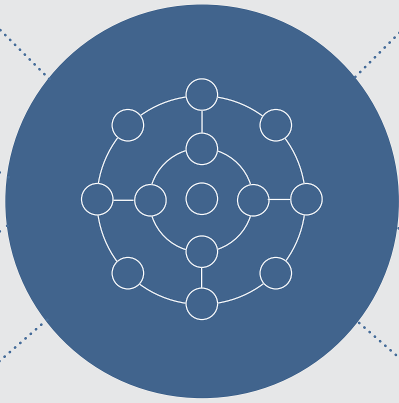
- Emerging markets have a unique opportunity to leverage medical innovations and invest in new healthcare delivery models to close the healthcare gap with more developed markets. Caution should be taken to ensure that new health innovations, and their related costs, do not exacerbate the health gap between the rich and poor. The true challenge for developing economies is often the lack of minimally functional health systems—and not necessarily a need for more R&D or new technologies. Low-tech or adapted technology applications can save more lives than the latest high-tech solutions.

- Finally, the GII 2019 report suggests a few key health innovation policy priorities, including the importance of ensuring sufficient medical innovation funding, in particular for public sector research; building functional medical innovation systems; facilitating the innovation path from "bench to bedside"; establishing and maintaining a skilled health workforce; moving from research on cures to innovation in the field of prevention; carefully evaluating the costs and benefits of medical innovations; supporting new data infrastructure and digital health strategies to focus on creating data infrastructure; and developing processes for efficient and safe data collection, management, and sharing.

FIGURE I

Promising fields for medical innovation and technologies

NEW SCIENTIFIC BREAKTHROUGHS, TREATMENTS, AND CURES



Genetics and stem cell research
— Single-cell analysis
— Gene and stem cell therapies
— Genetic engineering and editing including CRISPR technology

Nanotechnology
— Swallowable small devices

Biologics
— Development and manufacture of complex biologics

Brain research, neurology, and neurosurgery
— Characterization of the brain's major circuits
— New brain imagery for mental disorders
— Migraine treatment

New generation of vaccines and immunotherapy
— HIV and universal flu vaccine
— Cancer vaccine
— Immunotherapy
— New vaccine delivery methods

Pain management
— Effective, non-addictive medicines for pain management

Mental health treatments
— Pre-symptomatic diagnosis and treatment of Alzheimer's disease and other cognitive declines

NEW MEDICAL TECHNOLOGIES

Medical devices
— 3D printing
— Cardiac devices
— Implants and bionics

Medical imaging and diagnostics
— Optical high-definition imaging and virtual anatomic models
— Biosensors and markers
— 4D human charting and virtual reality
— Screening for diseases

Precision and personalized medicine
— Computer-assisted surgery
— Surgical robots
— Personalized medicine

Regenerative medicine
— Tissue engineering
— Effective bioartificial pancreas

ORGANIZATIONAL AND PROCESS INNOVATIONS

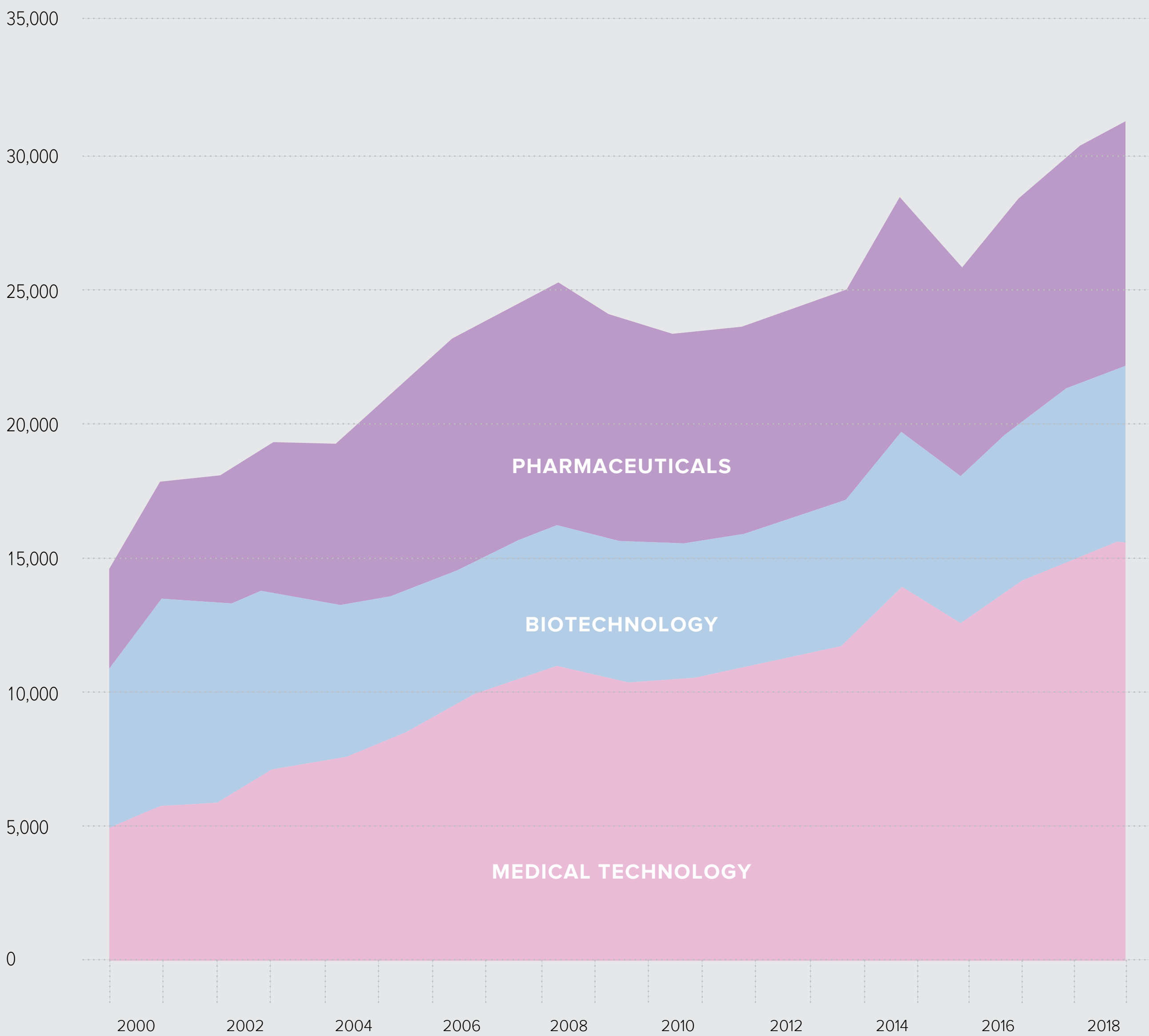
Novel approaches in healthcare research
— Software-based modeling to speed up research
— Artificial intelligence techniques to speed up research and clinical trials

New ways of delivering healthcare
— Telemedicine applications
— Drone delivery of medications
— Remote monitoring and portable diagnostics
— Improved data sharing

Source: Figure T-1.4 in Theme Section.

FIGURE J

Patent Cooperation Treaty (PCT) filings by technology, 2000-2018



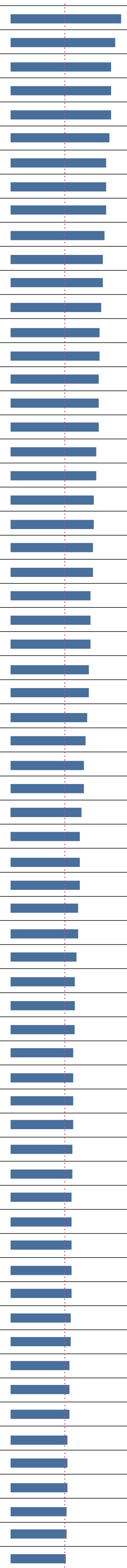
▲ Patent publications
▶ Year

Source: Figure T-1.3 in Theme Section.

RANKINGS

Global Innovation Index 2019 rankings

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median 33.86
Switzerland	67.24	1	HI	1	EUR	1	
Sweden	63.65	2	HI	2	EUR	2	
United States of America	61.73	3	HI	3	NAC	1	
Netherlands	61.44	4	HI	4	EUR	3	
United Kingdom	61.30	5	HI	5	EUR	4	
Finland	59.83	6	HI	6	EUR	5	
Denmark	58.44	7	HI	7	EUR	6	
Singapore	58.37	8	HI	8	SEAO	1	
Germany	58.19	9	HI	9	EUR	7	
Israel	57.43	10	HI	10	NAWA	1	
Republic of Korea	56.55	11	HI	11	SEAO	2	
Ireland	56.10	12	HI	12	EUR	8	
Hong Kong, China	55.54	13	HI	13	SEAO	3	
China	54.82	14	UM	1	SEAO	4	
Japan	54.68	15	HI	14	SEAO	5	
France	54.25	16	HI	15	EUR	9	
Canada	53.88	17	HI	16	NAC	2	
Luxembourg	53.47	18	HI	17	EUR	10	
Norway	51.87	19	HI	18	EUR	11	
Iceland	51.53	20	HI	19	EUR	12	
Austria	50.94	21	HI	20	EUR	13	
Australia	50.34	22	HI	21	SEAO	6	
Belgium	50.18	23	HI	22	EUR	14	
Estonia	49.97	24	HI	23	EUR	15	
New Zealand	49.55	25	HI	24	SEAO	7	
Czech Republic	49.43	26	HI	25	EUR	16	
Malta	49.01	27	HI	26	EUR	17	
Cyprus	48.34	28	HI	27	NAWA	2	
Spain	47.85	29	HI	28	EUR	18	
Italy	46.30	30	HI	29	EUR	19	
Slovenia	45.25	31	HI	30	EUR	20	
Portugal	44.65	32	HI	31	EUR	21	
Hungary	44.51	33	HI	32	EUR	22	
Latvia	43.23	34	HI	33	EUR	23	
Malaysia	42.68	35	UM	2	SEAO	8	
United Arab Emirates	42.17	36	HI	34	NAWA	3	
Slovakia	42.05	37	HI	35	EUR	24	
Lithuania	41.46	38	HI	36	EUR	25	
Poland	41.31	39	HI	37	EUR	26	
Bulgaria	40.35	40	UM	3	EUR	27	
Greece	38.90	41	HI	38	EUR	28	
Viet Nam	38.84	42	LM	1	SEAO	9	
Thailand	38.63	43	UM	4	SEAO	10	
Croatia	37.82	44	HI	39	EUR	29	
Montenegro	37.70	45	UM	5	EUR	30	
Russian Federation	37.62	46	UM	6	EUR	31	
Ukraine	37.40	47	LM	2	EUR	32	
Georgia	36.98	48	LM	3	NAWA	4	
Turkey	36.95	49	UM	7	NAWA	5	
Romania	36.76	50	UM	8	EUR	33	
Chile	36.64	51	HI	40	LCN	1	
India	36.58	52	LM	4	CSA	1	
Mongolia	36.29	53	LM	5	SEAO	11	
Philippines	36.18	54	LM	6	SEAO	12	
Costa Rica	36.13	55	UM	9	LCN	2	
Mexico	36.06	56	UM	10	LCN	3	
Serbia	35.71	57	UM	11	EUR	34	
Republic of Moldova	35.52	58	LM	7	EUR	35	
North Macedonia	35.29	59	UM	12	EUR	36	
Kuwait	34.55	60	HI	41	NAWA	6	
Iran (Islamic Republic of)	34.43	61	UM	13	CSA	2	
Uruguay	34.32	62	HI	42	LCN	4	
South Africa	34.04	63	UM	14	SSF	1	
Armenia	33.98	64	UM	15	NAWA	7	
Qatar	33.86	65	HI	43	NAWA	8	



CONTINUED

Global Innovation Index 2019 rankings, continued

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median 33.86
Brazil	33.82	66	UM	16	LCN	5	
Colombia	33.00	67	UM	17	LCN	6	
Saudi Arabia	32.93	68	HI	44	NAWA	9	
Peru	32.93	69	UM	18	LCN	7	
Tunisia	32.83	70	LM	8	NAWA	10	
Brunei Darussalam	32.35	71	HI	45	SEAO	13	
Belarus	32.07	72	UM	19	EUR	37	
Argentina	31.95	73	HI	46	LCN	8	
Morocco	31.63	74	LM	9	NAWA	11	
Panama	31.51	75	HI	47	LCN	9	
Bosnia and Herzegovina	31.41	76	UM	20	EUR	38	
Kenya	31.13	77	LM	10	SSF	2	
Bahrain	31.10	78	HI	48	NAWA	12	
Kazakhstan	31.03	79	UM	21	CSA	3	
Oman	30.98	80	HI	49	NAWA	13	
Jamaica	30.80	81	UM	22	LCN	10	
Mauritius	30.61	82	UM	23	SSF	3	
Albania	30.34	83	UM	24	EUR	39	
Azerbaijan	30.21	84	UM	25	NAWA	14	
Indonesia	29.72	85	LM	11	SEAO	14	
Jordan	29.61	86	UM	26	NAWA	15	
Dominican Republic	28.56	87	UM	27	LCN	11	
Lebanon	28.54	88	UM	28	NAWA	16	
Sri Lanka	28.45	89	LM	12	CSA	4	
Kyrgyzstan	28.38	90	LM	13	CSA	5	
Trinidad and Tobago	28.08	91	HI	50	LCN	12	
Egypt	27.47	92	LM	14	NAWA	17	
Botswana	27.43	93	UM	29	SSF	4	
Rwanda	27.38	94	LI	1	SSF	5	
Paraguay	27.09	95	UM	30	LCN	13	
Senegal	26.83	96	LI	2	SSF	6	
United Republic of Tanzania	26.63	97	LI	3	SSF	7	
Cambodia	26.59	98	LM	15	SEAO	15	
Ecuador	26.56	99	UM	31	LCN	14	
Tajikistan	26.43	100	LI	4	CSA	6	
Namibia	25.85	101	UM	32	SSF	8	
Uganda	25.60	102	LI	5	SSF	9	
Côte d'Ivoire	25.55	103	LM	16	SSF	10	
Honduras	25.48	104	LM	17	LCN	15	
Pakistan	25.36	105	LM	18	CSA	7	
Ghana	25.27	106	LM	19	SSF	11	
Guatemala	25.07	107	UM	33	LCN	16	
El Salvador	24.89	108	LM	20	LCN	17	
Nepal	24.85	109	LI	6	CSA	8	
Bolivia (Plurinational State of)	24.76	110	LM	21	LCN	18	
Ethiopia	24.16	111	LI	7	SSF	12	
Mali	24.03	112	LI	8	SSF	13	
Algeria	23.98	113	UM	34	NAWA	18	
Nigeria	23.93	114	LM	22	SSF	14	
Cameroon	23.90	115	LM	23	SSF	15	
Bangladesh	23.31	116	LM	24	CSA	9	
Burkina Faso	23.30	117	LI	9	SSF	16	
Malawi	23.00	118	LI	10	SSF	17	
Mozambique	22.87	119	LI	11	SSF	18	
Nicaragua	22.55	120	LM	25	LCN	19	
Madagascar	22.38	121	LI	12	SSF	19	
Zimbabwe	22.30	122	LI	13	SSF	20	
Benin	20.42	123	LI	14	SSF	21	
Zambia	20.36	124	LM	26	SSF	22	
Guinea	19.50	125	LI	15	SSF	23	
Togo	18.54	126	LI	16	SSF	24	
Niger	18.13	127	LI	17	SSF	25	
Burundi	17.65	128	LI	18	SSF	26	
Yemen	14.49	129	LI	19	NAWA	19	

Notes: World Bank Income Group Classification (July 2018): LI = low income; LM = lower-middle income; UM = upper-middle income; and HI = high income. Regions are based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

Innovation Input Sub-Index rankings

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median 43.46
Singapore	72.15	1	HI	1	SEAO	1	
Switzerland	71.02	2	HI	2	EUR	1	
United States of America	70.85	3	HI	3	NAC	1	
Sweden	70.43	4	HI	4	EUR	2	
Denmark	69.33	5	HI	5	EUR	3	
United Kingdom	68.22	6	HI	6	EUR	4	
Finland	68.04	7	HI	7	EUR	5	
Hong Kong, China	66.69	8	HI	8	SEAO	2	
Canada	66.40	9	HI	9	NAC	2	
Republic of Korea	65.95	10	HI	10	SEAO	3	
Netherlands	65.40	11	HI	11	EUR	6	
Germany	65.28	12	HI	12	EUR	7	
Norway	65.27	13	HI	13	EUR	8	
Japan	65.03	14	HI	14	SEAO	4	
Australia	64.35	15	HI	15	SEAO	5	
France	63.50	16	HI	16	EUR	9	
Israel	63.28	17	HI	17	NAWA	1	
New Zealand	63.09	18	HI	18	SEAO	6	
Austria	62.82	19	HI	19	EUR	10	
Ireland	62.13	20	HI	20	EUR	11	
Belgium	60.73	21	HI	21	EUR	12	
Iceland	59.07	22	HI	22	EUR	13	
Luxembourg	57.73	23	HI	23	EUR	14	
United Arab Emirates	57.65	24	HI	24	NAWA	2	
Spain	57.29	25	HI	25	EUR	15	
China	56.88	26	UM	1	SEAO	7	
Estonia	56.10	27	HI	26	EUR	16	
Cyprus	55.54	28	HI	27	NAWA	3	
Czech Republic	55.43	29	HI	28	EUR	17	
Italy	54.74	30	HI	29	EUR	18	
Portugal	54.69	31	HI	30	EUR	19	
Malta	54.58	32	HI	31	EUR	20	
Slovenia	54.10	33	HI	32	EUR	21	
Malaysia	52.93	34	UM	2	SEAO	8	
Brunei Darussalam	51.74	35	HI	33	SEAO	9	
Latvia	51.29	36	HI	34	EUR	22	
Poland	50.97	37	HI	35	EUR	23	
Lithuania	50.58	38	HI	36	EUR	24	
Hungary	50.35	39	HI	37	EUR	25	
Greece	50.20	40	HI	38	EUR	26	
Russian Federation	49.11	41	UM	3	EUR	27	
Slovakia	48.54	42	HI	39	EUR	28	
Chile	48.26	43	HI	40	LCN	1	
Georgia	48.19	44	LM	1	NAWA	4	
Bulgaria	48.08	45	UM	4	EUR	29	
Croatia	47.37	46	HI	41	EUR	30	
Thailand	46.58	47	UM	5	SEAO	10	
Peru	46.50	48	UM	6	LCN	2	
Saudi Arabia	46.40	49	HI	42	NAWA	5	
Belarus	46.02	50	UM	7	EUR	31	
South Africa	45.74	51	UM	8	SSF	1	
North Macedonia	45.72	52	UM	9	EUR	32	
Qatar	45.59	53	HI	43	NAWA	6	
Romania	45.51	54	UM	10	EUR	33	
Montenegro	45.43	55	UM	11	EUR	34	
Turkey	45.26	56	UM	12	NAWA	7	
Oman	45.08	57	HI	44	NAWA	8	
Colombia	45.06	58	UM	13	LCN	3	
Mexico	44.74	59	UM	14	LCN	4	
Brazil	44.71	60	UM	15	LCN	5	
India	44.66	61	LM	2	CSA	1	
Serbia	44.50	62	UM	16	EUR	35	
Viet Nam	43.75	63	LM	3	SEAO	11	
Kazakhstan	43.74	64	UM	17	CSA	2	
Rwanda	43.46	65	LI	1	SSF	2	

CONTINUED

Innovation Input Sub-Index rankings, continued

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median 43.46
Uruguay	43.31	66	HI	45	LCN	6	
Mauritius	43.25	67	UM	18	SSF	3	
Costa Rica	42.95	68	UM	19	LCN	7	
Bahrain	42.89	69	HI	46	NAWA	9	
Albania	42.42	70	UM	20	EUR	36	
Bosnia and Herzegovina	42.41	71	UM	21	EUR	37	
Argentina	42.34	72	HI	47	LCN	8	
Mongolia	42.24	73	LM	4	SEAO	12	
Tunisia	42.13	74	LM	5	NAWA	10	
Kuwait	41.90	75	HI	48	NAWA	11	
Philippines	41.68	76	LM	6	SEAO	13	
Azerbaijan	41.59	77	UM	22	NAWA	12	
Kyrgyzstan	41.48	78	LM	7	CSA	3	
Panama	41.06	79	HI	49	LCN	9	
Botswana	40.86	80	UM	23	SSF	4	
Republic of Moldova	40.77	81	LM	8	EUR	38	
Ukraine	40.73	82	LM	9	EUR	39	
Morocco	39.91	83	LM	10	NAWA	13	
Jamaica	39.47	84	UM	24	LCN	10	
Armenia	39.36	85	UM	25	NAWA	14	
Iran (Islamic Republic of)	39.00	86	UM	26	CSA	4	
Indonesia	38.64	87	LM	11	SEAO	14	
Trinidad and Tobago	38.63	88	HI	50	LCN	11	
Kenya	38.07	89	LM	12	SSF	5	
Dominican Republic	37.86	90	UM	27	LCN	12	
Jordan	37.10	91	UM	28	NAWA	15	
Lebanon	37.08	92	UM	29	NAWA	16	
Nepal	36.71	93	LI	2	CSA	5	
Sri Lanka	36.07	94	LM	13	CSA	6	
Paraguay	35.93	95	UM	30	LCN	13	
Uganda	35.66	96	LI	3	SSF	6	
El Salvador	35.62	97	LM	14	LCN	14	
Ecuador	35.42	98	UM	31	LCN	15	
Namibia	34.97	99	UM	32	SSF	7	
Algeria	34.64	100	UM	33	NAWA	17	
Honduras	34.46	101	LM	15	LCN	16	
Bolivia (Plurinational State of)	34.43	102	LM	16	LCN	17	
Senegal	33.58	103	LI	4	SSF	8	
Cambodia	33.51	104	LM	17	SEAO	15	
Guatemala	33.33	105	UM	34	LCN	18	
Egypt	33.32	106	LM	18	NAWA	18	
Tajikistan	33.12	107	LI	5	CSA	7	
Nicaragua	32.96	108	LM	19	LCN	19	
Ghana	32.80	109	LM	20	SSF	9	
Côte d'Ivoire	32.43	110	LM	21	SSF	10	
Burkina Faso	32.32	111	LI	6	SSF	11	
Cameroon	31.71	112	LM	22	SSF	12	
Pakistan	31.62	113	LM	23	CSA	8	
Benin	31.49	114	LI	7	SSF	13	
United Republic of Tanzania	31.47	115	LI	8	SSF	14	
Nigeria	31.46	116	LM	24	SSF	15	
Bangladesh	31.07	117	LM	25	CSA	9	
Mozambique	30.92	118	LI	9	SSF	16	
Malawi	30.76	119	LI	10	SSF	17	
Mali	30.73	120	LI	11	SSF	18	
Togo	29.79	121	LI	12	SSF	19	
Madagascar	29.30	122	LI	13	SSF	20	
Zimbabwe	29.22	123	LI	14	SSF	21	
Ethiopia	28.23	124	LI	15	SSF	22	
Niger	27.99	125	LI	16	SSF	23	
Zambia	27.97	126	LM	26	SSF	24	
Guinea	27.76	127	LI	17	SSF	25	
Burundi	26.54	128	LI	18	SSF	26	
Yemen	22.53	129	LI	19	NAWA	19	

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Innovation Output Sub-Index rankings

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median 23.54
Switzerland	63.45	1	HI	1	EUR	1	
Netherlands	57.49	2	HI	2	EUR	2	
Sweden	56.87	3	HI	3	EUR	3	
United Kingdom	54.38	4	HI	4	EUR	4	
China	52.75	5	UM	1	SEAO	1	
United States of America	52.61	6	HI	5	NAC	1	
Finland	51.62	7	HI	6	EUR	5	
Israel	51.59	8	HI	7	NAWA	1	
Germany	51.10	9	HI	8	EUR	6	
Ireland	50.08	10	HI	9	EUR	7	
Luxembourg	49.20	11	HI	10	EUR	8	
Denmark	47.55	12	HI	11	EUR	9	
Republic of Korea	47.15	13	HI	12	SEAO	2	
France	45.00	14	HI	13	EUR	10	
Singapore	44.59	15	HI	14	SEAO	3	
Hong Kong, China	44.40	16	HI	15	SEAO	4	
Japan	44.32	17	HI	16	SEAO	5	
Iceland	43.99	18	HI	17	EUR	11	
Estonia	43.83	19	HI	18	EUR	12	
Malta	43.44	20	HI	19	EUR	13	
Czech Republic	43.44	21	HI	20	EUR	14	
Canada	41.36	22	HI	21	NAC	2	
Cyprus	41.13	23	HI	22	NAWA	2	
Belgium	39.63	24	HI	23	EUR	15	
Austria	39.06	25	HI	24	EUR	16	
Hungary	38.67	26	HI	25	EUR	17	
Norway	38.46	27	HI	26	EUR	18	
Spain	38.42	28	HI	27	EUR	19	
Italy	37.87	29	HI	28	EUR	20	
Slovenia	36.40	30	HI	29	EUR	21	
Australia	36.33	31	HI	30	SEAO	6	
New Zealand	36.01	32	HI	31	SEAO	7	
Slovakia	35.55	33	HI	32	EUR	22	
Latvia	35.17	34	HI	33	EUR	23	
Portugal	34.60	35	HI	34	EUR	24	
Ukraine	34.07	36	LM	1	EUR	25	
Viet Nam	33.93	37	LM	2	SEAO	8	
Bulgaria	32.61	38	UM	2	EUR	26	
Malaysia	32.42	39	UM	3	SEAO	9	
Lithuania	32.34	40	HI	35	EUR	27	
Poland	31.66	41	HI	36	EUR	28	
Philippines	30.68	42	LM	3	SEAO	10	
Thailand	30.67	43	UM	4	SEAO	11	
Mongolia	30.35	44	LM	4	SEAO	12	
Republic of Moldova	30.26	45	LM	5	EUR	29	
Montenegro	29.96	46	UM	5	EUR	30	
Iran (Islamic Republic of)	29.85	47	UM	6	CSA	1	
Costa Rica	29.31	48	UM	7	LCN	1	
Turkey	28.64	49	UM	8	NAWA	3	
Armenia	28.60	50	UM	9	NAWA	4	
India	28.49	51	LM	6	CSA	2	
Croatia	28.28	52	HI	37	EUR	31	
Romania	28.02	53	UM	10	EUR	32	
Greece	27.61	54	HI	38	EUR	33	
Mexico	27.38	55	UM	11	LCN	2	
Kuwait	27.21	56	HI	39	NAWA	5	
Serbia	26.93	57	UM	12	EUR	34	
United Arab Emirates	26.68	58	HI	40	NAWA	6	
Russian Federation	26.13	59	UM	13	EUR	35	
Georgia	25.76	60	LM	7	NAWA	7	
Uruguay	25.32	61	HI	41	LCN	3	
Chile	25.03	62	HI	42	LCN	4	
North Macedonia	24.86	63	UM	14	EUR	36	
Kenya	24.20	64	LM	8	SSF	1	
Tunisia	23.54	65	LM	9	NAWA	8	

CONTINUED

Innovation Output Sub-Index rankings, continued

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median 23.54
Morocco	23.34	66	LM	10	NAWA	9	
Brazil	22.93	67	UM	15	LCN	5	
South Africa	22.34	68	UM	16	SSF	2	
Jamaica	22.14	69	UM	17	LCN	6	
Qatar	22.13	70	HI	43	NAWA	10	
Jordan	22.12	71	UM	18	NAWA	11	
Panama	21.95	72	HI	44	LCN	7	
United Republic of Tanzania	21.78	73	LI	1	SSF	3	
Egypt	21.62	74	LM	11	NAWA	12	
Argentina	21.56	75	HI	45	LCN	8	
Colombia	20.94	76	UM	19	LCN	9	
Sri Lanka	20.83	77	LM	12	CSA	3	
Indonesia	20.80	78	LM	13	SEAO	13	
Bosnia and Herzegovina	20.41	79	UM	20	EUR	37	
Ethiopia	20.10	80	LI	2	SSF	4	
Senegal	20.09	81	LI	3	SSF	5	
Lebanon	20.00	82	UM	21	NAWA	13	
Tajikistan	19.74	83	LI	4	CSA	4	
Cambodia	19.68	84	LM	14	SEAO	14	
Saudi Arabia	19.46	85	HI	46	NAWA	14	
Peru	19.35	86	UM	22	LCN	10	
Bahrain	19.31	87	HI	47	NAWA	15	
Dominican Republic	19.25	88	UM	23	LCN	11	
Pakistan	19.10	89	LM	15	CSA	5	
Azerbaijan	18.83	90	UM	24	NAWA	16	
Côte d'Ivoire	18.67	91	LM	16	SSF	6	
Kazakhstan	18.32	92	UM	25	CSA	6	
Albania	18.26	93	UM	26	EUR	38	
Paraguay	18.25	94	UM	27	LCN	12	
Belarus	18.12	95	UM	28	EUR	39	
Mauritius	17.96	96	UM	29	SSF	7	
Ghana	17.74	97	LM	17	SSF	8	
Ecuador	17.71	98	UM	30	LCN	13	
Trinidad and Tobago	17.54	99	HI	48	LCN	14	
Mali	17.34	100	LI	5	SSF	9	
Oman	16.88	101	HI	49	NAWA	17	
Guatemala	16.81	102	UM	31	LCN	15	
Namibia	16.73	103	UM	32	SSF	10	
Honduras	16.51	104	LM	18	LCN	16	
Nigeria	16.40	105	LM	19	SSF	11	
Cameroon	16.09	106	LM	20	SSF	12	
Uganda	15.55	107	LI	6	SSF	13	
Bangladesh	15.55	108	LM	21	CSA	7	
Madagascar	15.47	109	LI	7	SSF	14	
Zimbabwe	15.38	110	LI	8	SSF	15	
Kyrgyzstan	15.29	111	LM	22	CSA	8	
Malawi	15.25	112	LI	9	SSF	16	
Bolivia (Plurinational State of)	15.09	113	LM	23	LCN	17	
Mozambique	14.82	114	LI	10	SSF	17	
Burkina Faso	14.29	115	LI	11	SSF	18	
El Salvador	14.16	116	LM	24	LCN	18	
Botswana	13.99	117	UM	33	SSF	19	
Algeria	13.32	118	UM	34	NAWA	18	
Nepal	12.99	119	LI	12	CSA	9	
Brunei Darussalam	12.95	120	HI	50	SEAO	15	
Zambia	12.74	121	LM	25	SSF	20	
Nicaragua	12.13	122	LM	26	LCN	19	
Rwanda	11.31	123	LI	13	SSF	21	
Guinea	11.24	124	LI	14	SSF	22	
Benin	9.36	125	LI	15	SSF	23	
Burundi	8.75	126	LI	16	SSF	24	
Niger	8.26	127	LI	17	SSF	25	
Togo	7.29	128	LI	18	SSF	26	
Yemen	6.44	129	LI	19	NAWA	19	

Notes: World Bank Income Group Classification (July 2018): LI = low income; LM = lower-middle income; UM = upper-middle income; and HI = high income. Regions are based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

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In 2011, an Advisory Board was established to provide advice on the research underlying the Global Innovation Index (GII), generate synergies at its stages of development, and assist with the dissemination of its messages and results. The Advisory Board is a select group of leading international practitioners with expertise in the realm of innovation. Its members are from diverse geographical and institutional backgrounds and participate in their personal capacity. We extend our gratitude to all Advisory Board members for their continuous support and collaboration.

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CHAPTERS

CHAPTER 1

THE GLOBAL INNOVATION INDEX 2019

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Since the release of the Global Innovation Index (GII) 2018, global economic growth has weakened and new risks have emerged. The global innovation landscape, in turn, has further evolved.

This scene-setting chapter of the GII 2019 takes a look at the pulse of innovation around the world, before revealing the innovation performance of economies. Chapter 1 is complemented by two additional sections this year. First, we present the Theme Section: *Creating Healthy Lives—The Future of Medical Innovation* main findings and take a look at the role of innovation for health, which is covered by world experts in the chapters that follow. Second, we present the new ranking of the world's largest science and technology clusters in the Special Section: Identifying and Ranking the World's Largest Science and Technology Clusters (Cluster Rankings).

Key findings in brief

1. Amid economic slowdown, innovation is blossoming around the world; but new obstacles pose risks to global innovation.
2. Shifts in the global innovation landscape are materializing; some middle-income economies are on the rise.
3. Innovation inputs and outputs are still concentrated in very few economies; a global innovation divide persists.
4. Some economies get more return on their innovation investments than others.
5. Shifting focus from innovation quantity to innovation quality remains a priority.
6. Most top science and technology clusters are in the U.S., China, and Germany; Brazil, India, Iran, the Russian Federation, and Turkey also make the top 100 list.
7. Creating healthy lives through medical innovation requires more investment in innovation and increased diffusion efforts.

Taking the pulse of innovation expenditures and policies around the world

Previous editions of the GII have underscored the paramount importance of laying the foundation for innovation-driven growth.[2]

Current economic figures show a level of uncertainty that contrasts with the optimism observed in the GII 2018 edition. Global economic growth appears to be losing momentum, relative to last year and earlier predictions.[3] Investment and productivity growth around the world—of which innovation is a significant engine—are still sluggish by historical standards and certainly compared to the years before the last financial crisis in 2009.[4] Global foreign direct investment (FDI) fell last year.[5] Despite a short-lived revival in 2017, labor productivity growth is at a record low after a decade of slowdown.[6] Yet, an increase in productivity will be one of the most effective ways to prevent global growth from slowing down prematurely.

From an innovation perspective, two possible bottlenecks exist: a decline in the level and speed of innovation—possibly due to sub-par investments in research and development (R&D)—and uneven adoption of innovation across the economy and the world at large.[7] While breakthrough innovation related to digital technologies, automation, data processing, and artificial intelligence (AI) are proliferating, some fear that their impact on medium-term productivity growth is likely to be modest.[8] Moreover, businesses do not seem to engage in innovative processes, products, and solutions evenly, leading to slow productivity growth.[9] Knowledge gaps at the global level are still prominent and possibly growing.

In all likelihood, a combination of both factors is likely the culprit—noting that current economic and geopolitical uncertainties are a possible deterrent to forward-looking innovation investment and adoption. New barriers to international innovation networks, trade, and workforce mobility are likely to negatively impact the formation of more proficient global innovation networks.

As we are at a critical juncture in our search for new sources of innovation-driven growth, it helps to take the pulse of innovation around the world on these matters.

True progress in fostering innovation on the ground

Regardless of the economic and geopolitical uncertainties over the last few years, formal and informal innovation seem to be blossoming globally. The news is positive as regards the political determination across the globe to foster innovation and related policies on the ground.

A few years ago, innovation and innovation policies were still the reserve of high-income economies. Today, developed and developing economies—including those with an abundance of natural resources—have placed innovation firmly on their agenda to boost economic and social development. To some extent, the North-South divide of how economies perceive innovation has improved.

As a result, encouragingly, many developing economies—including low-income economies—increasingly monitor their innovation performance closely and work on improving it.

In that same vein, there is a better understanding that innovation is taking place in all realms of the economy, including sectors originally—and possibly erroneously—classified as low-tech. As previous editions of the GII have shown, countries are well-advised to see the potential for innovation in all economic sectors, including agriculture, food, energy, and tourism, be they classified as high- or low-tech.[10] This entails breaking the myth that innovation is solely concerned with heavily science-driven and high-tech outputs.

The move towards conceptualizing innovation as something beyond high-tech R&D—to also be a concept that is applicable to local industries and that solves local problems through incremental innovation—is well on its way. Policymakers nowadays take an active interest in promoting local, frugal, and inclusive innovation drawing on local riches, crafts, and skill sets.

Consequently, a number of important trends are visible in modern-day innovation policy.

First, innovation policy is invoked not only in relation to economic objectives related to growth and technological change, but also to cope with modern societal challenges, such as food security, environment, energy transitions, and health, as evidenced in the current and past editions of the GII.[11]

On the organizational front, innovation policies have moved out of the reserve of one ministry or policy agency only—usually the Science Ministry—into cross-ministerial task forces or various ministries, often with the attention of high-level policymakers, such as the Prime Minister's office.

Hearteningly, the center of attention is gravitating from fostering science and R&D expenditures alone to striving for the creation and upkeep of sound and dynamic innovation ecosystems. Economies at all development levels now ask questions on how to instill the curiosity of science and entrepreneurship in children and students, how to make public research more relevant to business, how to promote inward technology transfer and foster business innovation expenditures, or how to make intellectual property work for local innovation. The focus of innovation policies has also shifted to increasingly emphasize the adoption of innovation, necessitating investment in enabling conditions, such as infrastructure for research and technology transfer, education and skills, entrepreneurs, and venture capital markets.

Finally, data-based evidence and innovation metrics are increasingly at the center of crafting, deploying, and evaluating innovation policies. The availability and use of innovation metrics has advanced over the last years (Box 3).

These are big steps forward. The determination to anchor policy objectives in innovation across all economies is now strong and growing—not only on paper but also as evidenced by actions on the ground.

Innovation remains concentrated in a few economies, while some others show potential to catch up

Innovation is thus finally part of policy ambitions around the world. This good news aside, across countries and economies, divides still exist as to the absolute scale of innovation inputs and outputs.

Change on this front is sparse and slow. Innovation investments and outputs, as we measure them today, continue to be concentrated in a handful of economies—and in specific regional innovation clusters within countries (Special Section: Cluster Rankings).

"Leapfrogging", the way in which latecomers can catch up with forerunners and become important players worldwide, is not an easy feat. Moving from a successful middle-income economy with innovation potential to an innovation powerhouse remains hard; an impermeable innovation glass ceiling exists between middle- and high-income economies.

But, what do top performers in the GII have in common? For years, we have noted a positive correlation between an economy's level of development (measured by GDP per capita) and innovation performance. In other words, wealthier economies perform better on innovation. However, we have also found that:[12]

1. There is a positive and statistically significant relation between economy size and innovation performance that indicates that scale, and thus a large market that is able to sustain innovation activities and the demand for innovation, continues to matter.
2. Economies with a diversified export basket that extends beyond a few commodities are more innovative.

This year, as in the past eleven years of publication, the global innovation divide between income groups and regions persists (Box 2). Historically, only a few countries have managed to join the fray of top innovation nations—notably Japan and the Republic of Korea in the 1980s and 1990s.[13] Northern America, and Europe continue to lead in the top 10 global innovation rankings, while Singapore continues to lead in Asia. In general, Asia has made formidable progress over the last decades. Recently, only China—an upper middle-income economy and an exception among the otherwise stable group of high-income economies—had entered the top 20 in the GII. Progress remains slower in other regions, such as Africa, and Latin America and the Caribbean.

Even within the most innovative nations, innovation activities are often concentrated in a few cities, regions, or clusters driven by agglomeration effects, as discussed in the Special Section presenting the Cluster Rankings in this edition.[14]

Shifting global R&D and the innovation landscape

The global innovation landscape is changing; innovation expenditures and innovation efforts, including the number of researchers and entrepreneurs who actively drive innovation efforts, have been scaled up massively. Yet innovation remains relatively "spiky", concentrated in a few countries and regions only. This is reflected in other key innovation indicators, such as R&D, researchers, and intellectual property (IP).

From a historic perspective, the global landscape of science and technology investment, and investments in education and human capital, have undergone important shifts over the last three decades. Global R&D expenditures have continued to rise, more than doubling between 1996 and 2017.

Today, it is not only high-income economies carrying out R&D in earnest. While in 1996 high-income economies accounted for 87% of global R&D, in 2017, they only represented 64% of total investments—the lowest share registered in the last 30 years. In contrast, the share of R&D investments from upper middle-income economies, notably China, has consistently increased, from only 10% of global R&D expenditures in 1996 to 31% in 2017 (Figure 1.1). Middle-income economies represented 35% of total R&D expenditures in 2017. Asian R&D powerhouses, such as China, Japan, the Republic of Korea, and India, contributed to as much as 40% of the world's R&D in 2017, up from 22% in 1996. Of this 40%, China was responsible for 24% of the world's R&D expenditures in 2017, up from only 2.6% in 1996.

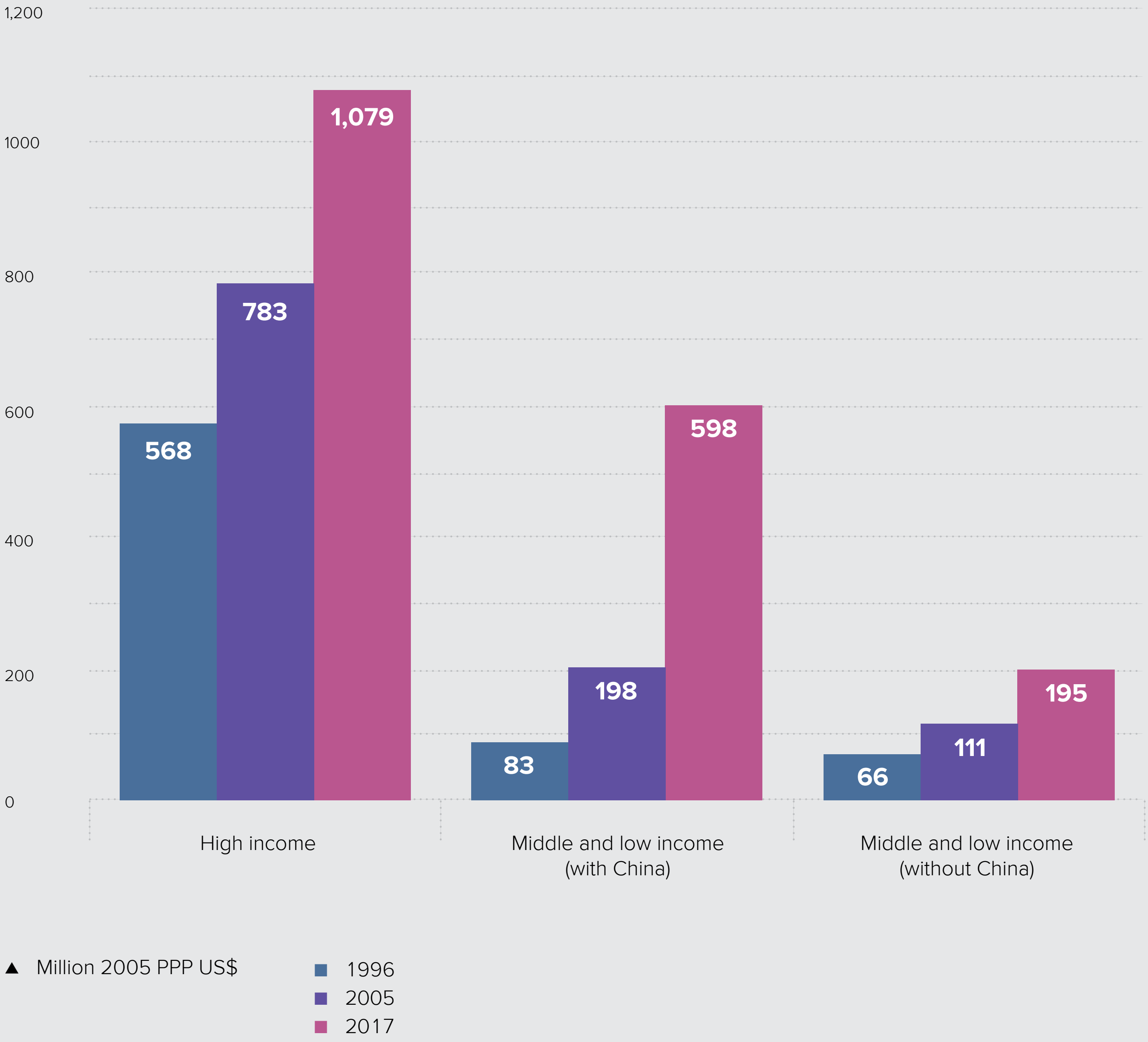
The world share of other emerging economies, such as India, have also substantially increased—from 1.8% in 1996 to 2.9% in 2017. In contrast, the regional R&D shares of Europe, and Latin America and the Caribbean have fallen with the rise of Asian economies. Sub-Saharan Africa continues to have low levels of R&D investments compared to what other world regions spend.

Private sector R&D funding also remains concentrated but it is evolving too. Only eight countries—the United States of America (U.S.), China, Japan, the Republic of Korea, Germany, France, the United Kingdom (U.K.), and India accounted for 82% of private sector R&D investments in 2017. Private sector R&D investments from China represented 27% of the world's total in 2017, almost on par with U.S. firms, and up from a negligible 2% in 1996 (Figure 1.2).

Middle-income economies and the South East Asia, East Asia, and Oceania region also played a central role when looking at the top 2,500 private sector companies who invested the largest sums in R&D in the world in the financial year 2017/18. In 2017, 591 companies from middle-income economies made the list of the top 2,500 private spenders.[15] Companies located in Argentina, Brazil, China, India, Iraq, Malaysia, Mexico, South Africa, Thailand, Turkey and Venezuela made it into the top ranks.

FIGURE 1.1

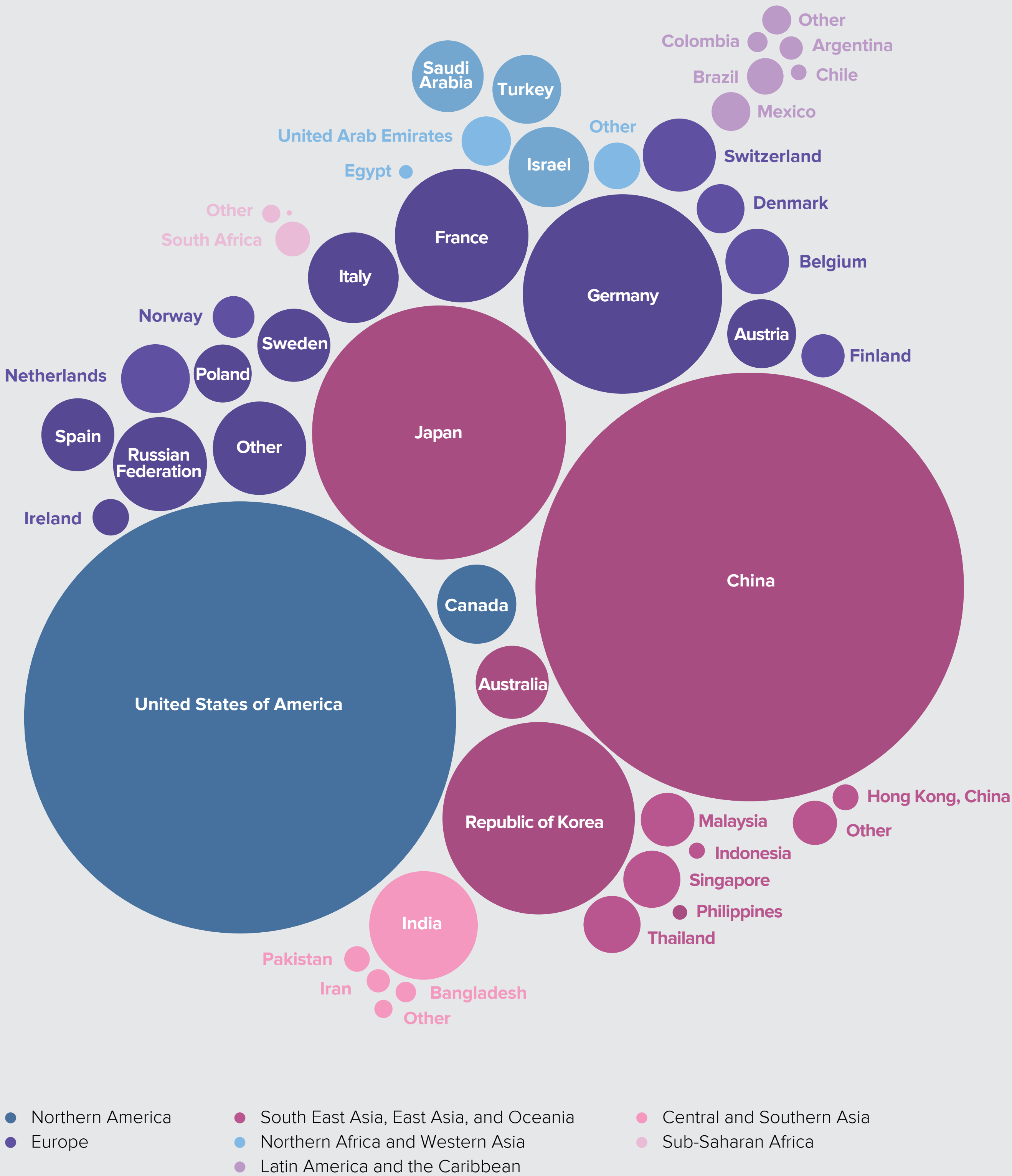
Worldwide R&D expenditures by income group, 1996, 2005, 2017



Source: Authors' estimate based on the UNESCO Institute for Statistics (UIS) database, OECD Main Science and Technology Indicators (MSTI), Eurostat, and the IMF World Economic Outlook database.
Notes: R&D data refers to gross domestic expenditure on R&D. The high-income group includes 54 economies, and the middle- and low-income groups include 97 economies.

FIGURE 1.2

Regional and economy shares in world business expenditures, 2017



Source: Authors' estimate based on the UNESCO Institute for Statistics (UIS) database, OECD Main Science and Technology Indicators (MSTI), Eurostat, and the IMF World Economic Outlook database.
Note: In PPP US$ in constant prices, 2015.

The number of researchers is also growing, again largely driven by China and emerging Asian innovation economies. In the period from 2008 to 2016, the number of researchers per million inhabitants grew by 19% worldwide. The largest contributors to this increase were middle-income economies, whose number of researchers increased by 34% in the same period.[16]

The same trends are true for intellectual property. Worldwide demand for IP reached record highs in 2017 and 2018, including for patents, trademarks, industrial designs, and other IP rights that are at the heart of the global innovation economy.[17] While in 1997, 88% of all patent applications originated from high-income economies, in 2017—largely driven by China—the origin of patent applications was almost equally distributed between high-income and upper middle-income economies. While in 1997 China accounted for 2% of all patent applications, in 2017 it represented 44% of the total.

Uncertainty around R&D and innovation in the years to come

So, what can we expect in terms of innovation efforts and R&D in the years to come? How will modest medium-term growth and world R&D intensities affect innovation in the future?

Last year, we warned of the challenge of keeping the global economy at sustained levels of economic growth in the years to come. We also warned that year-on-year growth of corporate and public R&D spending was still lower in 2016 than it was before the financial crisis.[18]

The good news this year is that global R&D expenditures have been growing faster than the global economy in real terms. Despite economic uncertainty and mirroring the determination of economies to stay true to their innovation agendas, innovation expenditures have been growing and are surprisingly resilient, suggesting a possible decoupling from economic cycles.

R&D grew in 2017 by 5.2%, the highest growth registered since 2011. These levels are more in line with the pre-crisis period (Figure 1.3). Projections show that this positive trend could continue: the 2018 Global R&D Outlook forecasts global R&D budgets to increase over the next five years.[19] By the same token, private sector funding has also been growing at a faster rate than the world economy and total R&D (Figure 1.3).[20] The world's business expenditures in R&D (BERD) grew by 6.7% in 2017, the largest increase registered since 2011 (Figure 1.2 and Figure 1.3). Private sector R&D also increased by 8.3% in the financial year 2017/18 relative to 2016/17.[21]

Are global R&D expenditures at risk to falter again, in line with slower GDP growth? Global government expenditures in R&D (GERD) fell on three occasions: in 2002, after a marked slowdown of the world economy; in 2009, with the aftermath of the global financial crisis; and most recently, in 2016, because of tighter government budgets in certain high-income economies and slower spending growth in key emerging economies. On these three occasions, public and private R&D followed the downward trajectory of global GDP growth. As global economic growth is declining in 2019, the question is whether R&D expenditures will remain resilient in light of the economic cycle this time around.

Another question is how to spread innovation expenditures more equally. R&D intensity, defined as global R&D expenditures divided by global GDP, has been relatively stable, increasing from 1.4% in 1996 to 1.7% since 2013. Most of the growth in R&D intensity has been registered among upper middle-income economies, with intensities passing from 0.6% in 1996 to 1.5% in 2017. Growth in R&D intensity is concentrated in a few countries, notably China, which increased from 0.6% in 1996 to 2.1% in 2017, and Malaysia, which increased from 0.2% to 1.3% in the same period. In contrast, R&D intensity has only improved marginally among middle-income economies, excluding China, from 0.5% in 1996 to 0.6% in 2017, and in low-income economies from 0.2% to 0.4%.

One additional worry is the waning public support for R&D, also relative to the strong expenditure increases in the post-crisis years (Box 1 in GII 2017 and 2018). R&D funding allocated by governments in the Organisation for Economic Co-operation and Development (OECD) countries show an increase of 0.9% in real terms in 2017, which is considerably lower than the 3.3% growth in 2016. R&D budgets decreased in the U.S. in 2017 relative to 2016. Moreover, even if public R&D in China grew by 7.9% in 2017, this is the lowest reported growth since 1997. In sum, most R&D budgets of governments in high-investing R&D countries remain below their pre-crisis levels. While companies become increasingly more important in driving global R&D expenditure growth—sometimes more important than countries (Box 1)—public R&D funding remains central to creating future breakthrough technologies. Public expenditures focus more on blue sky and basic research, which is critical to progress in the next decades, while private sector R&D is closer to product development. The importance of public and basic R&D—and current budgetary cuts to R&D programs—are further discussed in the Theme Section.

FIGURE 1.3

R&D expenditure growth, 2000-2017

Source: Authors' estimate based on the UNESCO Institute for Statistics (UIS) database, OECD Main Science and Technology Indicators (MSTI), Eurostat, and the IMF World Economic Outlook database.

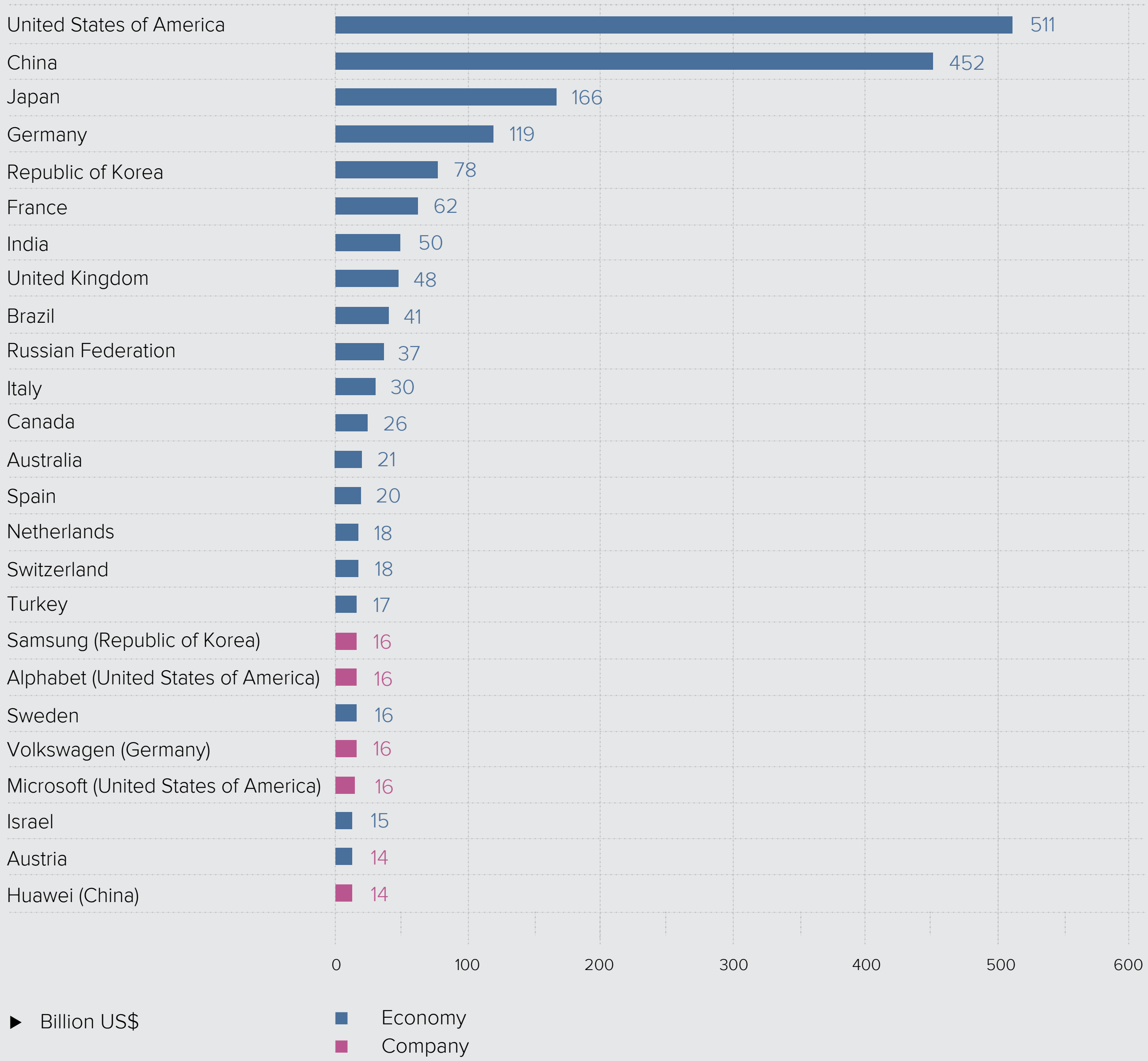
BOX 1

Private sector R&D investments on par with countries

Today, the R&D expenditure levels of a number of private sector companies are as high as government expenditures in R&D of a number of economies (Box 1, Figure 1). Companies such as Samsung (Republic of Korea), Alphabet (U.S.), Volkswagen (Germany), Microsoft (U.S.) and Huawei (China) are investing more, or almost the same, in R&D as governments located in the top-ranked countries in the GII 2019, including Sweden, Israel, Austria, and Switzerland.

BOX 1, FIGURE 1

Public and private R&D expenditures, 2017 (or latest available year)



Source: Authors' estimates, based on data from UNESCO Institute for Statistics (UIS); and EU Industrial R&D investment Scoreboard 2018.

In an environment dominated by uncertainty, the role of policymakers remains central in ensuring that this does not weaken R&D investments.[22]

While innovation remains concentrated in a few economies—although only a few have broken out as innovation leaders—the GII emphasizes the existence of success stories and that these economies need to be encouraged. It will take time and persistence, sometimes over decades, for the above-mentioned innovation policy ambitions to trickle down and make a true dent in the global innovation landscape. History has shown, however, that when developing economies consistently invest in innovation, they can embark on a journey that leads to prosperity. This includes all regions, in particular, certain African economies, such as Kenya or Rwanda, that have made a real difference in the global innovation landscape.

Over the years, the GII has shown that international openness and knowledge flows are critical to the development of successful innovation nations and international innovation networks. Economies at all levels of development are more innovative when they have a diversified export basket. The rise of global value chains and of global innovation networks has proven an essential building block of today's innovation landscape (see also the forthcoming WIPO World IP report).[23]

Finally, policymakers need to ensure that new barriers to international innovation networks, trade, and workforce mobility do not throttle the positive innovation dynamics at work. If left uncontained, these new obstacles to international trade, investment, and workplace mobility will lead to a slowdown of growth in innovation productivity and diffusion across the globe.

The Global Innovation Index 2019 results

Conceptual framework

The GII helps create an environment in which innovation factors are continually evaluated. This year, it provides detailed innovation metrics for 129 economies. All economies covered represent 91.8% of the world's population and 96.8% of the world's GDP.[24]

Three indices are calculated: the overall GII, the Innovation Input Sub-Index and the Innovation Output Sub-Index (Appendix I).[25]

- The overall GII score is the average of the Input and Output Sub-Index scores.
- The Innovation Input Sub-Index is comprised of five pillars that capture elements of the national economy that enable innovative activities: (1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication, and (5) Business sophistication.
- The Innovation Output Sub-Index provides information about outputs that are the result of innovative activities within economies. There are two output pillars: (6) Knowledge and technology outputs and (7) Creative outputs.

Each pillar is divided into three sub-pillars and each sub-pillar is composed of individual indicators, a total of 80 this year.[26]

The development of fitting and accurate innovation indicators is an ongoing priority for the GII (Box 3).

Results

The main GII 2019 findings are discussed in the following sections. The Rankings Section presents the GII results in tabular form for all economies covered this year, for the GII and for the Innovation Input and Output Sub-Indices.

Movement at the top: Switzerland, Sweden, and the United States of America lead

There are important changes to the top 10 in the GII 2019.

Switzerland leads the rankings for the ninth consecutive year, while Sweden returns to the 2nd position, as held already six times in the past. The U.S. moves up to 3rd. The Netherlands ranks 4th with the U.K. moving into 5th position. Finland and Denmark follow, each gaining one position from 2018, taking 6th and 7th place respectively. Singapore ranks 8th this year and, for the third consecutive year, Germany holds the 9th spot. Israel enters the top 10 for the first time, moving up one spot from 2018, marking the first occasion an economy from the Northern Africa and Western Asia region has featured in the top 10 rankings. Ireland leaves the top 10 and ranks 12th this year.

Figure 1.5 shows movement in the top 10 ranked economies over the last four years:

1. Switzerland
2. Sweden
3. The United States of America
4. The Netherlands
5. The United Kingdom
6. Finland
7. Denmark
8. Singapore
9. Germany
10. Israel

In the top 20, a notable move is the Republic of Korea, which edges closer to the top 10. Most notably, China continues its upward rise, moving to 14th (up from the 17th rank in 2018), and firmly establishes itself as one of the innovation leaders.

In the top 25, Hong Kong (China) (13th), Canada (17th), Iceland (20th), and Belgium (23rd) all move up, gaining between one and three spots each. Ireland (12th), Japan (15th), Luxembourg (18th), Australia (22nd), and New Zealand (25th) move down, while France (16th), Norway (19th), Austria (21st), and Estonia (24th) remain stable.

FIGURE 1.4

Global leaders in innovation in 2019

Every year, the Global Innovation Index ranks the innovation performance of nearly 130 economies around the world.

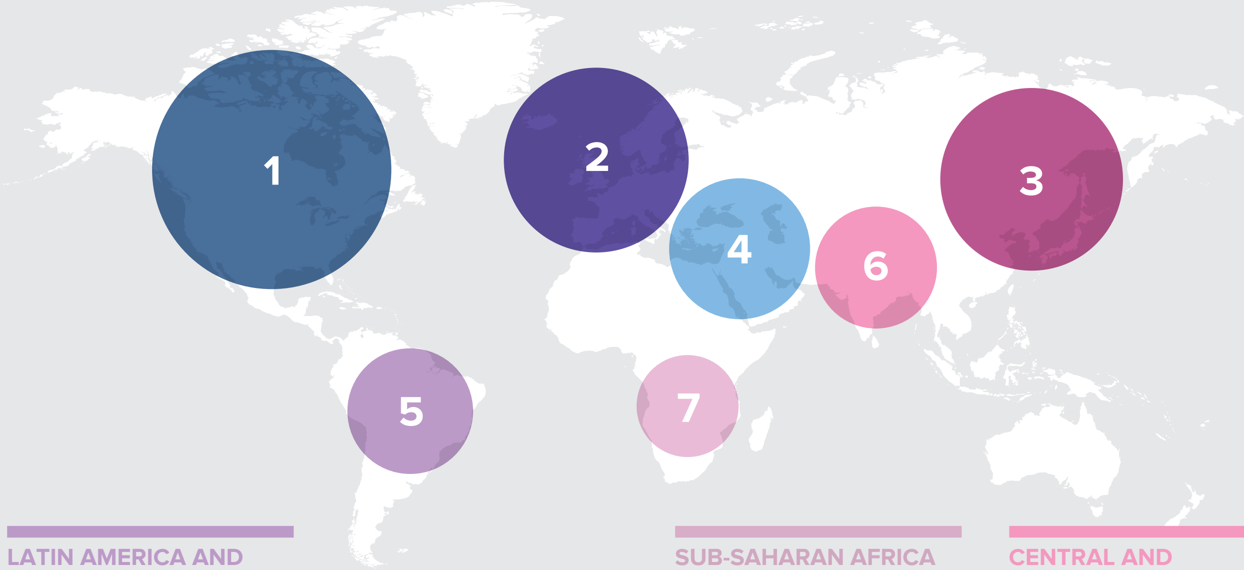
Top 3 innovation economies by region

NORTHERN AMERICA
1. U.S.
2. Canada

EUROPE
1. Switzerland
2. Sweden ↑
3. Netherlands ↓

NORTHERN AFRICA AND WESTERN ASIA
1. Israel
2. Cyprus
3. United Arab Emirates

SOUTH EAST ASIA, EAST ASIA, AND OCEANIA
1. Singapore
2. Republic of Korea
3. Hong Kong, China ★



LATIN AMERICA AND THE CARIBBEAN
1. Chile
2. Costa Rica
3. Mexico

SUB-SAHARAN AFRICA
1. South Africa
2. Kenya ↑
3. Mauritius ↓

CENTRAL AND SOUTHERN ASIA
1. India
2. Iran
3. Kazakhstan

↑↓ indicates the movement of rank within the top 3 relative to 2018, and ★ indicates a new entrant into the top 3 in 2019.

Top 3 innovation economies by income group

HIGH INCOME
1. Switzerland
2. Sweden ↑
3. U.S. ★

UPPER-MIDDLE INCOME
1. China
2. Malaysia
3. Bulgaria

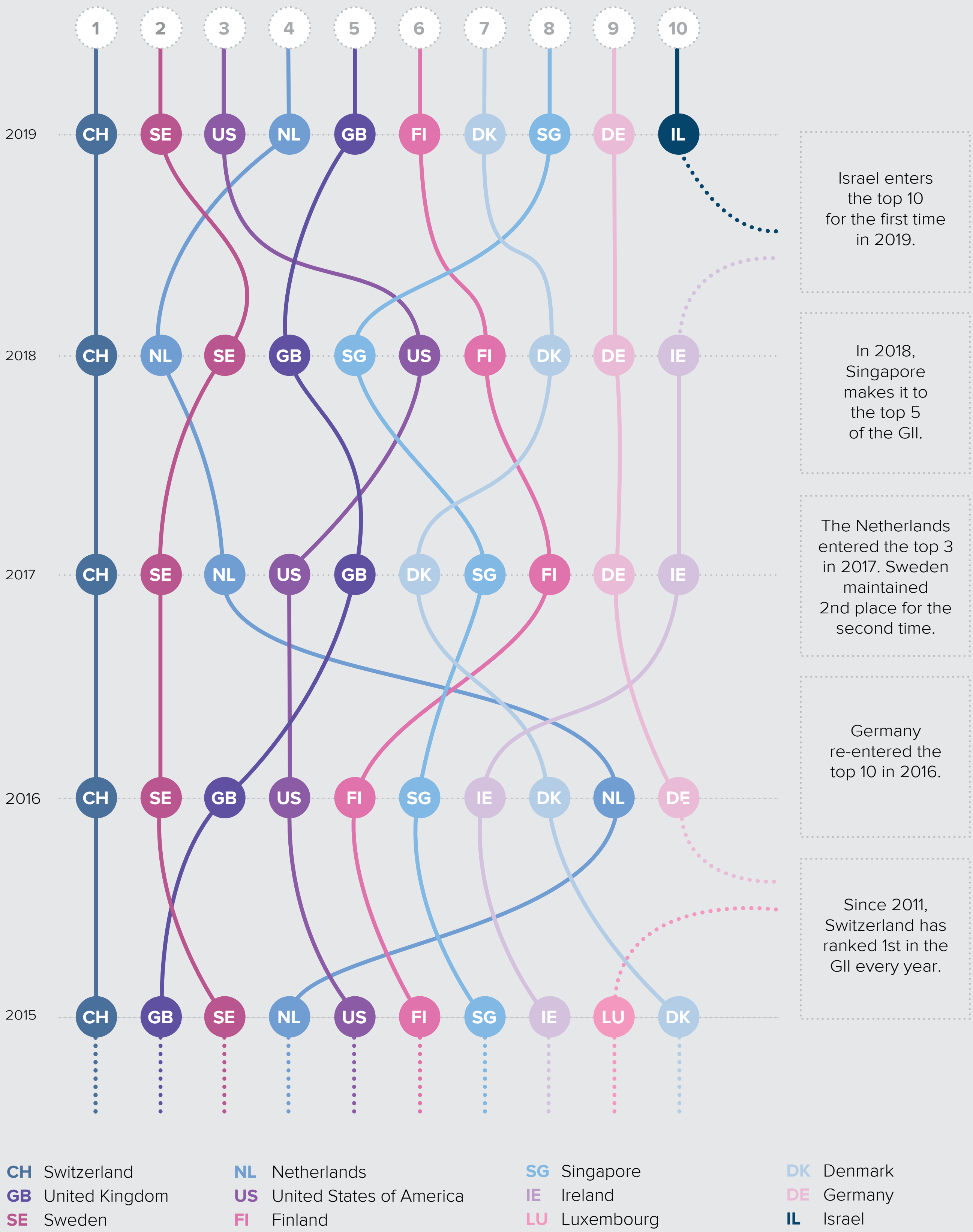
LOWER-MIDDLE INCOME
1. Viet Nam ↑
2. Ukraine ↓
3. Georgia ★

LOW INCOME
1. Rwanda ↑
2. Senegal ↑
3. Tanzania ↓

Source: Global Innovation Index Database; Cornell, INSEAD, and WIPO. 2019.
Notes: World Bank Income Group Classification (July 2018); Year-on-year GII rank changes are influenced by performance and methodological considerations; some economy data are incomplete (Appendix IV).

FIGURE 1.5

Movement in the GII, top 10, 2019



Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.
Note: Year-on-year comparisons of the GII ranks are influenced by changes in the GII model and data availability.

Notable changes in GII rankings this year include Viet Nam and Thailand, who each edged closer to the top 40. India moved closer to the top 50, the Philippines broke into the top 55, and the Islamic Republic of Iran stepped closer to the top 60 based on better innovation performance. The United Arab Emirates, 36th, is moving closer to the top 35 of the GII.

As always, it must be noted that year-on-year comparisons of the GII ranks are influenced by various factors, such as changes in the underlying indicators at source and changes in data availability (Appendix IV).

Despite fast movers in terms of innovation “catch-up”, the global innovation divide between income groups and regions remains (Box 2). The catching-up of economies from relatively emergent and fragmented innovation systems to more mature and functional ones is an arduous process.[27]

BOX 2

The global innovation divide

China breaks into the top 15 GII economies; otherwise, the gap across income groups and regions largely persists.

1. High-income economies and China in the top 15

The top-performing economies in the GII are almost exclusively from the high-income group. China is the only exception, ranking 14th this year and the only middle-income economy in the top 30. China edged into the top 25 in 2016 and moved to 17th in 2018.

Box 2, Figure 1 shows the average scores for six groups: (1) the top 10, composed of only high-income economies; (2) the top 11-25, also all high-income economies, with the exception of China; (3) other high-income economies; (4) other upper middle-income economies; (5) lower middle-income economies; and (6) low-income economies.

2. China, Malaysia, and Bulgaria continue to lead the middle-income group

Aside from China, Malaysia (35th) and Bulgaria (40th) remain the only other middle-income economies that are close to the top 25. The divide between economies in ranks 11 to 25 and the group of upper middle-income economies remains wide.

Thailand (43rd), Montenegro (45th), and the Russian Federation (46th) are among the upper middle-income economies that are performing above high-income economies in selected GII pillars. Other middle-income economies in the top 50 are: Turkey (49th) and Romania (50th), in the upper middle-income group; and Viet Nam (42nd), Ukraine (47th), and Georgia (48th), in the lower middle-income group. In the latter, Viet Nam continues to show a consistent improvement in its scores in Human capital and research, Market sophistication, and Knowledge and technology outputs.

This year, India (52nd) edges closer to the top 50, performing above the lower middle-income group average in all pillars. India performs higher on Human capital and research, Market and Business sophistication, and Knowledge and technology outputs when compared to the upper middle-income group average. Finally, India scores above the high-income group in Market sophistication.

Generally speaking, however, the innovation systems of most low- and middle-income economies have a set of common characteristics: low education levels, low levels of science and technology investments, reduced exposure to foreign technologies, limited inward knowledge flows, weaker science and industry linkages, challenging business environments with inadequate access to financial resources and underdeveloped venture capital markets, low absorptive and innovative capacity within domestic firms, and limited use of intellectual property. Informality is also widespread, making innovation more difficult to measure and study.[28]

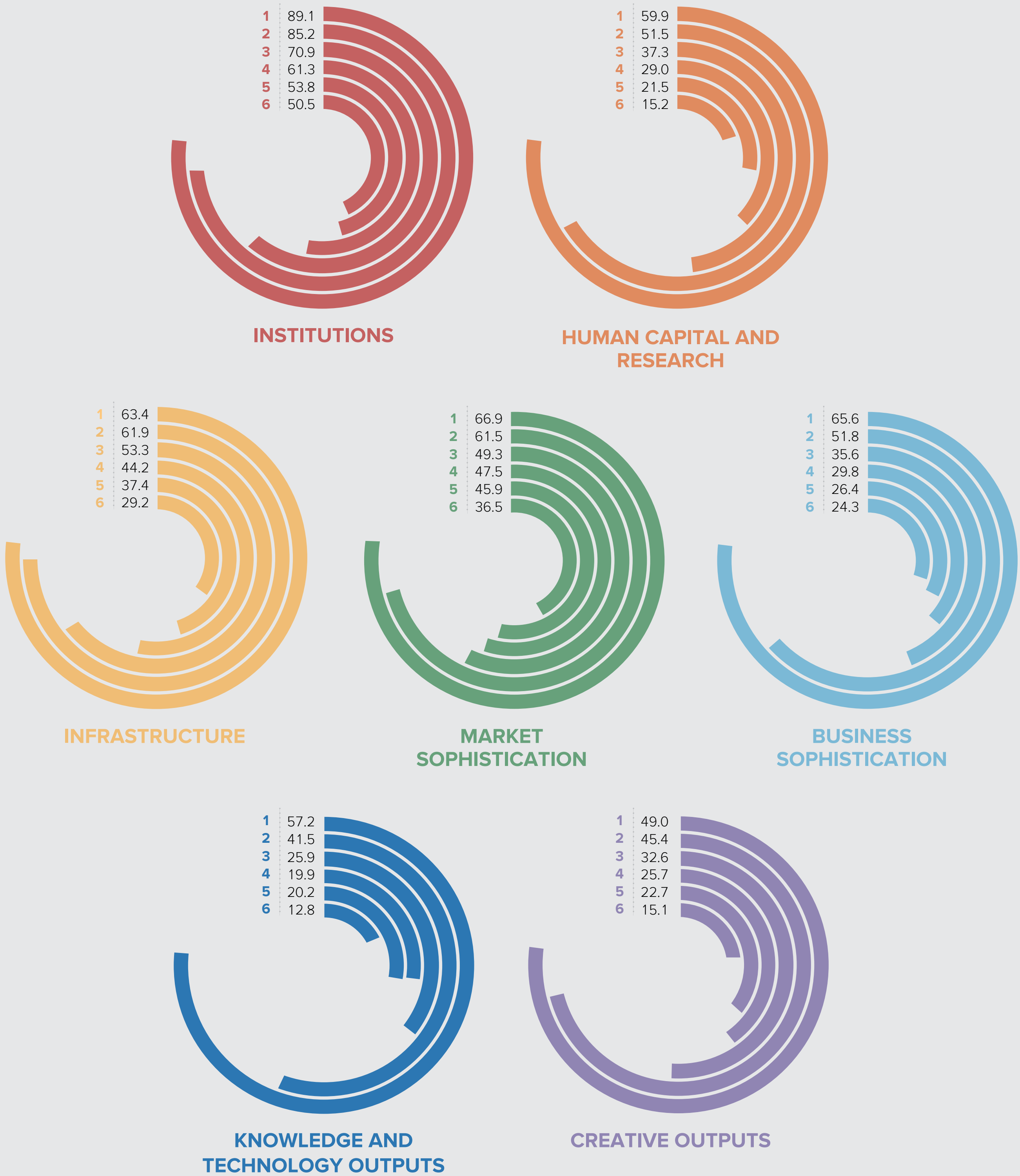
3. Regional divide

The innovation ranking of geographic regions has been stable since 2014. However, the South East Asia, East Asia, and Oceania region has been edging closer to Northern America and Europe over time. Northern America maintains its position as the top-performing region showing top average scores in all innovation pillars. Europe comes in 2nd, followed by South East Asia, East Asia, and Oceania, 3rd, and Northern Africa and Western Asia, 4th. Latin America and the Caribbean remain in 5th, with Central and Southern Asia, and Sub-Saharan Africa following in at 6th and 7th, respectively.

Scores this year show that Northern America, driven mainly by U.S. prowess, has the largest average score increase. Central and Southern Asia follow, driven by India and the Islamic Republic of Iran.

BOX 2, FIGURE 1

Innovation divide across income groups, 2019



1 Top 10 high income
2 11 to 25 high and upper-middle income
3 Other high income
4 Other upper-middle income
5 Lower-middle income
6 Low income

Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.

BOX 3

The importance of timely and apt innovation indicators

The provision of GII economy profiles and briefs—indicating missing and outdated data sources—actively helps policy or statistical officials to monitor their state of innovation metrics and collection efforts more closely. At times, cross-ministerial task forces address data requirements and are involved in the design of innovation policy responses. This interest has helped move innovation metrics to the center of policymaking, including in lower middle- and low-income economies. Accordingly, in the past years, indicator coverage has grown, with some 32 GII economies improving their data coverage by between 5 and 12 indicators.[29] Regionally speaking, progress has been widely visible in African economies (Appendix IV).

That said, the GII is only good as its data ingredients—see the Preface. The availability of data to assess innovation outputs and impacts remains medium to weak. Likewise, convincing metrics on key components of national innovation systems—be they from official statistical bodies or the private sector, such as entrepreneurship, venture capital, innovation linkages, or commercialization efforts—are lacking.

The GII appreciates the initiatives of economies seeking to improve the measurement of innovation performance through better data collection and design, and the reports and events of organizations such as the U.S. National Science Foundation's Science and Engineering Indicators Report, the African Innovation Outlook, and the OECD Blue Sky Forum on Science and Innovation Indicators.[30]

Developing economies, for example, regularly suggest additional innovation measurements, particularly as their contexts may be different from high-income contexts, where innovation metrics were originally devised. These metrics include innovation in the informal sector, or measures to capture knowledge and technology diffusion and adaptation efforts.

High-income economies, too, are not content with the state of play. The Australian Innovation Metrics Review, for example, was recently established to identify better innovation metrics.[31]

The future offers promising venues to also improve the way innovation data are collected. More bottom-up and big data approaches to gathering innovation metrics will become feasible, if certain shortcomings can be overcome (GII 2018, Annex 1, Box 1, developed with the U.K.'s Innovation Foundation Nesta). To improve the state of innovation metrics and the quality of relevant data, the GII will continue to act as a laboratory for novel innovation data.

The top performers by income group

Table 1.1 shows the 10 best-ranked economies by income group in the GII, and the top-ranked in the innovation input and output sub-indices. Switzerland, Sweden, the U.S., the U.K., and Finland are among the high-income top 10 in all indices.

A new entrant in the top 10 upper middle-income group is Mexico (56th). Among the lower middle-income group, Kenya (77th) rejoins the top 10 this year.[32]

Rwanda becomes the top low-income economy (94th) this year, gaining 5 positions since last year in the GII, and one position among the low-income group. Three economies enter the low-income group top 10: Tajikistan (100th), Ethiopia (111th) and Burkina Faso (117th).[33]

Which economies are outperforming on innovation relative to their peers?

The GII also identifies the innovation performance of economies relative to their peers with a similar level of development, as measured by GDP per capita (Figure 1.6). Most economies perform as expected on innovation based on their level of development. Yet, some economies break from this pattern to strongly outperform or underperform, relative to expectations.

All economies that are innovation leaders (dark blue) this year were also in the top 25 in 2018. As observed in previous years, all of them—with the exception of China—are high-income economies.

TABLE 1.1

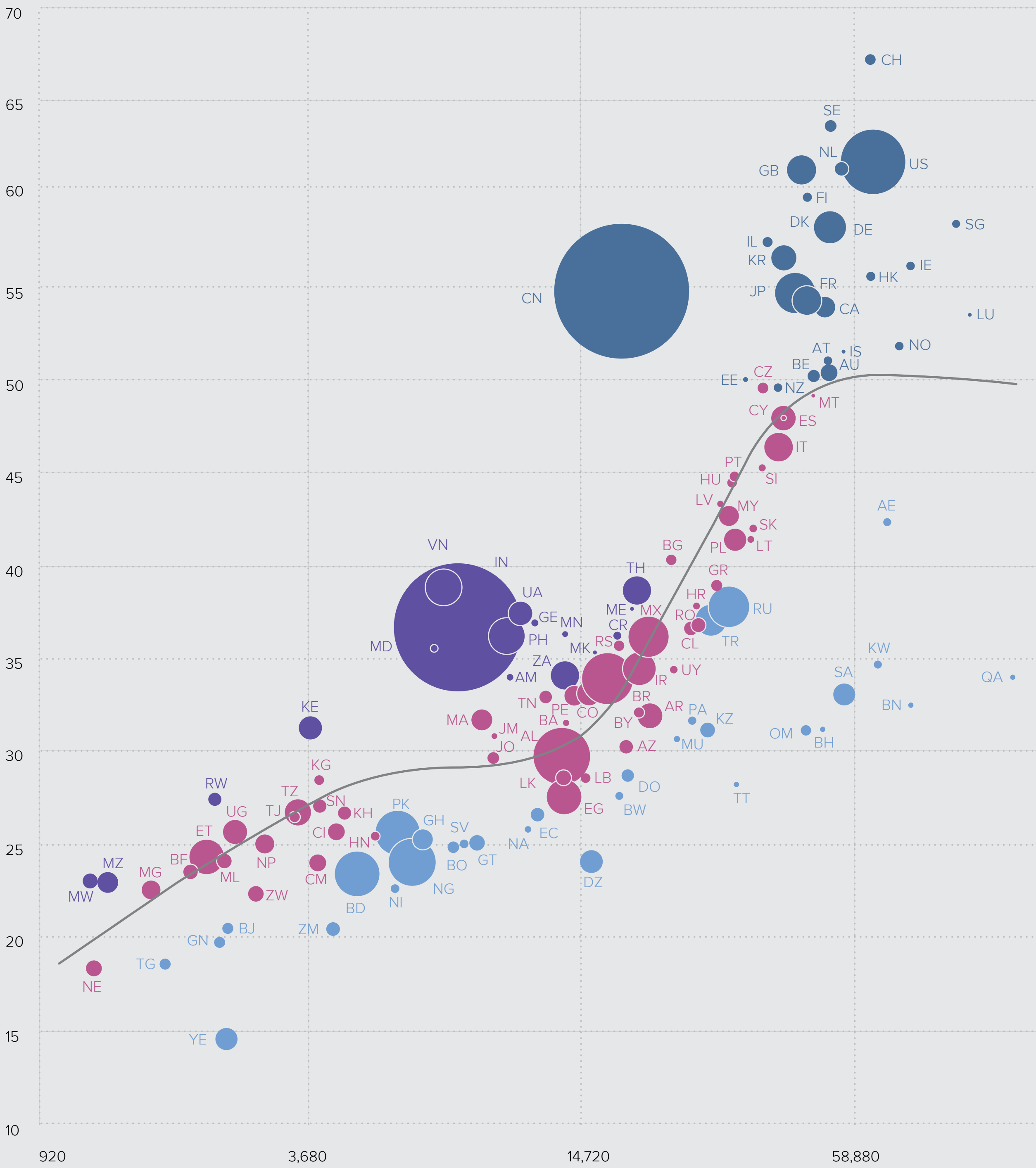
10 best-ranked economies by income group (rank)

Rank	Global Innovation Index	Innovation Input Sub-index	Innovation Output Sub-index
High-income economies (50 in total)			
1	**Switzerland (1)**	Singapore (1)	**Switzerland (1)**
2	**Sweden (2)**	**Switzerland (2)**	Netherlands (2)
3	**United States of America (3)**	**United States of America (3)**	**Sweden (3)**
4	Netherlands (4)	**Sweden (4)**	**United Kingdom (4)**
5	**United Kingdom (5)**	Denmark (5)	**United States of America (6)**
6	**Finland (6)**	**United Kingdom (6)**	**Finland (7)**
7	Denmark (7)	**Finland (7)**	Israel (8)
8	Singapore (8)	Hong Kong, China (8)	Germany (9)
9	Germany (9)	Canada (9)	Ireland (10)
10	Israel (10)	Republic of Korea (10)	Luxembourg (11)
Upper middle-income economies (34 in total)			
1	**China (14)**	**China (26)**	**China (5)**
2	**Malaysia (35)**	**Malaysia (34)**	**Bulgaria (38)**
3	**Bulgaria (40)**	Russian Federation (41)	**Malaysia (39)**
4	**Thailand (43)**	**Bulgaria (45)**	**Thailand (43)**
5	Montenegro (45)	**Thailand (47)**	Montenegro (46)
6	Russian Federation (46)	Peru (48)	Iran (Islamic Republic of) (47)
7	Turkey (49)	Belarus (50)	Costa Rica (48)
8	**Romania (50)**	South Africa (51)	Turkey (49)
9	Costa Rica (55)	North Macedonia (52)	Armenia (50)
10	Mexico (56)	**Romania (54)**	**Romania (53)**
Lower middle-income economies (26 in total)			
1	**Viet Nam (42)**	**Georgia (44)**	**Ukraine (36)**
2	**Ukraine (47)**	**India (61)**	**Viet Nam (37)**
3	**Georgia (48)**	**Viet Nam (63)**	**Philippines (42)**
4	**India (52)**	**Mongolia (73)**	**Mongolia (44)**
5	**Mongolia (53)**	**Tunisia (74)**	**Republic of Moldova (45)**
6	**Philippines (54)**	**Philippines (76)**	**India (51)**
7	**Republic of Moldova (58)**	Kyrgyzstan (78)	**Georgia (60)**
8	**Tunisia (70)**	**Republic of Moldova (81)**	Kenya (64)
9	**Morocco (74)**	**Ukraine (82)**	**Tunisia (65)**
10	Kenya (77)	**Morocco (83)**	**Morocco (66)**
Low-income economies (19 in total)			
1	Rwanda (94)	Rwanda (65)	**United Republic of Tanzania (73)**
2	**Senegal (96)**	Nepal (93)	Ethiopia (80)
3	**United Republic of Tanzania (97)**	**Uganda (96)**	**Senegal (81)**
4	**Tajikistan (100)**	**Senegal (103)**	**Tajikistan (83)**
5	**Uganda (102)**	**Tajikistan (107)**	Mali (100)
6	Nepal (109)	Burkina Faso (111)	**Uganda (107)**
7	Ethiopia (111)	Benin (114)	Madagascar (109)
8	Mali (112)	United Republic of Tanzania (115)	Zimbabwe (110)
9	Burkina Faso (117)	Mozambique (118)	**Malawi (112)**
10	**Malawi (118)**	**Malawi (119)**	Mozambique (114)

Note: Economies with top 10 positions in the GII, the Input Sub-Index, and the Output Sub-Index within their income group are highlighted.

FIGURE 1.6

GII scores and GDP per capita in PPP US$ (bubbles sized by population)



▲ GII score
▶ GDP per capita in PPP$ (logarithmic scale)

● Innovation leaders
● Innovation achievers

● Performing at expectations for level of development
● Performing below expectations for level of development

Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.

Notes: As in past editions, Figure 1.6 presents the GII scores plotted against GDP per capita in natural logs and PPP US$. The main element of the figure is the trend line, which shows the expected levels of innovation performance for a given economy relative to its level of GDP per capita. The figure presents all economies covered in the GII 2019 against this trend line. The trend line is the cubic spline with five knots determined by Harrell's default percentiles (R2 = 0.6928). Economies that are close to the trend line are those whose innovation performance is in line with expectations given its level of development (pink). The further above an economy is in relation to this trend line, the better its innovation performance is relative to its level of development and thus other peer economies at similar levels. In contrast, those economies located below the trend line are those whose innovation performance is lower than expectations (light blue).

ISO-2 codes

Code	Country/Economy
AE	United Arab Emirates (the)
AL	Albania
AM	Armenia
AR	Argentina
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BD	Bangladesh
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BH	Bahrain
BI	Burundi
BJ	Benin
BN	Brunei Darussalam
BO	Bolivia (Plurinational State of)
BR	Brazil
BW	Botswana
BY	Belarus
CA	Canada
CH	Switzerland
CI	Côte d'Ivoire
CL	Chile
CM	Cameroon
CN	China
CO	Colombia
CR	Costa Rica
CY	Cyprus
CZ	Czech Republic (the)
DE	Germany
DK	Denmark
DO	Dominican Republic (the)
DZ	Algeria
EC	Ecuador
EE	Estonia
EG	Egypt
ES	Spain
ET	Ethiopia
FI	Finland
FR	France
GB	United Kingdom (the)
GE	Georgia

Code	Country/Economy
GH	Ghana
GN	Guinea
GR	Greece
GT	Guatemala
HK	Hong Kong, China
HN	Honduras
HR	Croatia
HU	Hungary
ID	Indonesia
IE	Ireland
IL	Israel
IN	India
IR	Iran (Islamic Republic of)
IS	Iceland
IT	Italy
JM	Jamaica
JO	Jordan
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KH	Cambodia
KR	Republic of Korea (the)
KW	Kuwait
KZ	Kazakhstan
LB	Lebanon
LK	Sri Lanka
LT	Lithuania
LU	Luxembourg
LV	Latvia
MA	Morocco
MD	Republic of Moldova (the)
ME	Montenegro
MG	Madagascar
MK	North Macedonia
ML	Mali
MN	Mongolia
MT	Malta
MU	Mauritius
MW	Malawi
MX	Mexico
MY	Malaysia
MZ	Mozambique
NA	Namibia

Code	Country/Economy
NE	Niger (the)
NG	Nigeria
NI	Nicaragua
NL	Netherlands (the)
NO	Norway
NP	Nepal
NZ	New Zealand
OM	Oman
PA	Panama
PE	Peru
PH	Philippines
PK	Pakistan
PL	Poland
PT	Portugal
PY	Paraguay
QA	Qatar
RO	Romania
RS	Serbia
RU	Russian Federation (the)
RW	Rwanda
SA	Saudi Arabia
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SV	El Salvador
TG	Togo
TH	Thailand
TJ	Tajikistan
TN	Tunisia
TR	Turkey
TT	Trinidad and Tobago
TZ	United Republic of Tanzania (the)
UA	Ukraine
UG	Uganda
US	United States of America (the)
UY	Uruguay
VN	Viet Nam
YE	Yemen
ZA	South Africa
ZM	Zambia
ZW	Zimbabwe

TABLE 1.2

Innovation achievers in 2019: income group, region and years as an innovation achiever

Economy	Income group	Region	Years as an innovation achiever (total)
Viet Nam	Lower-middle income	South East Asia, East Asia, and Oceania	2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011 (9)
India	Lower-middle income	Central and Southern Asia	2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011 (9)
Republic of Moldova	Lower-middle income	Europe	2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011 (9)
Kenya	Lower-middle income	Sub-Saharan Africa	2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011 (9)
Armenia	Upper-middle income	Northern Africa and Western Asia	2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012 (8)
Ukraine	Lower-middle income	Europe	2019, 2018, 2017, 2016, 2015, 2014, 2012 (7)
Rwanda	Low income	Sub-Saharan Africa	2019, 2018, 2017, 2016, 2015, 2014, 2012 (7)
Malawi	Low income	Sub-Saharan Africa	2019, 2018, 2017, 2016, 2015, 2014, 2012 (7)
Mozambique	Low income	Sub-Saharan Africa	2019, 2018, 2017, 2016, 2015, 2014, 2012 (7)
Mongolia	Lower-middle income	South East Asia, East Asia, and Oceania	2019, 2018, 2015, 2014, 2013, 2012, 2011 (7)
Thailand	Upper-middle income	South East Asia, East Asia, and Oceania	2019, 2018, 2015, 2014, 2011 (5)
Montenegro	Upper-middle income	Europe	2019, 2018, 2015, 2013, 2012 (5)
Georgia	Lower-middle income	Northern Africa and Western Asia	2019, 2018, 2014, 2013, 2012 (5)
Costa Rica	Upper-middle income	Latin America and the Caribbean	2019, 2018, 2013 (3)
Burundi	Low income	Sub-Saharan Africa	2019, 2017 (2)
South Africa	Upper-middle income	Sub-Saharan Africa	2019, 2018 (2)
Philippines	Lower-middle income	South East Asia, East Asia, and Oceania	2019 (1)
North Macedonia	Upper-middle income	Europe	2019 (1)

Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.
Notes: Income group classification follows the World Bank Income Group Classification of June 2018. Geographic regions correspond to the United Nations publication on standard country or area codes for statistical use (M49).

Eighteen economies outperform on innovation relative to GDP this year. These are called innovation achievers (in purple).[34] Burundi, North Macedonia, and the Philippines are new entrants to this group, relative to the innovation achievers in 2018. North Macedonia and the Philippines are also innovation achievers for the first time in the GII. Bulgaria, Serbia, Tunisia, Colombia, and Madagascar—all innovation achievers in 2018—are no longer part of the group in 2019. South Africa, who joined the group of achievers in 2018 for the first time, remains an achiever this year.

As in previous years, six of the innovation achievers—and thus the largest group of economies—are from the Sub-Saharan Africa region (6). Innovation achievers from South East Asia, East Asia, and Oceania (4); Europe (4); Northern Africa and Western Asia (2); Central and Southern Asia (1) and Latin America and the Caribbean (1) complete the group by geographic region.

Viet Nam and Rwanda are ranked as the top economy in their income groups, which are lower middle-income and low-income, respectively. Viet Nam has been an innovation achiever for nine consecutive years, holding that record together with India, Republic of Moldova, and Kenya. Viet Nam scores above average in all the dimensions measured in the GII relative to the lower middle-income group and has an overall innovation performance that is comparable to the top economies in the upper middle-income group. Rwanda scores above the average of the low-income group in all innovation dimensions with the exception of Knowledge and technology outputs.

India ranks 4th among the economies in the lower middle-income group. It has also been an innovation achiever for nine consecutive years (Table 1.2).

The Philippines appears for the first time in the group of innovation achievers. It scores above average in all innovation dimensions, with the exception of Market sophistication, relative to its lower middle-income peers. It has remarkable performance in Knowledge diffusion and Knowledge absorption, not only relative to its income group and geographic region, but also relative to all other economies assessed in the GII.

Finally, the economies whose innovation performance is below their expected levels of economic development are colored in light blue. This group consists of 33 economies from different income groups and world regions. The majority (11 economies) are from the upper middle-income group, notably four from Latin America and the Caribbean (Dominican Republic, Paraguay, Ecuador, and Guatemala). The high-income group follows with 10 economies, notably six from the Western Asia region (the United Arab Emirates, Kuwait, Qatar, Saudi Arabia, Bahrain, and Oman). Eight underperformers are from the lower middle-income group, notably three from Sub-Saharan Africa (Ghana, Nigeria, and Zambia) and three from Latin America and the Caribbean (El Salvador, Bolivia, and Nicaragua). Only four economies underperform relative to their levels of development and are from the low-income group (Yemen, Benin, Guinea, and Togo). The regions with the most number of economies performing lower than expectations relative to their level of development are Latin America and the Caribbean (9), Northern Africa and Western Asia (9), and Sub-Saharan Africa (9).

The world's top innovators in the Global Innovation Index 2019

The top 10 economies

Switzerland remains the world's leader in innovation in 2019. It ranks first in the GII for the ninth consecutive year. It has ranked 1st in the Innovation Output Sub-Index and in the Knowledge and technology output pillar since 2012. It also keeps its 1st rank in the Creative outputs pillar since last year, consolidating once again its leadership in innovation outputs. Switzerland keeps its 2nd position in the Innovation Input Sub-Index. It improves its rank in three innovation input pillars: Market sophistication (up by 1); Business sophistication (up by 2); and notably Infrastructure (up by 5). In the latter, all improvements are in the Information and communication technologies (ICTs) sub-pillar; and notably in the Government's online service, and E-participation indicators. In contrast, the country drops positions in two innovation inputs pillars: Institutions, and Human capital and research.

In quality of innovation, Switzerland is ranked 4th worldwide, after the U.S., Germany, and Japan. Its rank decreases this year in the metrics for quality of innovation, notably in the quality of local universities and the internationalization of local inventions. Additionally, rank decreases are seen in the General infrastructure sub-pillar, where it positions below the top 25 (28th, down from 25th in 2018); and in Trade, competition, and market scale (26th, down from 19th).

Switzerland is a world leader in several key innovation indicators, including PCT patent applications by origin (a spot it shares with Sweden and Finland); ICT services imports; IP receipts; FDI net outflows; and Environmental performance. Conversely, and relative to the top 25 in the GII 2019, it has opportunities to improve in Ease of starting a business, Ease of resolving insolvency, and Ease of protecting minority investors.

Sweden recovers its 2nd position worldwide this year (up from 3rd), and remains the top Nordic economy in the GII 2019. It drops by one rank in the Innovation Input Sub-Index to 4th position; and retains 3rd in the Innovation Output Sub-Index. It ranks among the top 10 economies in all pillars except for Market sophistication (14th) where it loses two positions. It improves its rank in four pillars: Business sophistication, achieving 1st position in the world; Infrastructure (2nd); Knowledge and technology outputs (2nd); and Human capital and research (6th). Sweden makes remarkable improvements in Knowledge absorption (6th), Education (6th), ICTs (12th), and Knowledge diffusion (6th). The significant improvements in the Knowledge absorption sub-pillar are mainly due to improvements in the indicator FDI inflows, which remains a relative weakness for Sweden.

At the indicator level, Sweden keeps its 1st position in PCT patent applications by origin and IP receipts; and gains the 1st position on patent families (up from 5th). Sweden's areas for improvement include Pupil-teacher ratio, GDP per unit of energy use, Ease of getting credit, GERD financed by abroad, productivity growth (Growth rate of PPP$), and Printing and other media.

The United States of America reaches the 3rd position worldwide, in part due to performance increases and the availability of new U.S. innovation data (see below). The U.S. improves its rank in five of the seven GII pillars: Institutions (11th); Human capital and research (12th); Infrastructure (23rd); Business sophistication (7th); and Knowledge and technology outputs (4th).[35]

Keeping its world leading position in Market sophistication (1st); it also makes important progress in the Knowledge workers sub-pillar (4th); and in the Innovation linkages sub-pillar (9th). Relative to the top 25, it is strong in the sub-pillars of Business environment (2nd); R&D (3rd); Credit (1st); Knowledge creation (3rd); and Knowledge impact (2nd). It maintains leadership in a series of key innovation metrics such as Global R&D companies, quality of universities (QS university ranking), Venture capital deals, State of cluster development (Special Section: Cluster Rankings), quality of scientific publications (Citable documents H-index), Computer software spending, IP receipts, and Entertainment and media market. The U.S. also reaches 1st in University/industry research collaboration this year. It makes important innovation performance increases in a number of indicators, notably Creative goods exports (up by 17); Knowledge-intensive employment (up by 18); Government's online service; and E-participation, both up by 7.

The U.S.' improved ranking in the Human capital and research pillar, notably in sub-pillar Tertiary education, and in Knowledge workers is because of improved data availability in the indicators Tertiary enrolment and Females employed with advanced degrees, for which data was missing in GII 2018 and became available in GII 2019.

With regards to the quality of innovation, the U.S. ranks 1st, above Japan and Switzerland (Figure 1.7). The country achieves this top position thanks to a combination of its sustained world leadership on all innovation quality metrics and because of decreases in the performance of Switzerland (see above) and Japan.

The Netherlands is the 4th most innovative economy in the world. It ranks 11th in the Innovation Input Sub-Index and retains 2nd position in the Innovation Output Sub-Index. Innovation outputs remain a strength for the Netherland's innovation ecosystem, ranking 3rd in Knowledge and technology outputs, and 5th in Creative outputs.

The Netherlands remains in the top 25 in all innovation input pillars, and in the top 10 worldwide for Institutions (8th) and Business sophistication (6th). At the sub-pillar level, the country's strengths remain Innovation linkages (5th), ICTs (4th) and Knowledge absorption (2nd). At the indicator level, it remains 1st in IP payments and it is consistently strong on Regulatory quality, E-participation, Intensity of local competition, University/industry collaboration, State of cluster development (Special Section: Cluster Rankings), and FDI inflows. Important improvements are also observed in GERD financed by business, and Females employed with advanced degrees. Conversely, most of the decreases observed this year are in the Human capital and research pillar (17th), and notably on the Education (23rd), and Tertiary education sub-pillars (59th). In Education, the decrease is explained by data availability, notably for the indicator Government funding per pupil, where the country ranks 36th this year, and for which data was previously missing. In Tertiary education—amid the same levels of performance in Tertiary enrolment, Graduates in science and engineering, and Tertiary inbound mobility—the country drops ranks in relative terms as other economies improved their performance in these areas.

In Innovation Outputs, the Netherlands is strong on Knowledge diffusion (2nd) and Online Creativity (2nd), in particular in indicators such as IP receipts, FDI net outflows, ICTs and business model creation, and ICTs and organizational model creation. Progress is also observed in the quality of scientific publications (8th) and in Cultural and creative services exports (10th).

The United Kingdom ranks 5th this year, 6th in the Innovation Input Sub-Index, and gains two spots in the Innovation Output Sub-Index (4th). The U.K. improves its rank in two pillars: Knowledge and technology outputs (8th); and Market sophistication (4th). At the sub-pillar level, important increases are in Knowledge diffusion (12th), Intangible assets (12th), and Knowledge creation (5th). Some indicators that are responsible for rank improvements in these pillars include Industrial designs by origin (16th), IP receipts (8th), ICT services exports (28th), and High-tech net exports (18th). Despite these important gains, the U.K. loses between one and four positions in four of the GII pillars: Business sophistication (16th), Creative outputs (6th), Infrastructure (8th), and Human capital and research (9th). The country maintains its lead in the quality of scientific publications and remains strong in indicators, such as School life expectancy, the quality of its universities, ICT access, Government's online service, Environmental performance, Venture capital deals, Computer software spending, and Cultural and creative services exports. Due to its historic universities and the quality of its scientific publications, the U.K. is still the 5th world economy in quality of innovation (Figure 1.7).

A frequent question these days is how the U.K.'s planned withdrawal from the European Union affects the country's GII rank. As noted in previous years, the causal relations between plans or the actual withdrawal from the EU and the GII indicators are complex and uncertain in size and direction.

Finland moves up to the 6th position this year, continuing its upward trend from 2017. It ranks 7th in both the Innovation Input and Output Sub-Indices. On the input side, it improves its position in three of the GII pillars: Human capital and research (2nd, up by 2), Infrastructure (12th, up by 5), and Business sophistication (5th, up by 1). The largest decrease is observed in Market sophistication (27th, down by 12), notably in the Investment sub-pillar (34th); while it loses one position in Institutions (3rd). At the sub-pillar level, the largest increases are in Education (4th, up by 3); and Knowledge absorption (12th, up by 3), notably in indicator FDI inflows (31st, up by 18). On the output side, Finland improves notably in Knowledge diffusion (7th); particularly in the indicator FDI outflows (14th), and in Online creativity (6th). For the latter, changes to the GII model also partially explain the increase, notably in the indicator Mobile app creation, where Finland ranks 1st worldwide (Appendix IV).

Finland maintains its lead in PCT patent applications by origin, while it achieves the 1st rank this year in both Rule of law and E-participation. It remains a world leader in a number of important innovation metrics, such as Patent families, School life expectancy, and Ease of resolving insolvency. Relatively weak performance is observed in Pupil-teacher ratio, Gross capital formation, productivity growth, Trademarks by origin, and Printing and other media.

Denmark ranks 7th in the GII 2019, increasing by one rank from last year. It increases by two spots in the Innovation Input Sub-Index (5th), and by one spot in the Innovation Output Sub-Index (12th). Denmark remains in the top 15 in all GII pillars, and improves its position in 4 of the pillars: Human capital and research (4th, up by 2), Infrastructure (6th, up by 9), Business sophistication (9th, up by 5), and Knowledge and technology outputs (14th, up by 1). In Human capital and research, the most notable improvement is in the Education sub-pillar (2nd), notably because of sustained high levels of expenditure on education. In Infrastructure, increases are observed in ICTs (2nd) and General infrastructure (33rd) and, in particular, in indicators ICT use (1st), Government's online service (1st), E-participation (1st), and Logistics performance (8th). In Business sophistication, most improvements occurred in the sub-pillars Innovation linkages (7th, up by 11), notably in the indicator GERD financed by abroad; and in Knowledge absorption (20th, up by 6), in particular in ICT services imports. In addition, Denmark ranks in the top 3 in a number of indicators such as Scientific and technical articles (1st), Researchers (2nd) and Environmental performance (3rd). Opportunities for further improvement still exist, notably in indicators such as Graduates in science and engineering, Gross capital formation, Utility models by origin, productivity growth, Trademarks by origin, and Printing and other media.

Singapore ranks 8th this year. It remains first in the world in the Innovation Input Sub-Index and keeps its 15th position in the Innovation Output Sub-Index. However, Singapore loses positions in all Inputs pillars, with the exception of Institutions, in which it still ranks 1st. Improved data availability partially explains ranking decreases. Some indicators that were unavailable last year became available this year, notably in the Human capital and research pillar (5th), in which Singapore loses 4 ranks. In this pillar, there is an important decrease in the indicator Global R&D companies (30th). Drops in this indicator are caused by a re-location back to the U.S. of Broadcom, a technology hardware and equipment company. Broadcom was the largest R&D spender in Singapore until last year.[36]

Singapore loses two ranks in the pillars Infrastructure (7th) and Business sophistication (4th). In Infrastructure, ICTs (11th) and Ecological sustainability (22nd) are the weaker performing sub-pillars, with several indicators decreasing—notably E-participation, ICT use, and ISO 14001 environmental certificates. In Business sophistication, the country loses several ranks, particularly in the indicator Females employed with advanced degrees, but also in FDI inflows and IP payments. It loses one rank in the Market sophistication pillar (5th). Ease of getting credit and Market capitalization are the indicators where the country loses most positions in this pillar.

Singapore increases its performance in several indicators within the Knowledge and technology outputs pillar (11th), notably in labor productivity growth, and ICT services exports. However, other indicators, such as ISO 9001 quality certificates, FDI net outflows and Computer software spending, have decreased, leaving performance in this pillar unchanged relative to last year. Singapore improves its position by one rank in the Creative outputs pillar (34th), thanks to the indicator of Mobile app creation, in which it ranks 10th worldwide.

Singapore becomes the global leader (1st) in a number of important innovation parameters, notably in Tertiary inbound mobility (up from 5th), Knowledge-intensive employment (up from 2nd), and JV-strategic alliances deals (up from 3rd).

Germany retains 9th place for the third consecutive year. It improves to 12th position in the Innovation Input Sub-Index (up by 5 positions), and ranks 9th in the Innovation Output Sub-Index. It ranks in the top 20 across all GII pillars, and in the top 10 worldwide in both innovation output pillars. Germany improves its performance in three pillars: notably in Human capital and research, where it gains 7 positions and moves into the top 3; Infrastructure (13th); and Business sophistication (12th). In these three pillars, it improves the most in Tertiary education (5th), Innovation linkages (10th) and Information and communication technologies (15th). The largest increase in the Tertiary education sub-pillar is mainly due to better data coverage. For the indicator Graduates in science and engineering—for which data was missing in the GII 2018—Germany ranks 4th worldwide. On the output side, Germany keeps its 10th rank in Knowledge and technology outputs and loses three spots in Creative outputs (10th).

As in previous years, Germany remains 1st in Logistics performance and in Patents by origin. It remains 2nd in Global R&D companies; improves to 2nd in State of cluster development (up by 1); and remains 3rd in the quality of scientific publications. Thanks to these high ranks, Germany ranks 2nd in the quality of innovation. This increase is partly due to the increased quality of its scientific publications, but also to the relative decrease of innovation quality in Switzerland and Japan (Figure 1.7).

Despite important achievements, there is still opportunity for improvement in some innovation areas, such as the Ease of starting a business, Expenditure on education, Gross capital formation, GERD financed by abroad, FDI net inflows, productivity growth, New businesses, and Printing and other media. These opportunities for improvement have remained unchanged since last year.

Israel breaks into the top 10 of the most innovative economies in the world for the first time, after several years of increased performance. It remains 1st in the Northern Africa and Western Asia region, and keeps its position in the top 10 worldwide in two pillars: Business sophistication (3rd) and Knowledge and technology outputs (7th). This year it improves its rank in two pillars, Institutions (31st) and Creative outputs (14th). At the sub-pillar level, Israel improves in Research and development (2nd), and keeps its top rank in Innovation linkages. It also retains its 1st position in a number of important indicators, such Researchers, R&D intensity (GERD performed by business, % GDP), Research talent in business enterprise, ICT services exports, and Wikipedia edits. It also reaches the 1st rank in Mobile app creation.[37] Other indicators where Israel ranks in the top 3 include Patent families (2nd), a notable performance increase relative to last year; Females employed with advanced degrees (3rd); University/industry research collaboration (2nd), GERD financed by abroad (3rd); and Venture capital deals (3rd).

Israel's innovation weaknesses are mostly in innovation inputs. The Tertiary education sub-pillar is a weakness, and notably the indicator Tertiary inbound mobility. Other areas for improvement include Government funding per pupil, PISA results, Gross capital formation, Firms offering formal training, GERD financed by business, and IP payments. On the output side, there are two areas for improvement in the pillar Creative outputs: Trademarks by origin, and Printing and other media.

BOX 4

What is the innovation secret of small economies?

Why do a number of city-states or small economies—measured by their population or geographic size—make it into the GII top 20?

Here we look more in-depth at three examples to seek an answer: Singapore—ranked 8th with a population of 5.6 million; Hong Kong (China)—ranked 13th with a population of 7.5 million; and Luxembourg—ranked 18th with a population of 0.6 million. All three small economies share similar traits—reduced geographical space, no natural resources, and extremely open economies. They act as regional hubs for trade and investment and are strong in services—in particular, financial services. Relative to all high-income economies, these three economies score high in Institutions—in particular, Singapore and Hong Kong (China), Infrastructure—Hong Kong (China) and Singapore, and Business sophistication—Singapore and Luxembourg. Their high scores demonstrate an excellent environment that, for example, is supportive of innovation, has good regulatory quality, and ranks well in the ease of starting a business. In the pillar Human capital and research, Singapore stands out.

For innovation outputs, Singapore and Hong Kong (China) score high relative to other high-income economies in the pillar Knowledge and technology outputs. Yet, only Singapore has a strong lead. Except for Singapore, these economies are often not directly involved in high-tech manufacturing and their manufacturing base is small. They export few locally produced high-tech products.[38] In Creative outputs, in turn, Luxembourg and Hong Kong (China) perform best (Box 5).

What innovation ambitions and policies do these economies harbor for the near future?[39]

Singapore aims to be a center of innovation and a key node along the global innovation supply chain where innovative firms thrive on the basis of intellectual property and intangible assets. To achieve this ambition, one strategy is to strengthen Singapore's innovation ecosystem by helping enterprises to innovate and scale up. Singapore envisages advancing its conducive environment, international linkages, capabilities in intangible asset management, IP commercialization, and skilled workforce. In 2016, the Government of Singapore committed US$14 billion for research, innovation, and enterprise activities. It identified four strategic domains for prioritized research funding: (1) advanced manufacturing and engineering, (2) health and biomedical sciences, (3) services and digital economy, and (4) urban solutions and sustainability.[40] The Intellectual Property Office of Singapore (IPOS) has also transformed to better serve global innovation communities by conducting regular reviews of Singapore's IP policies and building capabilities in intangible asset management and IP commercialization, including IP skills.[41]

Hong Kong, China also plans to develop into a leading international innovation hub, benefiting from its position in Asia and its proximity and links to other parts of China. There are plans by China and Hong Kong (China) to further develop the Guangdong-Hong Kong-Macao Greater Bay Area (Bay Area)—which encapsulates the city of Hong Kong and Shenzhen—as a major global innovation cluster. The Government of Hong Kong (China) has committed over US$13.5 billion since 2017 to promote innovation and technology. Two research clusters are to be established—one on healthcare technologies and the other on artificial intelligence and robotics. In addition, the government has promoted re-industrialization to develop high-end manufacturing. In sum, innovation and technology development is pressing ahead swiftly under an eight-pronged strategy, including (1) increasing resources for R&D, (2) pooling technology talent, (3) providing investment funding, (4) providing technological research infrastructure, (5) reviewing legislations and regulations, (6) opening up government data, (7) enhancing government procurement arrangements, and (8) promoting science education. A Technology Talent Admission Scheme was set up to attract non-local talent. The government has also put emphasis on fostering smart city innovations.

Luxembourg, in turn, aims to develop its innovation leadership through its strong infrastructure, its location in the heart of Europe, its strong services economy, and its talent base. Luxembourg's efforts are focused on five key areas: infrastructure, skills, government, ecosystem, and policy. Luxembourg aims to invest around 2.5% of its GDP in research in 2020. New financing programs will be launched to foster digital high-tech start-ups. In May 2019, Luxembourg presented its national AI strategy and is rolling out its data-driven innovation strategy with focus on seven specific sectors: ICT, manufacturing industry, eco technologies, health technology, space, logistics, and financial services.[42] Examples of innovative initiatives are the rollout of fiber optic cable to homes, 5th generation networks, and its National CyberSecurity Strategy. Other areas of policy focus include increasing investments and strides in high-performance computing,[43] creating a national strategy for AI,[44] boosting the commercial adoption of block chain,[45] fostering digital skills,[46] and developing further the local space industry.[47] Luxembourg also prioritizes the exploitation of public sector information and open data to spur innovation. In the area of talent, Luxembourg has simplified residence permits for highly qualified workers.

What are the top 10 economies in innovation inputs?

The top 10 economies in the Innovation Input Sub-Index are Singapore, Switzerland, the U.S., Sweden, Denmark, the U.K., Finland, Hong Kong (China), Canada, and the Republic of Korea. Hong Kong (China), Canada, and the Republic of Korea are the only economies in this group that are not in the GII top 10.

Box 4 takes an in-depth look at the relationship between economy size and innovation performance.

Hong Kong, China keeps the 8th spot in the Innovation Input Sub-Index for the third consecutive year and ranks 13th in the GII overall, up from 14th in 2018. It moves downward in all input pillars except for Institutions (7th, up by 3) where it benefits from the introduction of the new indicator of Political and operational stability (Appendix IV). In this pillar, it keeps its top rank in the indicator of Cost of redundancy dismissal and gains in Regulatory quality. Government effectiveness and Ease of starting a business also rank well (5th rank overall). Hong Kong (China) also retains good rankings in Market sophistication (3rd) and Infrastructure (4th). In five of the 15 input sub-pillars, it ranks in the top 10; these are Political environment (4th), Regulatory environment (3rd), Ecological sustainability (2nd), Credit (2nd), and Knowledge absorption (8th). It ranks in the top 3 in several indicators, such as PISA results, GDP per unit of energy use, Domestic credit to private sector, High-tech imports, and FDI net inflows. Relative weaknesses on the input side include Expenditure on education, Global R&D companies, GERD financed by abroad, IP payments, and ICT services imports.

Canada moves up to the 9th position in the Innovation Input Sub-Index and to the 17th in the GII ranking, up one from 2018. Its strengths on the input side are a result of high and improved rankings in two pillars: Market sophistication (2nd) and Institutions (4th). This year, the country also improves in Business sophistication (22nd), where it gains the top rank in JV-strategic alliance deals. In Market sophistication, Canada maintains its top rank in Venture capital deals. However, country data for indicators Domestic credit to private sector and Microfinance gross loans were unavailable, making the Credit sub-pillar difficult to measure. In Institutions, the country ranks 3rd in Ease of starting a business and is in the top 10 in Political and operational stability, Government effectiveness, Regulatory quality, and Rule of law. Interesting changes occur also in Human capital and research, where data for four variables became available this year. This allows a better measurement of Canada's performance in Education (51st) and Tertiary education (32nd). In this pillar, the country takes the 6th spot in the quality of universities. Thanks to this higher score and to a higher score in quality of scientific publications, Canada also joins the top 10 in the quality of innovation this year (Figure 1.7). Canada's relative weak areas include Graduates in science and engineering, GDP per unit of energy use, and ICT services imports.

The Republic of Korea (Korea) enters the top 10 in the Innovation Input Sub-Index this year, keeping up its good performance and gaining four positions since 2018. In the overall GII ranking, it moves closer to the top 10 (11th, up by 1). On the input side, Korea improves the most in Business sophistication (10th, up by 10) and gains positions in Human capital and research—where it becomes the top economy in the world—and in Market sophistication (11th, up by 3). In these pillars, the indicators that see the largest gains include Knowledge-intensive employment, JV-strategic alliance deals, Expenditure on education, and Venture capital deals. Korea maintains its good ranks in a number of crucial variables, including most of the R&D-related indicators, as well as Tertiary enrolment, Researchers, Research talent in business enterprises, E-participation, ICT use, and Patent families in two or more offices. Despite this good performance, the country presents areas of relative weakness, which include Tertiary inbound mobility, GDP per unit of energy use, GERD financed by abroad, ICT services imports, and FDI net inflows.

What are the top 10 economies in innovation outputs?

The top 10 economies in the Innovation Output Sub-Index this year are Switzerland, the Netherlands, Sweden, the U.K., China, the U.S., Finland, Israel, Germany, and Ireland.

The 10 economies leading the Innovation Output Sub-Index remain broadly the same as in 2018, with six shifts and one substitution: the U.K., China, the U.S., and Finland move upward within the top 10; while Germany and Ireland move downward. Israel enters the top 10, while Luxembourg exits. Eight of these economies are ranked in the GII top 10. The innovation profile of the other two economies, China and Ireland, are discussed below. Box 5 presents an in-depth look at this year's results on the Creative outputs pillar.

China makes an impressive improvement in the Innovation Output Sub-Index this year, reaching the 5th position worldwide, up five positions from 2018—the year in which it reached the top 10 in the GII Output Sub-Index for the first time.

In Knowledge and technology outputs, it moves up one place in Knowledge impact to regain its 1st rank worldwide, and maintains its position in Knowledge creation (4th) and Knowledge diffusion (22nd). Most improvements in this pillar are due to sustained and increased performance in variables such as PCT patents (17th), ISO 9001 quality certificates (20th), and ICT services exports (75th). Improvements in this pillar are partially due to model changes, notably in the productivity growth variable, where China ranks 1st this year (up by 3). In this same pillar, China remains 1st in other key innovation metrics: Patents by origin, Utility models by origin, and High-tech net exports.

In Creative outputs, China improves in two sub-pillars: Creative goods and services (15th, up by 13); and Online creativity (79th, up by 5). It keeps its 1st position in Intangible assets. It remains top-ranked in Industrial designs by origin and

Creative goods exports, and achieves the 1st rank this year in Trademarks by origin (up by 2). China also maintains its first place in quality of innovation among middle-income economies for the seventh consecutive year (Figure 1.7). It improves its performance in all innovation quality metrics and ranks 3rd globally in the quality of universities.

Areas of improvement in the innovation output side include National feature films, Printing and other media, and Wikipedia edits.

Ireland ranks 10th in the Innovation Output Sub-Index this year. It is 6th in the Knowledge and technology outputs pillar—despite progress in a few areas, Ireland loses two ranks since last year, in part driven by better innovation performance in other economies. Ireland keeps its 19th position in Creative outputs.

In Knowledge and technology outputs, it moves up in Knowledge creation (31st, up by 6), and Knowledge impact (3rd, up by 2). It remains the top economy worldwide in Knowledge diffusion (1st). The most important improvements in this pillar are in PCT patents (22nd, up by 4), and High- and medium-high-tech manufactures (2nd, up by 1). Conversely, weaker performance is observed in Patents by origin (39th, down by 3), Scientific and technical articles (39th, down by 2), and High-tech net exports (16th, down by 1). In this pillar, Ireland remains 1st in the world in ICT services exports and FDI net outflows, and 2nd in Computer software spending.

In Creative outputs, Ireland improves in Intangible assets (8th, up by 4), but decreases in Creative goods and services (59th, down by 11), and Online creativity (24th, down by 2). Some of the areas responsible for the decreases are National feature films (21st) and Creative goods exports (40th). In contrast, progress is observed in Industrial designs by origin (59th, up by 9).

BOX 5

Which economies rank high on Creative outputs?

The GII considers creativity, and non-technological forms of innovation, as important ingredients befitting innovative economies and societies.

China leads in Intangible assets, Hong Kong (China) in Creative goods & services, and Luxembourg in Online creativity. Few economies rank in the top 10 for all three categories, but Luxembourg and Switzerland stand out with a top 10 position in all three. Hong Kong (China), and Malta each hold top 10 positions in two categories. The strength of small economies is particularly true in Online creativity, where Luxembourg trumps the list among other similarly small economies (Box 4). However, there are exceptions as large economies scoring high in Online creativity include Germany, France, the U.S., and the U.K.

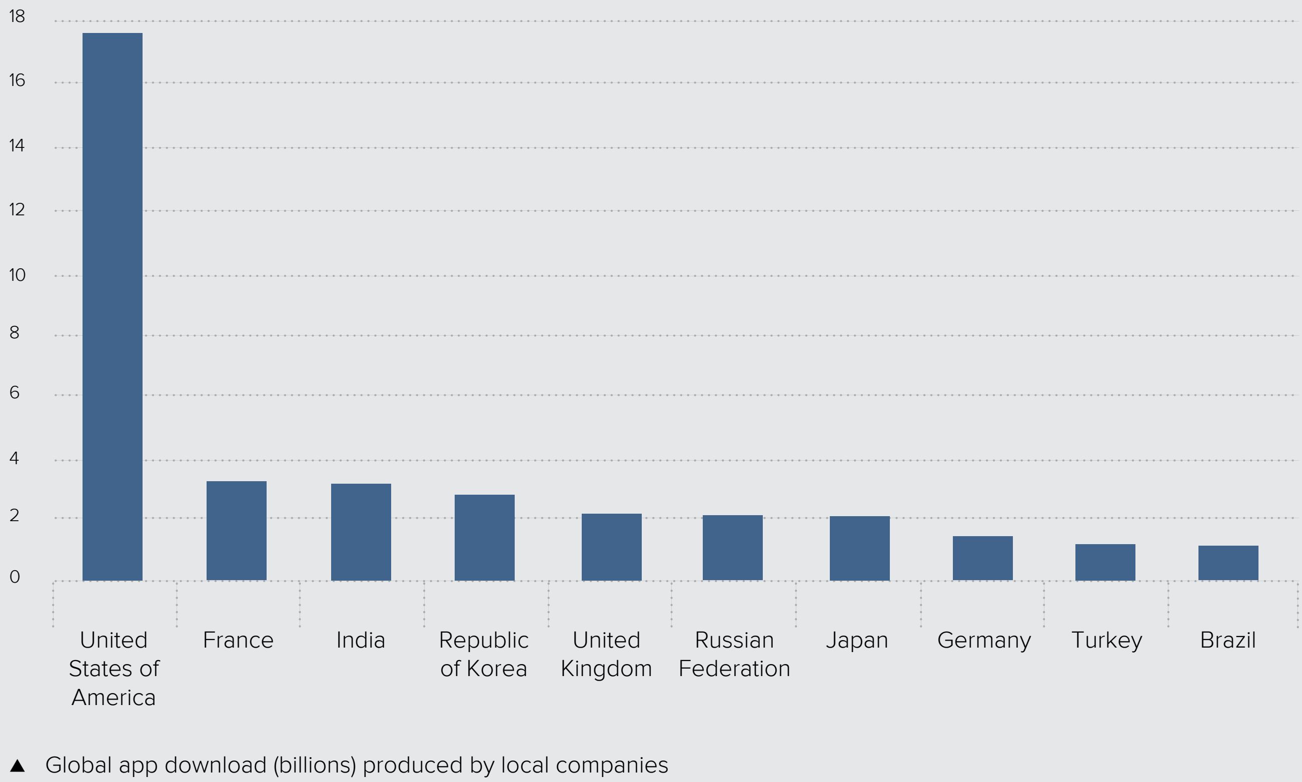
Since last year, in collaboration with App Annie and its mobile data platform, which tracks Google Play store and iOS App Store activity in each economy, the GII has been generating performance metrics based on the creation of mobile apps (Appendix IV). In absolute numbers, the U.S. is the uncontested leader in app creation, followed by France, India, the Republic of Korea, the U.K., and the Russian Federation (Box 5, Figure 1). Complete data for China is not available, but it would occupy a top slot.

When the GII scales this data for GDP, a different picture emerges. Cyprus, Finland, and Israel lead followed by economies in Eastern Europe (Lithuania and Estonia), and Asian economies such as Hong Kong (China) and Singapore.

Frequently, markets with companies that perform well in the app world are also ones with strong enough economies to attract entrepreneurs. The U.S. is where many tech companies are located and where the world's largest app stores began. For companies headquartered outside the U.S., their success represents both the size of their home markets and their ability to carve out a sizable share when it comes to app creation. While India, Brazil, and the Russian Federation are near the top, other large countries, such as Indonesia, primarily utilize apps created by companies from other countries. It is easier to create apps that address needs in local markets and then expand internationally from there. Gaming apps are unique in that, while regional preferences and localization influence success, they are generally scalable globally. In gaming, one or two successful companies have the potential to move the needle for an entire country.[48]

BOX 5, FIGURE 1

Global app downloads (billions) produced by local companies, 2018



Source: App Annie, 2019.

Who is best on the quality of innovation?

Moving beyond quantity to quality indicators of innovation has become an overarching concern to the innovation policy community. With this in mind, three indicators that measure the quality of innovation were introduced into the GII in 2013: 1) quality of local universities (indicator 2.3.4, QS university ranking, average score of top 3 universities); (2) the internationalization of local inventions (indicator 5.2.5, Patent families filed in at least two offices); and (3) the quality of scientific publications, as measured by the number of citations that locally produced research documents receive abroad (indicator 6.1.5, Citable documents H-index).

Figure 1.7 shows how the scores of these three indicators are added to capture the top 10 highest performing high- and middle-income economies in the quality of innovation.

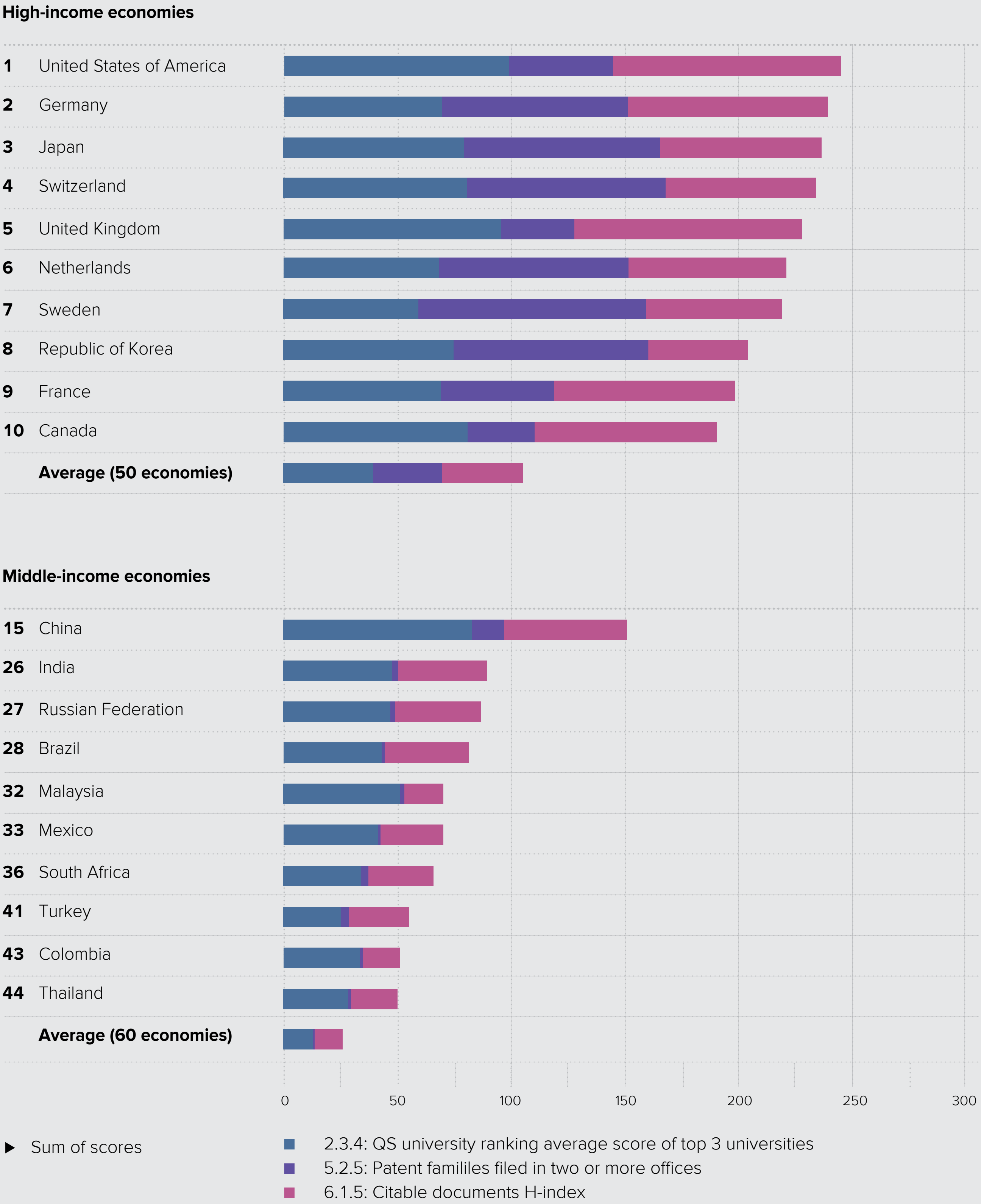
Among the high-income economies, the U.S. regains the top rank for quality of innovation, moving ahead of Japan, which moves down to 3rd this year. Germany is 2nd for the first time, above both Japan and Switzerland. The U.K. is stable at 5th, while the Netherlands moves up to 6th—its highest ranking in the quality of innovation to date. Sweden and the Republic of Korea rank 7th and 8th, respectively. France is stable at 9th and Canada, whose last appearance in this group was in 2016, re-enters in 10th, replacing Finland.

The U.S. returns this year to the top position in quality of innovation among the high-income economies. This achievement, seen before in 2017, reflects consistent performance in the quality of publications and high scores for the top 3 U.S. universities: The Massachusetts Institute of Technology (MIT), Stanford University, and Harvard University.

Germany improves this year in the quality of innovation (2nd) with a higher score in quality of scientific publications H-Index (1,059 to 1,131) and better scores for its top three universities: the Technical University of Munich (TUM), the Ludwig Maximilian University of Munich, and Heidelberg University.

FIGURE 1.7

Metrics for quality of innovation: top 10 high- and middle-income economies, 2019



Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.
Notes: Numbers to the left of the economy name are the innovation quality rank. Economies are classified by income according to the World Bank Income Group Classification (July 2018). Upper- and lower middle-income categories are grouped together as middle-income economies.

The U.K. remains stable in quality of innovation (5th) and remains 2nd in the quality of universities, with top scores for University of Oxford, University of Cambridge, and Imperial College London. The U.K. shares 1st place in quality of scientific publications with the U.S.—for the sixth consecutive year.

Sweden reaches the top position in patent families for the first time.

Canada joins the top 10 in quality of innovation with higher scores in the quality of scientific publications.

The ranking of middle-income economies in these innovation quality indicators remains steady, with China (15th), India (26th), and the Russian Federation (27th) in the top 3 positions. Brazil (28th), Malaysia (32nd), and Mexico (33rd) are next in line, followed by South Africa (36th), Turkey (41st), Colombia (43rd), and Thailand (44th). This year, aside from China, Malaysia and Thailand are the fastest movers in this group. Colombia is the third economy from Latin America and the Caribbean in this list.

China remains as the top middle-income economy in the quality of innovation for the seventh consecutive year. Positioned 15th, China is the only middle-income economy that is closing the gap with the high-income group in all three indicators. China ranks 3rd in quality of universities. Similarly, China's score for quality of scientific publications stands above the high-income group average.

India ranks 2nd in the quality of innovation among the middle-income economies for the fourth consecutive year, with top positions in quality of scientific publications (2nd) and in the quality of universities (3rd), notably due to the performance of its top 3 universities: the Indian Institute of Technology (Delhi and Bombay) and the Indian Institute of Science Bengaluru.

Brazil retains its 4th place among its middle-income peers and 28th globally, although displaying lower scores in the quality of universities this year.

Malaysia is 5th among middle-income economies and 32nd overall in the quality of innovation.

Colombia, 9th in this group, enters the middle-income top 10 for the first time since 2016. Higher scores in both international patents and the quality of scientific publications assist Colombia's performance, leading to an overall ranking of 43rd. Colombia is 8th among its income group peers in the quality of its universities, with notable scores for Los Andes University of Colombia, National University of Colombia, and Externado University of Colombia.

With regards to the quality of universities, high-income economies hold almost all top ranks. The U.S. and the U.K. take the top 5 positions for individual universities. Singapore is the only non-Northern American or European economy with universities in the top 15 worldwide (National University of Singapore and Nanyang Technological University).

In the middle-income group, the top 3 universities are located in China, after which, India holds the most top slots. India is also the only lower middle-income economy with a university in the top 10 among middle-income economies (Table 1.3).

Regarding the quality of scientific publications (Citable documents H-index), among the top 5 in the high-income group, only the U.S. and Canada are non-European economies. In the middle-income group, China takes the top position. India is 2nd, as the only lower middle-income economy in the top ranks. The Islamic Republic of Iran ranks 9th among middle-income economies in the quality of publications and 12th overall in the quality of innovation among middle-income economies.

TABLE 1.3

Top 10 universities in middle-income economies

Location	University	Score
China	Tsinghua University	87.2
China	Peking University	82.6
China	Fudan University	77.6
Malaysia	Universiti Malaya (UM)*	62.6
Russian Federation	Lomonosov Moscow State University	62.3
Mexico	Universidad Nacional Autónoma de México (UNAM)	56.8
Brazil	Universidade de São Paulo (USP)	55.5
India	Indian Institute of Technology Bombay (IITB)	48.2
India	Indian Institute of Science (IISC) Bengaluru	47.1
India	Indian Institute of Technology Delhi (IITD)**	46.6

Source: QS Quacquarelli Symonds Ltd, QS World University Ranking 2018/2019
Notes: Only universities among the top 3 in each economy are considered. *Shares the same rank (87th worldwide) with Rice University in the U.S.
**Shares the same rank (172nd worldwide) with the University of Aberdeen in the U.K. and University of Twente in the Netherlands.

On international patents, European economies take seven of the top 10 positions, with the other three spots going to Israel, Japan, and the Republic of Korea. Among middle-income economies, China and South Africa take the top two positions, with India and Turkey registering improvements in this indicator.

Which economies get more return on their innovation investments?

On the basis of the GII data, we analyze which economies most effectively translate innovation inputs into innovation outputs.

In 2018, the GII started plotting the input-output performance of economies against each other (Figure 1.8) based on advice from the European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC).

Among the high-income economies, located more towards the right of Figure 1.8, economies like Switzerland (CH), the Netherlands (NL) and Sweden (SE) produce more outputs relative to their levels of innovation inputs. In turn, Singapore (SG), the United Arab Emirates, Brunei Darussalam (BN), and Trinidad and Tobago (TT) are producing less outputs for their levels of inputs invested in innovation.

Viet Nam (VN) and India (IN) stand out as lower middle-income economies that are getting much more outputs for their inputs. Their levels are above those of high-income oil-rich economies like Kuwait (KW), Qatar (QA), Bahrain (BH), and Oman (OM) (Figure 1.8, Highlight 1).

Within upper middle-income economies, China stands out for producing innovation outputs that are comparable to those of Germany (DE), the U.K., Finland (FI), and Israel (IL), but at a lower level of innovation inputs invested. Assuming that both inputs and outputs are properly measured, both the U.S. and China produce similar outputs, with the U.S. investing more on the input side (Figure 1.8, Highlight 2).

Various economies at different levels of development have comparable output levels, although the efforts on the input side differ. With significantly lower investments on the input side, Zambia (ZM), a low-income economy, achieves the same level of outputs as Brunei, a high-income economy (Group 1). The Czech Republic (CZ) also achieves the same level of outputs as Singapore (SG), yet at much lower levels of input (Group 3).

Which countries lead their respective regions?

Sub-Saharan Africa (24 economies)

For several editions, the GII has noted that Sub-Saharan Africa performs relatively well on innovation (Table 1.2). Since 2012, Sub-Saharan Africa has had more economies among the group of innovation achievers than any other world region.

As in 2018, South Africa takes the top spot among all economies in the region (63rd), followed by Kenya (77th), Mauritius (82nd), Botswana (93rd), Rwanda (94th), Senegal (96th), and the United Republic of Tanzania (97th). Among these, Kenya, Rwanda, and Senegal improve their GII ranking compared to 2018, while South Africa, Mauritius, Botswana, and the Republic of Tanzania drop positions.

The remaining 19 economies in this region can be found at ranks lower than 100. Five of them have improved since 2018: Uganda (102nd), Côte d'Ivoire (103rd), Ghana (106th), Nigeria (114th), and Burkina Faso (117th).

Because of improved data coverage, Ethiopia (111th) and Burundi (128th) are covered in the GII rankings this year (Appendix IV).

Central and Southern Asia (9 economies)

Economies of the Central and Southern Asia region have seen further improvements in their GII rankings in 2019, with five economies improving their rankings and India moving forward into the top half of the GII.

India maintains its top place in the region, moving up five spots—from 57th last year to 52nd this year. The Islamic Republic of Iran remains 2nd in the region, moving up four positions to take the 61st spot. Kazakhstan moves down five positions, ranking 79th this year. The remaining economies rank in order within the region as follows: Sri Lanka ranks 89th this year, followed by Kyrgyzstan (90th), Tajikistan (100th), Pakistan (105th), Nepal (109th), and Bangladesh (116th).

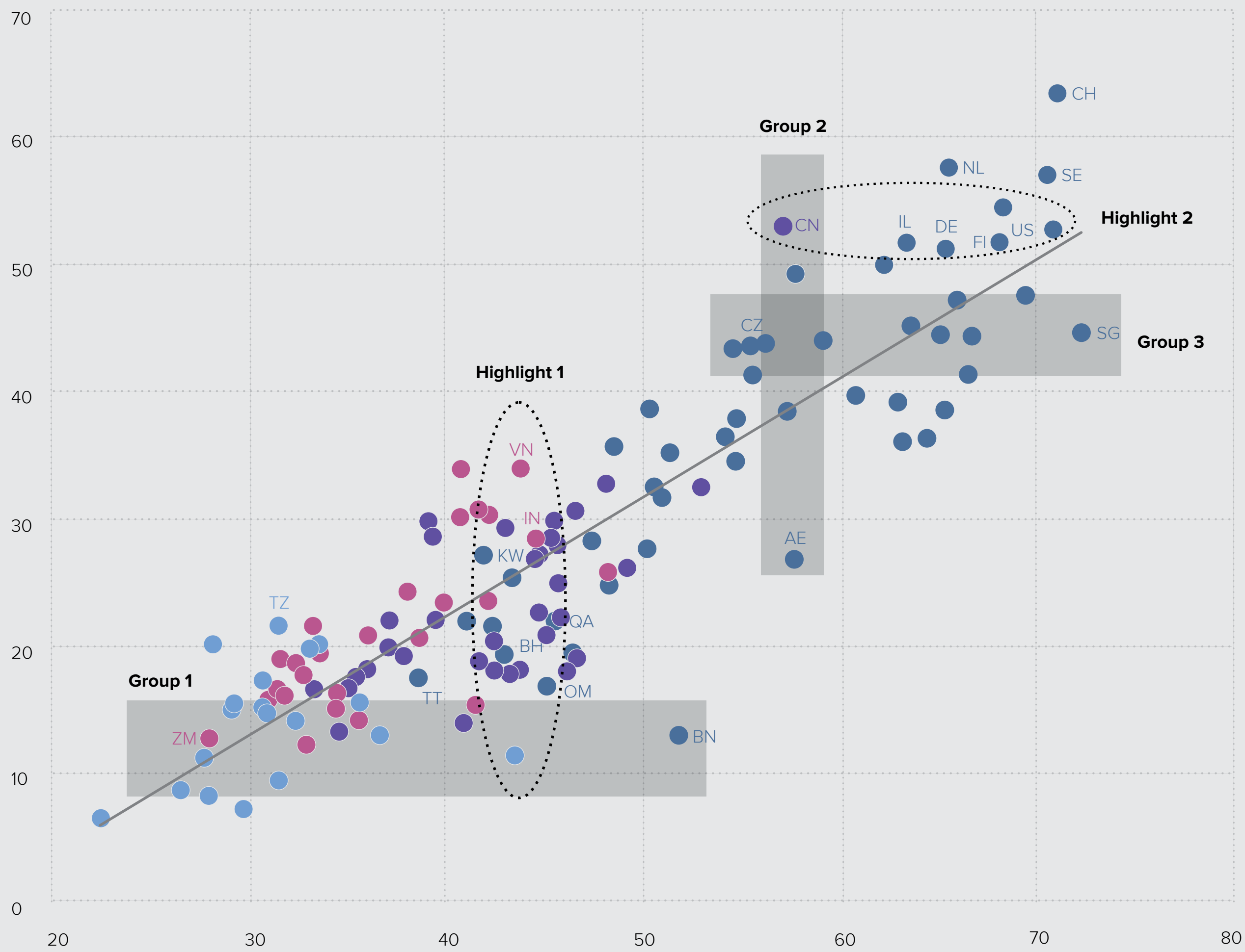
India ranks 52nd in the GII this year, gaining five positions since 2018. It remains 1st in the region and moves up to the 4th position in the GII rankings among lower-middle-income economies. India has also outperformed on innovation relative to its GDP per capita for nine years in a row, as shown in Table 1.2. The country confirms its rank among the top 50 economies in two pillars—Market sophistication (33rd) and Knowledge and technology outputs (32nd)—with the latter being the pillar in which India ranks the highest this year. Thanks to higher scores in patent families in two or more offices and the quality of scientific publications, India remains the 26th economy in the quality of innovation aggregate and the 2nd after China among middle-income economies (Figure 1.7).

India's improvement this year is largely due to its relative performance and less so to new GII data or methods. It improves in four of the seven GII pillars.

The pillar that improves the most is Knowledge and technology outputs, where the country gains 11 spots. Ranking improves for several variables—the most notable gains are in IP-related variables, notably Patents by origin and PCT patents by origin, and IP receipts, which benefits from a methodological changes (Appendix IV). In this pillar, India maintains its top position in ICT services exports, where it ranks 1st in the world, and in labor productivity growth (4th).

FIGURE 1.8

Innovation input/output performance by income group, 2019



▲ Output score
▶ Input score

High income
Upper-middle income
Lower-middle income
Low income
— Fitted values

AE United Arab Emirates
BH Bahrain
BN Brunei Darussalam
CH Switzerland
CN China
CZ Czech Republic
DE Germany
FI Finland
IL Israel
IN India
KW Kuwait
NL Netherlands
OM Oman
QA Qatar
SE Sweden
SG Singapore
TT Trinidad and Tobago
TZ United Republic of Tanzania
US United States of America
VN Viet Nam
ZM Zambia

Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.

FIGURE 1.9

India ahead of average lower middle-, upper middle-, and high-income economies, 2019

Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.

The other three GII pillars that move up this year are all related to innovation inputs; these are Institutions (77th, up by 3), Human capital and research (53rd, up by 3), and Market sophistication (33rd, up by 3).

In Institutions, the majority of the indicators present a better ranking this year. The most notable gains are found in Political and operational stability where a new indicator is used this year (Appendix IV) and in Ease of starting a business, thanks to important reforms aimed at streamlining bureaucratic procedures.[49]

In Human capital and research, two important variables improve: Gross expenditure on R&D and Global R&D companies (a relative strength for the country). In the former, despite improvement, India is still 50th. Its share in world R&D expenditures has increased since the mid-1990s, but less sharply than other middle-income countries, such as China, or other Asian powerhouses, such as the Republic of Korea (Figure 1.9). In Global R&D companies, India reaches the 15th spot as the second middle-income economy. In this pillar, the indicator Graduates in science and engineering (7th) remains a relative strength for the country. Thanks to the quality of its top 3 universities—the Indian Institute of Technology (Delhi and Bombay) and the Indian Institute of Science in Bengaluru, India achieves a relatively strong ranking in the indicator quality of universities (21st).

In Market sophistication, six of the nine indicators improve, and some quite substantially. Ease of getting credit (20th), Microfinance gross loans (23rd), Market capitalization (20th), and Venture capital deals (30th) all gain positions. In this pillar, Intensity of local competition also contributes to the improved performance of the country, moving up 23 positions.

The other three GII pillars—Infrastructure (79th), Business sophistication (65th), and Creative outputs (78th)—lose in relative strengths to other countries. In these pillars, the largest drops are found in Logistics performance, Females employed with advanced degrees, and Printing and other media.

Significant improvements are found in some pillars—for example, in State of cluster development. This is also confirmed in the Special Section: Cluster Rankings, highlighting the performance of Bengaluru, New Delhi, and Mumbai. In addition, High-tech imports move up by 24 spots, in part reflecting improved data (Appendix IV).

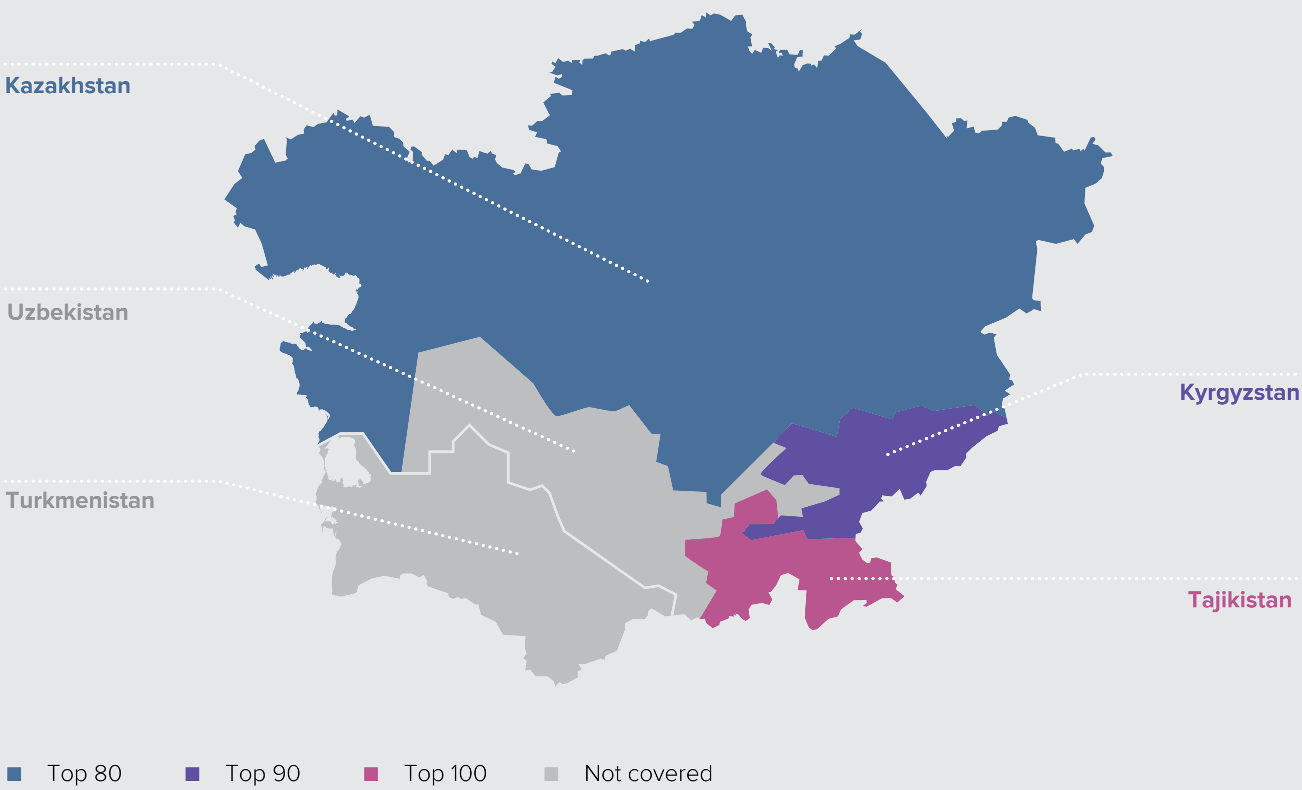
While India improved in the GII ranking, some relative weaknesses still persist. These include Environmental performance, New businesses, and Entertainment and media market.

Finally, it is worth noting that while India's data coverage is among the highest in the GII, two important indicators—notably GERD financed by business and GERD financed by abroad—are still missing. Moreover, a significant number of indicators are outdated. Almost half of them are in the pillar Human capital and research, with Education having 4 out of 5 variables outdated. Many relate to research—Researchers, R&D intensity (GERD as a percentage of GDP), R&D performed by business, and Research talent in business enterprise. The availability of complete innovation metrics would help obtain a fuller picture of India's performance. The country could also benefit greatly from updating and measuring all aspects of R&D more systematically. One example is the indicator on Global R&D companies' expenditures, which improved further this year and reflects the efforts of the Indian private sector in R&D.

The sub-region of Central Asia is noteworthy for starting to prioritize innovation activities and related policies in a sustained manner. Three economies in the sub-region are covered in the GII 2019: Kazakhstan (79th), Kyrgyzstan (90th) and Tajikistan (100th) (Figure 1.10). Uzbekistan is making continuous progress in data collection to be included in the GII rankings.

FIGURE 1.10

GII 2019 rankings of economies in Central Asia



Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.

Latin America and the Caribbean (18 economies)

Latin America and the Caribbean economies all position below the top 50 in the GII ranking. Most economies in this region are either among the upper middle- or lower middle-income groups, with five exceptions in the high-income group: Chile, Uruguay, Trinidad and Tobago, Argentina, and Panama, which are now classified in this group. The top 3 economies in the region are Chile (51st), followed by Costa Rica (55th), and Mexico (56th). Following this group are Uruguay (62nd), Brazil (66th), and Colombia (67th). An additional eight economies in the region stand in the top 100. These are Peru (69th), Argentina (73rd), Panama (75th), Jamaica (81st), the Dominican Republic (87th), Trinidad and Tobago (91st), Paraguay (95th), and Ecuador (99th).

Despite incremental improvements and encouraging initiatives, no clear signs for significant take-off are visible in Latin America and the Caribbean.[50] The GII has insisted that Latin America's innovation potential remains largely untapped.[51]

Despite these concerns, this year, one economy from this region—Costa Rica—continues to outperform on innovation relative to its level of development (Figure 1.6). Chile is the only country in the region that scores above the regional average in all GII pillars. Colombia and Peru score above the regional average in all innovation input pillars, showing potential for take-off in the future. Costa Rica, Mexico, and Uruguay show higher scores than the regional average in the innovation output pillars.

Chile ranks 51st, down from last year but remaining at the top of the region for the fourth consecutive year. It has rankings in the top 50 in three pillars: Institutions (39th), Infrastructure (50th), and Market sophistication (49th), and also shows an improved position in the latter two and Human capital and research (57th). Chile's best improvement at the pillar level is in Market sophistication, with higher rankings in Credit (51st) assisted by the indicators Microfinance gross loans, and in Trade, competition, and market scale, with improved Applied tariff rate and better perceived Intensity of local competition. On the Input side, it shows higher performance in Education (60th) with improvement in the Expenditure on education, Government funding per pupil, and School life expectancy (20th). In the Outputs, Chile advances in Knowledge creation (56th), with better rankings in Patents by origin, PCT patents by origin, and Utility models. It does well in Online creativity (58th), thanks to an improved measurement of Mobile app creation introduced this year. Chile shows areas of weakness in Business sophistication (53rd), particularly in high-tech imports, and ICT services imports (88th), both part of Knowledge absorption (49th). Outputs weaknesses for Chile are ICT services exports, Industrial designs by origin, and Creative goods exports.

Brazil ranks 66th in the GII this year, down two positions from 2018. In the Innovation Input Sub-Index, it improves in Institutions (80th) and Human capital and research (48th). In the Innovation Output Sub-Index, it improves in Knowledge and technology outputs (58th). Brazil ranks in the top 25 in several indicators in the 5 GII pillars: Human capital and research (48th), Infrastructure (64th), Market sophistication (84th), Business sophistication (40th), and Knowledge and technology outputs (58th). Most of Brazil's strengths are in Human capital and research, mainly in Expenditure on education (18th), Gross expenditure on R&D (28th), Global R&D companies (22nd), and the Quality of universities (25th). Other input strengths for Brazil are Government's online service (22nd), E-participation (12th), Domestic market scale (8th), Intellectual property payments (10th) and High-tech imports (28th). The quality of publications measured through the H-index (24th) is the only Innovation output strength for Brazil. Two areas of opportunity are also noted among Innovation inputs in the General infrastructure (102nd) and Credit (105th) sub-pillars: Gross capital formation (115th) and Microfinance gross loans (74th). Relative weaknesses in Innovation Outputs include the labor productivity growth (96th) and New businesses (98th).

Peru ranks 69th in the GII 2019, moving up two positions from 2018. The economy progresses the most in Human capital and research (66th), Infrastructure (65th), and Creative outputs (79th). Peru gains positions in Human capital and research due in part to available coverage for indicators in Tertiary education (21st)—mainly Tertiary enrolment (28th), and Graduates in science & engineering (36th). Peru has available data this year for School life expectancy, also located in this pillar. In Infrastructure, the country gains the most positions in Information and communication technologies (70th) and, in particular, in Government's online service (41st), and E-participation (36th). In Market sophistication, Peru moves up various positions in Trade, competition, and market scale (30th) due in part to a higher performance in Applied tariff rate (6th). Also in that pillar, it gains the most positions in Venture capital deals and the Intensity of local competition. In Business sophistication, Knowledge workers (27th) remains a strength for Peru, assisted by Females employed with advanced degrees (38th). On Innovation Outputs, Peru moves up in Creative outputs with gains in Entertainment & media market (41st) and Printing and other media (10th). Despite these improvements, Peru is relatively weak in Gross expenditure on R&D, Global R&D companies, University/industry research collaboration, and Joint venture-strategic alliance deals. Knowledge diffusion is also a relative weakness, both in ICT services exports and FDI net outflows.

Northern Africa and Western Asia (19 economies)

Israel, ranking 10th worldwide (up by 1), continues to be the most innovative economy in Northern Africa and Western Asia region since 2009. Cyprus (28th, up by 1) is second in the region, while the United Arab Emirates (36th, up by 2) achieves the third spot for the fourth consecutive year.

Five of the 19 economies in the region, including Cyprus (28th)—the only European Union member state in the region, the United Arab Emirates (36th), Georgia (48th), and Turkey (49th) rank within the top 50 of the GII. All of these countries exhibit an improvement in their global GII rank. Other countries which demonstrate an upward movement in the innovation landscape are Armenia (64th), Morocco (74th), Lebanon (88th), and Egypt (92nd).

Qatar (65th, down by 14) and Oman (80th, down by 11) experience the largest decrease in their global ranking relative to other countries in the region. Saudi Arabia (68th), Tunisia (70th), Bahrain (78th), Azerbaijan (84th), Jordan (86th), Algeria (113th) and Yemen (129th) see a more modest decline in their GII position.

Georgia (48th) leaps 11 positions—the highest move in the region. Such improvements are reinforced by Georgia's productivity growth rate where it ranks 8th, positive FDI net inflows (11th), and Ease of starting a business, where it positions 2nd globally. At the pillar level, Georgia improved its position in six of seven pillars, most remarkably in Market sophistication (15th). In the Investment sub-pillar, Georgia now places 1st globally (up from 21st last year), and is the 2nd top economy for the ease of protecting minority investors.

Algeria (113) sees its ranking decrease in all but one pillar this year—Human capital and research (74th), where it moves up by 6 spots. At the sub-pillar level, a weakening position is seen in Innovation linkages (122nd, down from 104th) and Knowledge absorption (117th, down from 86th). More notably, Algeria moves down in indicator High-tech net imports, placing 53rd (down from 28th last year). Algeria remains strong in its position of Infrastructure (81st), particularly in indicator Gross capital formation, where it has a 2nd spot globally, and in Human capital and research (74th), where it places as the 9th economy in Graduates in science and engineering.

Algeria is currently implementing a new innovation strategy in a move towards a knowledge-based society. The aim is to put firms at the center of innovation, to foster the innovation of small- and medium-sized enterprises, to aim at better integration of science and innovation policies, and to achieve better linkages between scientific research and innovation in firms. Several legislative changes are on the way in this regard.[52]

South East Asia, East Asia, and Oceania (15 economies)

This year, as in last year, all economies in the South East Asia, East Asia, and Oceania region rank in the top 100 of the GII. All economies in the region, except for Cambodia and Brunei Darussalam, are also in the top 100 of the Innovation Input and Innovation Output Sub-Indices.

Seven of the 15 economies in the region rank in the top 25 of the GII: Singapore (8th), the Republic of Korea (11th), Hong Kong (China) (13th), China (14th), Japan (15th), Australia (22nd) and New Zealand (25th). The top three economies in the region—Singapore, the Republic of Korea, and Hong Kong (China)—also rank in the top 25 of the GII in both the Innovation Input and Output Sub-Indices.

Malaysia ranks 8th in the region after New Zealand, and 35th overall in the GII. Viet Nam makes important progress this year, moving up three positions and reaching the 42nd place overall. It gains between 4 and 8 positions in three of the GII pillars: Human capital and research (61st), Market sophistication (29th) and Knowledge and technology outputs (27th). Thailand gains one position this year, ranking 43rd overall. Following next are Mongolia (53rd), the Philippines (54th), Brunei Darussalam (71st), Indonesia (85th) and Cambodia (98th).

As noted in previous editions of the GII, most economies in the ASEAN region continue to improve their GII rankings through better performance in innovation, R&D, and economic development indicators. Figure 1.11 shows the scores for selected input and output indicators for the ASEAN economies featured in the GII this year. Singapore is the top performer in most of these indicators. Viet Nam continues to lead in areas like Expenditure on education and trademarks, as well as on High-tech imports. Indonesia does the same in Gross capital formation and Thailand in Creative goods exports, where it shares the top position with Malaysia. With Myanmar still absent from the global innovation landscape, Cambodia is still the newest ASEAN economy to be part of the GII. Cambodia remains 2nd in the group in FDI net inflows and also takes that position in Joint venture-strategic alliance deals, behind Singapore. Yet, Cambodia shows the weakest scores in the group on most of the selected input and output indicators, with its lowest performance in Patents by origin.

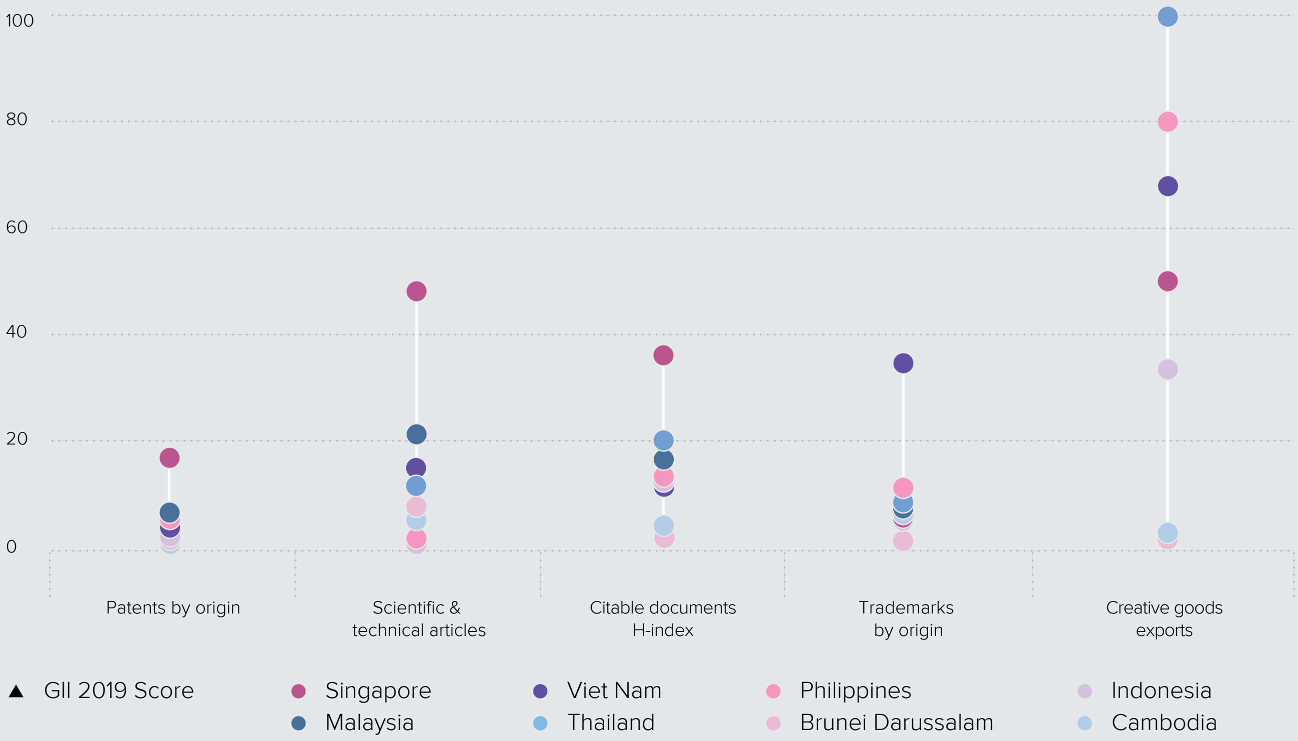
In input indicators, Viet Nam performs well in FDI net inflows but shows relatively low scores in Tertiary enrolment and Females employed with advanced degrees. It scores lowest in the group in Knowledge-intensive employment. In outputs, Viet Nam scores well in Scientific and technical publications, Creative goods and exports, and Patents by origin, and shows its lowest score for Citable documents H-index. This year Thailand is 2nd in Tertiary enrolment and quality of scientific publications and 3rd in Trademarks by origin. Malaysia scores well in both selected inputs and outputs, taking the 2nd position in Females employed with advanced degrees, Expenditure on education, High-tech imports, Patents by origin, and Scientific and technical articles. It also scores well in Tertiary enrolment, Knowledge-intensive employment, Joint venture and strategic alliance deals, and the quality of scientific publications. While performing at the top in Gross capital formation and relatively well in Tertiary enrolment, Indonesia shows relatively low scores for most of the other selected indicators. Philippines also displays relatively good scores for over half of the selected indicators, achieving 2nd in Trademarks and 3rd in Females employed with advanced degrees, High-tech imports, and Creative goods exports.

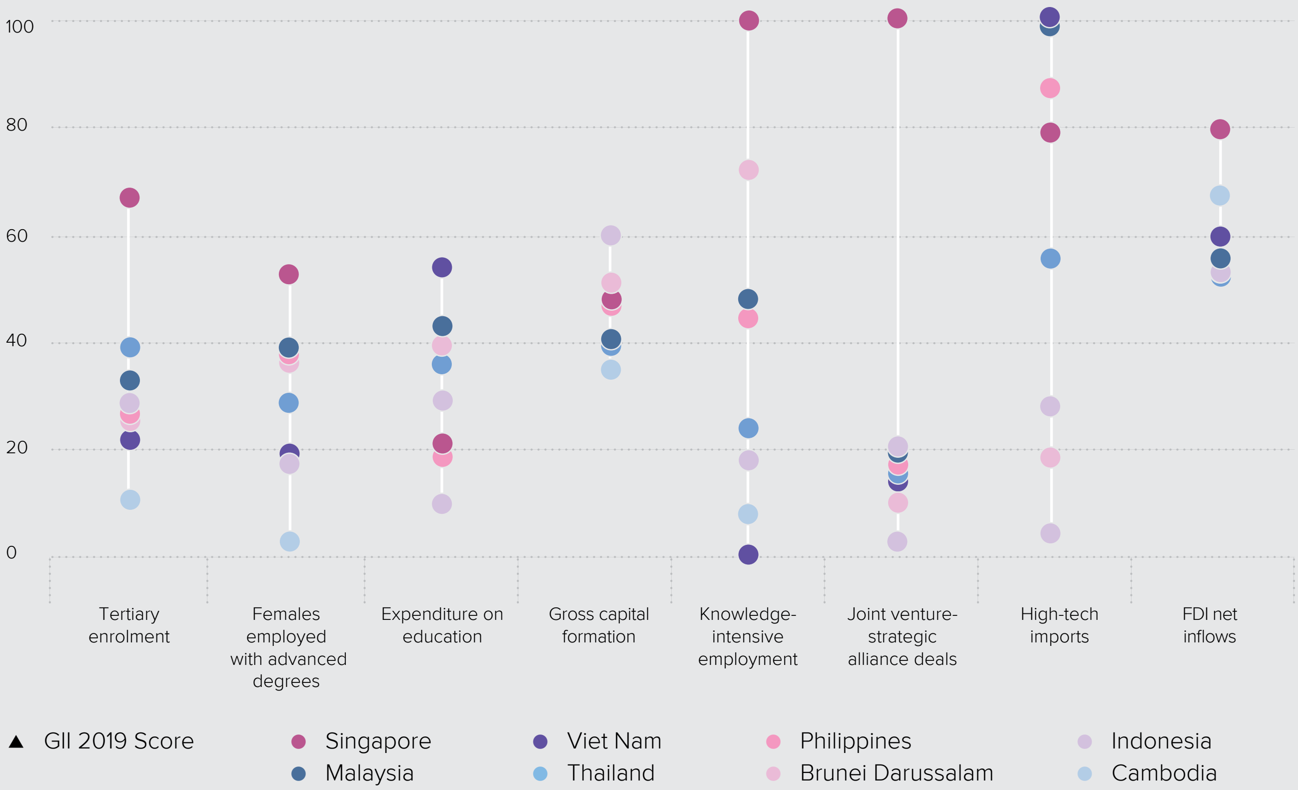
Lastly, in input indicators, Brunei Darussalam ranks 2nd in both Gross capital formation and Knowledge-intensive employment, and 3rd in Expenditure on education. The difference between the top performers and the other economies for these selected indicators is slightly larger for input indicators than for output indicators.

Malaysia ranks 35th, keeping the same position as last year. It remains among the middle-income economies that are bridging the innovation divide, thanks to its first rank in indicators such as High-tech net exports and Creative goods exports (Box 2). This year, Malaysia improves its rankings in four of the seven GII pillars: Institutions (40th), Infrastructure (42nd), Business sophistication (36th), and Creative outputs (44th). At the indicator level, the most significant improvements are in

FIGURE 1.11

ASEAN in selected innovation indicators, 2019





Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.

quality of universities, where it ranks 17th this year, and GERD performed by business as well as GERD financed by business, where it takes the 25th and 16th positions respectively. In several indicators, Malaysia ranks in the top 10; these include Graduates in science and engineering (8th), University-industry research collaboration (8th), State of cluster development (8th), and several trade-related variables—such as High-tech imports and High-tech net exports (respectively 3rd and 1st) and Creative goods exports (1st). Despite these top ranks, areas of relative weakness include PISA results, GERD financed by abroad, and Trademarks and industrial designs by origin.

Thailand ranks 43rd, gaining one position from last year. Like last year, the country remains among the innovation achievers of the GII 2019 and among the middle-income economies that are bridging the innovation divide (Box 2 and Table 1.2). This year, four of the seven GII pillars see improvements: Institutions (57th), Human capital and research (52nd), Business sophistication (60th), and Knowledge and technology outputs (38th). Thailand benefits from improvements in important indicators such as R&D expenditures, Research talent, and GERD financed by business, where it ranks 4th, as well as Tertiary enrolment, Researchers, and Patent families. As for other ASEAN economies, Thailand is exceptionally strong in trade-related variables, ranking 8th in High-tech net exports and 1st in Creative goods exports. If addressed, some weak areas—including PISA results, Venture capital deals, GERD financed by abroad, and ICT services imports and exports—could help the economy progress even faster on its path to catch up.

Philippines ranks 54th this year, gaining several positions from last year. While some changes to the GII model explain a small part of this leap, newly available metrics give a more thorough assessment of the country's innovation performance, which itself shows some signs of progress. Almost all GII pillars move up, except for Market sophistication. In the Business sophistication (32nd) pillar, the Philippines improves in almost all the indicators related to Innovation linkages and gains top ranks in High-tech imports (5th) and Research talent (6th). In Knowledge and technology outputs (31st), the data for indicator High-tech net exports became available this year and the country ranks 1st. Four other indicators rank in the top 10: Firms offering formal training (9th), productivity growth (10th), ICT services exports (8th), and Creative goods exports (8th). Despite these top ranks, Philippines presents a number of weak areas, which are concentrated in the innovation input side; these include Ease of starting a business, Ease of getting credit, Expenditure on education, and Global R&D companies. Scientific and technical articles and New businesses are relatively weak on the innovation output side.

Europe (39 economies)

As in the last two years, in this year's edition of the GII, 15 of the top 25 economies are from Europe. Seven of them are in the top 10 of the GII 2019: Switzerland (1st), Sweden (2nd), the Netherlands (4th), the U.K. (5th), Finland (6th), Denmark (7th), and Germany (9th). Following these innovation leaders, top 25 economies from the region are Ireland (12th), France (16th), Luxembourg (18th), Norway (19th), Iceland (20th), Austria (21st), Belgium (23rd), and Estonia (24th). It should be noted that most of the economies in this region have the fewest missing values, leading them to display the most accurate GII rankings (Appendix IV). This includes the following economies with 100% data coverage in the Innovation Input Sub-Index, the Innovation Output Sub-Index, or both: Finland, Denmark, Germany, France, Austria, the Czech Republic, Spain, Italy, Portugal, Hungary, Poland, Romania, and the Russian Federation.

The following 18 economies are among the top 50, with most of them maintaining relatively stable rankings since 2014: the Czech Republic (26th), Malta (27th), Spain (29th), Italy (30th), Slovenia (31st), Portugal (32nd), Hungary (33rd), Latvia (34th), Slovakia (37th), Lithuania (38th), Poland (39th), Bulgaria (40th), Greece (41st), Croatia (44th), Montenegro (45th), the Russian Federation (46th), Ukraine (47th), and Romania (50th).

The remaining European economies remain among the top 100 economies overall. The region's rankings continue as follows: Serbia (57th), the Republic of Moldova (58th), North Macedonia (59th), Belarus (72nd), Bosnia and Herzegovina (76th), and Albania (83rd).

France remains stable in 16th position in the GII 2019. It ranks in the top 15 economies in four of the seven GII pillars: Human capital and research and Infrastructure (11th in both), Market sophistication (12th), and Knowledge and technology outputs (15th). It shows top ranks in indicators such as Global R&D companies (7th), Environmental performance (2nd), and Venture capital deals (5th). This year, France gains most positions in Knowledge and technology outputs (15th, up by 4) where High- and medium-high-tech manufactures move to the 13th spot. At the indicator level, the most remarkable improvements are found in JV–strategic alliance deals and FDI net inflows, although the latter is also a weakness. Possibly benefiting from a new turn in French innovation and science policies, important gains are also visible in other areas related to universities and research, such as Graduates in science and engineering, Researchers, Quality of universities, and University/industry research collaboration. Despite these encouraging trends, France presents relatively weak ranks in Pupil-teacher ratio, Gross capital formation, Ease of getting credit, GERD financed by abroad, Utility models by origin, productivity growth, New businesses, ICT services exports, and Printing and other media.

The Russian Federation maintains the 46th position in the GII this year. The Russian Federation improves two positions in the Innovation Inputs Sub-index (41st) and ranks 59th in the Innovation Outputs Sub-Index, losing three positions from last year. On the inputs side, it increases its rank in Infrastructure pillar (62nd, up by 1), with higher rankings in Information and communication technologies (29th, up by 8), and in indicators ICT use (45th), Government's online services (25th), and E-participation (23rd). Although losing one position in Human capital and research (23rd), this year the Russian Federation shows strengths in Tertiary education (14th) due to its high levels of Tertiary enrolment (17th) and Graduates in science and engineering (10th). Pupil-teacher ratio is also a strength for the Russian Federation in the sub-pillar Education. In Market sophistication, its rank in Trade, competition, and domestic market scale are signaled as a relative strength

(11th). In Business sophistication, the Russian Federation's performance in Knowledge-intensive employment (18th) and the Females employed with advanced degrees (7th) are also strengths. Its most noted improvement in that sub-pillar is in High-tech imports (39th). On the Innovation Output side, the Russian Federation maintains its position in both the Knowledge and technology outputs (47th) and Creative outputs (72nd) sub-pillars. Although losing two positions in Knowledge creation, the Russian Federation maintains its top performance in Patents by origin (20th), as well as in Utility models (8th), where it gains one position since last year. In Creative outputs, rankings improve in Trademarks (38th) and Industrial designs (69th), while its rank for Intangible assets remains at 71st. In the quality of innovation, the Russian Federation retains its 3rd position among middle-income economies.

Northern America (2 economies)

The Northern America region includes two economies—the U.S. and Canada—in the top 20 in this year's GII. Both the U.S. and Canada are high-income economies. The U.S. ranks 3rd overall this year, up 3 positions from 2018, and is in the top 10 economies in both the Innovation Input Sub-Index (3th) and the Innovation Output Sub-Index (6th). Canada moves up both in overall rank (17, up by 1) as well as Innovation Inputs, where it ranks 9th. In the Innovation Output Sub-Index, Canada also achieves a higher position, reaching 22nd. These improvements are due, in part, to a better performance in Joint venture-strategic alliances deals in inputs and Trademarks by origin in outputs.

Conclusions

The theme for this year's GII is *Creating Healthy Lives—The Future of Medical Innovation*. For the first time, the thematic results are presented in a self-standing special section.

This chapter presented the main GII 2019 results, distilling main messages and noting some evolutions that have taken place since last year (see the Key Findings for more details).

The aim of the GII team is to continuously improve the report methodology in concert with its application and related analysis—based on the audit, external feedback, changing data availability, and shifting policy priorities. In this light, the GII team also continues to experiment with the use of novel innovation metrics. Every year, several dozen new innovation metrics are analyzed and tested for inclusion. These new metrics often replace currently inadequate data points on topics such as entrepreneurship, innovation linkages, open innovation, and new metrics for innovation outcomes at the local and national level. With each new edition, the GII seeks to improve the understanding of the innovation ecosystem with a view to facilitating evidence-based policymaking.

Over the last years, the GII has also been used by governments around the world to improve their innovation performance and associated innovation policies to craft and coordinate. In 2018 and 2019, numerous GII workshops in different countries and economies—including Algeria, Brazil, Belgium at the European Commission, China, the Czech Republic, Egypt, Germany, Hong Kong (China), India, Morocco, Oman, Peru, Thailand, Viet Nam, among others—took place or will take place, often with the presence of key ministers.

The mission of this work is to apply the insights gleaned from the GII. In a first step, statisticians and decision-makers are brought together to help improve innovation data availability. This work helps to shape the innovation measurement agenda at WIPO and at other international and domestic statistical organizations. In a second step, the challenge is to use the GII metrics and experiences in other countries to leverage domestic innovation opportunities while overcoming country-specific weaknesses. These exchanges generate feedback that, in turn, improves the GII and assists the journey towards improved innovation measurement and policy.

Often these activities are an exercise in careful coordination and orchestration among different public and private innovation actors, as well as between government entities at local, regional, and national levels. The GII becomes a tool for such coordination because the country is united in its common objective: to foster enhanced domestic innovation performance. At best, this coordination leads to policy goals and targets that are regularly revisited and evaluated.

For it is those countries that have persevered in their innovation agenda, with consistent focus and a set of priorities over time, that have been most successful in achieving the status of innovation leader or achiever relative to their level development.

Notes:

1 WIPO Consultant

2 Guellec et al., 2009; Dutta et al. 2017, 2018; WIPO, 2015, 2017; OECD, 2018.

3 IMF, 2019; OECD, 2019; World Bank, 2019.

4 IMF, 2019; Conference Board, 2019; OECD, 2019; World Bank, 2019.

5 UNCTAD, 2019.

6 Van Ark, 2018; OECD, 2018; Conference Board, 2019.

7 Dutta et al., 2018.

8 IMF, 2019; Van Ark, 2018; Conference Board, 2019.

9 Dutta et al., 2017, 2018; OECD, 2018; van Ark, 2018.

10 Cornell et al., 2015, 2017, 2018.

11 Dutta et al., 2017, 2018; OECD, 2018; Pfotenhauer et al., 2018; Edler & Boon, 2018.

12 The relationship between innovation (as measured by GII scores) and country characteristics such as size and economic structure was initially explored in Box 3 of the GII 2018 (Cornell et al., 2018). We have updated this analysis with the most recent data from GII 2019.

13 Lee, 2019.

14 Dutta et al., 2013; Bergquist et al., 2017, 2018.

15 In 2003, only 5 companies in middle-income economies made it to the top private sector R&D spenders (Hernández et al., 2018)

16 The number of researchers in countries like Brazil, China, India and Turkey, even if still low relative to the global stock of knowledge, have been rapidly increasing. These increases have been equal to 40% in China in the period 2008-2016, 38% in India between 2010-2015; 62% in Turkey between 2008-2016, and will be likely to continue rising given the countries' increased financial investments in R&D (UNESCO-UIS, 2019).

17 Innovators across the globe filed 3.17 million patent applications in 2017, up 5.8% for an eighth straight yearly increase. International patent applications filed under WIPO's Patent Cooperation Treaty (PCT) in 2018 grew at an annual growth of 3.9%, a ninth consecutive year of growth (WIPO, 2018; WIPO, 2019a).

18 Dutta et al., 2018.

19 R&D Magazine, 2018.

20 OECD, 2019.

21 Hernandez et al., 2018. R&D by the Higher Education sector and government institutions grew by 1.6% and 1.3% respectively (OECD, 2019)

22 In particular given that innovation is a long-term investment that requires action in the short-term, but with impacts that are noticeable in the medium- to long-term.

23 WIPO, 2017; Chen et al., 2017; WIPO, 2019b.

24 In current U.S. dollars.

25 This year the Innovation Efficiency Ratio has been replaced by an analysis of the connection between Innovation Inputs and Innovation Outputs, initially introduced in the GII 2018 (see Section "Which economies are best in translating innovation investments into innovation outputs?").

26 Further details on the GII framework and the indicators used are provided in Appendix I. It is important to note that each year the indicators included in the computation of the GII are reviewed and updated to provide the best and most current assessment of innovation. Methodological issues—such as missing data, the revision of scaling factors, and the number of economies covered in the sample—also impact the year-on-year comparability of the rankings. Details on the changes done this year to the methodological framework and an analysis of the factors impacting year-on-year comparability are provided in the Appendix IV.

Most notably, a more stringent criterion for the inclusion of countries in the GII was adopted in 2016, following the Joint Research Centre (JRC) recommendation of past GII audits (Appendix IV). Economies were included in the GII 2019 only if 66% of data were available within each of the two sub-indices and if at least two sub-pillars in each pillar could be computed.

27 See also Chaminade et al. (2018), and in particular Box 6.1; Lee, 2019.

28 On innovation in informal settings, see also Kraemer-Mbula and Wunsch-Vincent, 2016.

29 One caveat applies: the indicator framework of the GII is adapted marginally every year. This year-on-year comparison of data completeness is based on the given data requirements of the year in question, and not a fully stable list of indicators over time. For the most part, however, the indicators are the same; coverage is comparable. That caveat aside, Algeria, Brunei Darussalam, Burkina Faso, Mozambique, the United Arab Emirates, Yemen and Zimbabwe stand out as economies where data coverage has improved the most.

30 See: http://www.oecd.org/innovation/blue-sky.htm; https://www.nsf.gov/statistics/2018/nsb20181/

31 Australian Department of Industry, Innovation and Science and Australian Academy of Technology and Engineering (2019). WIPO is a contributor to this process. The review singles out a few areas where innovation data is in need of urgent improvement and in particular the following:

- non-R&D-based knowledge and idea creation
- capability to implement innovation
- new products and processes
- start-ups and spinouts
- stocks and flows of intangible capital
- employee skills
- innovation outputs and impacts
- entrepreneurship culture

32 Armenia is no longer part of the top 10 lower middle-income economies this year, as it has been reclassified as an upper middle-income economy. It ranks 15th among the 34 upper middle-income economies covered in the GII 2019.

33 Tajikistan was reclassified into the low-income group this year by the World Bank, after being part of the lower middle-income group up until 2018. See: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

34 Economies that outperform on innovation relative to their level of development (by at least 10% relative to their peers at the same levels of GDP).

35 This year, the U.S. had no available data for four indicators used in the GII (in GII 2018 it did not have available data for six indicators). Data availability is crucial in interpreting the GII results in particular across years.

36 See also https://www.reuters.com/article/us-broadcom-domicile/broadcom-completes-move-to-u-s-from-singapore-idUSKCN1HB34G

37 Note that model changes influence Israel's improvement in this indicator. See Appendix IV for more information.

38 Particularly, Hong Kong (China) re-exports high-tech products previously imported from elsewhere, notably from China, resulting in high levels of so-called re-exports.

39 For this Box, contributions have also been received from the Innovation and Technology Bureau, Government of the Hong Kong Special Administrative Region from Hong Kong (China), from the Ministry of State and Ministry of the Economy, Luxembourg Government, Grand Duchy of Luxembourg and from the Intellectual Property Office of Singapore (IPOS), Government of Singapore.

40 See also https://www.nrf.gov.sg/rie2020/advanced-manufacturing-and-engineering; https://www.nrf.gov.sg/rie2020/health-and-biomedical-science; https://www.nrf.gov.sg/rie2020/services-and-digital-economy; and https://www.nrf.gov.sg/rie2020/urban-solutions-and-sustainability.

41 See also https://www.ssg.gov.sg/wsq/Industry-and-Occupational-Skills/intellectual-property.html

42 See https://digital-luxembourg.public.lu/news/national-ai-vision-prioritizes-people

43 On June 25, 2018, the European Commission decided to establish the EuroHPC joint headquarters in Luxembourg. It will equip the EU with a pre-exascale and petascale infrastructure (1015 calculation operations per second) by 2020, and develop the technologies and applications needed to reach the exascale level (1018 calculation operations per second) by 2023. Lastly, the University of Luxembourg is home to an HPC and a €10 million budget was allocated for a new, faster one. More information is available at: https://meco.gouvernement.lu/

44 See https://digital-luxembourg.public.lu/news/luxembourg-gains-access-ai-technology-expertise-new-nvidia-partnership

45 See https://infrachain.com

46 More information available at: https://portal.education.lu/digital4education/; and https://www.skillsbridge.lu/

47 See https://space-agency.public.lu/en.html; and https://spaceresources.public.lu/en.html

48 For additional insights from App Annie on the mobile economy, check out App Annie's State of Mobile in 2019 report, available at: https://www.appannie.com/insights/market-data/the-state-of-mobile-2019/

49 See http://www.doingbusiness.org/content/dam/doingBusiness/country/i/india/IND.pdf

50 De la Torre and Ize, 2019 have argued that success in international markets, as measured by rising share of world exports, has been the route to income convergence in Latin American countries, including Peru, Chile, Uruguay, Costa Rica, the Dominican Republic,and Panama. See also: https://www.economist.com/the-americas/2019/05/30/why-latin-americas-economies-are-stagnating

51 See http://www.tradeforum.org/news/Latin-Americas-innovation-potential-remains-largely-untapped/

52 In December 2018, Algeria hosted a two-day GII conference to build on its innovation strength in the formulation of new innovation policies.

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CREATING HEALTHY LIVES—THE FUTURE OF MEDICAL INNOVATION

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The 2019 edition of the Global Innovation Index (GII) focuses on the theme *Creating Healthy Lives—The Future of Medical Innovation*. In the years to come, medical innovations such as artificial intelligence (AI), genomics, and mobile health applications will transform the delivery of healthcare in both developed and emerging nations.

The key questions addressed in this edition of the GII include:

- What is the potential impact of medical innovation on society and economic growth, and what obstacles must be overcome to reach that potential?
- How is the global landscape for research and development (R&D) and medical innovation changing?
- What health challenges do future innovations need to address and what types of breakthroughs are on the horizon?
- What are the main opportunities and obstacles to future medical innovation and what role might new policies play?

Five key messages emerge:

1. High quality and affordable healthcare for all is important for sustainable economic growth and the overall quality of life of citizens. While significant progress has been achieved across many dimensions over the last decades, significant gaps in access to quality healthcare for large parts of the global population remain.

2. Medical innovations are critical for closing the gaps in global healthcare provision. These innovations are happening across multiple dimensions, including core sciences, drug development, care delivery, and organizational and business models. In particular, medical technology related innovations are blossoming, with medical technology patents more numerous and growing at a faster path than pharmaceutical patents for the last decade. However, some challenges need to be overcome—notably, a decline in pharmaceutical R&D productivity and a prolonged process for deploying health innovations due to complex health ecosystems.

3. The convergence of digital and biological technologies is disrupting healthcare and increasing the importance of data integration and management across the healthcare ecosystem. New digital health strategies need to focus on creating data infrastructure and processes for efficient and safe data collection, management, and sharing.

4. Emerging markets have a unique opportunity to leverage medical innovations and invest in new healthcare delivery models to close the healthcare gap with more developed markets. Caution should be taken to ensure that new health innovations, and their related costs, do not exacerbate the health gap between the rich and poor.

5. To maximize the potential for future health innovation, it is important to encourage collaboration across key actors, increase funding from public and private sources, establish and maintain a skilled health workforce, and carefully evaluate the costs and benefits of medical innovations.

The section has benefited from comments by Hans Georg Bartels, Kyle Bergquist, Ridha Bouabid, Amy Dietterich, Carsten Fink, Mosahid Khan, Charles Randolph, and Ola Zahran, all at WIPO, Bruno Lanvin, INSEAD, and Bertalan Mesko, Author, *The Medical Futurist*. It draws on all outside chapter contributions that follow.

The impact of medical innovation—a high-stakes policy matter

Over the last century, improvements in healthcare have led to a doubling of life expectancy in both high-income and developing economies.[1] This increase in life expectancy has helped expand the global workforce, drive economic growth, and improve the quality of life for many.[2]

Innovations—on both technological and non-technological fronts—have contributed to better health and economic development. Improved hygiene, enhanced public health planning, the persistent pursuit of R&D in the medical field, and the increasing role of information technologies have been key. In particular, the decades after World War II are often considered the "golden age" of medical innovation. Many of the tools of modern medicine were developed between 1940 and 1980, including antibiotics, the polio vaccine, heart procedures, chemotherapy, radiation, and medical devices such as joint replacements.[3]

The benefits of improved health via innovation are becoming accessible to a growing number of people within and across developed and developing countries. As societies get richer, wealth buys better health and a higher quality of life, with more people in low- and middle-income economies having access to functioning health systems.[4]

Indeed, over the last decade, global spending on health has been growing faster than gross domestic product (GDP)—at roughly double the rate.[5] Health spending has been growing even more rapidly in low- and middle-income countries—close to 6% on average—than in high-income countries, which average 4%. In 2018, global healthcare expenditures amounted to US$7.6 trillion, accounting for around 10% of global GDP (Figure T-1.1).[6] By 2020, estimated global health expenditures will reach close to US$9 trillion.[7]

While significant progress in global healthcare has been made over the last couple of decades, there are major challenges that remain. A large proportion of the world's population lacks access to quality healthcare. Increasing health costs are also an issue, in particular, out-of-pocket payments by private households without complete medical insurance.

Medical innovation is expected to contribute to increased cost-effectiveness in the healthcare sector in the years to come. It is also key to the realization of the health-related United Nations Sustainable Development Goals (Box T-1.1).[8]

Now the logical question for economists and policymakers is how health innovations will continue to drive well-being and economic growth in the future.

At a glance, upcoming health innovations and their possible contributions are impressive. Policy and news reports abundantly cover much-anticipated innovations in health and medicine and the resulting improvements that patients will see.

If history is any guide, one has to avoid unwarranted optimism as to how fast health innovation arises and how efficiently it is deployed. Productivity in healthcare R&D has slowed in some respects.[12] Also, traditionally, innovation in health has diffused more slowly relative to other sectors.[13] This is due to the complex health innovation ecosystem and the seriousness of the outcomes that healthcare addresses: the life and well-being of people.[14]

While there is significant potential for new medical innovations, several obstacles must be overcome. Though the demand for innovation is high, there are concerns that the golden years of medical innovation may be behind us, as measured by decreases in major medical advances by year,[15] drug approvals,[16] and research productivity.[17]

BOX T-1.1

Sustainable development goals—innovation, health, and the United Nations

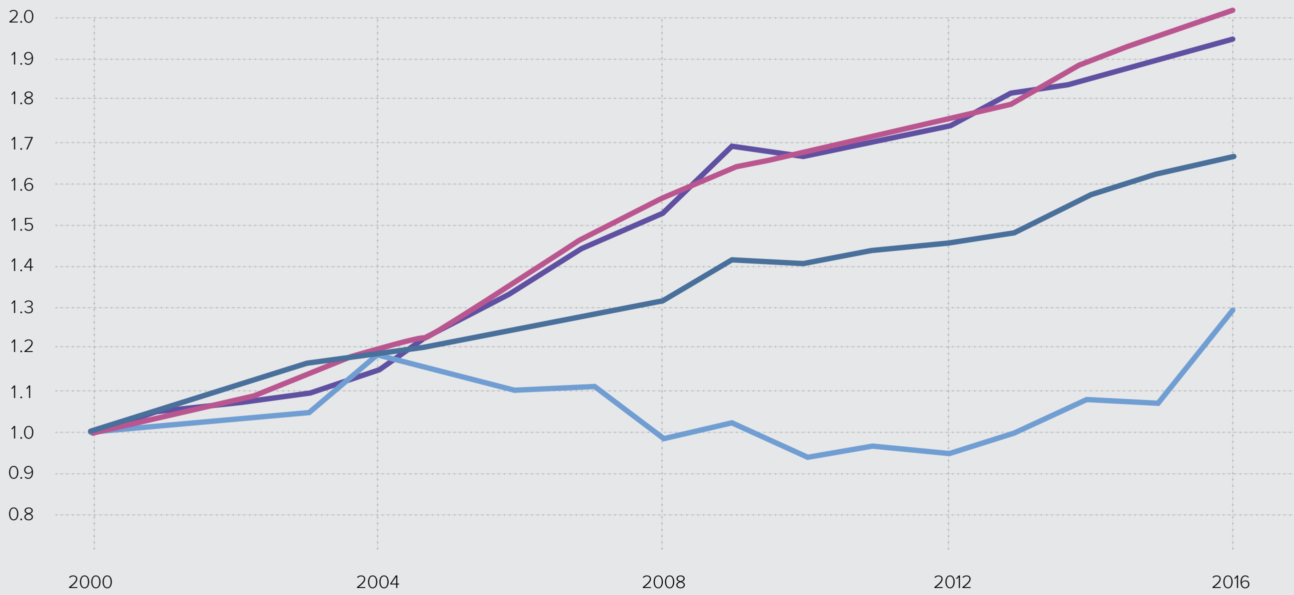
The United Nations (UN) Sustainable Development Goals (SDGs) are a collection of 17 global goals that seek to make significant progress on global matters, including health, by 2030. Specifically, SDG 3 sets global health targets in several areas. Importantly, it specifies the goal of universal health coverage—including access to essential healthcare services—and sets targets to support R&D for vaccines for communicable diseases, for example.[9]

To reach the 2030 goals, the UN General Assembly adopted health-related political declarations.[10] The SDGs and the ensuing declarations recognize the critical role of innovation and R&D. As a result, SDG Indicators were set up to monitor innovation and R&D progress—for example, SDG Indicators 9.5.1-2 measure gross domestic R&D expenditure on health (health GERD) as a percentage of gross domestic product, and the number of health researchers is measured in full-time equivalents (FTEs) per million inhabitants.[11]

In September 2019, the United Nations High-level Political Forum (HLPF) on Sustainable Development will convene to review the progress made on the first four-year cycle of the 2030 Agenda. The GII 2019—with up-to-date metrics on the underlying innovation systems—aims to be a useful guide, helping policymakers and other stakeholders engage in crafting coherent policies and implementation strategies to harness innovation for the achievement of SDG 3.

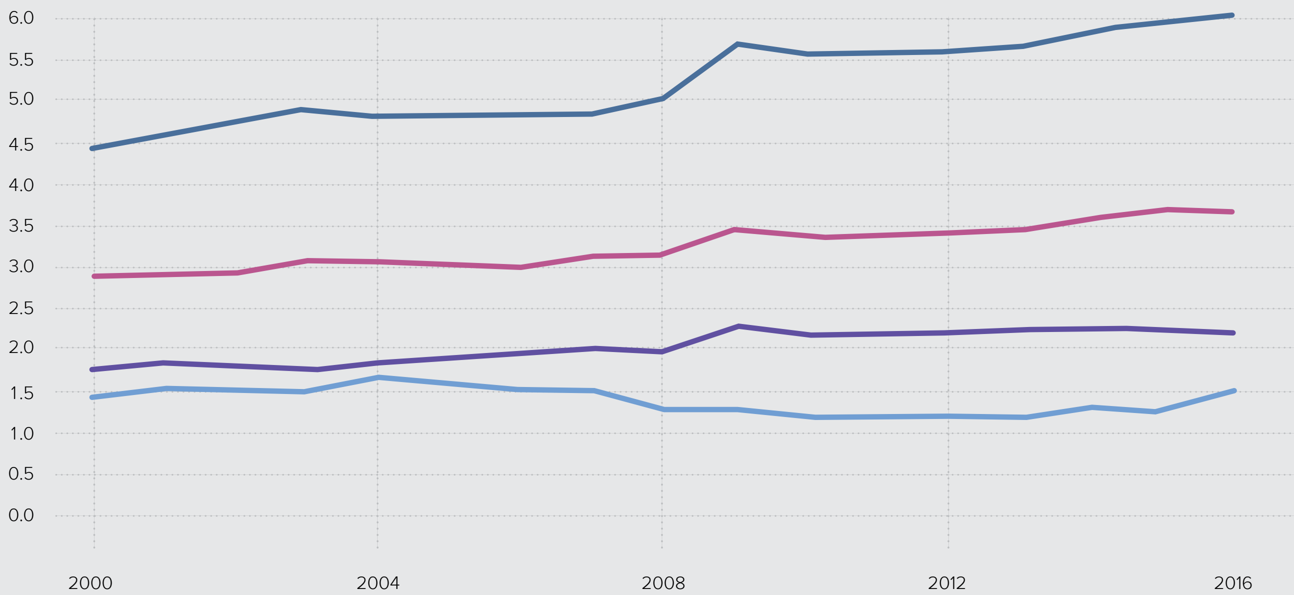
FIGURE T-1.1

Evolution of healthcare expenditures over time, in US$, and as a share of GDP



▲ Growth of health expenditures as a % per capita
▶ Year

Low income
Lower-middle income
Upper-middle income
High income



▲ Government spending on health as a % of GDP
▶ Year

Low income
Lower-middle income
Upper-middle income
High income

Source: Authors based on Xu et al., 2018; WHO data.

Pharmaceutical research is limited by rapidly increasing costs and a decline in major drug approvals over the past decade.[18] Cost increases are caused by multiple factors, including extensive research requirements, lengthier approval processes, longer development times, higher marketing expenditures, and a concentration of R&D investments in areas where the risk of failure is high.[19] To develop a drug for Alzheimer's, the process involves a commitment of nearly 10 years from research to use on patients—plus over 4 years of preclinical discovery and testing (Chapter 6–Eli Lilly and Company).[20] Diminishing returns on drug innovation may also be reducing incentives to invest in breakthroughs.

While later sections in this chapter point to a possible, recent turnaround in pharma R&D productivity, progress is generally slow with respect to some tenacious health challenges (Chapter 2–Bhaven Sampat). Many acute and chronic conditions have few treatment options beyond marginally mitigating disease progression and/or reducing discomfort resulting from symptoms. For some illnesses, such as cancer, depression, or Alzheimer's (Chapter 6), innovation has not yet produced breakthrough cures; failure rates and clinical trial setbacks are high.

Scientific advances in life sciences or biotech have often not been matched by a corresponding increase in medical innovation.[21] Efforts by pharmaceutical firms to overcome the pipeline challenge by buying biotechnology firms have not always produced the desired effect.[22] Gene development technologies have not created the breakthroughs many might have expected.[23] Moreover, new health-related research fields such as neuroscience are still in their infancy.

From the innovation diffusion perspective, the speed of adoption of existing medical innovations has been slow too, primarily due to complex interactions between actors in the health ecosystem.[24] Moving medical innovations "from bench to bedside" is a long process, sometimes extending over several decades. Multiple parties may be involved, such as private and public research actors, including medical technology, pharmaceutical firms, and universities; providers of healthcare, such as physicians and hospitals; patients; and payers, such as medical insurance companies.[25] Finally, the whole process is constrained by regulatory contexts and incentives, set by government or independent regulators to ensure safety and access.[26]

The fragmentation of healthcare across different actors—such as payers, insurers, providers, and manufacturers—leads to challenges (Chapter 8–GE Healthcare). The underlying innovation incentives for technology or new process adoption are regularly misaligned. Technologies to decrease the role of particular medical activities—such as minimally invasive surgery—might find lukewarm reception from a particular medical profession, slowing its deployment.[27] In addition, patients and insurers frequently have differing views as to the acceptable cost of new treatments.[28]

Slow feedback and knowledge flow between the actors can slow collaboration—often due to a lack of communication channels or lack of shared standards on how to exchange data and information across silos. These inefficiencies can lead to wasted time. They can also negatively affect patient outcomes (Chapter 8).[29]

It is noteworthy that the slow diffusion of medical innovations is more than a developed versus developing country issue. Many innovations fail to achieve widespread and sustainable use, even in economies with advanced health systems. This is true although many medical innovations are about applying existing technologies from non-medical fields in new ways in the health sector.[30]

Medical innovations are only slowly gravitating to developing countries; large segments of the population in the developing world remain underserved in terms of access to medical technologies and basic healthcare.[31] A broader diffusion of existing technologies and practices would pay large dividends (Chapter 2). The development of drugs, vaccines, medical devices, and overall healthcare operations designed for low-resource settings is key (Chapter 11–PATH).[32] Currently, market forces still result in pharmaceutical R&D targeting diseases that are typical of affluent societies, to the detriment of developing economies.[33]

Furthermore, while the focus is often on access to medicines, inadequate attention is given to contributions that would ensure the functioning of health systems in developing countries. Investments in innovations aimed at the delivery of healthcare are needed (Chapter 12–Ministry of Health, Egypt and Chapter 13–Narayana Health, India).[34]

Finally, too much effort is still spent on fixing health problems rather than preventing them in the first place (Chapter 9–iamYiam).[35] Technological and non-technological medical innovations go a long way to remedy this situation and improve prevention.

Medical innovations are changing the landscape of health

In the years to come, new technologies are likely to enrich the provision of healthcare at a rapid pace; they will help face some of the new medical challenges outlined in the section above while producing efficiencies and disrupting current ways of delivering healthcare.

This is not only about new technology. Innovation in health system organization—for example, how doctors are consulted, how monitoring is done, how diagnoses are established and shared, and how prevention takes place—is also on the way.[36]

These evolutions might help fix innovation obstacles in the health system, such as overcoming knowledge silos—created when specific medical actors keep data and information about patients to themselves—or allowing for a better assessment of the true impact of particular medical technologies or pharmaceutical inventions.

Beyond increasing innovation at the corporate- and country-level, the geographical landscape of global medical innovation is changing too.

Historically, the markets for health innovation—as well as the innovation pipelines themselves—have been concentrated in high-income economies, mostly in Europe and North America.[37] Today, the most R&D-intensive health industry firms are still in Europe and the United States of America (U.S.): Switzerland, the United Kingdom (U.K.), and the U.S. are the top holders of pharmaceutical patents; the Netherlands and the U.S. lead in medical technology patents; and Switzerland and the U.K. lead in biotech patents.

However, the geography of medical innovation is changing to progressively include emerging economies. The demand for improved health services is growing in these regions, driven by a rising middle class and robust economic growth. This is not only true for large emerging economies such as China and India but also Mexico, Viet Nam, Indonesia, South Africa, Nigeria, and many others.[38] The innovation capacity in emerging markets is also growing, with increasing R&D, patents, and investment in these countries (Figures T-1.2 and T-1.3, and Table T-1.1). Accordingly, pharmaceutical companies based in emerging economies have shown strong growth in recent years.[39]

A resurgence of health R&D

After the financial crisis in 2009 and a significant slowdown across sectors, worldwide pharmaceutical R&D plateaued at around US$135 billion for more than five years, including in 2013. Investment in health began a resurgence after 2013, reaching US$177 billion worldwide in 2019.[40]

Overall, the healthcare sector is one of the most important investors in innovation, second to the information technology (IT) sector. Pharmaceutical, biotech, and medical device firms are among the top global corporate investors in R&D, spending over US$100 billion annually; this represents close to 20% of global annual R&D expenditures by the top 2,500 R&D firms across all sectors.[41]

Health R&D is also a significant component of total private and public R&D expenditures, ranging from 10 to 12% of average annual R&D expenditures in high- and middle-income economies to about 14% in low-income economies.[42] In countries such as the U.K. and the U.S., governments place an even greater focus on R&D, allocating 20 to 25% of all government R&D expenditures on health.[43]

Medical technology patents growing faster than pharmaceutical patents

Patents in pharmaceuticals, biotechnology, and medical technology have been growing strongly year-over-year for the last decade (Figure T-1.2). Medical technology patents grew the fastest at close to 6% per year. This puts medical technologies among the top five fastest-growing technology fields since 2016, with the other four being IT-related fields.[44] Consequently, medical technology patents are now as numerous—about 100,000 patents worldwide—as pharmaceutical patents, with biotech at half that volume. Medical technology-related PCT filings are also nearly double the volume of pharmaceutical patents today, reflecting the increased importance of innovation in medical technology relative to pharmaceutical (Figure T-1.3). Finally, as evidenced in the 2019 Special Section on Identifying and Ranking the World's Largest Science and Technology Clusters, medical technology is now the most frequent field of patenting in these top clusters, overtaking pharmaceutical patents for the first time.[45]

Reflecting the increased spread of innovative capacity, Mexico and India are increasingly specialized in pharmaceutical patents relative to other patents—with India home to some of the top 10 pharmaceutical firms worldwide, such as Sun Pharmaceutical, Lupin, and Dr. Reddy's.[46] In absolute numbers of patents, China is also now the most important pharmaceutical patent origin (Table T-1.1).

As regards patent filings under the Patent Cooperation Treaty (PCT) at WIPO, medical technologies accounted for close to 7% of all applications in 2017 and were the fourth largest technology filing area in 2018, with IT-related fields topping this ranking.[47]

However, the above figures likely underestimate actual medical innovation activity. Health-related R&D and patenting are taking place in fields and firms as diverse as electrical and mechanical engineering, instruments—in particular, optics and measurement, chemistry, and the IT sector. Patents in the field of artificial intelligence are also forecast to be significant to future health systems.[48]

Furthermore, a number of the process and organizational innovations that are bound to have a positive influence in the health sector are not captured by R&D and patenting figures in the traditional health sector, as reported in the above data.

Is a revival of medical research productivity on the horizon?

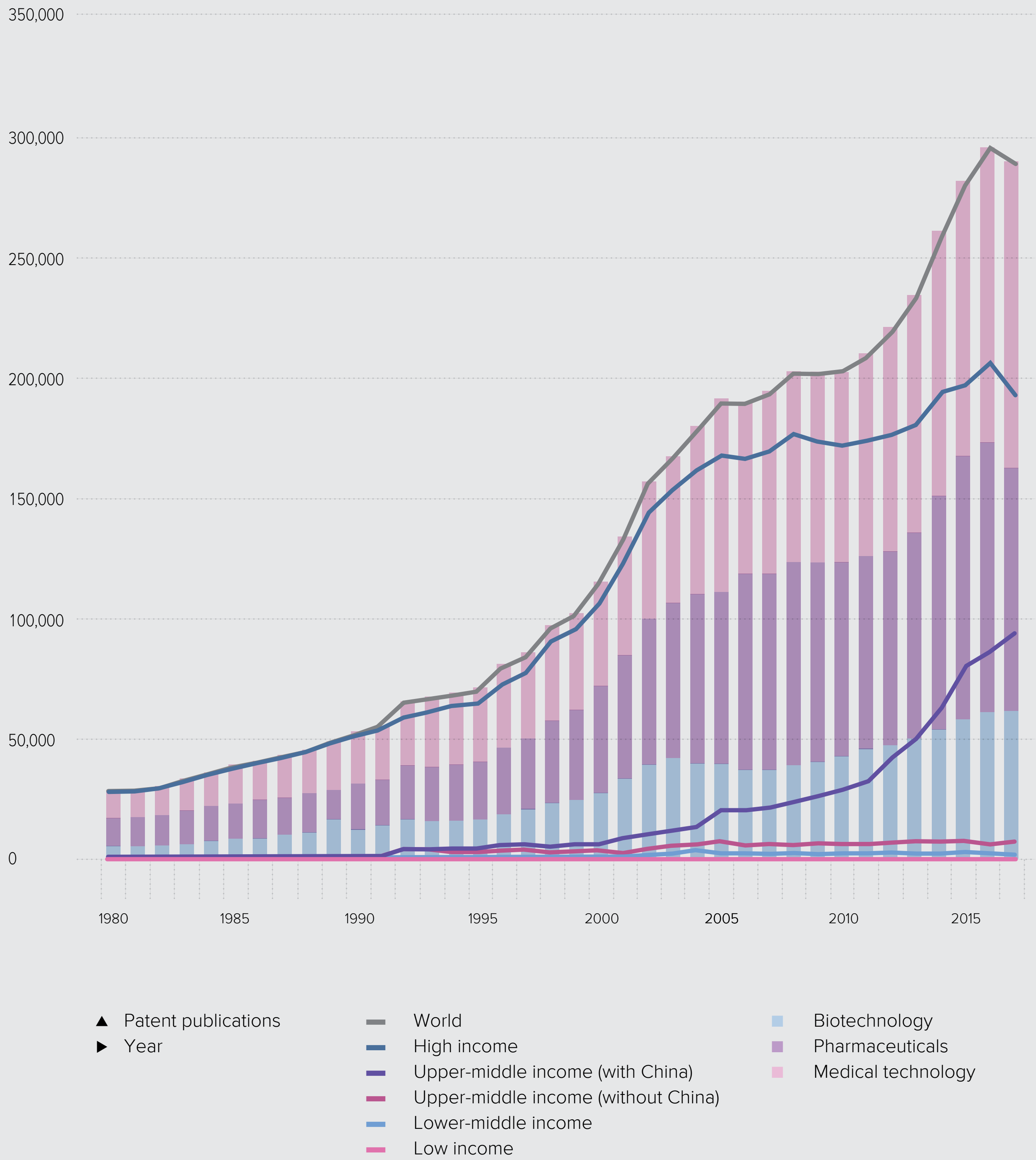
While pharmaceutical research productivity might have been slower in past decades, more recently, new health-related patenting and drugs on the market are signaling a possible reversal of the productivity crisis outlined earlier in this chapter.[49]

Since 2015, the number of drugs in Phase I and II clinical trials has grown substantially.[50] The launch of new drugs, such as novel active substances, has increased in the last decade and is expected to continue growing. The drug approval rates at the U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA) increased in 2017 and 2018; they are considerably higher today than in prior years.[51] The pending lineup of immunotherapies and drugs with the potential to become blockbusters—for diabetes, hepatitis C, and cancer—is trending upward.[52]

Does this mean the end of the medical research productivity decline? This is hard to answer with certainty. The number of drugs in Phase III clinical trials has yet to reach the high levels seen during the golden times of pharmaceutical innovation; a large percentage of drugs still fail to make the transition from

FIGURE T-1.2

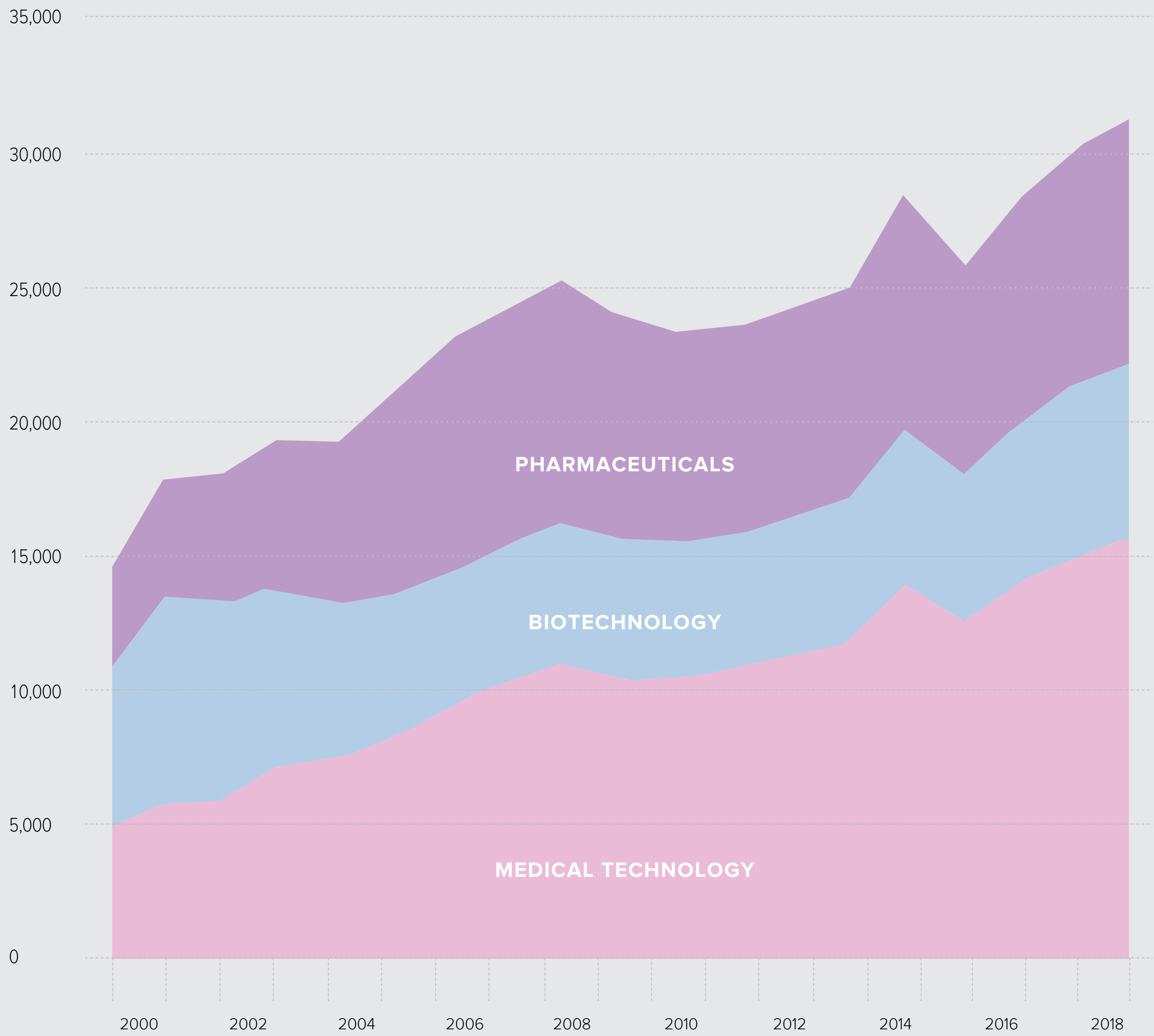
Patent publications by technology, 1980-2017



Source: WIPO Statistics Database, March 2019.

FIGURE T-1.3

Patent Cooperation Treaty (PCT) filings by technology, 2000-2018



▲ Patent publications
▶ Year

Source: WIPO Statistics Database, March 2019.

TABLE T-1.1

Overview of the top origins in health patent publications, 2010-2017

Top 10 in patent publications, 2010-2017

Biotechnology

Economy	Patent Publications
United States of America	126,581
China	92,107
Japan	33,818
Germany	24,094
Republic of Korea	21,045
Switzerland	15,750
France	15,292
United Kingdom	12,697
Netherlands	9,237
Denmark	7,942

Pharmaceuticals

Economy	Patent Publications
China	214,992
United States of America	204,057
Japan	45,850
Germany	38,279
Switzerland	33,694
Republic of Korea	28,036
France	25,814
United Kingdom	21,697
Russian Federation	11,566
Italy	10,286

Medical technology

Economy	Patent Publications
United States of America	284,223
Japan	116,745
China	115,805
Germany	62,050
Republic of Korea	43,533
Netherlands	21,984
Switzerland	21,909
France	20,643
United Kingdom	19,643
Russian Federation	16,171

Source: WIPO Statistics Database, March 2019.
Note: Figures show the sum of patent publications from 2010 to 2017 for all economies.

The fastest growing middle-income economies in health patent publications, 2010-2017

Economy	Sum	Average	Compound growth
Biotechnology			
China	92,107	11,514	19.0%
Mexico	509	64	8.8%
India	2,341	293	1.4%
Pharmaceuticals			
China	214,992	26,874	17.6%
Turkey	2,164	271	11.7%
Mexico	1,378	173	10.8%
Ukraine	1,032	129	3.3%
Russian Federation	11,566	1,446	0.9%
Medical technology			
China	115,805	14,476	29.7%
India	1,934	242	9.8%
Mexico	863	108	7.9%
Turkey	1,299	163	5.8%
Russian Federation	16,171	2,022	0.9%

Source: WIPO Statistics Database, March 2019.
Note: Economies considered for biotechnology show > 50 average patent publications from 2010 to 2017, and those considered for medical technology and pharmaceuticals show > 100 average patent publications over the period.

Phase II to Phase III. New pharmaceutical cures are harder to come by (Chapter 2).[53] While research expenditures are increasing, the return on drug-related R&D investments continues to be low.[54]

However, innovation is burgeoning in other increasingly health-related sectors, such as medical technologies or IT and software applications.[55] Over the last five years, regulatory agencies such as the FDA have announced record rates of novel medical device approvals for mechanical heart valves, digital health technologies, and 3D printing devices.[56]

Process and organizational innovations in healthcare delivery are also taking place due to increased automation and efficiency. These innovations are not necessarily captured by traditional R&D and patenting figures.

Finally, some important but less high-tech—and less measurable—medical innovation is taking place in low- and middle-income countries. Countries in Africa, Central and Eastern Asia, and Latin America have witnessed the novel use of existing technologies—"frugal" or "adapted" medical innovations—with considerable impact in low-resource contexts. For example, clean "delivery kits" contain essential items that allow doctors in low-resource contexts to deliver babies more safely, while many other examples arise in countries such as India.[57]

Upcoming breakthroughs in medical and health innovation

Novel ways to improve healthcare, to diagnose health problems, and to cure diseases are imminent (Chapter 4–National Institutes of Health, U.S. and Chapter 7–Dassault Systèmes).[58] Health-related technologies and organizational innovations have the potential to disrupt existing business models, to lower healthcare costs, and to improve overall healthcare efficiency (Chapter 3–ZS Associates and Chapter 5–Tencent, China).[59] Many of these medical innovations are relevant to developing countries, whether they are technological, such as 3D printing; new tools to diagnose infections, such as malaria, in Brazil (Chapter 14–CNI and SEBRAE);[60] organizational, such as the improved screening for non-communicable diseases in Egypt (Chapter 12); or remote telemedicine applications in Rwanda (Chapter 15–Ministry of Health, Rwanda).[61] While medical breakthroughs and their diffusion are tough to predict, the sections below describe several possible scientific and technological breakthroughs, developments in process, and organizational innovations.[62]

Identifying promising fields

The fields of genetics and stem cell research, nanotechnology, biologics, and brain research are promising domains for scientific breakthroughs. Breakthroughs may also come from prevention techniques and cures through new vaccines and immunotherapy, new pain management techniques, and cures for mental diseases. A large number of innovations are pending in the areas of medical devices, medical imaging and diagnostics, precision and personalized medicine, and regenerative medicine.

Organizational and process innovations are also improving healthcare delivery through novel approaches to research and clinical trials and new ways of delivering healthcare. These medical innovations could have a significant impact by helping overcome fragmentation of the healthcare ecosystem across different sectors—payers, insurers, providers, and manufacturers—and improving healthcare efficiency (Figure T-1.4).

IT and big data are often at the source of these innovations. New technologies, such as virtual modeling and AI techniques, enable new ways of conducting medical research (Chapter 5), facilitating breakthroughs, and increasing invention efficiency.[63] Many IT-enabled innovations have the potential to affect the delivery of healthcare and mitigate rising health costs (Chapter 14). Supported by the appropriate technology, health can be monitored in real time, conditions tracked remotely, data analyzed and shared, new modes of diagnosis applied, and treatments personalized. Individuals can also have access to their health data for the first time in history.[64]

These technologies have also begun impacting mobile health possibilities, some of which are critical for prevention and health monitoring. The technologies are starting to support a shift from a "react and revive" focus on ill-health to a "predict and prevent" model of wellness (Chapter 3, Chapter 7, Chapter 9, and Chapter 17–Thailand).[65] Examples include telemedicine applications, remote monitoring, portable diagnostics, and the delivery of medicines via drones. The surveillance of public health threats and the availability of data to drive policy and planning are key to optimizing health services in low-resource contexts (Chapter 12, Chapter 13, and Chapter 15).

The novel and better use of health data plays an important role in this context. Through big data analytics, machine learning, and AI, patient harm—and unintended consequences—may be predicted before they occur, and interventions can be provided to caregivers. Integrated data can help overcome silos and support medical professionals and care providers with insights that enable more predictive and efficient care (Chapter 5 and Chapter 8).[66]

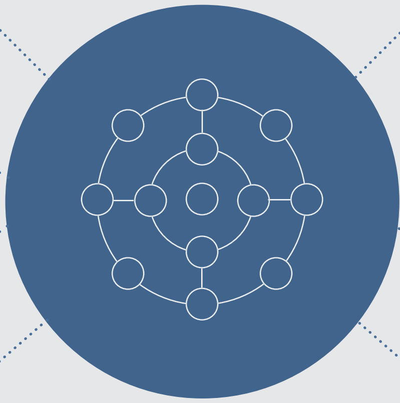
The data-driven shifts in health policies and strategies could be a core driver in reordering the relationships among—and processes between—health services providers, medical equipment manufacturers, patients, governments, public research, social security, and financial/insurance companies. In this setup, the patient is at the center of better feedback flows.

As the same time, as more innovation is geared to enriching the data intensity of medical equipment and processes, it is to be expected that the relative power of those who have the ability to collect, combine, and analyze large data sets will increase relative to that of traditional players in the health and medical arena. This may have important consequences, such as increased inequalities between the haves and the have nots of relevant technologies or a rising reliance on algorithms to make medical decisions, which may generate distrust vis-à-vis the medical profession.

FIGURE T-1.4

Promising fields for medical innovation and technologies

NEW SCIENTIFIC BREAKTHROUGHS, TREATMENTS, AND CURES



Genetics and stem cell research
- Single-cell analysis
- Gene and stem cell therapies
- Genetic engineering and editing including CRISPR technology

Nanotechnology
- Swallowable small devices

Biologics
- Development and manufacture of complex biologics

Brain research, neurology, and neurosurgery
- Characterization of the brain's major circuits
- New brain imagery for mental disorders
- Migraine treatment

New generation of vaccines and immunotherapy
- HIV and universal flu vaccine
- Cancer vaccine
- Immunotherapy
- New vaccine delivery methods

Pain management
- Effective, non-addictive medicines for pain management

Mental health treatments
- Pre-symptomatic diagnosis and treatment of Alzheimer's disease and other cognitive declines

NEW MEDICAL TECHNOLOGIES

Medical devices
- 3D printing
- Cardiac devices
- Implants and bionics

Medical imaging and diagnostics
- Optical high-definition imaging and virtual anatomic models
- Biosensors and markers
- 4D human charting and virtual reality
- Screening for diseases

Precision and personalized medicine
- Computer-assisted surgery
- Surgical robots
- Personalized medicine

Regenerative medicine
- Tissue engineering
- Effective bioartificial pancreas

ORGANIZATIONAL AND PROCESS INNOVATIONS

Novel approaches in healthcare research
- Software-based modeling to speed up research
- Artificial intelligence techniques to speed up research and clinical trials

New ways of delivering healthcare
- Telemedicine applications
- Drone delivery of medications
- Remote monitoring and portable diagnostics
- Improved data sharing

Sources: GII 2019 chapters, in particular Collins, 2010; Collins, 2019. Also, Kraft, 2019; Nature, 2018; Nature, 2019; Frost & Sullivan, 2018; Frost & Sullivan, 2019; European Commission, 2007; Medical Futurist, 2017; Mesko, 2018.

Opportunities and policy imperatives enabling healthy futures

Business and policy imperatives are key to creating a strong foundation for medical innovation systems—ranging from stable and predictable funding to technology transfer, skills, and regulation.

Ensuring sufficient medical innovation funding

The social returns of medical innovation expenditures far exceed the private returns of R&D.[67] For this reason, government R&D spending is still the primary source of scientific health research worldwide. Health-related R&D in public research institutes is of paramount importance. In fact, many state-of-the-art technologies behind healthcare innovations are initially developed as basic research projects carried out or financed by the public sector (Chapter 10–CERN, European Organization for Nuclear Research).[68]

It is thus vital to prioritize public funding—in particular, basic R&D. This holds true in middle- and low-income economies where health R&D expenditures are still relatively low, but also in high-income economies that have faced declining public R&D budgets—notably in health-related public research institutions—in recent years.[69] Discontinuities in public funding for health R&D can lead to brain drain and training gaps for qualified staff, not to mention the obsolescence of equipment (Chapter 14).

Government investment can help set up large funds to advance particular fields of research and to create health research centers or clusters, such as the Thai Center of Excellence for Life Sciences (Chapter 17), the Brazilian SENAI Innovation Institutes (Chapter 14), or the Iranian dedicated science and technology parks (Chapter 16–Iran).[70] More can be done to promote international research collaborations, which play a vital role as basic research ideas are translated into useful medical applications and solutions in the marketplace.[71]

There is also a need for innovative funding approaches—especially in the earliest and riskiest phases of drug discovery research (Chapter 6).[72] Often companies have difficulty funding early stage or strongly disruptive technology. The ability of academic spin-offs to become sustainable ventures is uneven; they remain highly dependent upon venture capitalists, who tend to foster short-term financial growth and whose understanding of healthcare challenges and needs remains incomplete.[73]

Funding for product R&D, outcomes research, and market analyses of uses for health technologies in low-resource settings remain insufficient (Chapter 11).[74] This is not a new consideration and positive developments are on the way.

Entities such as the Bill & Melinda Gates Foundation and Gavi—an organization bringing together public and private actors to deliver vaccines to children in low-income countries—contribute significantly to the financing and deployment of medical innovation.[75]

Still, new ideas and incentives are required to address certain health problems, particularly those affecting the least developed countries. R&D for such health innovations should be encouraged, along with special incentives and funding programs to encourage investment in health and medical research (Chapter 2).[76]

Finding solutions to these challenges requires multi-stakeholder consultation and coordination. The WIPO Re:Search public-private consortium, for example, shares valuable intellectual property and expertise with the health research community to promote the development of new drugs, vaccines, and diagnostics for neglected tropical diseases, malaria, and tuberculosis.[77]

Building functional medical innovation systems: from "bench to bedside"

Once significant health R&D is financed and carried out, effective medical innovation—and its diffusion—depend on linkages between public and private actors to translate basic research into medical applications. This is often a "giant leap" (Chapter 10).[78]

Businesses and policy actors need to focus on the translation of research into commercially viable applications, which may require initiating public-private collaborations, building a culture of entrepreneurship in public research bodies, stimulating academic spin-offs, and creating business incubators and centers of excellence.[79]

The actors involved in shaping medical innovation need to be reconsidered. Academic healthcare organizations, such as university hospitals, have traditionally been boundary-spanning organizations between care and science.[80] The critical role of hospitals and doctors in future demand-led health innovation is undeniable.[81] In health innovation systems, patients could also have a more central role in leading the direction of innovation.[82] The same is true for insurers. Building on the information they have for individual patients and the impact of particular treatments, insurers could contribute more toward raising awareness, informing patients, and preventing diseases—moving from a payer to a more active health system player.[83]

In sum, hospitals, insurers, patients, and regulators will need to cooperate more to influence the rate and direction of innovation by identifying prioritized needs and redefining modes of financing that incentivize the creation and diffusion of health solutions.[84]

For this to materialize, the various health system actors will have to create and use better channels and to transmit relevant information and feedback.[85] Improving knowledge flows across the different health actors will help. Practically speaking, this will require understanding differing needs and improving shared data infrastructures to overcome significant gaps in intersectoral communication.[86]

More funding instruments need to be made available to fund the stage between prototype and final product. Public-private partnerships can help in this precompetitive stage. Awards to particular researchers or research teams to encourage high-risk, high-reward research are promising (Chapter 4), as is launching prize competitions aimed at finding innovative solutions to major health challenges.[87] Other new possibilities include crowdfunding and funding through patient advocacy groups.

Policymakers can also strongly influence the translation and diffusion of research to medical applications through demand-side policies that specify innovation targets and focus areas. Moreover, governments can exert influence on the funding of innovation by influencing prices and reimbursements for health costs and by helping to align the costs and benefits of new technologies and related incentives.[88]

Moving from cure to prevention

Generally, as mirrored in this year's GII chapters, attention should also gravitate from curing diseases and health conditions to preventing them in the first place. Of course, prevention goes beyond medical research and innovation. Environmental, agricultural, and infrastructure policies with an impact on clean air, clean water, or functioning sewage systems, for example, also have a well-documented impact on overall health and well-being, as well as on the incidence of disease. All too often, however, health-related policies, including those governing R&D, are treated separately—condemning medical research to a perpetual game of catch-up with diseases and conditions that are triggered or aggravated by environmental pollutants.[89] The result is an inefficient use of resources.

Advancing skills and science education

The most important resource for the future of medical research will be having a workforce with the right skill sets (Chapter 4 and Chapter 7). Serious medical staff shortages exist in both developed and emerging markets. In addition, medical staff and researchers will need new sets of skills. The responsible implementation of health innovations requires local healthcare providers who are appropriately trained to use the latest technologies (Chapter 11 and Chapter 13).

To act as a bridge between research and the application of innovation in a real-life context, medical professionals with experience in research, training in the use of new hardware and software, and training in advanced research technologies—such as 3D modeling—are needed (Chapter 7 and the Australian Commonwealth Scientific and Industrial Research Organisation, CSIRO, 2017). Workforce planning is required to ensure that professionals and staff are equipped with the appropriate types of skills to put new health technologies into practice.

To ensure better transfer of knowledge, researchers and medical professionals should also move more freely between research and business contexts. Research institutes should be incentivized to employ a higher proportion of experienced industry professionals, while researchers should be encouraged to spend time in industry.[90] These exchanges will also help with the translation of research to applied medical solutions.

Supporting new data infrastructure and regulatory processes

Healthcare stakeholders will require increased health data sharing to increase their efficacy. At the same, time, patients will want greater access and control over their health data, along with assurances that their information is safe.

The security and privacy of health information have been confirmed as top priorities, and regulations on personal health data are being progressively harmonized (Chapter 7). Digital health strategies that create strong data infrastructure—as well as new processes for efficient and safe data collection, management, and sharing—will be required. Agreements will also be required to define how to design and operationalize electronic health records and how to create standards and interoperable technologies.[91]

How to harness the promise of big data medical research while respecting the security of data and honoring patient privacy? System security and data security principles need to be established for healthcare institutions (Chapter 5). Otherwise, a lack of data governance could decrease transparency and raise concerns about security and trust (Chapter 4, Chapter 7, and Chapter 12).

In addition to data infrastructure, new regulatory processes are needed to overcome the increasing duration and complexity of clinical trials. Breakthroughs in therapy have almost always been coupled with breakthroughs in regulatory standards (Chapter 6). Yet, current regulations and health regulation agencies may not be equipped for health innovation, while current processes may be too cumbersome (Chapter 14).[92] Developing countries, in particular, may not have the capacity to deal with multiple national regulatory regimes (Chapter 11).

Improving cost-benefit assessments of medical innovation

To prioritize and foster the diffusion of research and medical technologies, cost-benefit assessments must be improved.[93]

Going forward, health technology assessments will be increasingly important as a tool to foster industry accountability, cost-efficient solutions, and outcome-oriented innovations in healthcare.[94]

The idea of better assessing health innovation is not new. Sweden and Switzerland, for example, have been at the forefront of health technology assessments for many years.[95] In the U.K., the National Institute for Health and Care Excellence provides evidence-based guidance on metrics, including on new medical technologies.[96] More can be done to spread these approaches to more countries. Better collection, analysis, and sharing of outcomes and cost data—and possibly mandating a better tracking of technology-specific health outcomes—will help in this regard.[97]

Debating risks, social values, and the value of life

New technologies will bring new possibilities but also new risks and uncertainties—some of which will challenge current ethics and societal values (Chapter 4). This is the case for novel approaches in the field of genetic engineering in particular. As in the past, possibilities in the field of medical innovation will entail adaptable oversight and risk management functions, and possibly higher levels of precautionary oversight. To avoid a race to the bottom—in which countries will adopt the lowest-common safety or ethical denominator—international coordination is needed.

The challenges raised by novel approaches are not simply technical issues, but larger questions that will require discussion and agreement on matters at the core of ethics. Decision-making structures must be developed to encapsulate the far-reaching impacts on societal values. Similarly, as costs for new technologies increase exponentially, the potential for further challenges—to equity or access—may grow. Are there limits to the preservation of human life "at any price" and over an increasing life span? What are the limits to the cost of developing a new technology and under what circumstances should these limits be imposed?[98] These questions are beyond the scope of this edition of the GII research; nonetheless, societies around the world will increasingly have to confront them in this nexus between technology and health.

Conclusion

The future of medical innovation, and the role of medical innovation in improving health outcomes going forward, will depend crucially on the policies and institutions created by national and global actors to support research and innovation. There are important issues for policymakers to consider carefully, given the transformative economic, social, and health impact new medical technologies have had historically and the enormous potential value of further health improvements for current and future generations.

Some overarching observations are useful in the particular case of developing countries. While developing countries face many of the same constraints as developed countries, these low-resource contexts may have access to opportunities that developed countries lack. One indicator of this possibility is that some of the more interesting examples of new health technology applications have recently come from developing countries in fields such as telemedicine, real-time diagnostic tools, and even the establishment of electronic health records.

In the optimal scenario, developing countries might "leapfrog" their current health systems, due to lower sunk costs related to existing infrastructure and equipment, lower fixed costs from not building overcapacity, and possibly less regulatory constraint. They also have at their disposal technological innovations, alternative operating and financing models, and legal frameworks that were not previously available to developed countries. As a result, new health solutions might be deployed quickly and with immediate impact in developing countries—possibly without the need to proportionately increase healthcare facilities and professionals. The disruption of established health systems in developed countries is more challenging.

Several caveats apply:

First, although leapfrogging implies the closing of a health gap between the rich and the poor, there are risks that costly new health innovations will exacerbate the health gap rather than narrow it. This will require careful monitoring. Diffusion should be encouraged, proper financing made available, public-private partnerships created, and technologies fostered (Chapter 2).

Second, new health innovations aside, the true challenge to developing countries is the lack of minimally functional health systems and not necessarily a need for more R&D or new technologies. The most pervasive unmet need in the developing world is still providing basic and affordable healthcare at scale (Chapter 3).[99] Technology is not always the remedy. The mere availability and training of nurses that can go door-to-door looking for signs of childhood diseases such as diarrhea, malaria, and pneumonia have been shown to have widespread and sustainable impacts in countries such as Mali.[100] Basic but impactful improvements of this kind are not necessarily devoid of technology. Often the contrary is the case: low-tech or adapted technology applications can save more lives than the latest high-tech solutions.

Third, evidence-based decision-making and assessments will be particularly important in developing countries. As new technologies, such as drones for the delivery of medicines, are much discussed, and hyped to some extent, a sober evidence-based look at the true costs and benefits of these innovations will bear great value.

Notes:

1 Roser, 2019; Ma, 2019; Shetty, 2019.

2 WIPO, 2015a; Sampat, 2019.

3 Gordon, 2012, 2014; WIPO, 2015a, 2015b; Sampat, 2019.

4 Kenny, 2011; WIPO, 2015a.

5 Deloitte, 2018a; EIU, 2017, 2018.

6 Deloitte, 2018a; Biot et al., 2019.

7 Deloitte, 2018a; EIU, 2017, 2018; Frost et al., 2019.

8 Dutta et al., 2019.

9 It also sets up targets aimed at specific challenges including, for example, maternal mortality, AIDS, tuberculosis, malaria and neglected tropical diseases and a goal to support R&D for vaccines and medicines for communicable and non-communicable diseases.

10 First in 2016, the Political Declaration on Antimicrobial Resistance and the Political Declaration on HIV and AIDS; and in 2018, the Political Declaration on the Fight against Tuberculosis and the Political Declaration on Non-Communicable Diseases.

11 To illustrate the cross-border dimension, and the need for specific research aimed at developing countries, SDG Indicator 3.b.2 monitors, the Official development assistance (ODA) for medical research and basic health sectors as a % of gross national income (GNI) and as a % of all ODA, by donor country.

12 Sheiner et al., 2016.

13 Nelson, 2003.

14 Bartfai et al., 2013; Andrade et al., 2019.

15 Casadevall, 2018.

16 Scannell et al., 2012.

17 Bloom et al., 2017—While most of the economic literature confirms this prospect of declining R&D pharmaceutical productivity, some contributions question the extent finding that the above trends are exaggerated as R&D costs are seriously overstated. Measuring the R&D productivity of a sector, let alone the overall productivity, in a field such as health is daunting. Invariably metrics are imperfect.; Cockburn, 2006—e.g., by failing to account for inflation in R&D input costs; Schmid et al., 2005.

18 Vijg, 2011—In one study, the total out-of-pocket R&D costs per new approved drug are estimated to be around US$1.9 billion.; Pammolli et al., 2011; DiMasi et al.,2016.

19 Cross, 2018.—The development of a new health product is a risky activity; estimates indicate that the percentage of drugs that reach the market after starting clinical trials, which is already an advanced phase of R&D in the sector, varies between 6% and 13.8% depending on the estimate.

20 Ricks et al., 2019.

21 Hopkins et al., 2007; Singh, 2018.

22 Comanor, 2013.—Note that recent mergers have indeed contributed to the observed decline in pharmaceutical innovation.

23 R&D Magazine, 2018.

24 Abrishami et al., 2014; Penter, 2018.

25 Drolet et al., 2011.

26 Metcalfe et al., 2005.

27 Herzlinger, 2006.

28 Herzlinger, 2006.

29 Murphy, 2019.

30 Żaneta, 2019.

31 WHO, WIPO, and WTO, 2012, 2018.—Lack of access to medical technologies is rarely due to a single determinant. Important factors include: needs-based research, development, and innovation; intellectual property and trade policies; manufacturing processes and systems; regulatory environment; price transparency, pricing policies, and health system infrastructure; integrity and efficiency in procurement and supply chain management; and appropriate selection, prescribing and use.

32 Kaslow, 2019.

33 Murray et al., 2012; Woodson, 2016; von Philipsborn et al., 2015.—One study finds that diseases prominent in low-income economies cause about 14 % of the global disease burden. Yet they only receive about 1.3 % of health-related R&D expenditure.

34 Zaid et al., 2019; Shetty, 2019.

35 Puica et al. 2019.

36 Dewhurst, 2017.

37 Tannoury et al., 2017.

38 Frost et al., 2018.

39 EIU, 2017, 2018.

40 Evaluate Pharmaceutical, 2018; WifOR, 2018.

41 Hernández et al., 2018; R&D Magazine, 2018.—Top investors such as Roche (Switzerland), Johnson and Johnson (U.S.) and Merck US (U.S.) invested on average around US$10 billion in R&D last year.

42 In some countries, the figures can be significantly higher—typically about 30% of total R&D—e.g. in selected African countries such as Kenya. Some high-income economies also stand out with a remarkably high share of health R&D; e.g. Singapore and Qatar (both 19%), but also the Netherlands (17%). Data drawn from Global Observatory on Health R&D of the WHO, with special tabulations made available to authors. The gross domestic expenditure on R&D (GERD) and GERD in the health and medical sciences (health GERD) are collected from the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Organisation for Economic Co-operation and Development (OECD), and Eurostat, the statistical office of the European Union. They are reported using the most recent available data since 2010 by country (Note: not all countries have reported data on this indicator). See also https://www.who.int/research-observatory/monitoring/inputs/gerd/en/

43 Among high-income countries ranges vary greatly with, for example, France, Germany, Republic of Korea, and Italy between 5-10%, and other such as New Zealand, Spain, Denmark, Canada and Norway between 10-15%. Source: Authors based on OECD R&D Statistics.

44 WIPO, 2018.— see Patent applications and grants worldwide

45 Bergquist et al., 2019.

46 WIPO, 2018, WIPO Statistics Database, 2017; Retrived from https://www.wipo.int/ipstats/en/; Gokhale, 2017.

47 WIPO, 2018; WIPO, 2019b.

48 Cornell University, INSEAD, and WIPO, 2019; Ma, 2019; Bergquist et al., 2019; WIPO, 2019a; WIPO, 2019b.

49 Bloom et al., 2017.

50 Pharmaceutical Intelligence, 2019 ; Smietana, 2016.

51 Baedeker et al., 2018; Nature, 2019a; R&D Magazine, 2019; IQVIA Institute, 2019.—In 2018, the European Medicines Agency (EMA) had approved 84 (vs 94 in 2017) new drugs with 42 (vs 35 in 2017) of these being new active substances. At the same time, the US Food and Drug Administration (FDA) had approved 59 novel drugs and biologics in 2018 (vs 46 in 2017).

52 EIU, 2017; EIU, 2018; Casadevall, 2018.

53 Bloom et al., 2017; Vijg, 2011; Casadevall, 2018; Gordon, 2018.

54 R&D Magazine, 2018; Deloitte, 2018b.

55 Coffano, 2016.—gives an analysis of the dynamic field of medical device innovation.

56 FDA Statement from FDA Commissioner Scott Gottlieb, M.D., and Jeff Shuren, M.D., Director of the Center for Devices and Radiological Health, on a record year for device innovation, January 28, 2019.

57 On the delivery kits, see PATH, 2002; Beun et al., 2003; On frugal medical innovation in India, see Verma, 2017.

58 Collins, 2019; Biot, 2019.

59 Khedkar et al., 2019; Ma, 2019.

60 Andrade et al., 2019; Jewell, 2018.

61 Zaid et al., 2019; Uwaliraye, 2019.

62 See on this caveat: GII 2019 chapters, in particular Sampat, 2019; Collins, 2019 and also earlier work on breakthrough innovation; WIPO, 2015a; WIPO 2015b.

63 Ma, 2019; Mahnken, 2018.

64 CSIRO, 2017; Basel et al.,2013.

65 Khedkar et al., 2019; Biot et al., 2019; Puica et al., 2019,; Boonfueng et al., 2019.

66 Ma, 2019; Murphy, 2019.

67 For pharmaceuticals in particular, see Lichtenberg, 2003 and Grabowski et al., 2002.

68 Anelli et al., 2019.

69 R&D Magazine, 2018; Research!America, 2018.

70 Boonfueng et al., 2019; Andrade et al., 2019; Fartash et al., 2019.

71 Anelli et al., 2019.

72 Ricks et al., 2019.

73 Lehoux et al., 2016; Foray et al.,2012.

74 Kaslow, 2019.

75 For more information see: https://www.gatesfoundation.org/What-We-Do; and https://www.gavi.org/

76 Sampat, 2019.

77 WIPO actively involves a wide range of stakeholders—from civil society, to academia, business, and more—in order to ensure that all members of society benefit from intellectual property. For its multi-stakeholder platforms, see https://www.wipo.int/cooperation/en/multi_stakeholder_platforms/

78 Anelli et al, 2019.

79 Gelijns et al., 1994; Thune, 2016.

80 Lander, 2016; Miller, 2016.

81 Gulbrandsen et al., 2016; Smits et al., 2008.

82 Llopis et al., 2016; The Medical Futurist, 2017, including the idea for a role of patients on the board of pharmaceutical companies.

83 See the Daniel Schmutz, CEO, Helsana, Interview at https://pharmaboardroom.com/interviews/interview-daniel-schmutz-ceo-helsana-switzerland/

84 Thune et al., 2016.

85 Barberá-Tomás et al., 2012.

86 Li et al., 2018.

87 Gandjour, 2011; Murray et al., 2012.

88 BCG and World Economic Forum, 2017.

89 There are many studies that tie air pollution in to increased rates of cardiovascular disease and death, for example. See https://www.eurekalert.org/pub_releases/2019-03/esoc-apc030819.php for a study on the European Union.

90 CSRIO, 2017.

91 BCG and World Economic Forum, 2018.—In January 2017, the health ministers of OECD recommended that countries develop and implement health-data governance frameworks that secure privacy while enabling health data uses that are in public interest.

92 The Medical Futurist, 2017.

93 Thune, 2016.

94 Proksch et al., 2019.

95 See also: http://www.inahta.org/members/sbu/ and https://www.bag.admin.ch/bag/de/home/begriffe-a-z/health-technology-assessment.html

96 More information at https://www.nice.org.uk/about

97 BCG and World Economic Forum, 2017.

98 Mossialos, 2018.

99 Khedkar et al., 2019.

100 Mali's "astounding" community health programme should be emulated, By David Pilling, *Financial Times*, March 1, 2019.

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IDENTIFYING AND RANKING THE WORLD'S LARGEST SCIENCE AND TECHNOLOGY CLUSTERS

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As in the previous two years, this Special Section presents the latest ranking of the world's largest science and technology (S&T) clusters. This spatial view of innovation performance is rooted in the recognition that innovation activities tend to be geographically concentrated. In other words, innovation performance often varies substantially within countries, and the cluster perspective highlights where such performance is strong—at least as far as the S&T dimension of innovation is concerned.

The methodological approach underlying this year's ranking is the same as last year. We identify clusters based on the locations of inventors listed in international patent applications and authors appearing in scientific journal articles. Our data sources continue to be patent filings under WIPO's Patent Cooperation Treaty (PCT) and scientific publications contained in the Web of Science's SCI Expanded, published by Clarivate. Our data for this year's ranking spans 2013-2017, compared to the 2012-2016 time frame used last year.

For a more detailed description of the cluster ranking methodology, we refer the interested reader to last year's Special Section (Bergquist et al., 2018).

The top 100 S&T clusters

Table S-1.1 summarizes our geocoding results, and Table S-1.2 presents our top 100 cluster rankings. There are relatively few changes from last year, partly reflecting the overlap in time frames but arguably also the persistence of local innovation performance. The composition of the top 10 clusters remains unchanged, with Tokyo–Yokohama at the top of the list, followed by Shenzhen–Hong Kong (2) and Seoul (3). Beijing (4) and San Jose–San Francisco, CA (5) swapped rank compared to last year.

In both 2018 and 2019, the same 27 countries comprise the top 100 clusters. The United States of America (U.S.) continues to host the largest number of clusters (26), followed by China (18)—which is two more than China hosted in 2018. Germany (10), France (5), the United Kingdom (U.K.) (4), Canada (4), and Japan (3) follow next, all unchanged from the previous year.[1]

Compared to last year, almost all of the Chinese clusters moved up the ranks. Guangzhou, the 21st ranked cluster in 2019, moved up 11 places as compared to its 2018 ranking (21, +11). Likewise, Hangzhou (30, +11), Qingdao (80, +22), Suzhou (81, +19), Chongqing (88, +15) and Jinan (89, +10) also registered double-digit rank increases. This reflects faster overall growth in international patent applications and scientific publications by Chinese entities compared to most other countries (Figure S-1.1).

Two factors may explain rank changes from one year to the next. First, rank changes may be due to changes in the volume of patent applications and scientific publications during the two time frames. The declines in the rankings of Heidelberg–Mannheim, 53 in 2019 as compared to 46 in 2018 (53, -7), and Stuttgart (26, -5) mostly reflect declining S&T output while the climb in rankings by Phoenix (76, +10) and Portland (44, +4) reflect increases in S&T output. Second, rank changes may be due to a growing or shrinking cluster geography. For example, the rank increases of Brussels (40, +11) and Istanbul (69, +15) mostly reflect growing cluster areas.[2] It is important to note that such geographical shifts may be sensitive to the threshold

The views expressed here are those of the authors and do not necessarily reflect those of WIPO or its member states.

TABLE S-1.1

Summary of geocoding results

Country	Scientific publications		PCT applications				
	Number of addresses	City-level address accuracy (%)	Number of addresses	Block-level address accuracy (%)	Sub-City-level address accuracy (%)	City-level address accuracy (%)	Total address accuracy (%)
United States of America	5,659,179	97.23	838,413	94.13	5.46	0.17	99.76
China	3,414,955	97.53	375,251	14.25	0.63	84.13	99.02
Japan	1,090,018	93.96	530,013	38.21	31.07	29.50	98.79
Germany	1,218,674	97.33	254,040	97.49	0.43	1.56	99.48
Republic of Korea	706,442	93.55	200,694	0.14	0.94	80.84	81.92
United Kingdom	1,219,072	96.55	77,764	77.87	8.28	11.48	97.63
France	1,028,646	92.81	105,291	85.29	1.51	7.19	93.99
Italy	948,100	95.47	40,238	86.57	5.00	7.02	98.59
Canada	775,947	98.23	41,799	96.71	2.37	0.55	99.63
India	587,078	92.25	36,651	32.63	43.42	19.41	95.46
Spain	716,434	96.63	26,598	69.98	9.54	19.11	98.64
Netherlands	458,825	97.32	50,294	88.96	0.53	10.00	99.49
Australia	712,786	81.55	20,032	92.29	5.30	1.28	98.87
Brazil	541,686	98.67	8,949	78.74	12.71	7.15	98.59
Sweden	263,589	97.60	39,949	94.59	0.88	3.93	99.40
Switzerland	284,132	90.65	35,052	88.15	5.29	4.74	98.17
Russian Federation	313,634	99.02	15,279	83.24	5.56	9.22	98.02
Turkey	360,651	96.56	11,173	31.17	50.54	14.63	96.35
Iran (Islamic Republic of)	326,572	97.00	317	0.63	1.58	86.44	88.64
Israel	140,961	89.81	27,369	50.39	8.51	30.09	88.98

Source: WIPO Statistics Database, March 2019.
Notes: This list includes the top 20 countries that account for the highest combined shares of patents and scientific articles. PCT inventor addresses were geocoded to the highest level of detail. Due to the much larger volume, scientific author addresses were geocoded to the city level only.

parameters of our clustering algorithm.[3] In particular, the addition of relatively few inventor and author locations may lead to sizeable shifts in the identified clusters. The rank changes associated with geographical shifts should therefore be treated with due caution.

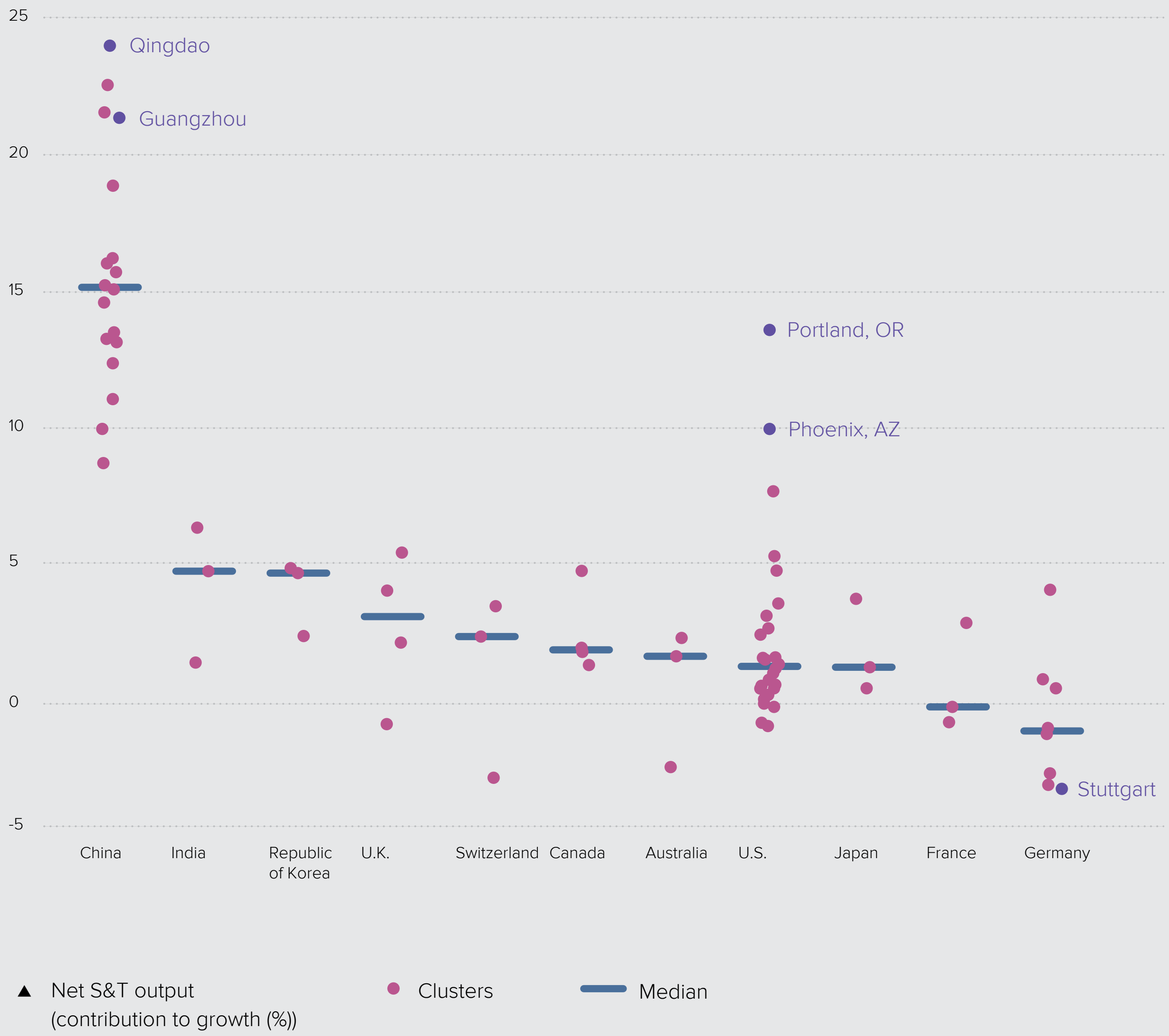
Figure S-1.1 depicts the percentage change in net S&T output by country. It highlights the fast growth of Chinese clusters and the declining S&T outputs for selected clusters—especially in Germany. US clusters show high variance in net S&T output, with two showing double-digit increases and several registering small declines.

Table S-1.3 shows the top field of scientific publishing, the top organizations with which scientific authors are affiliated, the top patenting field, and the top patent applicant. The data illustrates the diversity of clusters around the world in terms of the technology fields represented and the entities generating most S&T output. Compared to last year, there is a notable shift in the distribution of top patenting fields. Coinciding with this year's GII theme, medical technology is now the most frequent top field—appearing in 19 clusters, compared to 16 last year. Pharmaceuticals dropped to second place, with only 15 clusters featuring this field as the top field, compared to 22 clusters in 2018. Digital communications also saw a decline, with this field as the top field in 14 clusters, compared to 16 clusters in 2018. Within the top scientific fields, chemistry remained the most frequent one, though it declined from 36 clusters in 2018 to 32 clusters in 2019 (32, -4). Neurosciences & Neurology (17 clusters, +4) became more prominent, whereas Oncology (4 clusters, -6) turned out to be less prominent.

To provide insight into the national and global innovation networks in which the top 100 clusters operate, we list their top collaborating clusters in Table S-1.4. These collaborating clusters are identified by the volume of co-inventor relationships for patents and co-authorships for scientific publications. Table S-1.4 also lists the top collaborating entities within those top collaborating clusters. For many clusters, the top co-inventing and top co-authoring clusters are the same, partly reflecting the size and proximity of nearby clusters. However, there also many cases for which they do not coincide. For example, Beijing's strongest scientific links are with Shanghai, whereas the strongest patenting links are with San Jose–San Francisco, CA. Overall, Beijing is the top collaborating cluster for scientific co-authorships (18 cases), followed by Washington, DC–Baltimore, MD (8), New York City, NY (7), Boston-Cambridge, MA (6), and Cologne (6). San Jose–San Francisco, CA is the most frequent top co-inventing cluster (20 cases), followed by Beijing (8), Shenzhen–Hong Kong (6), and New York City, NY (5).

FIGURE S-1.1

Net science and technology (S&T) output



Source: WIPO Statistics Database, March 2019.
Notes: Net S&T output refers to the difference of total patents and publications for each cluster, for all points that were located inside the same cluster as the previous year. For simplicity, Switzerland was assigned all three clusters it was associated with. Only economies with 3 or more clusters are presented here.

TABLE S-1.2

Top 100 cluster rankings

Rank	Cluster name	Economy	PCT applications	Scientific publications	Share of total PCT filings, %	Share of total pubs, %	Total	Rank 2012-16	Rank change
1	Tokyo-Yokohama	JP	108,973	144,559	10.90	1.72	12.62	1	-
2	Shenzhen-Hong Kong	CN/HK	55,433	45,393	5.54	0.54	6.08	2	-
3	Seoul	KR	39,545	136,654	3.95	1.63	5.58	3	-
4	Beijing	CN	23,014	222,668	2.30	2.65	4.95	5	1
5	San Jose-San Francisco, CA	US	38,399	88,243	3.84	1.05	4.89	4	-1
6	Osaka-Kobe-Kyoto	JP	28,027	67,127	2.80	0.80	3.60	6	-
7	Boston-Cambridge, MA	US	14,364	120,404	1.44	1.43	2.87	7	-
8	New York City, NY	US	12,329	133,195	1.23	1.59	2.82	8	-
9	Paris	FR	13,426	94,982	1.34	1.13	2.47	9	-
10	San Diego, CA	US	19,280	34,403	1.93	0.41	2.34	10	-
11	Shanghai	CN	8,736	114,395	0.87	1.36	2.24	12	1
12	Nagoya	JP	19,370	23,705	1.94	0.28	2.22	11	-1
13	Washington, DC-Baltimore, MD	US	4,498	117,623	0.45	1.40	1.85	13	-
14	Los Angeles, CA	US	9,398	68,337	0.94	0.81	1.75	14	-
15	London	GB	4,070	107,131	0.41	1.28	1.68	15	-
16	Houston, TX	US	10,681	49,969	1.07	0.59	1.66	16	-
17	Seattle, WA	US	10,773	33,796	1.08	0.40	1.48	18	1
18	Amsterdam-Rotterdam	NL	4,491	78,994	0.45	0.94	1.39	17	-1
19	Chicago, IL	US	6,455	55,718	0.65	0.66	1.31	19	-
20	Cologne	DE	7,374	43,621	0.74	0.52	1.26	20	-
21	Guangzhou	CN	4,029	59,762	0.40	0.71	1.11	32	11
22	Daejeon	KR	7,699	25,689	0.77	0.31	1.08	23	1
23	Tel Aviv-Jerusalem	IL	6,950	30,971	0.70	0.37	1.06	22	-1
24	Munich	DE	6,833	30,764	0.68	0.37	1.05	24	-
25	Nanjing	CN	1,440	75,749	0.14	0.90	1.05	27	2
26	Stuttgart	DE	8,261	18,347	0.83	0.22	1.04	21	-5
27	Minneapolis, MN	US	6,438	24,878	0.64	0.30	0.94	25	-2
28	Singapore	SG	3,899	44,988	0.39	0.54	0.93	28	-
29	Philadelphia, PA	US	3,176	50,014	0.32	0.60	0.91	26	-3
30	Hangzhou	CN	3,773	44,950	0.38	0.54	0.91	41	11
31	Eindhoven	BE/NL	8,175	6,198	0.82	0.07	0.89	29	-2
32	Stockholm	SE	5,587	27,121	0.56	0.32	0.88	31	-1
33	Moscow	RU	2,147	55,451	0.21	0.66	0.87	30	-3
34	Raleigh, NC	US	3,006	46,797	0.30	0.56	0.86	34	-
35	Melbourne	AU	1,955	54,842	0.20	0.65	0.85	33	-2
36	Frankfurt Am Main	DE	5,226	25,235	0.52	0.30	0.82	35	-1
37	Sydney	AU	2,454	47,979	0.25	0.57	0.82	36	-1
38	Wuhan	CN	1,333	56,349	0.13	0.67	0.80	43	5
39	Toronto, ON	CA	2,298	47,218	0.23	0.56	0.79	37	-2
40	Brussels	BE	3,149	39,340	0.31	0.47	0.78	51	11
41	Berlin	DE	3,393	35,542	0.34	0.42	0.76	39	-2
42	Madrid	ES	1,605	49,980	0.16	0.59	0.76	38	-4
43	Taipei	TW	1,428	51,144	0.14	0.61	0.75	40	-3
44	Barcelona	ES	2,283	43,549	0.23	0.52	0.75	42	-2
45	Portland, OR	US	5,813	12,041	0.58	0.14	0.72	49	4
46	Tehran	IR	99	59,717	0.01	0.71	0.72	44	-2
47	Xi’an	CN	745	51,701	0.07	0.62	0.69	52	5
48	Milan	IT	2,177	37,953	0.22	0.45	0.67	45	-3
49	Denver, CO	US	2,818	31,458	0.28	0.37	0.66	47	-2
50	Zürich	CH/DE	3,007	29,651	0.30	0.35	0.65	48	-2

CONTINUED

TABLE S-1.2

Top 100 cluster rankings, continued

Rank	Cluster name	Economy	PCT applications	Scientific publications	Share of total PCT filings, %	Share of total pubs, %	Total	Rank 2012-16	Rank change
51	Montréal, QC	CA	2,046	36,761	0.20	0.44	0.64	50	-1
52	Chengdu	CN	1,364	42,467	0.14	0.51	0.64	56	4
53	Heidelberg-Mannheim	DE	3,903	20,938	0.39	0.25	0.64	46	-7
54	Istanbul	TR	2,437	31,452	0.24	0.37	0.62	69	15
55	Copenhagen	DK	2,854	27,185	0.29	0.32	0.61	53	-2
56	Atlanta, GA	US	1,591	36,308	0.16	0.43	0.59	54	-2
57	Rome	IT	821	40,435	0.08	0.48	0.56	55	-2
58	Cambridge	GB	2,431	26,164	0.24	0.31	0.55	59	1
59	São Paulo	BR	756	38,494	0.08	0.46	0.53	57	-2
60	Tianjin	CN	807	37,572	0.08	0.45	0.53	67	7
61	Cincinnati, OH	US	3,616	13,736	0.36	0.16	0.53	62	1
62	Nuremberg-Erlangen	DE	3,699	12,357	0.37	0.15	0.52	58	-4
63	Pittsburgh, PA	US	1,555	30,051	0.16	0.36	0.51	60	-3
64	Dallas, TX	US	3,135	16,772	0.31	0.20	0.51	61	-3
65	Bengaluru	IN	3,119	16,800	0.31	0.20	0.51	65	-
66	Ann Arbor, MI	US	1,413	30,555	0.14	0.36	0.51	63	-3
67	Changsha	CN	984	33,067	0.10	0.39	0.49	68	1
68	Helsinki	FI	2,837	17,100	0.28	0.20	0.49	64	-4
69	Vienna	AT	1,523	26,719	0.15	0.32	0.47	66	-3
70	Delhi	IN	782	32,275	0.08	0.38	0.46	72	2
71	Oxford	GB	1,419	26,692	0.14	0.32	0.46	70	-1
72	Vancouver, BC	CA	1,478	24,217	0.15	0.29	0.44	73	1
73	Cleveland, OH	US	1,460	23,982	0.15	0.29	0.43	71	-2
74	Lyon	FR	2,270	16,950	0.23	0.20	0.43	74	-
75	Busan	KR	2,136	17,640	0.21	0.21	0.42	75	-
76	Phoenix, AZ	US	2,318	13,166	0.23	0.16	0.39	86	10
77	Ankara	TR	435	28,652	0.04	0.34	0.38	76	-1
78	Ottawa, ON	CA	1,829	16,573	0.18	0.20	0.38	80	2
79	Austin, TX	US	2,151	13,516	0.22	0.16	0.38	77	-2
80	Qingdao	CN	1,480	19,128	0.15	0.23	0.38	102	22
81	Suzhou	CN	2,119	13,692	0.21	0.16	0.37	100	19
82	Bridgeport-New Haven, CT	US	1,275	20,583	0.13	0.24	0.37	81	-1
83	Brisbane	AU	1,098	21,591	0.11	0.26	0.37	83	-
84	Hamburg	DE	1,874	15,020	0.19	0.18	0.37	79	-5
85	Grenoble	FR	2,045	13,286	0.20	0.16	0.36	78	-7
86	Lausanne	CH/FR	1,859	14,605	0.19	0.17	0.36	85	-1
87	Harbin	CN	168	28,773	0.02	0.34	0.36	93	6
88	Chongqing	CN	333	26,799	0.03	0.32	0.35	103	15
89	Jinan	CN	477	25,528	0.05	0.30	0.35	99	10
90	Hefei	CN	350	26,560	0.04	0.32	0.35	97	7
91	Basel	CH/DE/FR	2,064	11,889	0.21	0.14	0.35	82	-9
92	Manchester	GB	965	21,028	0.10	0.25	0.35	84	-8
93	Changchun	CN	191	27,372	0.02	0.33	0.34	95	2
94	St. Louis, MO	US	916	20,729	0.09	0.25	0.34	89	-5
95	Lund	SE	1,925	12,124	0.19	0.14	0.34	90	-5
96	Columbus, OH	US	991	19,902	0.10	0.24	0.34	88	-8
97	Mumbai	IN	1,199	17,784	0.12	0.21	0.33	92	-5
98	Indianapolis, IN	US	1,755	12,616	0.18	0.15	0.33	91	-7
99	Dublin	IE	766	20,750	0.08	0.25	0.32	94	-5
100	Warsaw	PL	429	23,419	0.04	0.28	0.32	98	-2

Source: WIPO Statistics Database, March 2019.
Notes: Patent filing and scientific publication shares refer to the 2013–17 time frame and are based on fractional counts, as explained in the text. Codes refer to the ISO-2 codes. See page 17 for a full list, with the following addition: TW = Taiwan, Province of China.

The entities driving collaboration between two clusters remained constant for scientific publications but differed for patenting. The Chinese Academy of Sciences (18, Beijing) emerged as the most frequent top collaborating entity for all 18 times that Beijing is listed as collaborating cluster for scientific co-authorships. The same is true for Johns Hopkins University (8, Washington, DC–Baltimore, MD), Columbia University (7, New York City, NY), and Harvard University (6, Boston-Cambridge, MA). In contrast, a wider array of firms drive co-patenting relationships. For example, 14 different firms are listed as the top collaborating entities for the 20 times that San Jose–San Francisco, CA is listed as a top collaborating cluster. Beijing has 8 different entities as the primary driver for its patent collaborations. Shenzhen-Hong Kong, conversely, has only 2 entities for the 6 times it is listed as a top collaborating cluster for co-patenting—Huawei (5) and Shenzhen Guohua OptoElectronics (1).

Concluding remarks

The 2019 S&T cluster ranking offers a window into the world's innovation hotspots. The microdata, on the basis of which we identify and measure S&T clusters, further provide insight into the nature and direction of innovative activity taking place within different clusters.

As in previous years, it is important to point out several caveats and limitations of our approach. First, the precise shape of the identified clusters depends critically on the threshold parameters of our clustering algorithm. Although the relative ranking does not change substantially within a plausible range of threshold parameters, especially for the top 25 clusters, the geographic coverage of each cluster does fluctuate depending on the parameters chosen.

Second, our approach places equal weight on patenting and scientific output. Different weights would imply different rank orders, though changes would only be significant for the lower half of the top 100 list. Finally, while S&T activity is central to innovation performance, it naturally focuses on the upstream segments of the innovation value chain. Our data do not capture how S&T activity translates to productivity gains as well as new products and services in the marketplace.

Notes:

1 Gothenburg (Sweden) and Tainan–Kaohsiung (Taiwan) dropped out of the top 100; Qingdao (China) and Chongqing (China) entered the top 100.

2 Both Guangzhou (#21, + 11) and Phoenix, AZ (#76, +10) also experienced non-trivial increases in cluster area, however their growth was still primarily driven by new S&T output.

3 See Bergquist et al. (2018) for a description of our clustering algorithm and the threshold parameters chosen.

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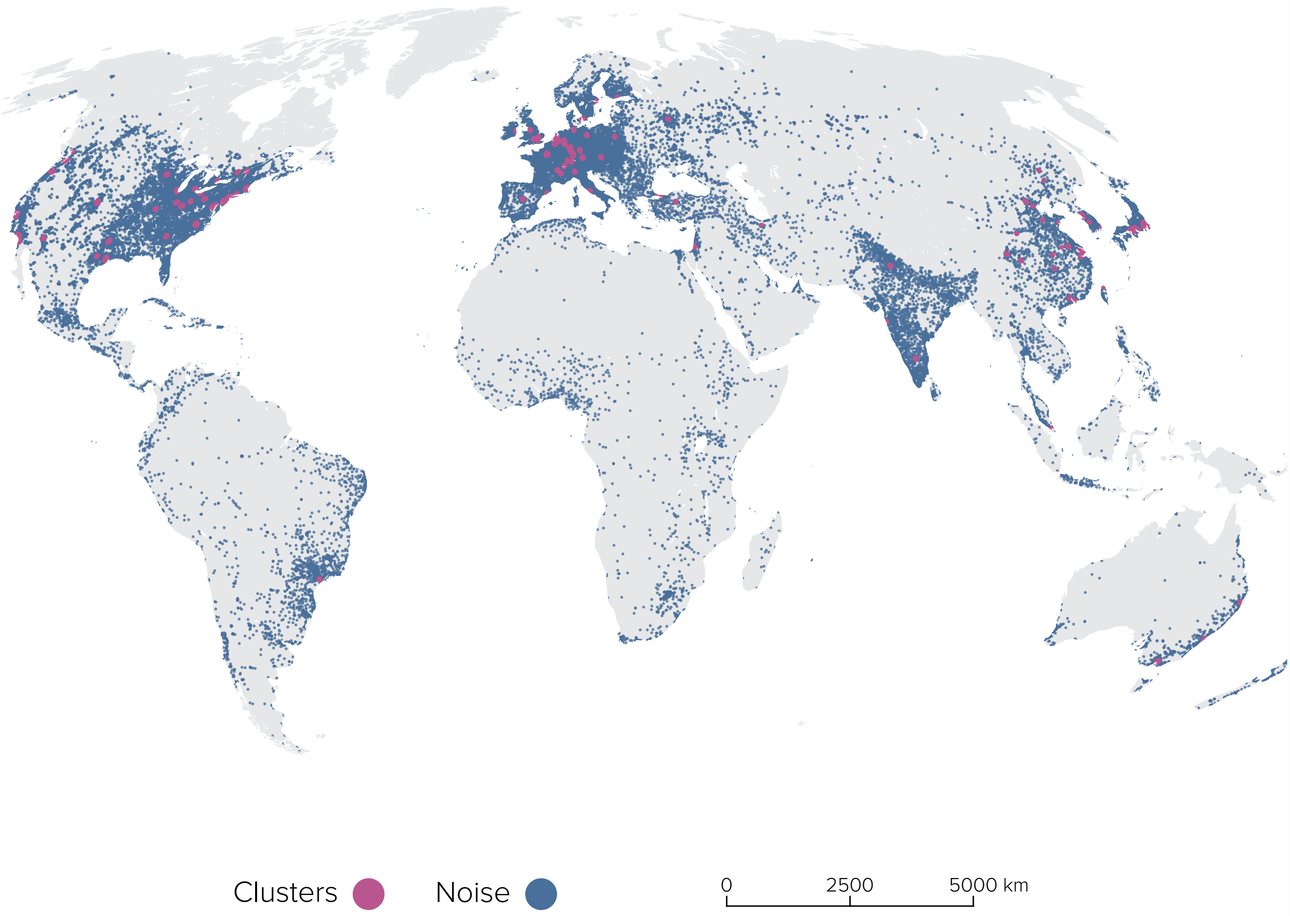
FIGURE S-1.2

Top 100 clusters worldwide



Source: WIPO Statistics Database, March 2019.
Note: Noise refers to all inventor / author locations not classified in a cluster.

TABLE S-1.3

Top 100 cluster rankings by publishing and patent performance

			Scientific publishing performance		
Rank	Cluster name	Economy(ies)	Top science field	Share, %	Top scientific organization
1	Tokyo-Yokohama	JP	Physics	9.22	University of Tokyo
2	Shenzhen-Hong Kong	CN/HK	Engineering	10.81	University of Hong Kong
3	Seoul	KR	Engineering	7.53	Seoul National University
4	Beijing	CN	Chemistry	10.30	Chinese Academy of Sciences
5	San Jose-San Francisco, CA	US	Chemistry	6.14	University of California
6	Osaka-Kobe-Kyoto	JP	Chemistry	10.41	Kyoto University
7	Boston-Cambridge, MA	US	Oncology	5.63	Harvard University
8	New York City, NY	US	Neurosciences & Neurology	5.72	Columbia University
9	Paris	FR	Physics	7.48	CNRS
10	San Diego, CA	US	Science & Technology-Other Topics	6.21	University of California
11	Shanghai	CN	Chemistry	13.07	Shanghai Jiao Tong University
12	Nagoya	JP	Chemistry	9.24	Nagoya University
13	Washington, DC-Baltimore, MD	US	Neurosciences & Neurology	5.11	Johns Hopkins University
14	Los Angeles, CA	US	Neurosciences & Neurology	5.35	University of California
15	London	GB	General & Internal Medicine	6.90	University of London
16	Houston, TX	US	Oncology	11.86	Baylor College of Medicine
17	Seattle, WA	US	General & Internal Medicine	4.79	University of Washington
18	Amsterdam-Rotterdam	NL	Cardiovascular System & Cardiology	6.09	University of Utrecht
19	Chicago, IL	US	Neurosciences & Neurology	5.26	Northwestern University
20	Cologne	DE	Chemistry	6.77	University of Bonn
21	Guangzhou	CN	Chemistry	10.32	Sun Yat Sen University
22	Daejeon	KR	Engineering	13.45	KAIST
23	Tel Aviv-Jerusalem	IL	Neurosciences & Neurology	6.21	Tel Aviv University
24	Munich	DE	Physics	7.95	University of Munich
25	Nanjing	CN	Chemistry	12.35	Nanjing University
26	Stuttgart	DE	Chemistry	7.23	Eberhard Karls University of Tubingen
27	Minneapolis, MN	US	Chemistry	5.64	University of Minnesota
28	Singapore	SG	Engineering	10.56	National University of Singapore
29	Philadelphia, PA	US	Neurosciences & Neurology	5.84	University of Pennsylvania
30	Hangzhou	CN	Chemistry	12.43	Zhejiang University
31	Eindhoven	BE/NL	Engineering	14.72	Eindhoven University of Tech.
32	Stockholm	SE	Science & Technology-Other Topics	5.70	Karolinska Institutet
33	Moscow	RU	Physics	17.44	Russian Academy of Sciences
34	Raleigh, NC	US	Science & Technology-Other Topics	4.56	University of North Carolina
35	Melbourne	AU	General & Internal Medicine	5.42	University of Melbourne
36	Frankfurt Am Main	DE	Physics	9.05	Goethe University Frankfurt
37	Sydney	AU	General & Internal Medicine	5.43	University of Sydney
38	Wuhan	CN	Chemistry	10.43	Huazhong University of Science & Tech.
39	Toronto, ON	CA	Neurosciences & Neurology	7.07	University of Toronto
40	Brussels	BE	Physics	4.93	KU Leuven
41	Berlin	DE	Chemistry	7.28	Free University Of Berlin
42	Madrid	ES	Chemistry	5.77	CSIC
43	Taipei	TW	Engineering	8.22	National Taiwan University
44	Barcelona	ES	Chemistry	5.29	University of Barcelona
45	Portland, OR	US	Neurosciences & Neurology	6.54	Oregon University System
46	Tehran	IR	Engineering	15.92	Tehran University of Medical Sciences
47	Xi’an	CN	Engineering	13.97	Xi’an Jiaotong University
48	Milan	IT	Neurosciences & Neurology	7.96	University of Milan
49	Denver, CO	US	Meteorology & Atmospheric Sciences	5.00	University of Colorado
50	Zürich	CH/DE	Chemistry	7.87	University of Zurich

		Patent performance		
Share, %	Top patenting field	Share, %	Top applicant	Share, %
13.85	Electrical machinery, apparatus, energy	9.86	Mitsubishi Electric	7.83
17.23	Digital communication	38.39	Huawei	25.76
16.10	Digital communication	16.63	LG Electronics	18.71
22.69	Digital communication	23.60	BOE Technology Group	24.43
38.59	Computer technology	23.18	Google	8.04
22.53	Electrical machinery, apparatus, energy	13.27	Murata Manufacturing	10.61
53.87	Pharmaceuticals	17.03	M.I.T	6.81
13.26	Pharmaceuticals	14.52	Honeywell	5.49
22.81	Transport	11.49	L'Oréal	7.60
51.51	Digital communication	30.37	Qualcomm	58.45
23.06	Digital communication	10.48	Alcatel Lucent	3.36
37.49	Electrical machinery, apparatus, energy	17.99	Toyota	23.97
24.62	Pharmaceuticals	17.74	Johns Hopkins University	13.52
44.49	Medical technology	18.52	University of California	6.00
49.28	Digital communication	11.71	British Telecom	8.06
20.49	Civil engineering	34.74	Halliburton	18.55
65.07	Computer technology	41.74	Microsoft	35.47
13.01	Civil engineering	6.61	Shell	8.86
28.12	Digital communication	8.22	Illinois Tool Works	14.76
15.84	Basic materials chemistry	10.37	Henkel	9.55
27.92	Electrical machinery, apparatus, energy	8.95	South China University of Tech.	5.26
25.41	Electrical machinery, apparatus, energy	20.90	LG Chem	40.16
34.05	Computer technology	17.76	Intel	5.30
50.80	Transport	12.33	BMW	15.74
17.55	Electrical machinery, apparatus, energy	10.35	Southeast University	9.36
44.09	Electrical machinery, apparatus, energy	13.02	Robert Bosch	46.89
70.89	Medical technology	30.22	3M Innovative Properties	35.40
37.35	Computer technology	7.64	A*Star	17.76
50.32	Pharmaceuticals	20.85	University of Pennsylvania	10.85
57.90	Computer technology	31.29	Alibaba Group	48.68
61.43	Medical technology	26.00	Philips Electronics	77.26
49.23	Digital communication	39.76	LM Ericsson	45.89
37.50	Computer technology	11.24	Yandex Europe	3.91
50.62	Pharmaceuticals	12.78	Duke University	8.44
24.56	Pharmaceuticals	8.99	Monash University	5.56
23.62	Medical technology	12.31	Merck Patent	9.04
40.15	Medical technology	12.09	Cochlear	4.83
29.81	Optics	15.27	Wuhan China Star Optoelectronics Tech.	16.88
81.09	Medical technology	12.76	Synaptive Medical	5.10
34.62	Basic materials chemistry	7.79	Procter & Gamble Company	5.23
36.71	Electrical machinery, apparatus, energy	11.12	Siemens	12.67
15.35	Digital communication	12.45	CSIC	9.16
26.77	Computer technology	12.08	Hewlett-Packard	12.13
29.52	Pharmaceuticals	9.93	Hewlett-Packard	19.87
65.73	Computer technology	24.08	Intel	53.80
10.85	Medical technology	12.43	Gharooni, Milad	3.04
29.28	Digital communication	16.74	Xi'an Jiaotong University	11.90
24.40	Electrical machinery, apparatus, energy	6.97	Pirelli Tyre	7.64
56.07	Medical technology	13.77	University of Colorado	6.94
36.18	Medical technology	8.39	Sika Technology	5.14

TABLE S-1.3

Top 100 cluster rankings by publishing and patent performance, continued

Rank	Cluster name	Economy(ies)	Scientific publishing performance: Top science field	Share, %	Top scientific organization
51	Montréal, QC	CA	Engineering	7.20	McGill University
52	Chengdu	CN	Engineering	11.14	Sichuan University
53	Mannheim	DE	Oncology	9.31	Ruprecht Karl University Heidelberg
54	Istanbul	TR	Engineering	6.99	Istanbul University
55	Copenhagen	DK	Neurosciences & Neurology	5.41	University of Copenhagen
56	Atlanta, GA	US	Public, Environmental & Occupational Health	6.76	Emory University
57	Rome	IT	Neurosciences & Neurology	6.62	Sapienza University Rome
58	Cambridge	GB	Science & Technology-Other Topics	7.50	University of Cambridge
59	São Paulo	BR	Neurosciences & Neurology	4.24	Universidade de Sao Paulo
60	Tianjin	CN	Chemistry	18.13	Tianjin University
61	Cincinnati, OH	US	Pediatrics	6.49	University of Cincinnati
62	Nürnberg	DE	Chemistry	7.95	University of Erlangen Nuremberg
63	Pittsburgh, PA	US	Neurosciences & Neurology	5.76	PCSHE
64	Dallas, TX	US	Cardiovascular System & Cardiology	6.50	Univ. of Texas Southwestern Med. Center
65	Bengaluru	IN	Chemistry	12.54	IISC-Bengaluru
66	Ann Arbor, MI	US	Chemistry	4.68	University of Michigan
67	Changsha	CN	Engineering	10.81	Central South University
68	Helsinki	FI	Science & Technology-Other Topics	4.81	University of Helsinki
69	Vienna	AT	Physics	4.89	Medical University of Vienna
70	Delhi	IN	Chemistry	7.83	All India Institute of Medical Sciences
71	Oxford	GB	Physics	7.19	University of Oxford
72	Vancouver, BC	CA	Neurosciences & Neurology	4.86	University of British Columbia
73	Cleveland, OH	US	Cardiovascular System & Cardiology	7.84	Cleveland Clinic
74	Lyon	FR	Chemistry	6.98	CNRS
75	Busan	KR	Engineering	9.69	Pusan National University
76	Phoenix, AZ	US	Neurosciences & Neurology	6.76	Arizona State University
77	Ankara	TR	Cardiovascular System & Cardiology	5.64	Hacettepe University
78	Ottawa, ON	CA	Engineering	6.12	University of Ottawa
79	Austin, TX	US	Chemistry	10.52	University Of Texas Austin
80	Qingdao	CN	Chemistry	13.52	Ocean University of China
81	Suzhou	CN	Chemistry	17.40	Suzhou University
82	Bridgeport-New Haven, CT	US	Neurosciences & Neurology	6.27	Yale University
83	Brisbane	AU	Engineering	5.32	University of Queensland
84	Hamburg	DE	Physics	7.89	University of Hamburg
85	Grenoble	FR	Physics	17.55	CNRS
86	Lausanne	CH/FR	Chemistry	7.95	EPFL
87	Harbin	CN	Engineering	12.15	Harbin Institute of Technology
88	Chongqing	CN	Chemistry	10.09	Chongqing University
89	Jinan	CN	Chemistry	14.24	Shandong University
90	Hefei	CN	Physics	14.69	University of Science & Tech. of China
91	Basel	CH/DE/FR	Pharmacology & Pharmacy	7.54	University of Basel
92	Manchester	GB	Chemistry	6.77	University of Manchester
93	Changchun	CN	Chemistry	23.62	Jilin University
94	St. Louis, MO	US	Neurosciences & Neurology	6.39	Washington University (WUSTL)
95	Lund	SE	Science & Technology-Other Topics	5.59	Lund University
96	Columbus, OH	US	Oncology	5.29	Ohio State University
97	Mumbai	IN	Chemistry	16.28	Bhabha Atomic Research Center
98	Indianapolis, IN	US	Pharmacology & Pharmacy	5.05	Indiana University
99	Dublin	IE	General & Internal Medicine	17.79	Trinity College
100	Warsaw	PL	Chemistry	9.32	Polish Academy of Sciences

Source: WIPO Statistics Database, March 2019.
Notes: Patent filing and scientific publication shares refer to the 2013–17 period and are based on fractional counts, as explained in the text. We use the location of inventors to associate patent applicants to clusters; note that addresses of applicants may well be outside the cluster(s) to which they are associated. The identification of technology fields relies on the WIPO technology concordance table linking International Patent Classification (IPC) symbols with 35 fields of technology (available at http://www.wipo.int/ipstats/en/).

	Patent performance			
Share, %	Top patenting field	Share, %	Top applicant	Share, %
42.47	Digital communication	17.11	LM Ericsson	9.10
42.54	Pharmaceuticals	11.70	Sichuan Haisco Pharmaceutical	4.32
58.56	Basic materials chemistry	13.27	BASF	42.53
18.58	Other consumer goods	18.74	Arcelik	46.21
72.62	Biotechnology	15.25	Novozymes	11.02
37.21	Medical technology	13.66	Georgia Tech	7.93
31.67	Medical technology	10.87	Bridgestone	7.12
73.38	Computer technology	15.46	ARM	9.09
46.86	Medical technology	8.32	Mahle Metal Leve	3.23
29.17	Pharmaceuticals	9.14	Tianjin University	11.93
46.17	Medical technology	32.37	Procter & Gamble Company	43.19
67.33	Electrical machinery, apparatus, energy	16.91	Siemens	37.99
67.50	Medical technology	12.86	University of Pittsburgh	13.39
39.25	Civil engineering	17.24	Halliburton	16.39
30.39	Computer technology	22.79	Hewlett-Packard	11.26
89.15	Pharmaceuticals	10.20	University of Michigan	27.71
42.83	Civil engineering	15.63	Zoomlion	32.84
56.72	Digital communication	31.13	Nokia	10.89
28.13	Pharmaceuticals	9.29	Siemens	4.11
14.08	Pharmaceuticals	13.98	Ranbaxy Laboratories	6.49
78.10	Biotechnology	12.84	Oxford University	17.77
70.21	Medical technology	9.60	University of British Columbia	7.07
47.33	Medical technology	15.62	Cleveland Clinic	10.83
31.25	Basic materials chemistry	10.63	IFP Energies Nouvelles	10.95
35.02	Electrical machinery, apparatus, energy	7.61	Pusan National University	5.09
50.97	Semiconductors	15.41	Intel	23.66
17.32	Medical technology	13.63	Aselsan	21.65
57.42	Digital communication	44.40	Huawei	35.66
66.99	Computer technology	22.27	University Of Texas	12.58
21.54	Other consumer goods	33.11	Qingdao Haier Washing Machine	14.66
68.69	Electrical machinery, apparatus, energy	9.53	Positec Power Tools	4.68
85.32	Pharmaceuticals	15.50	Yale University	11.13
49.46	Civil engineering	12.68	University of Queensland	8.84
57.59	Organic fine chemistry	16.14	Henkel	9.17
42.01	Electrical machinery, apparatus, energy	13.97	CEA	40.01
46.74	Food chemistry	8.87	NESTEC	26.77
42.85	Measurement	12.51	Harbin Institute of Technology	38.65
26.46	Medical technology	13.23	Chongqing Runze Pharmaceutical	10.51
58.50	Computer technology	10.79	Shandong University	10.04
41.28	Other consumer goods	12.12	Anhui Jianghuai Automobile	10.56
60.83	Pharmaceuticals	19.04	F. Hoffmann-La Roche	13.38
65.91	Electrical machinery, apparatus, energy	15.71	Micromass	13.76
57.67	Measurement	14.00	Changchun Institute Of Applied Chemistry	15.69
69.55	Biotechnology	16.63	Monsanto Technology	16.54
86.72	Digital communication	22.79	LM Ericsson	21.81
89.88	Pharmaceuticals	13.23	Abbott Laboratories	13.01
22.72	Organic fine chemistry	18.23	Piramal Enterprises	5.26
68.17	Basic materials chemistry	11.81	Dow AgroSciences	22.46
30.49	Computer technology	11.08	Alcatel Lucent	8.07
19.76	Medical technology	8.18	General Electric	4.00

The top scientific field is based on SCIE's Extended Ascatype subject field. An article can be assigned to more than one subject field. Fractional counting was used when more than one subject was assigned to an article. Codes refer to the ISO-2 codes. See page 17 for a full list, with the following addition: TW = Taiwan, Province of China. CNRS = Centre National de la Recherche Scientifique, CSIC = Consejo Superior de Investigaciones Cientificas, PCSHE = Pennsylvania Commonwealth System of Higher Education, IISC = Indian Institute of Science, EPFL = Ecole Polytechnique Federale de Lausanne, CEA = Commissariat a L'Energie Atomique et aux Energies Alternatives.

TABLE S-1.4

Top collaborating entities by cluster

			Scientific publishing collaboration		
Rank	Cluster name	Economy(ies)	Top scientific collaborating cluster	Share, %	Top collaborating organization
1	Tokyo-Yokohama	JP	Osaka-Kobe-Kyoto	8.15	Kyoto University
2	Shenzhen-Hong Kong	CN/HK	Beijing	9.66	Chinese Academy of Sciences
3	Seoul	KR	Daejeon	4.32	KAIST
4	Beijing	CN	Shanghai	3.15	Chinese Academy of Sciences
5	San Jose-San Francisco, CA	US	Boston-Cambridge, MA	5.28	Harvard University
6	Osaka-Kobe-Kyoto	JP	Tokyo-Yokohama	20.16	University of Tokyo
7	Boston-Cambridge, MA	US	New York City, NY	4.95	Columbia University
8	New York City, NY	US	Boston-Cambridge, MA	4.88	Harvard University
9	Paris	FR	Lyon	2.53	CNRS
10	San Diego, CA	US	San Jose-San Francisco, CA	5.36	University of California
11	Shanghai	CN	Beijing	6.00	Chinese Academy of Sciences
12	Nagoya	JP	Tokyo-Yokohama	24.42	University of Tokyo
13	Washington, DC-Baltimore, MD	US	Boston-Cambridge, MA	4.62	Harvard University
14	Los Angeles, CA	US	San Jose-San Francisco, CA	4.77	University of California
15	London	GB	Oxford	2.62	University of Oxford
16	Houston, TX	US	San Jose-San Francisco, CA	6.49	Stanford University
17	Seattle, WA	US	Boston-Cambridge, MA	5.30	Harvard University
18	Amsterdam-Rotterdam	NL	Nijmegen	4.70	Radboud University Nijmegen
19	Chicago, IL	US	New York City, NY	4.35	Columbia University
20	Cologne	DE	Berlin	3.97	Free University of Berlin
21	Guangzhou	CN	Beijing	7.06	Chinese Academy of Sciences
22	Daejeon	KR	Seoul	29.76	Seoul National University
23	Tel Aviv-Jerusalem	IL	Haifa	4.11	Technion Israel Institute of Tech.
24	Munich	DE	Cologne	5.12	University of Bonn
25	Nanjing	CN	Beijing	6.55	Chinese Academy of Sciences
26	Stuttgart	DE	Cologne	4.42	University of Bonn
27	Minneapolis, MN	US	Washington, DC-Baltimore, MD	4.14	Johns Hopkins University
28	Singapore	SG	Beijing	2.39	Chinese Academy of Sciences
29	Philadelphia, PA	US	New York City, NY	6.27	Columbia University
30	Hangzhou	CN	Beijing	5.58	Chinese Academy of Sciences
31	Eindhoven	BE/NL	Amsterdam-Rotterdam	24.27	Delft University of Technology
32	Stockholm	SE	Uppsala	6.31	Uppsala University
33	Moscow	RU	Saint Petersburg	2.02	Russian Academy of Sciences
34	Raleigh, NC	US	Washington, DC-Baltimore, MD	4.85	Johns Hopkins University
35	Melbourne	AU	Sydney	6.37	University of Sydney
36	Frankfurt Am Main	DE	Cologne	5.74	University of Bonn
37	Sydney	AU	Melbourne	7.47	University of Melbourne
38	Wuhan	CN	Beijing	7.48	Chinese Academy of Sciences
39	Toronto, ON	CA	Mississauga, ON	2.97	McMaster University
40	Brussels	BE	Gent	5.43	Ghent University
41	Berlin	DE	Cologne	4.95	University of Cologne
42	Madrid	ES	Barcelona	8.82	University of Barcelona
43	Taipei	TW	Taichung	7.15	China Medical University Taiwan
44	Barcelona	ES	Madrid	8.24	CSIC
45	Portland, OR	US	San Jose-San Francisco, CA	6.12	University of California
46	Tehran	IR	Kuala Lumpur	0.34	Universiti Malaya
47	Xi'an	CN	Beijing	6.89	Chinese Academy of Sciences
48	Milan	IT	Rome	6.10	Sapienza University Rome
49	Denver, CO	US	Washington, DC-Baltimore, MD	5.05	Johns Hopkins University
50	Zürich	CH/DE	Bern	3.38	University of Bern

		Patent collaboration			
Share, %	Top patent collaborating cluster	Share, %	Top collaborating applicant	Share, %
24.89	Osaka-Kobe-Kyoto	1.30	Hitachi	4.15
20.15	Beijing	0.21	Huawei	70.34
16.93	Daejeon	2.82	LG Chem	9.80
32.13	San Jose-San Francisco, CA	1.19	Intel	58.38
55.82	Portland, OR	1.71	Intel	83.05
13.44	Tokyo-Yokohama	5.16	Hitachi	3.20
15.52	San Jose-San Francisco, CA	2.65	Robert Bosch	4.78
56.89	Boston-Cambridge, MA	3.18	Merck Sharp & Dohme Corp.	7.76
25.27	Lyon	1.39	IFP Energies Nouvelles	26.68
35.93	San Jose-San Francisco, CA	2.04	Qualcomm	10.11
38.80	New York City, NY	1.72	Merck Sharp & Dohme Corp.	63.36
12.98	Tokyo-Yokohama	3.35	Toyota	6.70
56.85	San Jose-San Francisco, CA	3.13	Robert Bosch	6.33
37.56	San Jose-San Francisco, CA	4.22	University of California	4.07
76.75	Cambridge	1.73	British American Tobacco	7.08
51.03	New York City, NY	0.89	Exxonmobil	16.76
61.10	San Jose-San Francisco, CA	2.28	Elwha LLC	10.62
54.38	Houston, TX	1.70	Shell	53.50
16.34	San Jose-San Francisco, CA	1.69	Motorola Mobility	10.53
39.63	Aachen	2.61	Grüenthal	15.95
38.12	Shenzhen-Hong Kong	0.83	Shenzhen Guohua Optoelectronics	18.10
16.14	Seoul	12.69	Lg Hausys	6.30
46.91	Haifa	5.72	Intel	18.77
15.48	Nürnberg	1.95	Siemens	56.89
36.02	Beijing	1.78	LM Ericsson	15.08
14.55	Mannheim	1.25	BASF	26.75
28.14	San Jose-San Francisco, CA	1.18	Pure Storage	8.08
23.94	San Jose-San Francisco, CA	1.72	Hewlett-Packard	17.96
14.00	New York City, NY	14.37	Merck Sharp & Dohme Corp.	19.73
20.88	Shanghai	0.73	Shenzhen Luoshuhe Tech. Development	17.31
14.23	Amsterdam-Rotterdam	0.67	ASML	8.99
80.32	Uppsala	2.88	LM Ericsson	61.77
29.89	Saint Petersburg	2.45	Rawllin International	11.87
26.58	San Jose-San Francisco, CA	3.19	Carbon3D	12.51
38.37	Sydney	1.92	Onesteel Wire	5.33
15.29	Mannheim	10.18	BASF	44.98
23.95	San Jose-San Francisco, CA	1.73	Dolby Laboratories	48.55
38.69	Shenzhen-Hong Kong	2.08	Huawei	79.45
85.53	Mississauga, ON	4.05	Flextronics AP	7.51
85.67	Gent	2.70	Universiteit Gent	8.91
13.95	Cologne	5.50	Bayer	36.76
29.91	Barcelona	2.19	Laboratorios del Dr. Esteve S.A.	14.83
32.62	Hsinchu	7.86	MediaTek	55.61
8.11	Madrid	1.25	CSIC	11.30
37.69	San Jose-San Francisco, CA	9.93	Intel	76.00
79.81	Houston, TX	2.10	Rice University	100.00
25.90	Shenzhen-Hong Kong	3.60	Huawei	91.60
22.38	Turin	1.13	Pirelli Tyre	30.35
20.28	San Jose-San Francisco, CA	3.99	Intel	7.59
78.28	Basel	2.30	F. Hoffmann-La Roche	13.27

CONTINUED

TABLE S-1.4

Top collaborating entities by cluster, continued

Rank	Cluster name	Economy(ies)	Scientific publishing collaboration: Top scientific collaborating cluster	Share, %	Top collaborating organization
51	Montréal, QC	CA	Toronto, ON	3.94	University of Toronto
52	Chengdu	CN	Beijing	7.46	Chinese Academy of Sciences
53	Mannheim	DE	Cologne	5.91	University of Cologne
54	Istanbul	TR	Ankara	5.06	Hacettepe University
55	Copenhagen	DK	Århus	4.79	Aarhus University
56	Atlanta, GA	US	Washington, DC-Baltimore, MD	4.99	Johns Hopkins University
57	Rome	IT	Milan	5.60	University of Milan
58	Cambridge	GB	London	10.73	University of London
59	São Paulo	BR	Rio De Janeiro	2.99	Universidade Federal do Rio de Janeiro
60	Tianjin	CN	Beijing	9.34	Chinese Academy of Sciences
61	Cincinnati, OH	US	Washington, DC-Baltimore, MD	4.07	Johns Hopkins University
62	Nürnberg	DE	Munich	9.44	University of Munich
63	Pittsburgh, PA	US	Washington, DC-Baltimore, MD	4.30	Johns Hopkins University
64	Dallas, TX	US	New York City, NY	4.61	Columbia University
65	Bengaluru	IN	Delhi	2.40	CSIR
66	Ann Arbor, MI	US	Boston-Cambridge, MA	4.41	Harvard University
67	Changsha	CN	Beijing	5.61	Chinese Academy of Sciences
68	Helsinki	FI	Stockholm	3.32	Karolinska Institutet
69	Vienna	AT	Graz	2.37	Medical University of Graz
70	Delhi	IN	Pune	1.31	CSIR
71	Oxford	GB	London	12.14	University of London
72	Vancouver, BC	CA	Toronto, ON	5.55	University of Toronto
73	Cleveland, OH	US	New York City, NY	3.93	Columbia University
74	Lyon	FR	Paris	19.11	APHP
75	Busan	KR	Seoul	26.06	Seoul National University
76	Phoenix, AZ	US	Washington, DC-Baltimore, MD	3.79	Johns Hopkins University
77	Ankara	TR	Istanbul	5.04	Istanbul University
78	Ottawa, ON	CA	Toronto, ON	8.78	University of Toronto
79	Austin, TX	US	Houston, TX	3.81	UTMD Anderson Cancer Center
80	Qingdao	CN	Beijing	12.97	Chinese Academy of Sciences
81	Suzhou	CN	Beijing	8.30	Chinese Academy of Sciences
82	Bridgeport-New Haven, CT	US	New York City, NY	7.29	Columbia University
83	Brisbane	AU	Melbourne	8.32	University of Melbourne
84	Hamburg	DE	Cologne	6.12	University of Bonn
85	Grenoble	FR	Paris	15.85	CNRS
86	Lausanne	CH/FR	Zürich	5.93	University of Zurich
87	Harbin	CN	Beijing	6.73	Chinese Academy of Sciences
88	Chongqing	CN	Beijing	5.73	Chinese Academy of Sciences
89	Jinan	CN	Beijing	7.03	Chinese Academy of Sciences
90	Hefei	CN	Beijing	8.33	Chinese Academy of Sciences
91	Basel	CH/DE/FR	Zürich	7.78	University of Zurich
92	Manchester	GB	London	8.03	University of London
93	Changchun	CN	Beijing	11.07	Chinese Academy of Sciences
94	St. Louis, MO	US	Boston-Cambridge, MA	4.13	Harvard University
95	Lund	SE	Stockholm	7.38	Karolinska Institutet
96	Columbus, OH	US	Washington, DC-Baltimore, MD	3.58	Johns Hopkins University
97	Mumbai	IN	Pune	2.11	University of Pune
98	Indianapolis, IN	US	New York City, NY	4.21	Columbia University
99	Dublin	IE	London	2.49	University of London
100	Warsaw	PL	Kraków	3.37	Jagiellonian University

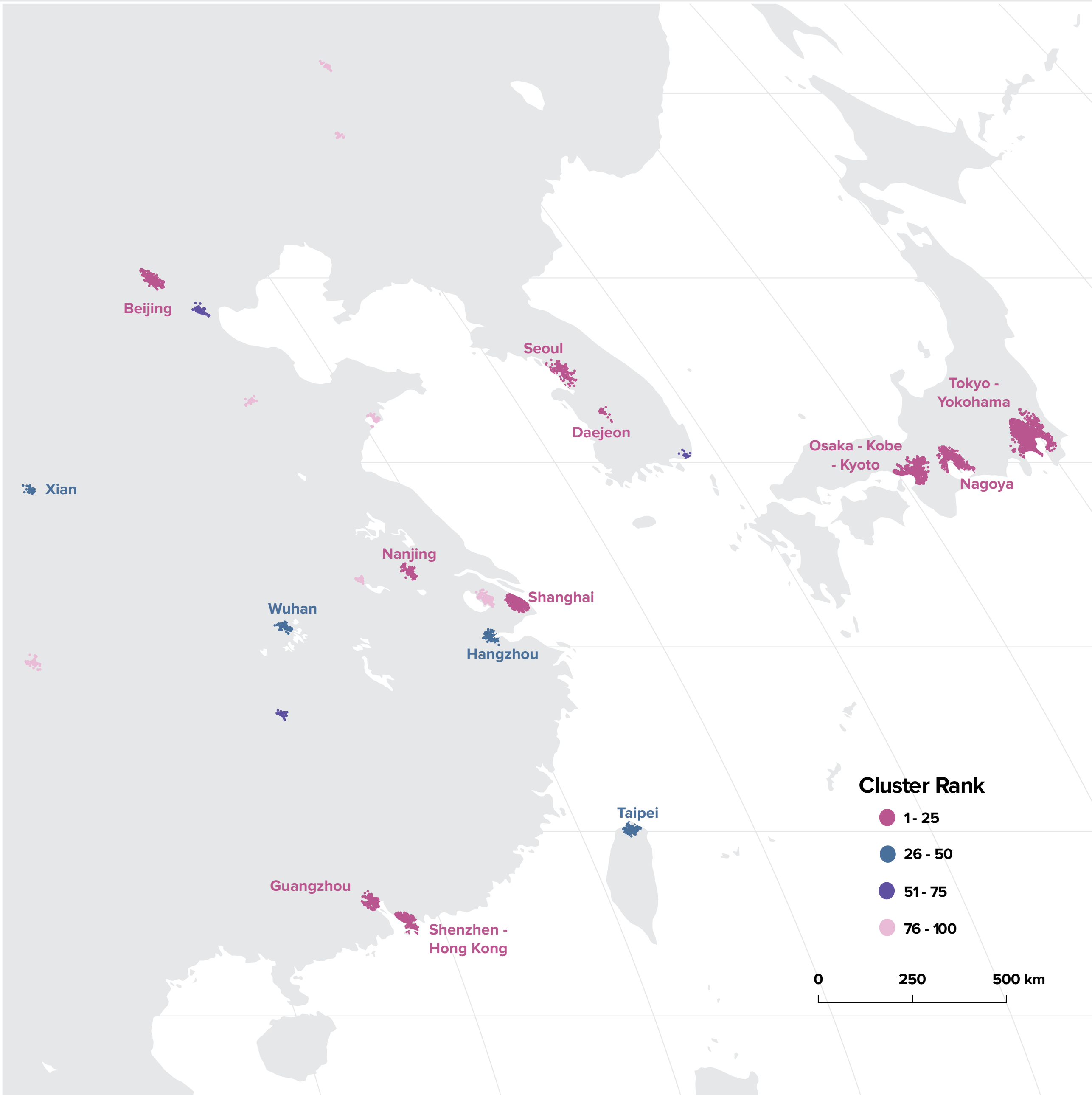
Source: WIPO Statistics Database, March 2019.
Notes: Patent filing and scientific publication shares refer to the 2013–17 period and are based on fractional counts, as explained in the text. Collaboration is based on the locations of authors/inventors listed on the same article/patent. Codes refer to the ISO-2 codes. See page 17 for a full list, with the following addition: TW = Taiwan, Province of China. CNRS = Centre National de la Recherche Scientifique, CSIC = Consejo Superior de Investigaciones Cientificas, CSIR = Council of

Share, %	Top patent collaborating cluster	Share, %	Top collaborating applicant	Share, %
	Patent collaboration			
80.05	New York City, NY	2.80	Interdigital Patent Holdings	41.02
32.60	Shenzhen-Hong Kong	1.24	Huawei	73.47
16.50	Frankfurt Am Main	10.81	BASF	25.02
16.01	Ankara	0.41	Arcelik	21.92
89.74	Lund	1.37	Danmarks Tekniske Universitet	12.22
21.76	San Jose-San Francisco, CA	2.85	Stanford University	6.43
20.88	Cologne	2.45	Bayer	96.21
55.30	London	2.83	British American Tobacco	9.31
30.80	Rio De Janeiro	1.31	Petrobras	20.65
25.00	Beijing	1.28	China Electric Power Research Institute	16.67
22.88	Frankfurt Am Main	2.57	Procter & Gamble Company	82.39
50.66	Munich	3.54	Siemens	58.26
30.78	Boston-Cambridge, MA	2.51	Berkshire Grey	17.44
15.18	San Jose-San Francisco, CA	3.73	Hewlett-Packard	17.20
10.25	San Jose-San Francisco, CA	5.33	Applied Materials	28.00
63.27	Detroit, MI	4.72	BASF	11.23
25.37	Basel	0.42	Novartis	100.00
57.86	Beijing	2.75	Broadcom	32.12
46.22	Graz	2.00	AVL List	21.15
40.65	Bengaluru	3.84	Mcafee	13.62
54.67	London	2.73	Sony	12.24
80.16	San Jose-San Francisco, CA	3.37	Genentech	6.45
12.65	San Jose-San Francisco, CA	1.08	Cisco Technology	23.30
26.28	Paris	8.28	IFP Energies Nouvelles	22.25
15.30	Seoul	21.29	Samsung Electronics	8.84
24.62	Portland, OR	6.03	Intel	94.14
11.74	Istanbul	3.16	Santa Farma Ilac	30.02
76.62	Dallas, TX	2.74	Blackberry	51.43
15.98	San Jose-San Francisco, CA	7.32	Applied Materials	9.51
45.07	Shanghai	0.52	Dow Global Technologies	74.23
42.80	Beijing	1.74	Jiangsu Huadong Inst. of Li-Ion Battery	74.93
14.93	New York City, NY	5.71	Bristol-Myers Squibb	25.73
24.30	Melbourne	1.70	University of Queensland	10.59
15.45	Cologne	2.40	Henkel	35.93
30.03	Paris	5.99	CEA	39.14
32.16	Genève	5.00	NESTEC	18.14
17.84	Beijing	3.61	MediaTek	50.84
24.88	Shenzhen-Hong Kong	1.30	Huawei	83.08
22.11	Beijing	1.13	Nokia	23.13
36.97	Shenzhen-Hong Kong	3.27	Huawei	76.16
44.58	Zürich	3.71	Abb Technology Ag	8.13
51.13	Cambridge	2.46	AstraZeneca	28.01
58.97	Beijing	3.75	Peking University	22.07
67.33	Seattle, WA	2.62	Elwha LLC	75.48
64.40	Stockholm	9.26	LM Ericsson	81.90
27.09	Cincinnati, OH	2.48	Procter & Gamble Company	36.43
23.22	Bengaluru	3.95	Unilever	25.91
12.66	Boston-Cambridge, MA	1.17	Constellation Pharmaceuticals	13.32
50.08	San Jose-San Francisco, CA	1.62	Hewlett-Packard	25.04
42.84	Kraków	1.91	ABB Technology	20.10

Scientific & Industrial Research – India, APHP = Assistance Publique Hopitaux Paris (APHP), KAIST = Korea Advanced Institute of Science & Technology, CEA = Commissariat a L'Energie Atomique et aux Energies Alternatives.

FIGURE S-1.3

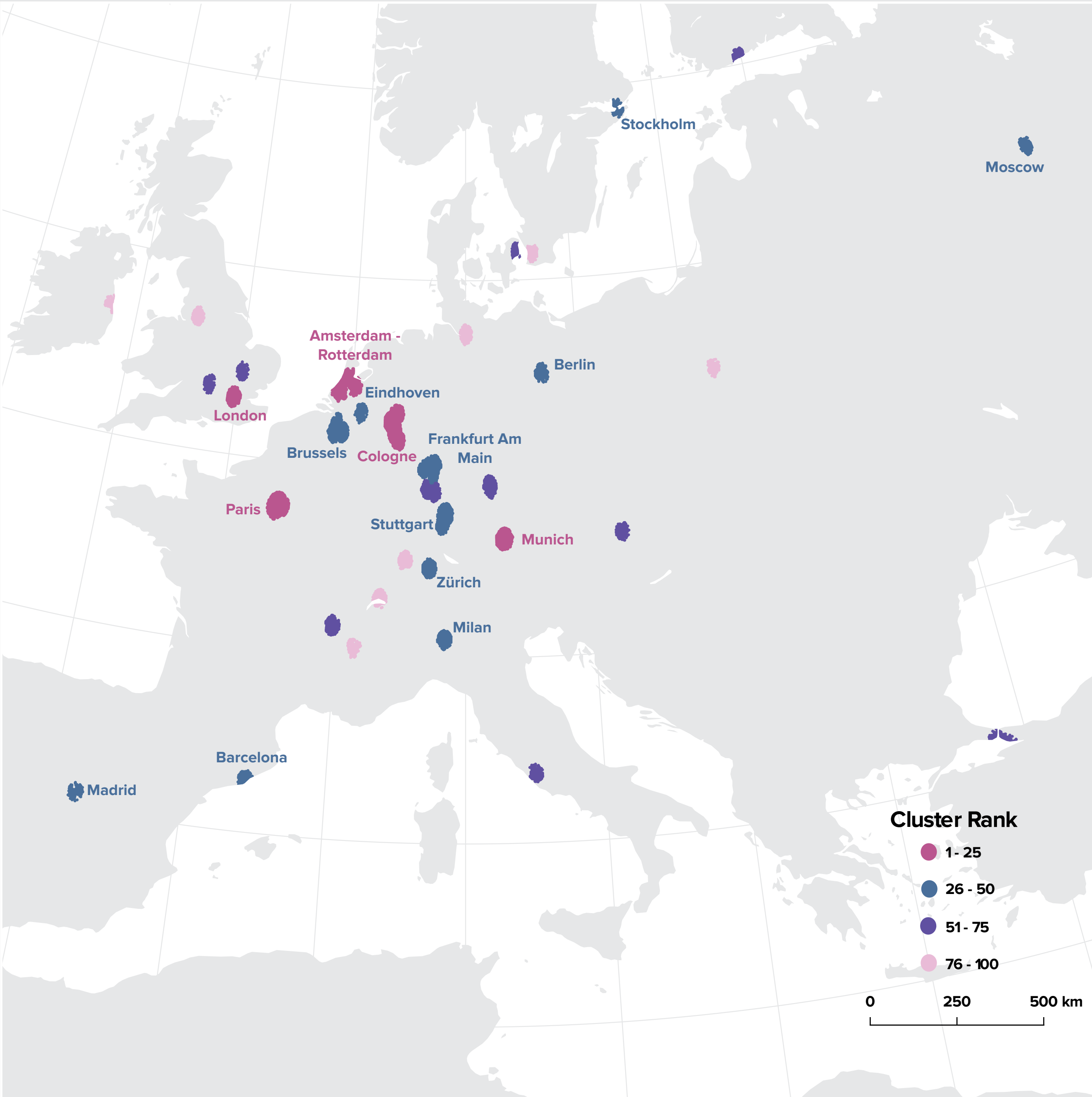
Regional clusters: Asia



Source: WIPO Statistics Database, March 2019.
Note: Cluster rank is based on total share in patent filing and scientific publication using fractional counting and the publication period of 2013-2017, as explained in the text.

FIGURE S-1.4

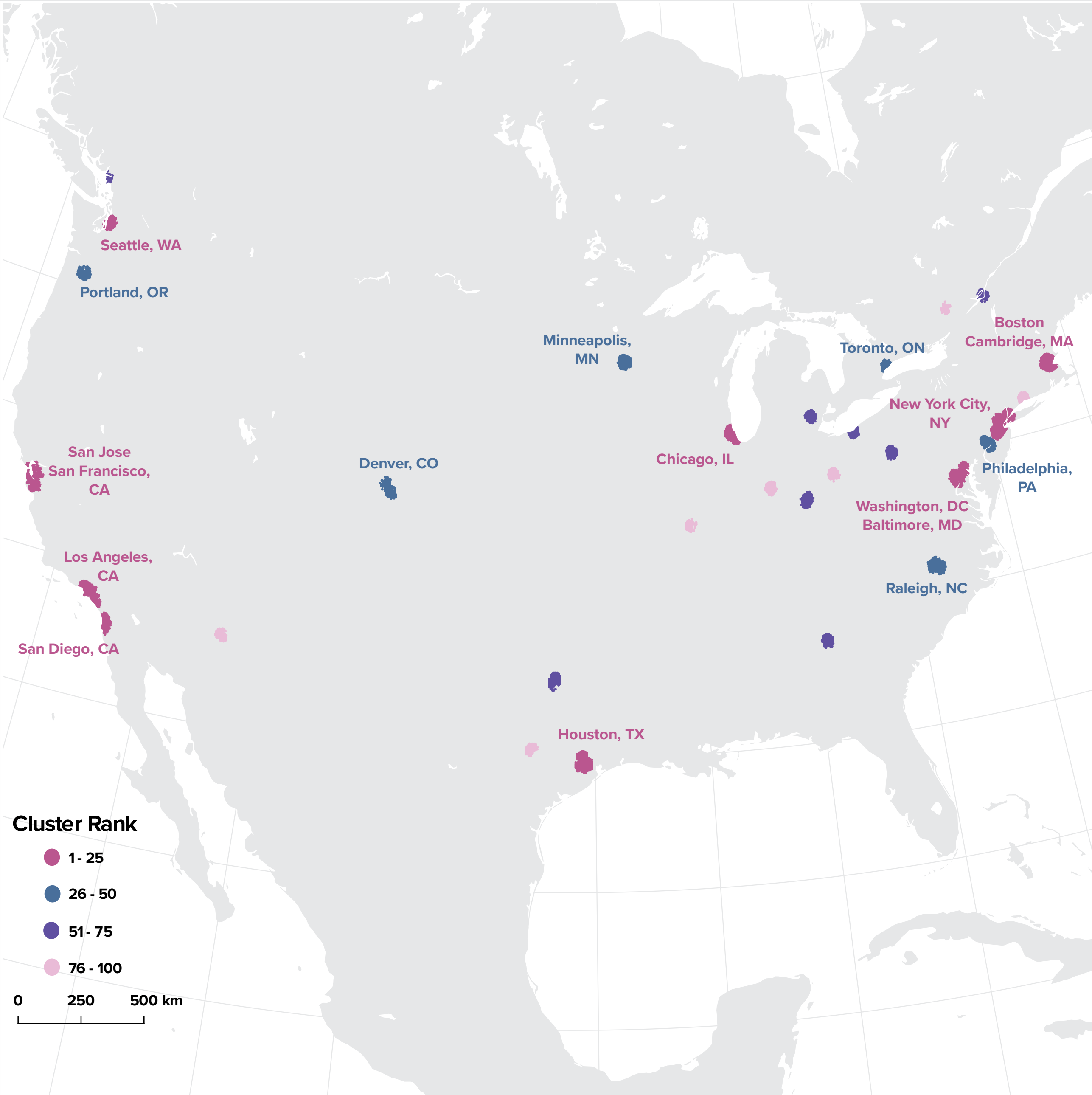
Regional clusters: Europe



Source: WIPO Statistics Database, March 2019.
Note: Cluster rank is based on total share in patent filing and scientific publication using fractional counting and the publication period of 2013-2017, as explained in the text.

FIGURE S-1.5

Regional clusters: Northern America



Source: WIPO Statistics Database, March 2019.
Note: Cluster rank is based on total share in patent filing and scientific publication using fractional counting and the publication period of 2013-2017, as explained in the text.

CHAPTER 2

THE ECONOMICS OF HEALTH INNOVATION: LOOKING BACK AND LOOKING FORWARD

Bhaven Sampat, Columbia University

Technological progress is widely recognized as a source of long-run economic growth. Some forms of progress, however, are not captured by standard growth statistics. Health improvements are one example. The Nobel-Prize winning economist William Nordhaus has calculated that the economic value of increases in longevity in the last 100 years is as large as measured economic growth *in all other sectors*. He illustrates the basic point with the following thought experiment:[1]

> Consider the improvements to both health and non-health technologies over the last half century (say from 1948 to 1998). Health technologies include a variety of changes such as the Salk polio vaccine, new pharmaceuticals, joint replacement, improved sanitation, improved automotive safety, smoke-free workplaces. Over this period, life expectancy at birth increased from a little above 68 years to a little less than 76 years. Non-health technologies were also wide-ranging and included the jet plane, television, superhighways, VCRs, and computers….
>
> Now consider the following choice. You must forgo either the health improvements over the last half-century or the non-health improvements. That is, you must choose either (a) 1948 health conditions and 1998 non-health living standards or (b) 1998 health conditions and 1948 non-health living standards. Which would you choose?

If you choose (b) or have difficulty choosing, you basically agree with the idea that improvements in health are as valuable as improvements in all other sectors combined. While these estimates were based on data from the United States of America (U.S.), similar health improvements were observed in other high-income countries over the past half century. Lower income countries also saw significant improvements in standard indicators of health status during the 1950s, 1960s, and 1970s.[2]

Looking back: the role of innovation in health improvement

Nordhaus and others have suggested that the creation and diffusion of new medical knowledge and technologies—medical innovation—were important sources of these health improvements.

What is medical innovation? While this is a more complicated question than it may seem, our focus here is on the incorporation into practice of new drugs, diagnostic methods, procedures, and devices that improve healthcare, as well as of new medical knowledge that shapes individual health behaviors, clinical practices, and informs public health policies and interventions.

Over the first half of the twentieth century, with some important exceptions,[3] new physical technologies had a limited role in improving health. Indeed, one influential scholar has argued that most historical improvements in health had little to do with healthcare or medical interventions at all, instead reflecting broader socioeconomic factors such as higher incomes, improved nutrition, and better sanitation.[4]

The antibiotics and sulfa drugs developed during the 1930s and 1940s were the first miracle medical technologies.[5] The diffusion of these drugs, first in rich countries and then globally, led to sharp decreases in morbidity and mortality in the 1940s and 1950s. Many new antibiotics and other new drugs, vaccines, and treatments were introduced in the two decades after World War II—often considered the "golden age" of medical innovation. By about 1960, antibiotics and vaccines virtually eliminated known infectious diseases as a major source of mortality in developed countries.

There has been continued improvement in health since that time. In most high-income countries, the main source of these gains has been a reduction in cardiovascular disease mortality.

Even though cardiovascular disease remains a leading cause of death, mortality fell sharply in the second half of the twentieth century. In the U.S., mortality from heart disease has fallen by about two-thirds since 1950, leading to a 5-year increase in life expectancy for the average 45-year-old.[6] Much of this has come through new knowledge of risk factors, which led to behavioral changes—such as less smoking and better diets—and disease prevention. Estimates suggest that about one-third of the gains are due to drug innovation, one-third to prevention, and the final third to high-tech medical treatments such as cardiac catheterization, bypass surgery, angioplasty, and others.[7] In reducing cardiovascular mortality, both medical technologies and new medical knowledge play an important role.

Another major source of morbidity and mortality is cancer. Cancer deaths have not declined in most countries in the postwar era, despite billions of dollars spent globally on the "war on cancer." One reason that deaths have not declined is competing risks: with fewer people dying of cardiovascular disease, more develop cancer. However, despite decades of frustration, there have been recent signs of progress in reducing mortality from some cancers, driven by screening technologies, such as mammography for breast cancer and colonoscopy, and by behavioral changes. In addition to better prevention, there have been new treatments as well, including surgeries, radiation, chemotherapy, and new drugs.[8] In an approach similar to Nordhaus, economists have found that improvements in cancer survival generated social benefits valued around US$1.9 trillion in the U.S. between 1988 and 2000.[9]

The HIV/AIDS epidemic threatened to negate some of the improvements in global life expectancy in the 1980s. For this disease, new technologies—especially antiretroviral therapy and follow-on drugs—have been crucial to making it a treatable disease. Economic estimates suggest that, by the end of the last century, new HIV/AIDS drugs generated US$1.4 trillion in economic value in the U.S.—a figure that would be significantly higher if global gains were included.[10] As with cancer and cardiovascular disease, more needs to be done to reduce the toll of HIV in developing countries in particular, yet the response to the HIV/AIDS epidemic presents perhaps the strongest recent example of the benefits from new medical technologies.

The basic empirical approach in many of the assessments above is to put an economic value on improvements in individual health outcomes, such as mortality and/or quality of life, that are linked to medical innovation. But there are other benefits from medical innovation as well. A study of AIDS treatment in sub-Saharan Africa shows that beyond the health benefits, these drugs helped improve labor force participation, childhood schooling, and other economic outcomes that influenced productivity and economic growth.[11] Beyond the value of reduced mortality and improved productivity, new medical technologies also improve the quality of life. Depression treatments and hip replacement, for example, have dramatically reduced morbidity and improved quality of life. Some new medical technologies, such as birth control pills, have completely revolutionized the labor force and social dynamics.[12]

In many cases, these advances have not come cheap. New medical technologies are widely recognized as major drivers of healthcare costs, perhaps because of the unique demand for improved health—in medicine invention may be the mother of necessity. There is now a large body of literature on whether the "technological imperative" in medicine is worthwhile and sustainable.[13] Overall, medical innovations seem to be cost-effective, and the social value of the technologies surveyed above—HIV treatments, cardiovascular improvements, infectious disease interventions— are orders of magnitude larger than their measured costs.[14] But there are many treatments where cost and value are out of line, which may account for a large share of health expenditures by patients and insurers.[15] Even technologies that are valuable from a clinical perspective can create budgetary pressures and affordability problems for governments and patients. The recent policy debate about high-cost prescription drugs is but one vivid illustration of the tension between new technologies, prices/access, and budgetary impact.

Unevenness and potential

While medical knowledge and technology have been essential to generating valuable health improvements, progress has been uneven.[16] Many cancers remain untreated and diseases—from Alzheimer's to neglected tropical diseases and mental health disorders—lack effective prevention, treatment, and/or management and continue to drive morbidity and mortality globally. Perhaps worse, antibiotic resistance, rising obesity, and emerging infectious diseases could reverse some benefits of the past.

The potential economic benefits from new approaches to preventing and treating disease are significant. In a framework similar to that used by Nordhaus, economists have estimated that in the U.S., a 10% reduction in mortality from heart disease would generate US$6 trillion in value to current and present generations.[17] Reductions in morbidity and mortality from other major diseases would yield benefits of similar orders of magnitude. Economists have also calculated that delaying aging by 20% would generate social benefits of over US$7 trillion in the U.S.—even as it would create serious fiscal challenges due to the need for supporting a growing, elderly population.[18] Economically valuable health gains and productivity improvements could also come from reducing the burden of neglected tropical diseases, continuing progress in HIV/AIDS, combating antibiotic resistance, and improving the efficiency of healthcare delivery.

Can future medical innovation match the gains from the past?

It is important to remember that innovations in medical care are not the only route to improving health status and achieving potential gains, and in some contexts, they may not even be the most productive. Promoting broader economic development, reducing income disparities, and improving educational attainment could also generate health improvements, independent of medical care. As discussed above, these "social determinants" have been extremely important in the past, and poverty, education, and diets continue to be associated with health outcomes today. Even as we focus on new technologies, the diffusion and adaptation of existing technologies and practices may also pay large dividends.

That said, the scope for new medical knowledge and technology to improve health and generate value is tremendous. But this raises another question: Is medical innovation up to the task? While the demand for innovation is high, there is concern that the golden years may be behind us—whether measured by the decline in major medical advances by year,[19] drug approvals,[20] or research productivity.[21] There is no consensus explanation for these trends. They may reflect that scientific and technological opportunities have dried up, ideas are getting harder to find, or the "low hanging fruit" has been picked. Perhaps more troubling, they may also reveal fundamental structural problems with the biomedical innovation system and incentives facing both public and private sector researchers.[22]

It is interesting that, at the same time, there is also tremendous enthusiasm about the future of medical science and technology. In the past few years, we have seen the launch of new hepatitis C treatments that essentially cure the disease—for those who can afford them—and cures for some cancers.[23] New areas of science and technology—cancer immunotherapies, gene editing, improvements in imaging and diagnostics, and many others—could transform prevention and treatment of specific diseases or healthcare in general. At the same time, some believe these new approaches may ultimately have limited impact on population health and potentially high costs. For example, echoing the historical debates about the role of healthcare in health alluded to earlier, public health scholars have questioned whether current levels of investment and enthusiasm in personalized medicine are the best route forward for improving population health, as opposed to greater investment in known behavioral and structural interventions.[24] Some warn that over-enthusiasm and hype may surround the new fields of medical science and innovation, as is also common for emerging technologies.[25]

Interestingly, much of the discussion about innovation in health today—in both high- and low-income countries—is not about new pills or products, but instead about improving healthcare delivery.[26] There is also excitement about new technologies and organizational innovations that may "disrupt'' existing business models—and, in particular, reduce costs without sacrificing value—though, at the same time, concerns exist about the obstacles to developing and diffusing such innovations in existing healthcare systems.[27] These trends reveal not only widespread dissatisfaction with current healthcare delivery models in many countries but also demand for new technologies that lead to cost-effective care. Interestingly, many of these new technologies are enabled by advances from another sector—information and communication technology. Information technology (IT) could have particular relevance in developing countries and resource-poor locations. Beyond their impact on healthcare delivery, new IT approaches—in particular, artificial intelligence (AI), machine learning, and big data—may also reshape drug discovery, new treatment evaluations, and the medical innovation system itself.

Conceptually, for medical innovations to have major economic impact, one of several things will have to be true:

- innovations must help prevent or treat diseases with a high disease burden, or at least eventually spill over to diseases and health problems with broad prevalence;
- treatments or interventions focused on specific diseases would have a cumulative impact, such as when genetic therapies target individual diseases;
- beyond individual disease-specific interventions, the process of innovation would be transformed by new general-purpose technologies, such as AI, machine learning, gene editing, cell therapy, and synthetic biology that open up new areas of exploration and invention;[28] or
- new technologies (e.g., digital technologies) facilitate broad systemic improvements in healthcare delivery, lowering costs and/or improving outcomes.

Predictions are hard. History teaches us that "the vast majority of attempts at innovation fail."[29] Enthusiasts making strong statements that any technology will transform, revolutionize, or disrupt healthcare should keep this in mind. However, history has also demonstrated an "inability to anticipate the future impact of successful innovations, even after their technical feasibility has been established."[30] Nathan Rosenberg and other economic historians have emphasized that technological forecasting is very difficult, since the success and economic impact of individual technologies depend, among other factors, on the rate and direction of incremental innovation following introduction, improvements in complementary enabling technologies, the scope for learning by doing and using, and the state of broader technological systems.[31] History shows that new technologies, including general purpose technologies, can take a long time to generate economic impact, and their ability to do so is contingent on many broader socio-economic factors.[32] Technical advances are often enabled by complementary advances in other fields, some of which are completely unanticipated.[33] Complicating things further, whether a technology "works" is often not known until it is embedded in clinical practice for a large number of patients.[34]

Although predicting the impact of specific areas of medical innovation is difficult, the potential for new medical innovation to generate valuable gains going forward certainly seems high, given the large value of health improvements and the unevenness of progress to date. Whether these potential gains are realized will depend on factors such as whether investments in innovation are aligned with social value, the pool of scientific and technological opportunities for advancement in different fields, the scalability of individual technical advances, and the extent to which healthcare providers and healthcare systems are incentivized to adopt and diffuse valuable new technologies. The costs of these innovations will determine affordability and ultimate benefit to patients.

Looking ahead: governing the future

Policymakers will face trade-offs in supporting and regulating new medical innovation. These include, among others:

- **Public funding:** How much should the government be spending on research? What is the right balance between spending on fundamental science and more clinical and applied activities? How should public funds be allocated across different diseases and fields, between new science and old approaches?
- **Human capital:** What kinds of educational and other investments are needed to enable the development and effective diffusion of new medical innovations?
- **Patents and intellectual property:** How should national patent laws and global governance regimes be designed to promote innovation and access/diffusion?
- **Regulation:** How strong should regulations on new health technologies be to balance risk, including potential ethical considerations, against benefits from innovation and incentives/costs of entrepreneurship?
- **Evaluation:** How and when should policymakers evaluate the cost and benefits of new medical technologies to enable the creation and diffusion of safe, effective, high-value care?
- **Costs:** What role should governments have in influencing prices? How should they do so, and how would these policies affect the rate and direction of health innovation and diffusion?
- **Diffusion:** How should health and health innovation systems be designed to promote broad diffusion of, and access to, valuable existing technologies and organizational models? How should systems be designed to encourage "disadoption" of technologies that don't work or are too costly?

The future of health innovation, and the role of medical innovation in improving health outcomes going forward, will depend on the policies and institutions created by national and global actors to support research and innovation. There are no easy answers to the questions above; they are the subject of considerable research by economists and others and in many cases involve starkly competing values and objectives. Nonetheless, they are important issues for policymakers and the public to consider carefully and deliberately—given the transformative economic, social, and health impacts that new medical technologies have had historically and the enormous potential value of further health improvements for current and future generations.

Notes:

1 Nordhaus, 2002.

2 Cutler et al., 2006.

3 Cutler et al., 2005.

4 McKeown, 1976; However even in the early twentieth century, new medical knowledge, including the germ theory of disease, helped buttress the sanitation and hygiene movements that contributed to reductions in infectious disease mortality that accounted for most of the global decline in mortality over this period; Mokyr, 1993.

5 World Intellectual Property Report (WIPO), 2015.

6 Cutler et al., 2003.

7 Cutler et al., 2003.

8 Cutler, 2008; Lichtenberg, 2013.

9 Lakdawalla et al., 2010.

10 Philipson et al., 2006

11 Thirumurthy et al., 2012.

12 Bailey, 2006.

13 Cutler et al., 2001

14 Cutler et al., 2006.

15 Cutler, 2005.

16 Nelson et al., 2011.

17 Murphy et al., 2006.

18 Goldman et al., 2013.

19 Casadevall, 2018.

20 Scannell et al., 2012.

21 Bloom et al., 2017.

22 Sarewitz, 2016; Casadevall, 2018; Gittelman, 2016; Scannell et al., 2012.

23 Casadevall, 2018.

24 Bayer et al., 2015.

25 Deyo et al., 2005.

26 Herzlinger, 2006.

27 Hwang et al., 2008; Cutler, 2011.

28 Mokyr, 2018.

29 Rosenberg, 1998.

30 Rosenberg, 1998.

31 Rosenberg, 1969.

32 David, 1989.

33 Rosenberg, 1969.

34 Gelijns et al., 2001.

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CHAPTER 3

TRENDS IN HEALTHCARE AND MEDICAL INNOVATION

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Global healthcare's significant progress in the last several decades can be attributed to advancements in biological science, which were made possible by innovative medicines, medical devices, and health provider infrastructure. While biotechnology will continue to contribute, due in large part to a combination of genomics, microbiomics, and proteomics, information technology will drive the next wave of healthcare evolution. As a result, healthcare will benefit from rapid advancements in digital technology and artificial intelligence.

The primacy of the electron over the molecule impacts all aspects of health, from helping patients stay healthy to discovering more precise and cost-effective solutions for diagnosis and treatment, and improving outcomes. Furthermore, while the innovations of previous decades disproportionately benefited the developed world, IT-led innovation should give a much-needed boost to providing basic healthcare at a greater scale and reduce significant gaps that exist between developed and developing countries today. That said, the combined innovation in biotechnology and information technology will provide individualized solutions for the developed world by discovering cures and treatments for niche and unmet medical needs.

Drivers of innovation

Five key underlying trends will bring significant change to global healthcare. Of these trends, three are technological and two are related to human behavior and preferences. Many of these trends are reaching maturity in other industries, giving healthcare a chance to leverage those that are best suited for the industry.

1. **An information revolution is taking place globally.** Broadband access and smartphone usage are becoming ubiquitous throughout the world, with 90% of the developed world and 41% of the developing world on broadband.[1] Such access enables not only the transmission of information to the patient but also the transmission of data from the patient to the provider, with room for future growth. The availability of smartphones, projected to reach 40% of the global population by 2021, also enables providers to gather patient details and deliver treatment remotely.[2] In addition to advances in communication, the collection of healthcare data has also exploded. Two examples are the sequencing, storing, and studying of individual genomes—expected to cost US$1 by 2025[3]—and the penetration of electronic health records (EHR), which currently exceeds 80% in the developed world.[4] Both have been driven largely by policy and cost.

2. **The healthcare industry is gathering all the ingredients to succeed with artificial intelligence (AI).** In its applications, AI needs rich data on the individual, cross-sectional data across a population, affordable computing, and accurate non-linear models. Prior waves of AI were unremarkable because they were missing some of these key ingredients.[5] But the information revolution has put all of the pieces into place, making it possible for healthcare practitioners to predict and diagnose diseases earlier and more accurately, select the most effective treatment, and close the loop to nudge human behavior. This will enable AI to serve as a substitute for hard-to-find clinical skills and knowledge, when appropriate.

3. **Deeper understanding of science is enabling more targeted treatments.** As more genomic data becomes available and our understanding of human biochemistry improves, the push is on to design custom products for biomarker-tagged populations, offering significant efficacy all the way up to a curative therapy. In fact, 73% of the compounds under trial in oncology are associated with biomarkers,[6] and the future will involve many highly effective—and expensive—niche medicines.[7]

4. **Consumerism is on the rise.** Particularly in the developed world, healthcare consumers have assumed a larger share of the financial burden, have access to better information for comparisons, and have developed higher expectations of a good experience. Technologies like AI combined with a push for transparency are making it feasible for consumers to demand metrics on provider quality and price. At the same time, the emphasis on experience is encouraging providers and manufacturers to offer better services.

5. **Healthcare's traditional business models are evolving.** Over time, the fragmentation of healthcare into different sectors—such as payers, insurers, providers, and manufacturers—has made the healthcare industry inefficient and rife with misaligned incentives. Many of these sectorial distinctions are now beginning to blur in the U.S., with employers getting into health management, insurers investing in care delivery, and providers exploring manufacturing opportunities.[8] Meanwhile, horizontal consolidation continues as well. Public-private partnerships are a powerful force here because the public sector has a sense of mission, the power to mandate, and the perspective to set policy for an ecosystem, whereas the private partners have the resources, the technology, and the expertise.

These five drivers are combining to create change, but to what end? The World Health Organization (WHO) defined health in its broader sense as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity."[9] At an individual or population level, this goal can be broken down into four main areas: diagnosis, treatment, outcome, and wellness (see Table 3.1 for a summary of innovations in these four steps). As each of these areas continues to be influenced by the information revolution and technological advancements, we'll get closer to creating a holistically healthy population.

Diagnosis

To improve the way that patients are diagnosed on a global scale, healthcare providers need to make tests and toolkits available to patients, have the medical skills to administer and interpret the tests, and be able to do so cheaply. Thanks in part to the prevalence of smartphones and broadband, we can tele-diagnose patients and send the data to an interpreter rather than requiring patients to travel to the access point. Technological advancements also are seeking to streamline the ongoing health tracking aspect of diagnosis by making follow-up tests, measurements, and other onerous parts of chronic conditions more convenient and less expensive. Because it's not enough

TABLE 3.1

Current innovations in the four steps to a healthy planet

Diagnosis	Treatment	Outcome	Wellness
• Two-way data transmission from the patient • Wearable tech for monitoring • AI for diagnosis, reducing skill needed • Telehealth, reducing need for proximity	• Focused factories (industrialization) • Digital therapeutics • AI for treatment selection • Data on social determinants of health • Drug discovery in silica • Faster global trials • Cell and gene therapies • Oncology advances • Precision medicine	• Real-world evidence • Value-based care	• Prevention incentives • Interventions for social determinants of health

to produce continuous data if the system cannot consume it, AI-based technologies are stepping in to digest the data. AI, of course, is "always on" and is looking for signals in data in a way that human reasoning might not be able to emulate, potentially making AI-enabled diagnoses more accurate and effective. Moreover, AI-powered diagnoses could take the place of human-driven diagnoses in some cases. An algorithm can detect pneumonia by listening to your cough on the phone,[10] whereas a human would want to listen to your heart through your lungs. This is not just moving the process of diagnosing to a remote location but reducing the need for human expertise altogether.

Treatment

Artificial intelligence can leverage data to select the most effective treatment, though it cannot by itself make that treatment option more affordable. But as business models change, providers are beginning to invest in specialized care—creating focused factories that treat a narrow problem repeatedly and that drive costs down. Examples of this range from the Mayo Clinic in the developed world to Narayana Health in India.[11] Vertical integration—especially between payers, providers, and insurers—makes it worthwhile by aligning incentives so that cheaper treatments aren't equated with revenue losses. Increasingly, social determinants of health, which include attributes that drive 60% of your health and go beyond your genome and medical history,[12] are making the enablement of health and wellness more effective in the long run. For example, food insecurity and loneliness are bigger drivers of morbidity than drugs in the elderly population,[13] and only a cross-sector entity would have the resources and influence to solve that.

Pharmaceutical drugs are a key aspect of treatment. One trend here is invention efficiency: drug development costs roughly double every 10 years.[14] Can the development be sped up or automated? A third of all AI investments in healthcare are projected to be in drug discovery,[15] specifically using computer simulation to find better molecules faster. Companies are also beginning to leverage AI and data to reduce clinical trial costs and waste, though progress has been slower than desired. The other trend in drug creation is *precision medicine*, which focuses on increasing efficacy by designing treatments for a specific patient population.

Outcome

Pricing pressures in the U.S. and the developing world are necessitating a shift to value- and evidence-based medicine. The overarching question is, are we getting good value for the countries' total healthcare spending, and at what percentage of GDP is it affordable? The value needs to include the obvious medical metrics such as disease indicators, morbidity, mortality rates, and lifespan. In the developed world, consumers need to be satisfied with the experience and patient-reported outcomes, as patients begin to demand much more than sick care. The shift from cost to value is happening slowly because incentives aren't well aligned. Healthcare stakeholders need an objective and comprehensive approach to evaluate the impact of treatment in the real world—not in an ideal, clinical trial world. The collection of healthcare data from actual patient treatments is making this real-world evidence generation possible, and investment and interest in real-world evidence have spiked threefold in the last 10 years.[16]

Wellness

We can expect to see continued taming of diseases during the next decade, but the WHO's broader goal of well-being—and avoiding all of these interventions—is coming into focus in the developed world. Will we soon be able to "predict and prevent" as opposed to "react and revive"? The biggest wellness trends are in addressing social determinants of health—for example, identifying and eliminating food deserts and promoting vaccination penetration—and individual incentives, such as nudges for exercise, proper nutrition, and data collection.[17] Information technology plays a secondary role to the change management challenges that healthcare will face when turning its focus to wellness efforts.

The promise of global health

There is universal dissatisfaction with the healthcare status quo, but the challenges and unmet needs vary widely between the developed and developing worlds. Regardless, an IT-led healthcare innovation trend promises to address the needs of patients across the globe, but in different ways (summarized in Table 3.2).

In the developed world, the rising cost of healthcare has been a prominent subject lately, but other issues such as medical errors, overworked healthcare professionals, and poor patient experiences are equally important. In contrast, the developing world is challenged to provide basic healthcare beyond a small urban segment, with limited government budgets and a severe shortage of healthcare professionals and infrastructure. The contrast is stark. For example, while India and Africa combined share nearly 45% of the global disease burden,[18] they employ less than 5% of the world's healthcare professionals.

The next wave of healthcare innovation ideally will connect all aspects of individual and population health, including diagnosis, treatment, outcome, and wellness. It will also impact the four main elements of the healthcare delivery system: cost, access, outcome and customer experience. And because health systems have different needs in different parts of the world, the level of impact will vary.

Impact in the developed world

In the developed world, innovation is likely to have the greatest impact on reducing costs, improving outcomes, and moving to targeted and individualized treatment. We're also likely to see an improvement in the experiences for patient and healthcare professionals.

On the cost front, manual processes and health data silos are some of the key drivers for wasted spending. It is estimated that in the United States of America (U.S.) alone, wasted spending exceeds US$1 trillion annually.[19] In recent years, there has been

TABLE 3.2

The four elements of the healthcare delivery system will impact the developed and developing worlds differently

	Level of impact and potential solutions	
Element of the healthcare delivery system	**Developed world**	**Developing world**
Reduced cost	**Impact: high** • Reduce administrative cost with automation • Reduce waste with diagnostics and more targeted treatment • Reduce drug development cost with drug development in silica and precision medicine	**Impact: high** • Scale basic healthcare without proportionate increase in cost
Improved healthcare access	**Impact: moderate** • Provide better healthcare support in remote areas and convenience with telemedicine	**Impact: very high** • Provide platform-based basic healthcare to a large population using a combination of universal electronic health record (EHR) systems and mobile health applications
Health outcome	**Impact: high** • Raise health awareness with wellness applications • Improve diagnosis with AI-based diagnostics and targeted treatments • Move to value-based healthcare where outcome is the new currency of success and focus for healthcare players • Make treatments more targeted and individualized with move to precision medicine	**Impact: moderate** • Improve health outcomes for the rising middle class
Customer experience	**Impact: high** • Improve consumer experience with reduced wait time, improved long-term engagement	**Impact: low** • Recognize that customer experience is important to a small percentage of the urban population in a largely cash market

a surge in start-ups promising to reduce inefficiencies using intelligent automation. These range from intelligent scheduling and revenue booking systems to AI-based virtual assistants that can capture patient stories into electronic health records systems. Moreover, two-thirds of doctors would like AI to help with workflow management, administrative assistant tasks, and patient experience analysis.[20]

The high cost of drug development is also a source of rising healthcare spending. AI can speed up drug discovery (more than a third of AI investment in healthcare is in this space[15]), cut R&D costs, decrease failure rates in drug trials, and eventually create better medicines. Artificial intelligence also will help reduce clinical trial costs and timelines by not just predicting trial enrollment and duration, but also making them adaptive.

Remote monitoring can make clinical trials more patient-centric and thereby help to cut a 30% abandonment rate.[21]

Another trend in the developed world is the move from a fee-for-service to a value- or outcome-based care model. As patient data becomes richer and more complete, the ability to measure the outcome has improved significantly. This shift likely will encourage a "holistic" treatment team approach to care in which parties will be paid for providing better care—outcomes and satisfaction—at a lower cost.

The current "react and revive" approach to healthcare is designed to help the sick get better as opposed to the "predict and prevent" approach in which the focus is on helping people stay healthy. A focus on wellness and preventive measures helps to delay the onset of disease, and self-diagnosis tools help to reduce the dependency on healthcare systems for ongoing health maintenance. More precise diagnosis augmented with automated expertise will significantly reduce onerous tests that are currently conducted to identify and monitor disease conditions.

Care is also likely to move to more customization, as treatments can be targeted for individual genetic profiles and biomarkers. Pharmaceutical companies are making large investments in precision medicine to create more targeted and niche therapies that are angling to replace mass-market medicine.[22]

Poor patient experience is another major source of dissatisfaction. In the U.S., patients wait over 24 days for scheduled appointments and have to provide the same information multiple times to different healthcare professionals.[23] Healthcare stakeholders are increasingly using virtual and augmented reality to make the patient experience more engaging and interactive. These technologies are being integrated into patient treatment and engagement efforts, enhancing the ability to improve patient outcomes.

Impact in the developing world

In the developing world, the biggest unmet need is providing basic and affordable healthcare at scale. The last decade has seen a significant increase in government focus on healthcare, including several mobile health, telemedicine, and AI-based initiatives in China, India, and some African countries. China has already edged closer to Europe in leading health indicators, while Africa still lags far behind and India is somewhere in between. As an example, the leading cause of death is moving from infectious diseases to non-communicable diseases (85% in China compared to 61% in India[24]). The next phase of healthcare evolution in these countries will require universal access to basic healthcare and a way to address the demanding needs of growing middle-class populations.

A platform-based healthcare approach, with an integrated e-health record system powered by mobile health, telemedicine, and AI-based diagnosis and treatment can help developing countries leapfrog ahead on healthcare access at scale without the need to proportionately increase healthcare facilities and professionals.

Mobile devices have become increasingly common in developing countries and, most recently, there has been an emergence of inexpensive smartphones like Reliance Jio in India. The smartphone's applications enable users to schedule appointments and order medicines,[25] and to access simple diagnostics and self-monitoring tools. The growing wearable devices market provides mobile devices with an interface designed to capture vital signs. For example, South African start-up Vitls developed a tool that enables healthcare providers to continuously and remotely monitor a patient's pulse, respiration rate, body temperature, sleep, and movement patterns.[26] In another example, Khushi Baby developed a program to address an unmet need in rural India with its digital necklace that stores immunization records.[27]

China is turning to AI-based technologies to provide better healthcare, especially in rural areas where doctors are relying on perceptual senses, like vision and hearing, to gather information about patient health.[28] In India, Arvind Eye Care is working with Google Brain to detect signs of diabetes-related eye disease by analyzing photographs.[29]

To offer platform-based healthcare access at scale, countries will need mobile health, telemedicine, and AI to integrate with universal patient health records. This would help healthcare access evolve from acute diagnosis and treatment to the deployment of preventive measures and the management of chronic diseases. Encouraged by the success of Aadhaar, a biometric-based universal identification system for 1 billion people,[30] India is embarking on an ambitious project called Ayushman Bharat to provide health insurance to 100 million families.[31] One goal of such a program will be to develop a database of EHR records for registered patients. China is embarking on a similar effort with a Precision Medicine Initiative to sequence the genomes of 100 million individuals by 2030. But there are multiple challenges to overcome in building a universal EHR database, and it's likely to be a while before we see material progress in this area.

By focusing on providing healthcare access at scale, developing countries will improve healthcare quality, outcomes, and experiences for their growing middle- and upper-middle-class populations. These populations often pay cash for healthcare and demand a better experience, which is why China and India, in particular, are launching advanced technology-led customer experience initiatives to serve them.

Moving from defining the promise to realizing the promise

A variety of forces, in both the developed and developing worlds, will challenge technology-led changes to healthcare. In developed countries, overcoming legacy issues, such as silos in healthcare data and systems, and leading change management for healthcare professionals and other stakeholders will be the greatest challenges. That said, the enablers for change will include increasing cost pressure and rising consumer power, likely resulting in operational efficiencies through automation and leveraging AI as an assistant—rather than a peer or advisor—to the physician. Government will play an important role in setting up policies and enable an environment where different stakeholder incentives align to drive the intended change.

Meanwhile, developing countries are starting with more of a clean slate, but they are challenged by affordability and the priority that their governments give to healthcare. China is an exception, since its government is likely to drive the change, but elsewhere in the developing world, effective public-private partnerships may be critical to driving progress in platform-based healthcare. To entice the private sector to invest in healthcare, developing countries can leverage well-structured partnerships that mobilize private investment into public service delivery, and that have a risk-sharing agreement built in. In the last few years, public-private partnerships in the health sector have brought immense benefits to the poor in Africa,[32] and the approach to healthcare innovation has been effective in a few countries, including Kenya, Tanzania, and Ghana. As partnerships of this kind are highly complex undertakings, it is important for governments to ensure that project outcomes support larger health system goals and that facilities and services developed by the public-private partnerships are integrated into the broader health system.

We are at the beginning of a significant shift as the primary driver of global healthcare impact switches from biotechnology to information technology. This shift holds considerable promise for healthcare in all parts of the world—developed and developing. The overall impact of this evolution ought to increase life expectancy and quality of life everywhere. But while the promise is exciting and immense, the speed of progress will depend on how the various stakeholders work to find common ground, focus on the right priorities, and find creative models for success through affordable scale.

Notes:

1 ITU, 2017.

2 Next Conference, 2018.

3 Medium, 2017.

4 KPMG, 2018; The Office of the National Coordinator for Health Information Technology, 2017.

5 Quartz, 2018; Quartz, 2017.

6 ThermoFisher Scientific, 2018.

7 Genome Biology, 2018; The Conversation, 2018.

8 Bailey Southwell & Co., 2018.

9 World Health Organization, 2011.

10 MedCity News, 2017.

11 Advisory Board, 2015; The Commonwealth Fund, 2017.

12 GoInvo, 2017.

13 NCBI, 2018; BMJ Open, 2017.

14 The Library of Economics and Liberty, 2017.

15 MarketWatch, 2019.

16 Leela Barham Economic Consulting, 2017.

17 Healthcare Intelligence Network, 2019.

18 NCBI, 2018; BusinessWorld, 2019.

19 Health Affairs, 2018.

20 The Active Ingredient, 2018.

21 CenterWatch, 2016.

22 Critical Care, 2017.

23 Forbes, 2017.

24 World Health Organization, 2015; Times of India, 2017.

25 Practo; MedLife.

26 Disrupt Africa, 2017.

27 Global Citizen, 2018.

28 TechWire Asia, 2018.

29 VentureBeat, 2019.

30 FirstPost, 2017.

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CHAPTER 4

TEN OPPORTUNITIES FOR BIOMEDICAL INNOVATION OVER THE NEXT TEN YEARS

Francis Collins, National Institutes of Health (NIH)

As the world's largest public funder of biomedical research, the National Institutes of Health (NIH) provides a unique vantage point from which to survey—and to shape—the rapidly evolving landscape of biomedical innovation. Over many decades, NIH's scientific vision has proven crucial to the health and economic well-being of those living in the United States of America (U.S.). But NIH is also a major supporter of global health that holds increasing promise for low- and middle-income countries, and medical research essentially knows no national boundaries.

Let us begin by recognizing that the future of biomedical innovation is built on fundamental knowledge—that the long arc of discovery begins with basic science. Experiments going on right now in basic laboratories around the globe contain the seeds of advances that will transform medicine and improve human health. We can already identify a great number of promising opportunities on the near horizon. This chapter will highlight 10 of the most exciting areas in which, given a sustained commitment of resources for biomedical research, we can expect to see striking progress 10 years from now. It will also examine scientific and public policy challenges that fall along the pathway to biomedical innovation, as well as explore a few examples of the many creative mechanisms being used by NIH and its partners to address such challenges.

Making big plans

The architect Daniel Burnham once said, "Make no little plans, they have no magic to stir men's blood and probably themselves will not be realized." While the source of the next major innovative breakthrough is hard to predict, the NIH has big plans—some might even say audacious plans—for biomedical innovation in the near future. Following is a high-level overview of 10 of the many rapidly emerging fields of biomedicine in which we anticipate extraordinary advances over the next decade.

Single-cell analysis

Let us fast-forward to 2029 and what is likely to be among the first of these 10 breakthroughs: advances in the understanding of the exquisite complexity of the functions of individual human cells. Cells are to biology what atoms are to chemistry—the basic unit of understanding. Yet, during the long history of biomedical research, scientists have not possessed the technical ability to study individual cells in their normal environment. Instead, they have had to be content with low-resolution technologies that could only analyze millions, or maybe even billions, of cells as a group. With a variety of new technologies invented in the last few years, especially to ascertain what genes are turned on or off in an individual cell, this is all changing.[1] For example, using new approaches to single-cell analysis, we can now decode the process by which individual immune cells attack and destroy healthy tissue in autoimmune disorders. This promises to transform how healthcare professionals approach lupus, rheumatoid arthritis, multiple sclerosis, and many other autoimmune diseases. Likewise, single-cell analysis will likely prove valuable in understanding—and combating—the deadly process of cancer metastasis, in which malignant cells spread from their original location into other vital parts of the body, such as the brain, bone, lungs, and liver.

Mapping the brain

Improved understanding of basic science is also the aim of the NIH-led Brain Research through Advancing Innovative Neurotechnologies® (BRAIN) Initiative.[2] With roughly 100 billion cells and 100 trillion connections, the human brain remains one of science's most daunting frontiers and one of medicine's greatest challenges. In a decade, researchers will have used the tools and technologies developed through BRAIN to identify the hundreds of different types and subtypes of cells within our brain. Beyond that, BRAIN-supported research will also have mapped the key features of the circuits responsible for motor function, vision, memory, and emotion—all functioning at the speed of thought. As a result, we will have a much better grasp of the details of how the brain works in real time. This understanding will enable healthcare professionals to diagnose neurological conditions earlier and more precisely. We will also have uncovered new targets to explore for prevention and treatment of autism, epilepsy, traumatic brain injury, schizophrenia, Parkinson's disease, and many other disorders in urgent need of new approaches. Progress will even be made against formidable foes like Alzheimer's disease and spinal cord injuries.

Alzheimer's disease

Aided by new imaging techniques developed and optimized by the BRAIN Initiative, and biomarker discoveries made through NIH's partnership with private sector collaborators,[3] we will be able in 10 years time to identify individuals at high risk for Alzheimer's disease even before symptoms appear. Right now, this fatal, neurodegenerative condition can only be conclusively diagnosed by examining the brain after death. With the arrival of ways to diagnose Alzheimer's much earlier, healthcare professionals may be able to provide at-risk people with effective therapies aimed at slowing or changing the course of the disease. Such innovation would delay or avert countless personal and family tragedies all around the world and translate into hundreds of billions of dollars of economic savings in the U.S. alone. Even the ability to delay the onset of cognitive decline by five years could provide profound human and economic benefit.

Spinal cord injuries

A decade from now, we will have developed effective treatments for spinal cord injuries. Already, groundbreaking research supported by NIH has enabled several young men, paralyzed from the waist down by a traumatic injury, to move their legs and walk through the use of surgically implanted electrical stimulators that bypass the severed cord.[4] Other NIH-funded work has used a noninvasive spinal stimulation technique—electrodes strategically placed on the skin—to help people with lower body paralysis move their limbs again and those with upper body paralysis improve hand strength and dexterity.[5] With additional follow-up studies, we may be able to give freedom of movement back to many more of the millions of people worldwide who are coping with spinal cord damage from traffic accidents, sports injuries, and other trauma.

Pain management

Ten years from now, researchers in the public and private sectors will have made tremendous progress toward developing effective, non-addictive, non-opioid approaches to pain management. Chronic pain is a serious and costly public health problem, affecting tens of millions of people worldwide. NIH researchers recently showed that disability is just as likely for people suffering from chronic pain as it is for those with kidney failure, emphysema, or stroke. Unfortunately, current treatments used to manage chronic pain can be addictive, and that can lead to tragic outcomes. In the U.S., more than 130 people die every day from overdosing on opioids.

To help tackle this monumental challenge, the NIH recently launched the Helping to End Addiction Long-Term (HEAL) research initiative.[6] A key part of this effort is developing non-addictive strategies for preventing and managing pain. Toward that end, NIH-supported researchers are utilizing the latest advances in genomics, neuroscience, and structural biology to better understand the biology of pain, and to uncover entirely new targets for treating this longtime scourge of humankind. For example, in a recent study of over 1,600 people injured in traffic accidents, researchers discovered that individuals with a specific variant in a stress-controlling gene, called *FKBP5*, were more likely to develop pain than those with other variants.[7] The findings suggest that non-addictive small molecules that target the FKBP5 protein might reduce the pain response or prevent the transition from acute to chronic pain.

Regenerative medicine

The next decade will also witness large strides in regenerative medicine.[8] For example, many are eagerly awaiting the introduction of a safe and effective bioartificial pancreas. For individuals with diabetes, such a system will continuously track changes in blood glucose levels and use that information to deliver more precise doses of insulin. Already approved are various "closed loop" systems,[9] which typically use wireless technology to connect a monitor that continually measures the amount of glucose in a person's body with a small pump that, using real-time data from the monitor, infuses an appropriate dose of insulin subcutaneously. Such real-time monitoring and dose adjustment should significantly improve the management of diabetes, preventing countless complications like heart disease, amputations, and vision loss.

However, the ultimate achievement would be the creation of a completely biological replacement pancreas. To reach this goal, researchers might take advantage of bioengineering advances that enable reprogramming of a patient's own cells, ideally implanted within the portal circulation.[10] The amazing innovation that makes this type of breakthrough a real possibility is induced pluripotent stem cell (iPS) technology. Derived from mature human skin or blood cells, iPS cells can be encouraged to differentiate into a wide variety of human tissues in the lab, including pancreatic islet cells that respond to blood glucose and make insulin. In fact, some researchers recently used iPS cells, in combination with other regenerative medicine techniques, to produce human pancreatic islets that not only secrete insulin, but also develop their own circulatory system to nourish the islets.[11] When transplanted into a mouse model of type 1 diabetes, these bioengineered islets successfully treated the animals' diabetes. Not only do iPS cells hold the potential to help people with diabetes, they may also make it possible to make advances in many other areas of regenerative medicine. For example, it will likely be possible to rebuild damaged hearts, kidneys, and livers—rendering many organ transplants, organ waiting lists, and anti-rejection drugs a thing of the past.

Cancer immunotherapy

Cancer is another regrettably common disease poised for significant progress over the next decade, especially in the area of immunotherapy.[12] In the early 1970s, basic research, spearheaded in large part by NIH-funded scientists, led to the development of methods to splice fragments of DNA together, giving birth to the field of biotechnology. When merged with fundamental advances in molecular immunology, this set of technologies made it possible to pursue ideas for cancer immunotherapy—a radical new approach that involves enlisting a patient's own immune system in the fight against cancer. In one promising strategy, immune cells are collected from patients and engineered to produce special cancer-fighting warriors, called chimeric antigen receptors. This work has already saved the lives of many children and adults with treatment-resistant leukemia, lymphoma, and other blood cancers.[13]

Now, cancer researchers in the public and private sectors are setting their sights on even tougher targets: breast, prostate, colon, ovarian, pancreatic, and other solid types of cancer, which have so far proven rather resistant to immunotherapy. Recent developments make us optimistic that a pathway forward is taking shape. In the last couple of years, an NIH team announced a novel modification of an immunotherapy approach, built upon a precise understanding of the driver mutations in a particular individual's cancer. This strategy led to regression, most likely cure, of widely metastatic disease in individuals with breast cancer and bile duct cancer.[14] Of course, this must be replicated in further studies, but without a doubt, these life-saving experiences represents hope for millions more. How phenomenal it would be if we could offer people with solid tumors that have metastasized to other parts of the body a chance of not just being treated, but actually being cured of their disease.

New vaccines

Important strides will also be made in the next 10 years in the prevention of influenza, HIV, and many other infectious diseases, thanks to the development of innovative vaccine strategies. Currently, a new flu vaccine must be produced each year to protect against the rapidly mutating influenza virus. Despite our best efforts, the vaccine isn't always ideal and, in an average year in the U.S. alone, the flu kills nearly 50,000 people, at a cost to the economy of more than US$87 billion. But it does not have to be that way. NIH is providing substantial resources to catalyze the arrival of a "universal" flu vaccine—strategically designed to target mutation-resistant parts of the influenza virus—that will provide long-lasting protection against a wide variety of flu strains. Not only will such a vaccine reduce the need for the annual flu shot, it will prepare us for the next overdue worldwide pandemic, potentially saving millions of lives. Human clinical trials of the first version of such vaccines are now underway, through active collaboration between NIH and industry.[15]

We are also optimistic that a safe, effective vaccine for HIV/AIDS will finally be available, providing an opportunity to bring an end to this most frightening and costly global epidemic. One approach involves the assumption that a particular type of immune response would be protective against HIV infection. After all, some people living with HIV naturally produce broadly neutralizing antibodies (bNAbs), albeit too late after infection to clear the virus. Researchers have isolated— from people living with HIV—several varieties of bNAbs that have been shown in the laboratory to inhibit most HIV strains from infecting human cells. The challenge is to use that information to design a vaccine that will induce production of bNAbs in individuals who have never been exposed to HIV. Tests in animals have been encouraging, and a first-in-human trial is expected to begin within a year.[16]

Gene editing to cure disease

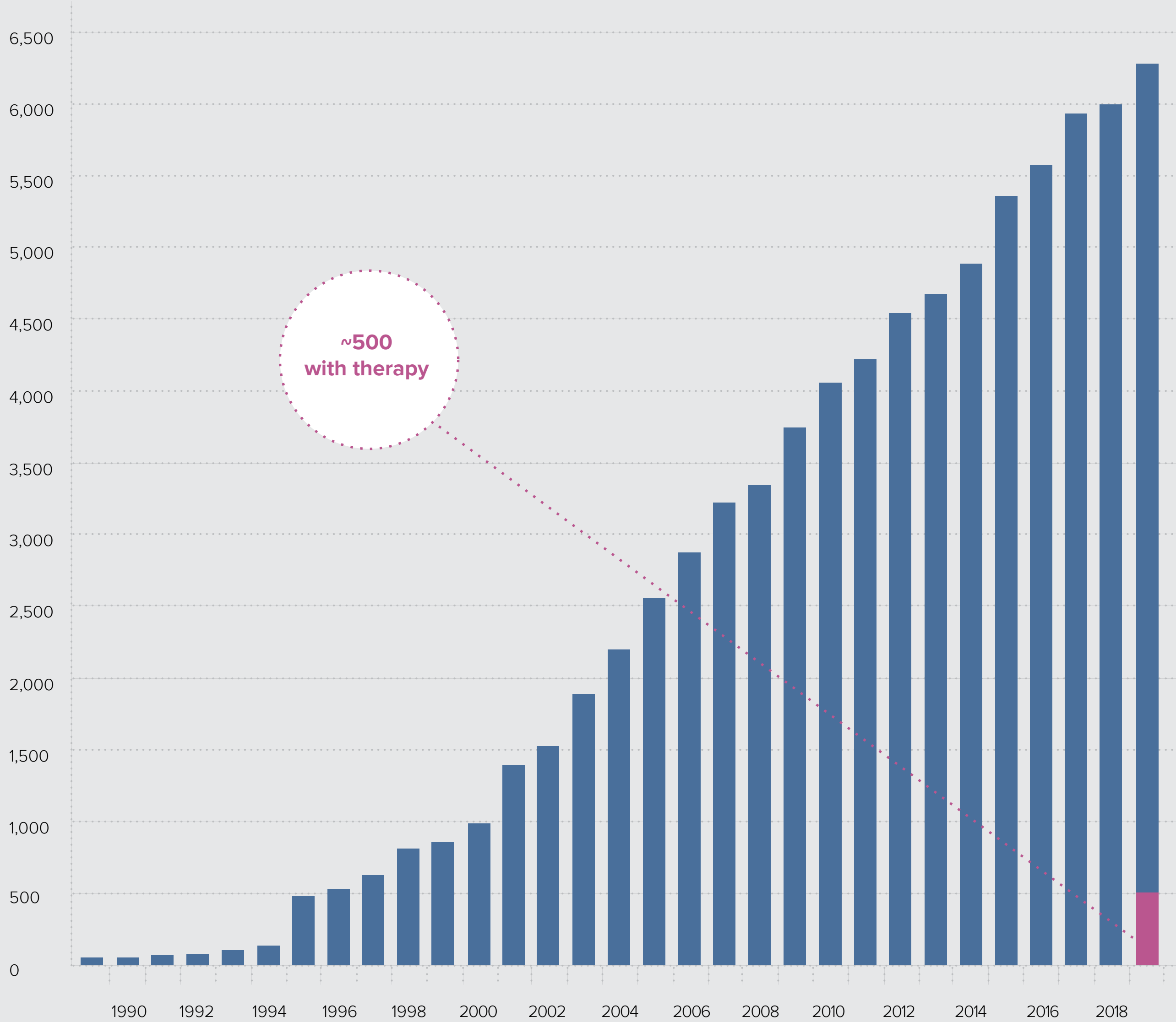
Within the next 10 years, biomedical research will also begin to realize the promise of new genetic technologies to treat or even cure diseases that once seemed out of reach. Scientists have identified the molecular causes of nearly 6,500 human diseases, yet treatments currently exist for only about 500 (Figure 4.1). Particularly exciting is the potential of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR-Cas) technology for somatic cell gene editing—an approach that corrects gene mutations only in relevant tissues without the risk of passing those changes on to a future generation.

One of the first successful applications of gene editing will likely be for curing sickle cell disease (SCD), which affects over 20 million people worldwide, mostly in developing nations.[17] SCD is the first "molecular disease," with its genetic cause having been identified many decades ago. However, the need for a widespread cure for SCD has not been met. Since 1998, doctors have used a drug called hydroxyurea to reduce symptoms, but it can cause serious side effects. At present, the only way to cure SCD is through a bone marrow transplant, which is not an option for many patients due to a lack of matched donors, or possibly through experimental gene therapies delivered by viral vectors. CRISPR-Cas gene editing is offering a new strategy: remove blood precursor cells, called hematopoietic stem cells (HSCs), from a patient's own bone marrow or bloodstream; use the magic of CRISPR-Cas to fix or offset the negative effects of the SCD-causing gene mutation in the HSCs; and then return the now-cured—no longer sickling—HSCs to the patient. Admittedly, that rather complicated process may not be practical for quite some time in places like sub-Saharan Africa. That is one reason why NIH recently launched a new effort to speed the development of safe, effective genome-editing approaches that could be delivered directly into a patient's body (*in vivo*), perhaps by infusion of the CRISPR gene editing apparatus.[18]

As research moves forward in the fast-paced field of genetic therapy, it will be important that these endeavors remain ethical, but also remain bold, on behalf of the hundreds of millions

FIGURE 4.1

Disorders with known molecular basis



Source: Online Mendelian Inheritance in Man, available at https://www.omim.org/statistics/geneMap.

of people with genetic diseases who are still awaiting cures. Importantly, those therapeutic strategies can be pursued without altering the part of the genome that is inherited by future offspring. Over the next decade and beyond, scientific, economic, and thought leaders around the globe must continue to assess and address the very serious ethical concerns raised by *germline* gene editing of human embryos, which will irreversibly alter the DNA instruction book of future generations of humankind. NIH contends that our society is not ready to undertake such experiments in the foreseeable future.[19]

Precision medicine

Thanks to opportunities that span a wide range of biomedical disciplines, we also have the potential to develop a wide variety of tailored approaches to medicine that reflect the fact that not all individuals are the same. In the U.S., this opportunity will be enabled by the NIH-led *All of Us* Research Program.[20] This monumental undertaking is building a research cohort of 1 million or more volunteers from all across the nation, with roughly half of those participants coming from traditionally underrepresented racial and ethnic minorities. *All of Us* will capitalize on a broad array of innovations in a wide range of scientific fields. For example, it will apply the latest methods and approaches in data science, including advances in large-scale databases, computational tools, and "omics" methodologies of characterizing individuals. The aim is to pioneer efforts to merge, integrate, and analyze data from a wide variety of sources—biological, environmental, socioeconomic, and geospatial—that have implications for individualized disease prevention and treatment, and for understanding the causes and the solutions to health disparities.

NIH envisions that the willingness of the diverse array of *All of Us* participants to share a wide variety of their health-related information will establish a valuable research resource that will foster the emergence of important new insights—basic, translational, and clinical. Such insights will ensure that people from all walks of life, all around the world, will be healthier than ever.

Overcoming challenges together

This list of opportunities for biomedical innovation is ambitious. Not only will it take tremendous effort and ingenuity on the part of the worldwide research community to make these 10 advances happen in just 10 years, but it will also require some serious actions by other sectors of society. Perhaps the most significant action will be encouraging the next generation of researchers through a strong, sustained commitment to biomedical research by the public sector. The most important resource for the future of biomedical research is not buildings or technologically advanced equipment—it is the people that will have the dreams and do the work.

NIH leadership has recently taken several creative steps aimed at spurring biomedical innovation. These actions include: initiating special awards to encourage high-risk, high-reward research; encouraging the next generation of researchers; launching prize competitions aimed at finding innovative solutions to major health challenges; and fostering the development of public-private partnerships to accelerate and transform current models for developing new diagnostics and treatments. However, NIH cannot do this alone. We need partners in the public policy and private sectors from all around the world to realize the full potential of biomedical innovation over the next decade and beyond. Among the areas in which we are calling our global partners to join us are measures aimed at facilitating data sharing, improving scientific rigor and reproducibility, and establishing oversight for emerging biotechnologies.

Data sharing

Opportunities to harness the power of big data and new technological breakthroughs in artificial intelligence (AI) and machine learning will depend on the development of infrastructure and policies that reflect the Findable, Accessible, Interoperable, and Reusable (FAIR) principles.[21] This includes the establishment of field-appropriate data standards and interoperable, sustainable data resources. While protection of privacy and confidentiality of research participants is crucial, certain data protection policies and regulations may present obstacles to data sharing, especially through variable and conservative interpretation of such regulations in the absence of clear guidance from governmental entities and coalitions.[22] We are working with our global counterparts across the public sector to find the balance between appropriate data protection and accessibility for research progress.

Rigor and reproducibility

Two of the related cornerstones of biomedical innovation are rigor in designing and performing research, along with the ability to reproduce research findings.[23] The application of rigor ensures robust and unbiased experimental design, methodology, analysis, interpretation, and reporting of results. When a result can be reproduced by multiple scientists, it validates the original results and indicates readiness to progress to the next phase of research. This is especially important for clinical trials in humans, which are built on studies that have demonstrated a particular effect or outcome. Research funders and journals are establishing policies to ensure rigorous methodology in all realms of research, including power analyses, validation/authentication of reagents or cell lines, justification of animal models, and consideration of sex as a biological variable.

Oversight of emerging biotechnologies

For new and emerging biotechnologies, it is appropriate to establish oversight systems commensurate with the risk and uncertainty related to the technology. However, such oversight systems need to be flexible enough to adjust as the technology, and the related risks, are better understood. For example, recombinant DNA merited intense scrutiny and oversight in the late 1970s, when the technology was new, the risks were unknown, and biosafety systems to contain the risk were in their infancy. Over time, our understanding of the risks has become highly sophisticated, the technology has become ubiquitous, and biosafety protocols have become well established, thus allowing a risk-based adjustment to the framework of oversight.[24]

Compare that to a new technology such as gene editing. The use of CRISPR-Cas for creating gene-edited babies has already been highlighted above. But that is not the only application that raises ethical and societal concerns. Consider the use of CRISPR-based gene drives for control of disease vectors like mosquitoes, where the environmental risk is still uncertain and where high levels of precautionary oversight are still warranted.

In closing, it is imperative that we keep our minds open to the possibility that this vision of future opportunities—and future challenges—may change, perhaps even dramatically, over the next decade. There certainly is no guarantee that these 10 goals will be attained by 2029, but they are offered as examples in hope of inspiring the rapidly moving field of biomedical research to aim even higher for the benefit of all humankind. As has been the case so often in the past, the greatest biomedical innovations of tomorrow may very well come from directions that none of us could anticipate today.

Notes:

1 National Institutes of Health. 2018c.

2 National Institutes of Health, n.d.-b.

3 National Institutes of Health, n.d.-c.

4 National Institutes of Health, 2014.

5 Lu et al., 2016.

6 National Institutes of Health, 2019a.

7 Linnstaedt et al., 2018.

8 National Institutes of Health, n.d.-d.

9 Russell et al., 2014.

10 Yoshihara et al., 2016.

11 Takahshi et al., 2018.

12 National Institute of Health, 2018e.

13 Novartis, 2017.

14 Zacharakis et al., 2018.

15 National Institutes of Health, 2018a.

16 National Institutes of Health, 2018f.

17 Collins, 2018b.

18 National Institutes of Health, 2019b.

19 Collins, 2018a.

20 National Institutes of Health, n.d.-a.

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22 European Commission.

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CHAPTER 5

APPLICATION OF ARTIFICIAL INTELLIGENCE AND BIG DATA IN CHINA'S HEALTHCARE SERVICES

Ma Huateng, Tencent

In recent years, with a flourishing economy and the continuous progress of medical reform, China's healthcare system has experienced rapid expansion and significant service improvements. Today, there are over one million medical institutions in China.[1] Medical insurance covers more than 95% of the Chinese population.[2] Life expectancy has reached 76.4 years, an average higher than that of some high-income countries.[3]

However, population aging has put enormous pressure on China's healthcare system. To relieve this pressure, we consider how technology could help improve healthcare efficiency, and how solutions could be integrated into the healthcare system to help relieve the pain of patients and reduce the financial and psychological burden on their families.

The next generation of information technology (IT) represented by artificial intelligence (AI) and big data analytics could offer new tools to address China's healthcare challenges. Medical AI has the potential to complement doctor resources and enable broader access to high-quality medical services. This is of great significance for China where the current supply of healthcare services falls short of the growing demand from an aging population of 1.4 billion.

Impetus: potential of IT integration and innovation in China's healthcare services

The integration of IT into China's healthcare services is an inexorable trend and will unleash great potential. Growing demand for healthcare services, a favorable policy environment, surging capital investment, and emerging technology are four driving factors. Combined, they bring new opportunities for IT integration and innovation to the healthcare system and facilitate innovative applications on a global scale.

1. Demand: growing healthcare demand creates opportunities for technological innovation

China's large healthcare sector is in the process of rapid expansion. Total national health expenditures exceeded 5 trillion yuan in 2017, accounting for 6.2% of the gross domestic product (GDP).[4] This number will reach 16 trillion yuan by 2030, according to the *Healthy China 2030 Planning Outline*.[5]

This growth in national health expenditures is creating opportunities for medical AI in China. According to Tractica's forecast, China's AI medical market is developing rapidly, with the market size soaring from 9.661 billion yuan in 2016, and 13.65 billion yuan in 2017, to 20.4 billion yuan in 2018, maintaining a compound annual growth rate of more than 40%.[6] At the same time, Chinese medical institutions and businesses are taking a proactive attitude towards AI. Nearly 80% of hospitals and medical companies are planning to, or already have, carried out medical AI applications and more than 75% of hospitals believe that such applications will become popular in the future.[7]

2. Technology: increasing standards and patents safeguard innovation

In recent years, AI technologies have flourished globally, and particularly in China. According to the Derwent World Patents Index (DWPI), global annual AI patent applications have surged since 2010. China contributed the highest number with a total of 76,876 applications from 1985 to 2017 (Figure 5.1). According to the China Patent Abstract Database (CNABS), the top five patent applicants in China were Baidu, Chinese Academy of Sciences (CAS), Microsoft, Tencent, and Samsung.[8]

According to the Patentics database, in the field of healthcare, keyword analysis of global AI patents indicates two features.[9] During the period 1985 to 2017, China ranked fourth in the total number of healthcare AI patent applications filed, contributing to 12% of the total. This implies that China's technological innovation has been comparatively less active in the field of healthcare AI compared to overall AI activity. In this same period, China rapidly increased patent applications from 2010 and surpassed Japan and the European Union to become the world's second largest healthcare AI applicant in 2016, which reflects the strong momentum of medical technology innovation in China (Figure 5.2).[10]

Also in the Patentics database, China's healthcare AI patents are classified into five categories: medical diagnostics, nursing/caring, medical devices, data and archiving, and pharmaceuticals. Among them, patents for AI in medical diagnostics and nursing/caring account for 29% and 28% respectively, far more than any other category, making these the two most active fields of healthcare AI innovation in China (Figure 5.3).

3. Capital: accelerating capital investment fuels innovation

Healthcare AI is drawing the attention of investors, which is bringing capital to the field and accelerating technological innovation. According to third-party statistics, global healthcare AI start-ups have raised US$4.3 billion through 576 deals since 2013. China overtook the United Kingdom in the first half of 2018 to become the second most active country in terms of capital investment in healthcare AI.[11]

Innovation: emergence of AI and big data applications in China's healthcare

Under favorable market and policy environments, healthcare AI and big data have developed more quickly in recent years. From 2007 to 2017, more than 100 companies dedicated to healthcare AI emerged in China. Since 2014, a surge in companies entering the space has caused innovation to accelerate.[12]

Many types of businesses and institutions have participated in the development of healthcare AI in China. Representative participants range from established Internet companies to technology start-ups, from healthcare software companies to medical device manufacturers, and from pharmaceutical companies to hospitals, universities, and research institutions.

Attempts to apply AI to over 20 types of diseases have been made. Lung cancer diagnosis and diabetic retinopathy are the most popular applications and are attracting the most start-ups. Many companies are also exploring AI applications in cardiovascular diseases.[13]

AI has already been extensively integrated into several sub-fields of the healthcare sector. In addition to medical services and hospital management and administration, applications are also deployed in fields such as pharmaceutical research and development, cost control for payers, and health management for individual consumers.

1. Smart doctors: leveraging medical imaging

Medical imaging has become the leading and most popular field for AI application in China's healthcare sector, having benefited from the mature technology found in machine learning-based image recognition and from the availability of massive medical imaging data. A wide range of products targeting cancers and chronic diseases have entered the clinical validation phase. These products focus on areas such as disease screening, target volume delineation for radiation therapy, and three-dimensional reconstruction.

In disease screening, AI-enabled software automatically marks lesions so that doctors can improve their focus and efficiency when reading medical images by referencing these marks. Clinical Target Volume (CTV) delineation, mainly used in radiotherapy, employs AI to automatically delineate target volumes based on medical images generated from computed tomography and/or magnetic resonance imaging machines.[14] The results are then subject to use and correction by doctors. The application can significantly shorten the time required by traditional manual delineation and accelerate the implementation of radiotherapy. Three-dimensional reconstruction refers to the automatic creation of 3D models of human organs by machines, from which realistic physical models can be obtained to facilitate high-quality surgical procedures and other medical treatments.

For example, Tencent AI Medical Imaging, developed in 2017, is a system used for screening several diseases such as diabetic retinopathy, lung cancer, and esophageal cancer. The system is undergoing clinical validation in more than 100 major hospitals in China. It has assisted doctors in reading over 100 million medical images and served nearly one million patients cumulatively.

With the advancement of image recognition technologies, diagnostic precision has reached new levels. For example, data from Tencent shows that recognition accuracy reaches 90% for esophageal cancer, 97% for diabetic retinopathy, and 97.2% for colorectal cancer, making disease screening highly effective.

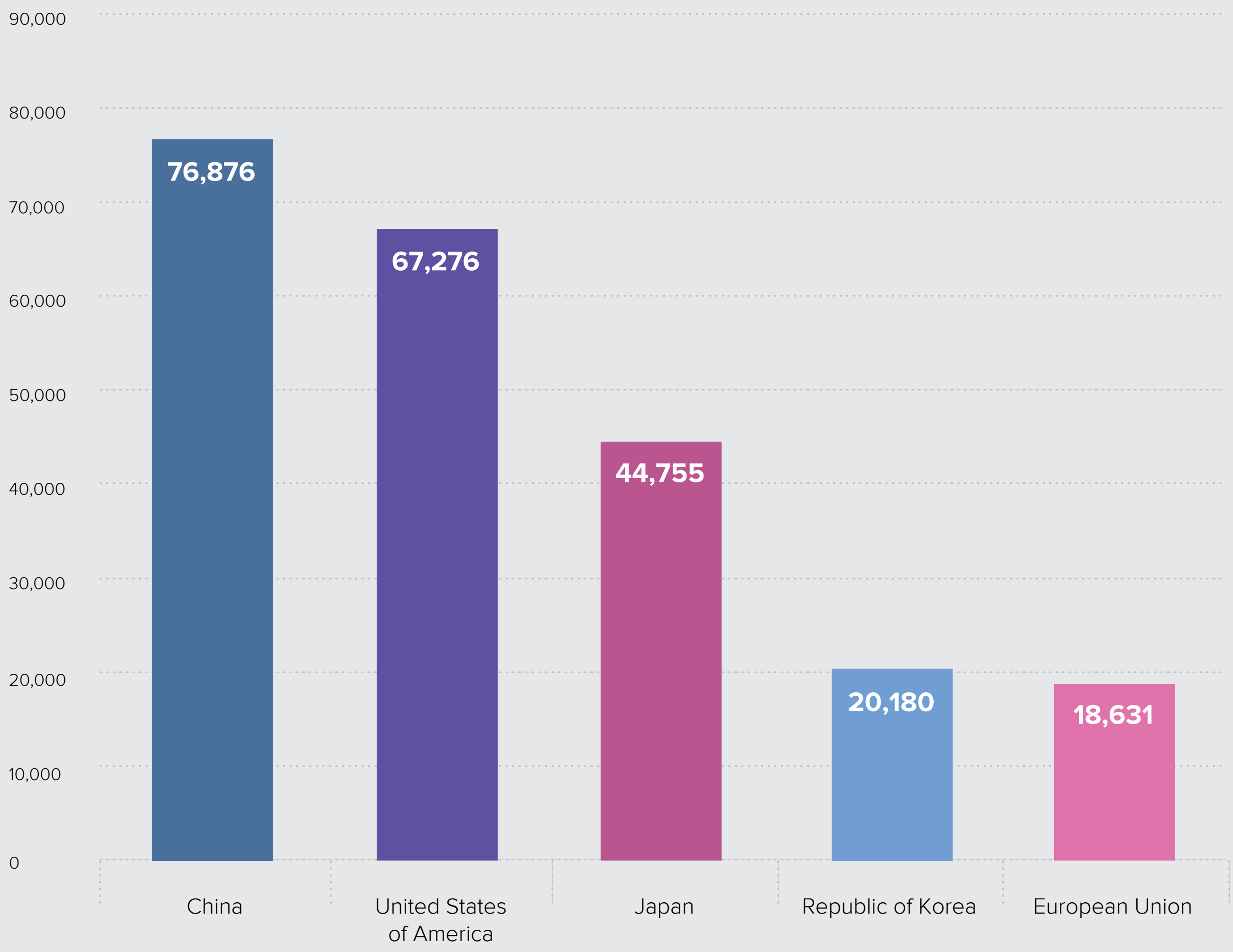
2. Smart doctors: leveraging diagnosis support

Healthcare services involve extensive and varied text data such as consultation records, medical records, and research studies. Using AI to comprehensively mine and analyze text data will help doctors improve diagnostic efficiency and create significant opportunities for AI and big data applications throughout healthcare. Specific applications include:

- **Intelligent triage:** Patients can quickly and accurately obtain triaging information by entering symptoms and other required information in mobile apps and robotic devices that guide patients in hospitals.

FIGURE 5.1

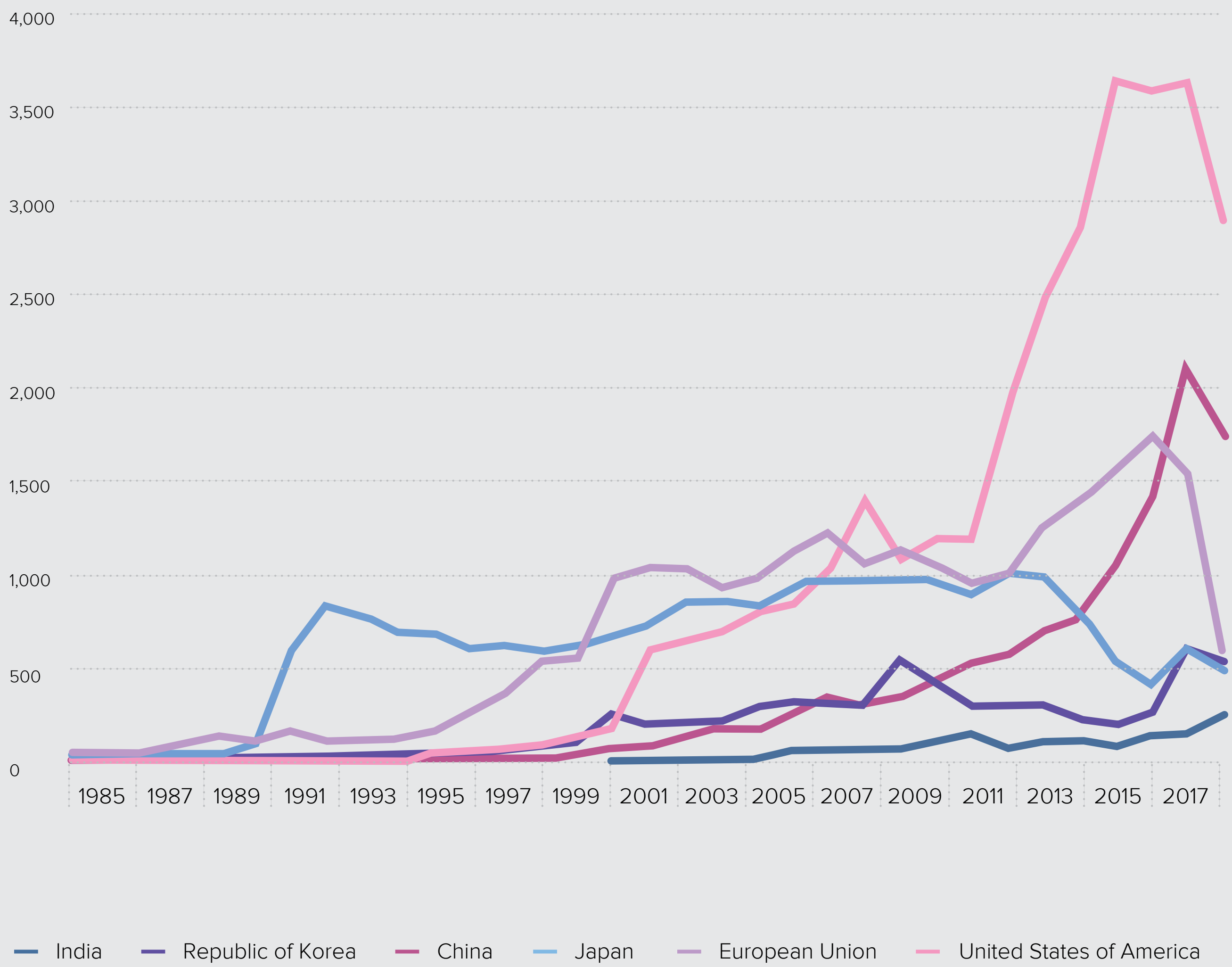
Top five countries/regions for AI patent applications, 1985 to 2017



Source: Patent Protection Association of China, 2018.
Note: Analysis report based on data sourced from China Patent Abstract Database (CNABS).

FIGURE 5.2

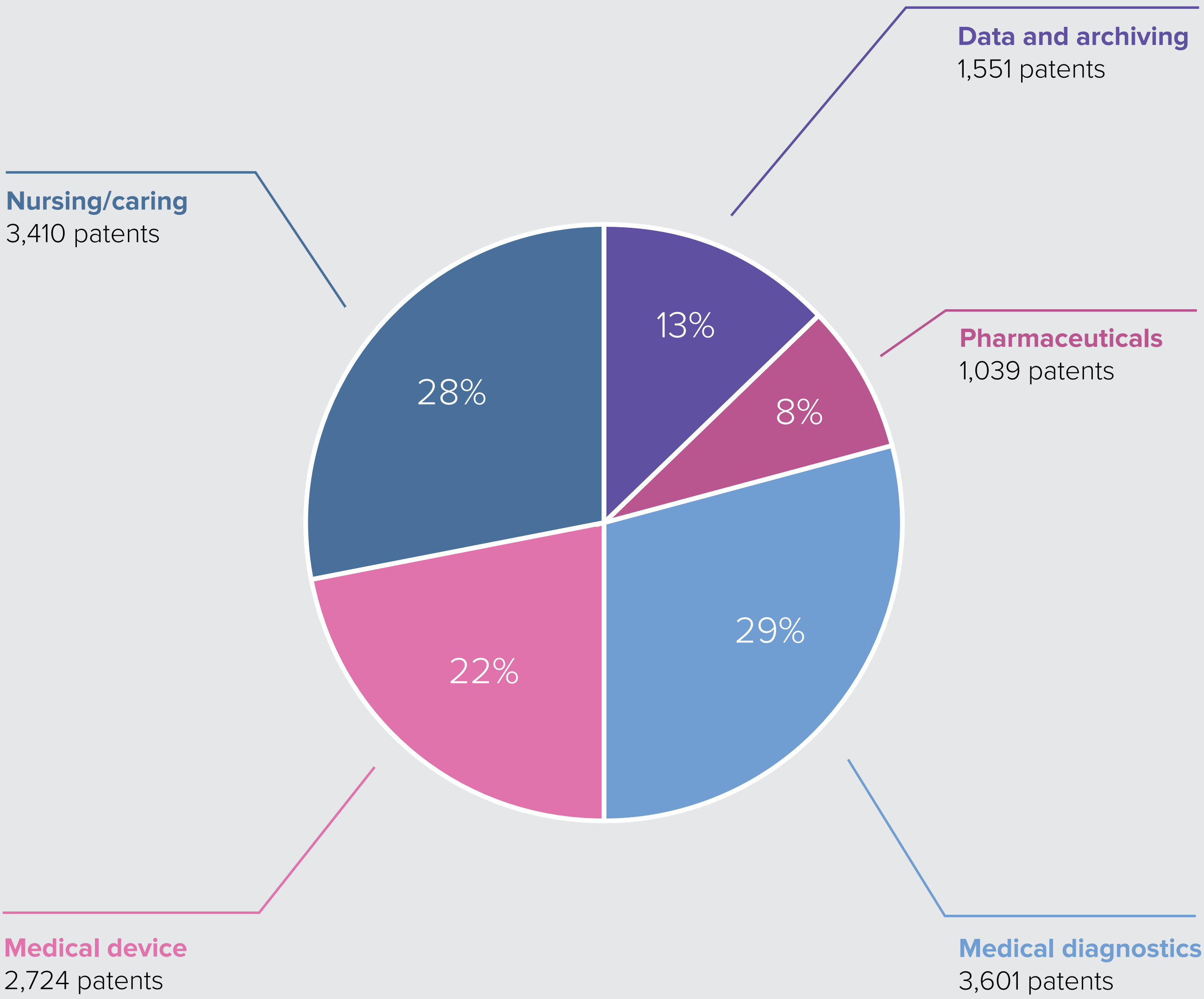
Healthcare AI patent applications in major countries and regions, 1985 to 2017



Source: Patentics Database.
Note: Data analyzed by Tencent.

FIGURE 5.3

Healthcare AI patent categories in China



Source: Patentics Database.
Note: Data analyzed by Tencent.

- **Intelligent medical record management:** Medical records retain essential information for medical services, but it is challenging to manage and utilize medical records because the data are primarily recorded as unstructured, free-form text. Text recognition and natural language processing not only improves the efficiency of medical record processing but also supports the extraction and analysis of disease characteristics, improving follow-up diagnosis and scientific research.
- **Intelligent risk monitoring:** AI helps doctors monitor and adjust their diagnosis and treatment plans and further reduces the risk of missed diagnosis and misdiagnosis.

At the level of implementation, the concept of enabling clinical decision support systems (CDSS) with AI is drawing more attention. AI-enabled CDSS is expected to provide doctors with efficient decision support throughout a patient's continuum of care. Several national projects are underway including projects jointly conducted by Tencent, CAS Institute of Automation, and multiple medical institutions such as the People's Hospital of Peking University. These projects have already shown promising outcomes. For cardiovascular and cerebrovascular diseases, an intelligent analysis system for electrocardiogram has been introduced. For Parkinson's disease, intelligent assessment of motor function has been enabled by applying AI-based video analysis technologies. For head and neck radiotherapy, an innovative rapid organ guidance technique has been developed.

3. Intelligent hospitals: boosting management and operational efficiency through mobile Internet

One primary reason that Chinese hospitals adopted IT applications was to improve the efficiency of management and operations. At present, most hospitals are in the process of migrating to mobile Internet services, that is, digitalizing hospital services, management, and operation procedures through mobile applications. The use of mobile apps is greatly improving the efficiency of hospitals and is emerging as a distinct feature of some forward-thinking hospitals in China. Exploration is extending to the automation of administrative tasks with the help from AI technologies and intelligent decision support based on big data analytics.

4. Intelligent pharmaceuticals: exploring digital and intelligent pharmaceutical research & development

The environment for innovation in pharmaceutical research and development (R&D) improved significantly in China over the past few years. The *Opinions on Deepening the Reform of Review and Approval System to Encourage the Innovation of Drugs and Medical Devices*, issued by the State Council in 2017, noted that China's pharmaceutical and medical device industries have developed rapidly amid ascending innovation and entrepreneurship, medical review reform, and approval system advances. China has independently researched and developed new drugs in recent years that have contributed about 4% to the global novel drug market, approximately one-twelfth of the contribution from that of the United States of America.[15] Digital modeling and simulation will facilitate independent drug R&D in China by effectively reducing cost and accelerating development. A group of Chinese emerging start-ups, including Deep Intelligent Pharma (compound synthesis), XtaiPi (crystal structure prediction), and LinkDoc (recruitment of clinical trial participants), are at the forefront of exploration.

5. Smart users: expanding from medical knowledge to health management

For individuals, medical care is only a means, while health is the end goal. As the standard of living improves, people become more proactive about preventing and treating health issues. In this context, health management has become an emerging field for IT application. AI and big data technologies can be applied in two ways:

- **Making specialized healthcare knowledge accessible to the public:** Knowledge and information can be more accurately disseminated to users from content databases that integrate AI and big data technologies. For example, Tencent Medipedia provides users with information based on content from internationally acclaimed medical information providers—such as WebMD or Healthline—and leading hospitals in China.
- **Managing and monitoring personal health data:** AI and big data technologies are also used to monitor users' health conditions with the help of intelligent wearables that provide personalized health advice.

Future: fostering synergies to make healthcare more intelligent in China

New technologies, such as artificial intelligence and big data analytics, have been innovatively applied in China's medical service sector and exhibit great potential for further development. Looking ahead, joint efforts are needed to advance these applications toward *Tech for Social Good*.[16]

First, data governance should be strengthened. Using digital technologies such as cloud computing and big data, appropriate rules and processes should be established for data collection, utilization, and protection among healthcare institutions. Data sharing and circulation mechanisms should be secured to achieve standardized collection, integration, sharing, and compliant application of healthcare big data.

Second, collaboration should be encouraged. Open platforms of innovation in the field of healthcare should be built through joint efforts, which could strengthen the sharing of mature technologies and expertise to solve common problems and lower the technical threshold for large-scale application of digital technology.

Finally, coordinated security assurance should be established. A sound and coordinated system that covers network security, system security, and data security for healthcare institutions should be established. The principles and requirements of security assurance should be clearly defined for involved parties to ensure privacy and prevent unintended disclosure.

Notes:

1 National Health Commission of People's Republic of China, 2018a.

2 Xinhuanet, 2018.

3 World Health Organization, 2018.

4 National Health Commission of People's Republic of China, 2018b.

5 Xinhua News Agency, 2017.

6 iResearch, 2019.

7 HC3i, 2017.

8 Patent Protection Association of China, 2018.

9 Patentics database, n.d.

10 Tencent, 2019. New patent applications are usually not published in 18 months, therefore part of the applications in the late 2017 are not included.

11 CB Insights, 2018.

12 EO Intelligence, 2017.

13 VCbeat, 2018.

14 In radiotherapy, Clinical Target Volume (CTV) refers to a tissue volume that contains the Gross Tumor Volume and/or subclinical malignant disease at a certain probability level. It is a proxy of the extent of tumor spread, plus a margin of safety.

15 Wu et al., 2017.

16 Tencent upgraded it's mission and vision to Tech for Social Good recently, aiming to harness technology for the benefit of mankind.

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CHAPTER 6

REACHING NEW FRONTIERS FOR ALZHEIMER'S THROUGH RESEARCH AND INNOVATION

David Ricks and **Brandy Matthews**, Eli Lilly and Company

Alzheimer's is one of the most feared diseases in the world—for good reason. No other disease takes from its victims both their pasts and their futures. No other disease among the top 10 causes of death worldwide lacks a treatment to slow it down.

We see Alzheimer's both personally and professionally. One of us has a close relative with Alzheimer's disease who lives in a nursing home. One of us treats patients in a dementia clinic, where many suffer from Alzheimer's without the hope of an effective treatment. Our pharmaceutical company has been trying to develop an Alzheimer's medicine for over three decades—so far without success.

The Alzheimer's challenge is a window into the future. Aging populations will continue to strain budgets for health services—whether that's care for Alzheimer's, cancer, diabetes, heart disease, or other conditions that increase with age. The only viable solution is to stimulate innovation to produce therapies that delay disease and lessen the need for expensive services.

In this chapter, we describe the current state of Alzheimer's and the challenges of Alzheimer's drug development, which have contributed to longer development timelines for Alzheimer's and higher failure rates for clinical trials. We suggest policy solutions that could lower these barriers—helping deliver treatments that give hope to patients and the health systems that care for them.

The state of Alzheimer's

Alzheimer's disease (AD) is a chronic, progressive illness, which mostly affects people over the age of 65. Symptoms typically begin with subjective concerns related to memory and thinking, followed by more objective deficits in cognition and behavior. Eventually, patients' daily activities become impaired. They lose the ability to care for themselves and typically spend the last years of their lives receiving care in nursing homes, which is also highly expensive (Figure 6.1).[1]

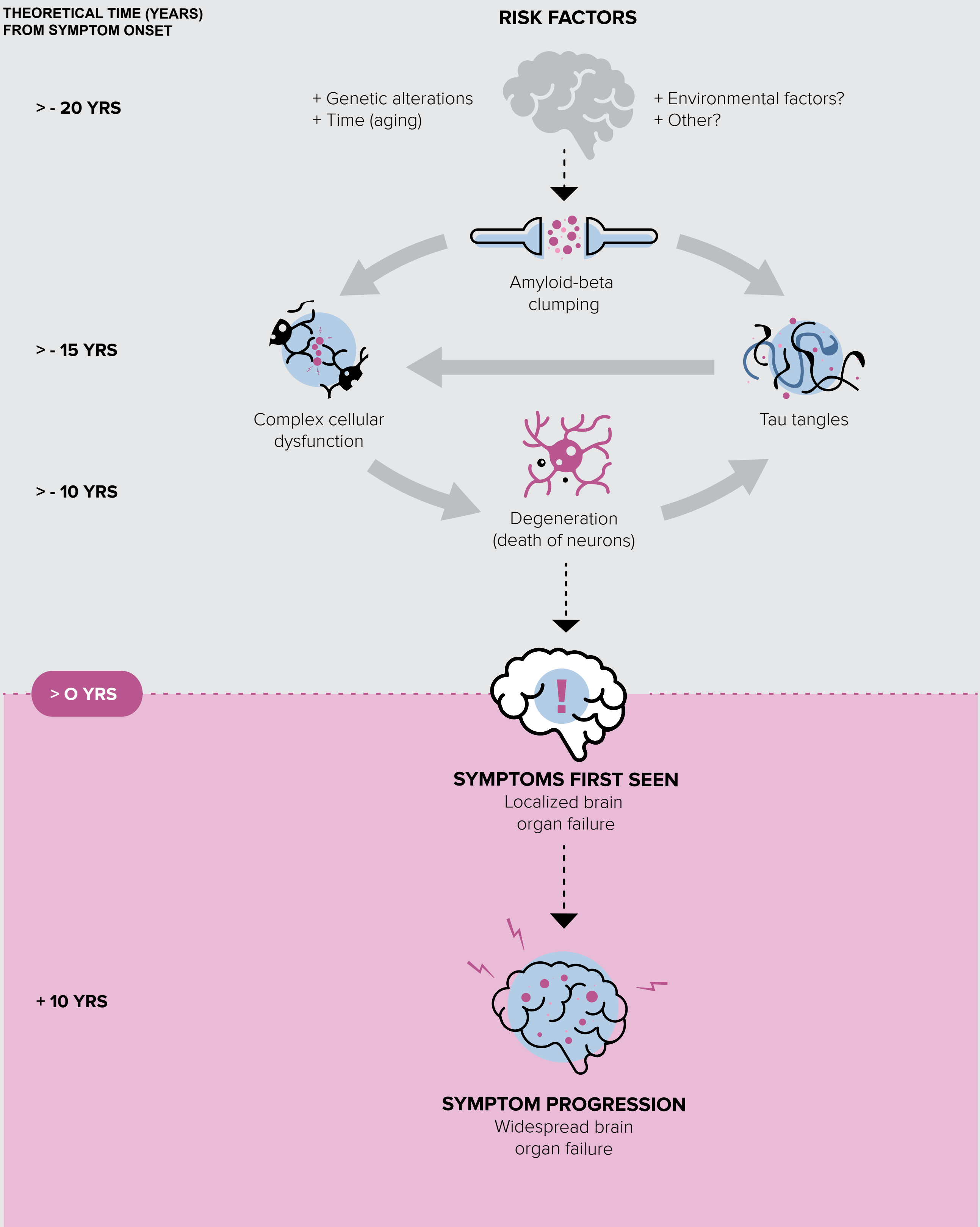
Across the globe, 50 million people are living with dementia; Alzheimer's is the most common form. The estimated yearly cost to treat and care for people with dementia is US$1 trillion. That's equal to the total amount spent each year on all pharmaceuticals globally.[2] But Alzheimer's costs are expected to double in a decade as the prevalence rises to 82 million people in 2030. By 2050, as populations age significantly in numerous countries, the prevalence is expected to triple from today's levels.[3]

A delay in progression of only one year could reduce the total number of patients with Alzheimer's by more than 9 million by 2050.[4] Delaying the onset of symptoms for individuals over 70 by one year could reduce healthcare payments by 14%, with longer delays saving even more.[5]

Alzheimer's appears in the brain 10-20 years before patients experience any change in thinking or memory. The telltale signs under the miscroscope are clumps of misfolded proteins,

FIGURE 6.1

Progression of Alzheimer's disease



Source: Golde et al., 2018.

inflammation, loss of function in the synapses between neurons, and, ultimately, the death of neurons—called neurodegeneration. One estimate suggests that eight times more people have undetected buildup of misfolded proteins or neurodegeneration than have observable Alzheimer's symptoms.[6]

Targeting the following pathological proteins is a major focus of attempts to develop a disease-modifying therapy for Alzheimer's.

Amyloid

The foundation of attempts to treat Alzheimer's is the amyloid cascade hypothesis. This hypothesis suggests that a protein called amyloid-beta slowly accumulates into clumps, which triggers a complicated cascade of events: the pathological misfolding and spread of another brain protein, tau; the activation of inflammatory pathways in the central nervous system; and eventually the death of neurons.

Tau

The second hallmark of Alzheimer's is clumps of misfolded tau protein inside neurons. These clumps, called neurofibrillary tangles, correlate with the clinical symptoms of Alzheimer's based on autopsy studies and, more recently, based on molecular imaging of living patients' brains. Efforts to reduce the load of tau still lag behind the anti-amyloid approaches.

Additional targets

Other potentially disease-modifying approaches currently in clinical testing target inflammation, neurotransmission, and vascular and metabolic contributions to Alzheimer's. Others attempt to promote growth of neurons and synapses, to protect neurons from damage, or to reverse brain damage via stem cell therapy (Figure 6.2).

Challenges of development

Attempting to impact the trajectory of decline in a chronic and slowly progressive disease is inherently time-consuming. In Alzheimer's, Phase 1 human testing takes about 13 months to complete; Phase 2 lasts approximately 28 months; and Phase 3 takes about 51 months, followed by an 18-month regulatory review. The process involves a commitment of nearly 10 years from bench to bedside—in addition to more than 4 years of preclinical discovery and testing. That's about one more year than average drug development—when everything works as planned. In Alzheimer's, it rarely does.[7] Development failure rates have been higher in Alzheimer's than in almost any other disease—99.6% from 2002 to 2012, compared with 81% in cancer.[8] And there have been many late-stage failures in Alzheimer's since then, including two—crenezumab and aducanumab—this year alone.

Future research will likely continue to drive disease-modifying therapeutics to earlier stages of the disease process—especially given the initial 10-20 year stage of Alzheimer's in which pathological proteins are active but there are no clinical symptoms. However, such trials will require an even greater investment of time and money.

The development challenges of Alzheimer's start in the discovery phase with pre-clinical models. Although several transgenic mouse models of Alzheimer's develop clumps of protein, or plaques, to serve as a target for amyloid-beta therapies, these mouse models differ from humans in significant ways. They do not develop the full spectrum of the human disease. They are missing tau deposition and loss of neurons, and have only a limited inflammatory response. A further challenge for Alzheimer's is that small molecules—chemical drugs, rather than complex protein-based drugs—must penetrate the blood-brain barrier, and a molecule that does so in a mouse model does not always do the same in humans.

The challenges continue in human testing. There is a mismatch between the progression of the disease, based on the buildup of pathological proteins in the brain, and the symptoms described by patients and observed by clinicians. Clearly delineating the stages of disease progression is still imprecise and potentially inaccurate, yet has been required to define groups for standard clinical trials. This mismatch is further complicated because the rates of decline among individual patients span a wide range—due to differences in genetics, experiences, exposures, and the presence or absence of other maladies of the aging brain. Some patients present with amyloid, but then never develop the symptoms of Alzheimer's. Others develop dementia, but not Alzheimer's dementia. These variations among patients make it difficult to see clearly whether a treatment is having a desired effect in the right set of patients.

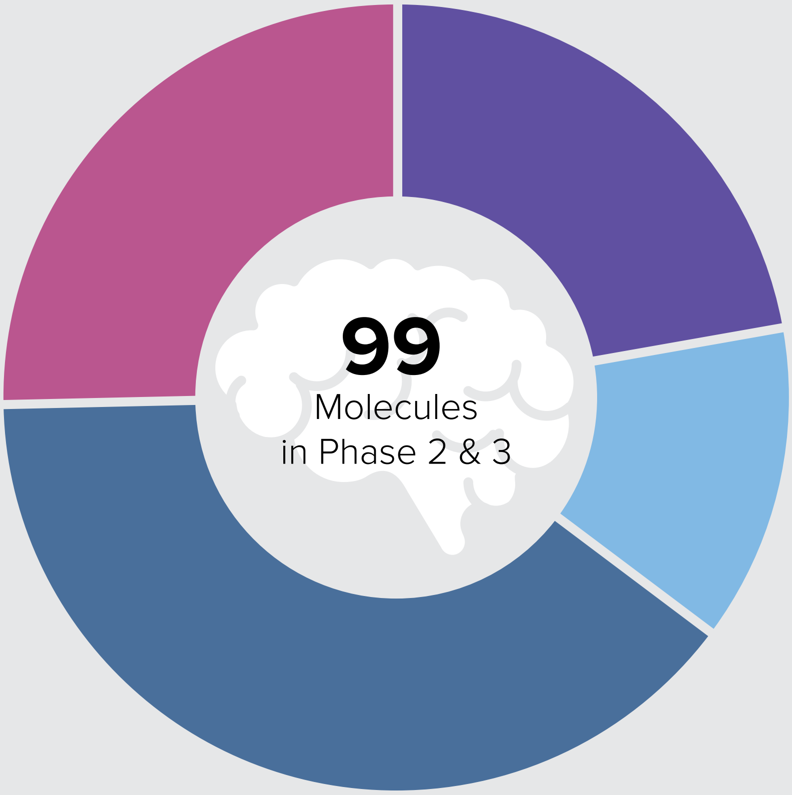
A key part of the solution to these challenges is biomarkers. They could stand in for, and even predict the progression of, Alzheimer's—in the same way blood pressure measurement is a biomarker for hypertension and hemoglobin A1C is a biomarker for diabetes.

Potential biomarkers for Alzheimer's are now routinely integrated into clinical trials, including brain imaging agents visible with positron emission tomography (PET) scans or measurements of cerebrospinal fluid (CSF) ratios. However, finding a biomarker that conveniently allows clinicians to track patients' response to a treatment has proved elusive. Yet this last use may be the most critical in such a slowly progressive and individually variable disease.

Negative clinical trial findings exemplify the importance of using biomarkers to select trial participants. In some studies, approximately 25% of participants clinically diagnosed with mild Alzheimer's and selected for clinical trial participation were later shown by amyloid imaging not to have brain amyloid consistent with Alzheimer's.[9] Still, some trials that have used amyloid biomarkers have also failed, suggesting other factors may be contributing—such as lack of adequate engagement between the experimental drug and its intended target in the brain or failure to identify the maximum tolerated dose.

FIGURE 6.2

Pipeline of experimental Alzheimer's medicines



22	13	39	25
Amyloid	Tau	Other disease-modifying therapies*	Symptomatic

Source: ResearchersAgainstAlzheimer's, 2018.

*Includes therapies that target inflammation, neurotransmission, and vascular and metabolic contributions to Alzheimer's disease.
Other therapies attempt to promote growth of neurons and synapses, to protect neurons from damage, or to reverse brain damage via stem cell therapy.

Until a disease-modifying therapy demonstrates a significant slowing of the decline of Alzheimer's, the interpretation of biomarkers will likely remain challenging. This presents a chicken-and-egg problem. To prove a biomarker works requires testing a drug over many years to show it successfully slows the decline of Alzheimer's. Yet the expense and practical realities of Alzheimer's testing make such a long trial difficult, if not impossible, without an accepted biomarker.

This will likely not be a one-time problem. Researchers now generally expect that successful treatment of Alzheimer's will come through a combination of therapies—as is the case with the cocktail treatment for HIV. A successful combination for Alzheimer's could pair a molecule that blocks amyloid formation with an agent that removes amyloid plaques. Or multiple molecules that function as anti-amyloid, anti-tau, and anti-inflammatory agents could be deployed simultaneously, or in series, depending on the stage of the disease. Any trials of combination therapies will be considerably more complex than trials with a single agent.

Overcoming the increasing length and complexity of Alzheimer's clinical trials requires innovative policy responses. Breakthroughs in therapy in the past have almost always been coupled with breakthroughs in regulatory standards. That was true when developing medicines for oncology, AIDS, and other diseases. It is needed now in Alzheimer's.

The need for policy innovation

Innovation can change the math of Alzheimer's that challenges governments around the world. But to do that, governments need to change the math for innovators. Currently, the extra time and high failure rate for Alzheimer's medicines make the costs of bringing one through the regulatory process more than double the highest estimate for overall drug development.[10] Yet current policy offers a relatively fixed period during which an innovator can recoup those costs. Innovators are incentivized to focus their investments elsewhere—in disease areas with faster clinical trials and lower failure rates.

Pharmaceutical companies are studying more than 20 times as many drugs for cancer than for Alzheimer's, even though the global societal costs of each disease are about the same.[11] Empirical analysis of clinical trials has shown that private funding flows to cancers, and stages of cancer, where potential survival times are shorter—because the longer trials needed for earlier interventions or for slower-progressing cancers consume too much of a drug's patent life.[12]

Various solutions have been put forward to address the problematic math of Alzheimer's drug development. Below we describe five categories of policies that could make a difference.

Research

Drug development has always operated in an ecosystem of researchers in public and private organizations, both large and small, sustained by a mix of public and private funds. Publicly funded research often produces insights into biology that create the conditions for the development of new medicines.[13] So governments should maintain or even increase their funding for research for Alzheimer's.[14]

Start-up companies and private investors, along with large pharmaceutical companies, are also critical in this ecosystem. The vast majority of new drugs are discovered and developed by private efforts.[15] So governments should also take great care to create the best environment to enable private efforts to advance drug development.

One Alzheimer's drug tested by our company, Eli Lilly and Company, shows this ecosystem in action. The protein, called solanezumab, was discovered via a collaboration with Lilly scientists at a university that receives both private and public research funding. When Lilly moved solanezumab into Phase 3 testing, it helped fund those studies via a partnership with an outside hedge fund. Later studies of solanezumab relied on a brain imaging biomarker developed by a small biotech firm, which Lilly has since acquired. Solanezumab showed small effects but not enough to be clinically meaningful. We are now working with public partners to test solanezumab at four times the previous dose.

Innovative funding

There is a need for innovative funding approaches—especially in the earliest and riskiest phases of drug discovery research. Public-private partnerships and open innovation can help in precompetitive areas, such as biomarker development, better models of Alzheimer's disease, and big data analytics to identify and stratify patients. Other possibilities include crowd-funding, patient advocacy group funding, prizes and government R&D contracting. Governments can help to integrate the disparate set of current funding sources—perhaps, as some have suggested, creating mega funds to advance research.[16] Some have even proposed advance market commitments, in which innovators promise to offer a new drug at a lower price while donors make a long-term contractual pledge to pay a "top-up" price. We concur with various scholars that these efforts, on a voluntary basis, are welcome additions to the search for an effective therapy.[17]

However, with biopharmaceutical companies sponsoring or co-sponsoring more than 70% of Alzheimer's clinical trials,[18] the biggest thing governments can do is change the math for these companies. The next three categories aim at that goal.

Faster testing

In recent years, biopharmaceutical companies have worked to reduce clinical development periods through gains in operational efficiency and statistical methodologies that permit shorter and smaller trials.[19] But these efforts are inadequate in the face of Alzheimer's because of two major challenges.

First, a constant challenge in clinical trials of Alzheimer's therapies is getting patients enrolled. There are significant barriers—both scientific and psychosocial—to diagnosing patients. Half or more of dementia patients are not clinically diagnosed—far higher than other diseases.[20] Because existing biomarkers such as PET imaging are not widely available—or widely reimbursed—diagnosis in the pre-symptomatic phase can be especially difficult. Also, doctors are reluctant to commit to a diagnosis of Alzheimer's when they can offer no effective treatment.

In response to the challenge of patient enrollment, governments and other groups could help by organizing advanced patient registries of well-characterized candidates for clinical trials. As it becomes ever clearer that Alzheimer's begins damaging people's brains years before symptoms show up, it is more critical that public and private health plans offer coverage for diagnostic tests that do exist. It may not be prudent to open coverage to everyone. But the willingness of health plans to pay for tests at the earliest signs of cognitive change would provide a significant stimulus to the makers of medical and digital technologies to push for even better and easier-to-use diagnostic tools.

The second big challenge in Alzheimer's clinical trials is the endpoints required by regulators. The ultimate goal is to find a disease-modifying therapy that changes clinical symptoms—slowing the decline in thinking and daily functioning. But to get to that point, it may be necessary for regulators to experiment with surrogate endpoints of Alzheimer's. In cancer, regulators have long accepted progression-free survival as a surrogate endpoint for new drugs—even though the ultimate goal is always overall survival for patients. Alzheimer's trials need similar flexibility from regulators. The field may not yet know what the Alzheimer's version of "progression-free survival" is. But regulators could approve a new Alzheimer's medicine that proves safe and shows progress against a surrogate endpoint—and then require a pharmaceutical company to gather the real-world evidence and long-term data necessary to see if the surrogate endpoint successfully predicted improvement in later symptoms.

In the United States of America (U.S.), the Food and Drug Administration (FDA) has this kind of accelerated approval authority—which was granted in the early 1990s to find solutions to the HIV/AIDS crisis. Former President Obama's Council of Advisors on Science and Technology recommended that the FDA use this authority broadly by approving more drugs based on surrogate endpoint results.[21] Such policies, if adopted by regulators worldwide, would encourage innovators to keep working on slow-progressing diseases, like Alzheimer's.

Intellectual property

Patents provide 20 years of protection for a new medicine. But that 20-year clock starts years before a medicine is approved for sale. Patents are necessarily filed before any public disclosure, which typically is before human testing begins. The result is that every extra year of clinical testing means one less year in patent-protected sales. Over the past two decades, average post-approval patent life in the U.S. and Europe has fallen to 13 years—even including the impact of patent-term extension policies.[22] The combination of lengthening development timelines and fixed patent terms creates a perverse incentive for innovators to give high priority to molecules with faster development times, rather than to the medicines patients need most.

For this reason, the single best thing governments can do to incentivize development of a drug that will slow Alzheimer's is to create more uniform and sufficiently long periods of data exclusivity. There is a patchwork of terms of data exclusivity around the world—with protection running from as high as 12 years to as low as zero. Many countries also have shorter periods of data exclusivity for traditional small molecule drugs than for biologics.[23] These inconsistent terms mean a drug that takes a long time to develop—running out most of the years on its patent—must rely on data exclusivity in fewer countries to recoup the capital and risk expended to develop it. It also skews research arbitrarily toward biologic drugs—even though they may not be the best way to treat a disease. In short, weaker data exclusivity policies mean less money invested in fewer medicines for difficult and slow-progressing diseases like Alzheimer's.

Lilly has experienced this dynamic first hand with solanezumab, which we continue to test in Alzheimer's patients. The U.S. patent on solanezumab will expire in 2021. Yet Lilly continues to manufacture and test this molecule because the data exclusivity we have—12 years in the U.S. and 10 years in Europe—offers some potential to recoup our continued investment. Without data exclusivity, solanezumab—and many other promising compounds without adequate patent protection—would have almost no hope of reaching patients.

We recognize that extending data exclusivity is an unpopular idea to many who believe the key to pharmaceutical affordability is to reduce the duration of intellectual property (IP) protection. We believe, however, that an appropriate period of data exclusivity is essential to generate the investment necessary to create a sufficient supply of disease-modifying Alzheimer's medicines to begin with. A strong IP system, in the long run, produces more breakthroughs today and provides more bargains tomorrow. Even a disease-modifying therapy for Alzheimer's would, after about 13 years, be sold for a small fraction of its initial price and would continue delivering value to patients and health systems for decades. In our view, nothing in healthcare is more productive.

Reimbursement

It is always healthy to ask for proof that any healthcare service is worth its cost. The evidence for pharmaceuticals is encouraging. An analysis of 15 developed countries found that those that introduced the newest medicines soonest saved the most on hospital costs—US$2.50 saved for every US$1.00 extra spent on the latest pharmaceuticals.[24] In addition, a recent analysis of the U.S. Medicare health plan for seniors found that growth in other healthcare spending slowed significantly after Medicare started paying for prescription medicines.[25]

The problem is that few, if any, government-funded health programs financially reward a pharmaceutical that enables reduced spending in other areas—such as, lower hospital costs or doctor fees. Funding for pharmaceuticals is typically separate from hospital and doctor care, which is separate from nursing home care. Government officials that oversee these funding streams work separately to control costs, without trying to calculate how spending in one stream might save money in another. To prepare for the arrival of a disease-modifying therapy for Alzheimer's, governments should create mechanisms to connect these disparate funding streams.

Mechanisms could include better horizon scanning by government health programs, followed by restructuring of health systems. This is what the Government of Australia did in the 1990s and 2000s—gradually shrinking the infrastructure and workforce needed to conduct traditional Pap smear tests for cervical cancer screening, and shifting resources to simpler and cheaper polymerase chain reaction (PCR) testing.[26]

Mechanisms could also include outcome-based contracts. Because the clinical and economic value of a disease-modifying therapy for Alzheimer's may not be completely clear at launch, it may make sense for governments to pay a portion of a drug's cost up front, with additional payments made over time only if patients taking the drug show slower disease progression. Other innovative payment models that could work in Alzheimer's are prices that vary based on patient severity; a "Netflix" model of pricing that smooths out costs to payers; or, in the case of multiple therapies, combination pricing.[27]

Funding streams could even be connected via the sale of social impact bonds, which have been used to fund recidivism programs in the U.S. and the United Kingdom. In the case of a successful disease-modifying therapy for Alzheimer's, selling such bonds could raise private money to enable a government to fund payments for the new medicine. The government would repay bondholders only if, years later, savings on nursing home care materialize, freeing up the funds needed to repay bondholders.

Conclusion

Governments face a clear choice today. Unless public policies steer private funding to difficult diseases with long development times and high failure rates—and do so strongly enough to generate multiple successful therapies—Alzheimer's will likely remain an ongoing health and budgetary challenge. If, instead, governments around the world act to change the math for innovators—by accelerating testing and strengthening incentives—they will provide the certainty that drug developers need to take on the biggest and broadest challenges society faces, including Alzheimer's.

Notes:

1 Jack et al., 2018.

2 Aitken et al., 2019.

3 Patterson, 2018.

4 Brookmeyer et al., 2007.

5 Zissimopoulos et al., 2014.

6 Brookmeyer et al., 2018.

7 Cummings, Lee, Ritter et al., 2018; DiMasi et al., 2016.

8 Cummings et al., 2014.

9 Cummings, 2018.

10 Cummings, Reiber et al., 2018.

11 Long, 2017.

12 Budish et al., 2015.

13 Cleary, 2018.

14 Grabowski et al., 2015.

15 Chakravarthy et al., 2016; Kneller, 2010 (76% of new drugs approved from 1998 to 2007 were discovered inside drug companies, compared with 24% by university researchers); Sampat et al., 2011 (of drugs approved from 1988 to 2005, 9% had public-sector patents; 48% had some public-sector influence).

16 Cummings, Reiber et al., 2018.

17 Cummings, Reiber et al., 2018; Kremer, 2010.

18 Cummings et al., 2017.

19 Morgan et al., 2018.

20 Eichler et al., 2014.

21 President's Council, 2012.

22 Grabowski et al., 2014; Copenhagen Economics, 2018.

23 The U.S. offers 12 years for biologic medicines but five years for chemical, or small molecule, medicines. The EU and Canada offer 10 years for both kinds of drugs. Japan offers roughly eight years. Australia and Mexico offer five years—although Mexico recently agreed to 10 years as part of a pending trade deal with the U.S. and Canada. India offers none, and China offers practically none—although China has recently proposed adopting a policy of up to 12 years.

24 Lichtenberg, 2018.

25 Cutler et al., 2019.

26 Kearney, 2018; Oortwijn et al., 2018.

27 Multi-year payments and the "Netflix" model have been proposed by the Massachusetts Institute of Technology's New Drug Development Paradigms Initiative.

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CHAPTER 7

IMPROVING PATIENT HEALTHCARE THROUGH VIRTUAL PLATFORMS

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It is expected that by 2030, the healthcare system will be proactive and benefit from knowledge and know-how that create sustainable innovation. The health experience of patients will be fluid and continuous. Virtual models will represent the human body and help in handling diseases. The whole health ecosystem will be oriented towards long-term prevention and personalized care.[1] These transformations are necessary, but they cannot happen without digital platforms. How will these new platforms change the relationship between patients and physicians? How will these platforms influence pharmaceutical research and the production of drugs? How will society handle health in this new era of connectivity? Based on the strong belief that virtual universes extend and improve the real world, this article describes the current challenges of the health system and shows how digital platforms can bridge these frontiers and promote a more sustainable environment for healthy citizens.

Proactive medicine: from cure to care

Health is a highly precious state of life, which enables individuals to fulfill themselves, unlimited by anything but their will and environment. Maintenance of health is a costly pursuit, as healthcare spending is projected to reach over US$10 trillion, nearly 10% of global GDP, by 2022.[2] A swift upward trajectory in global health spending is particularly noticeable in low- and middle-income countries, where health spending is currently growing, on average, 6% annually compared with 4% in high-income countries (Figure 7.1).[3]

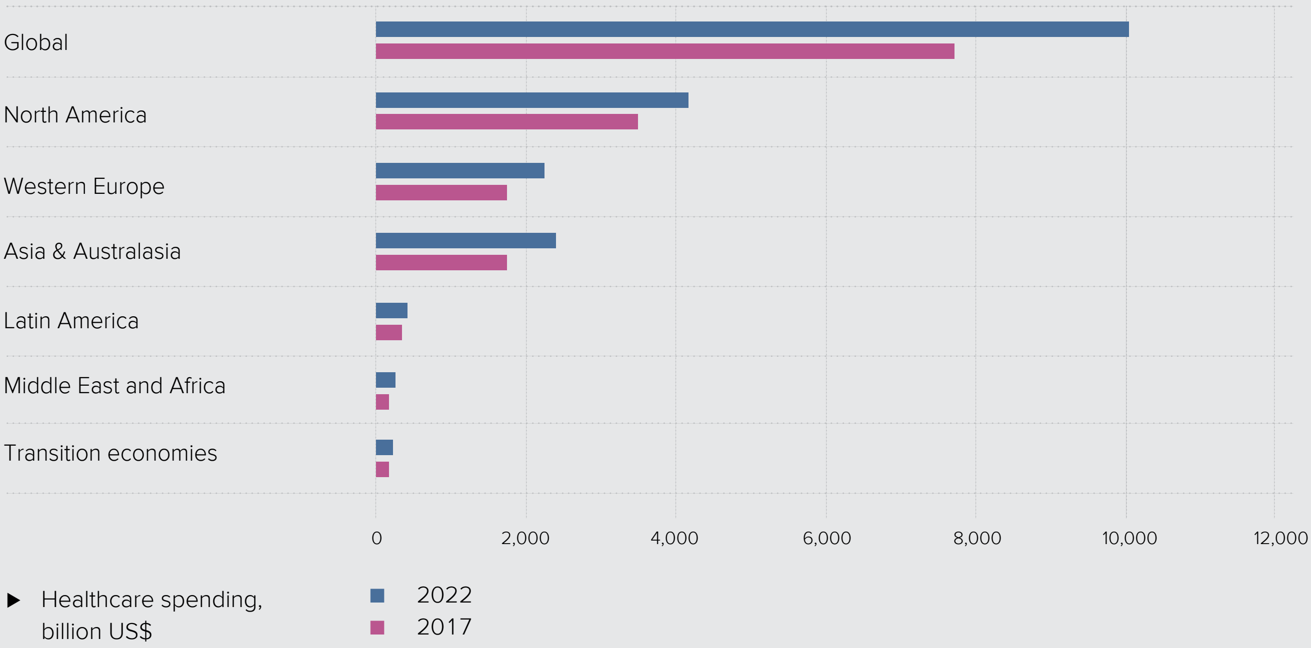
A series of innovations have driven better health for people, including hygiene, infectious disease prevention, precision diagnostics, therapeutic devices, biological pharmaceutical compounds, and minimally invasive surgical procedures.

However, chronic diseases have never been so common. Globally, the number of people living with diabetes has risen from 108 million in 1980 to 422 million in 2014 and is now rising even more rapidly in low- to middle-income countries.[4] Vascular diseases are the number one cause of death: 17.9 million people die annually from cardiovascular diseases, representing 31% of all deaths globally, and over three-quarters of these deaths occur in low- to middle-income countries.[5] In high-income countries, nearly 50% of citizens suffer from chronic disease while the other half are diagnosed with cancer during their lifetime. The current rise of non-communicable diseases (NCDs) is associated with lifestyle choices—tobacco use, unhealthy diet, obesity, physical inactivity, and harmful use of alcohol—and environmental factors, yet NCDs could be largely prevented by early detection and appropriate counseling and management.

To face this challenge, healthcare stakeholders—individuals, physicians, payers, policymakers, and health technology companies—must converge on digital platforms to connect, combine and share data, which will allow for global innovation of care that includes social and environmental determinants of health. Such platforms will allow stakeholders to capitalize on knowledge about health factors both at the individual- and population-level. These data-based approaches will lead to a new human-centered view of healthcare that includes personalized prevention and support. “Knowledge is the only good that multiplies, when you share it” and sharing among patients, caregivers, payers, and regulators will not only provide information to support better decision-making and service, but will also expand global knowledge of health and life science—leading to sustainable and accelerated progress.[6] By 2030, the life sciences industry will increasingly shift from reactive to proactive medicine, enabled by personalized health. This new era will encompass a holistic view of the citizen, where health will become a core value of daily life and cities. Digital platforms will play a key role in this transformation.

FIGURE 7.1

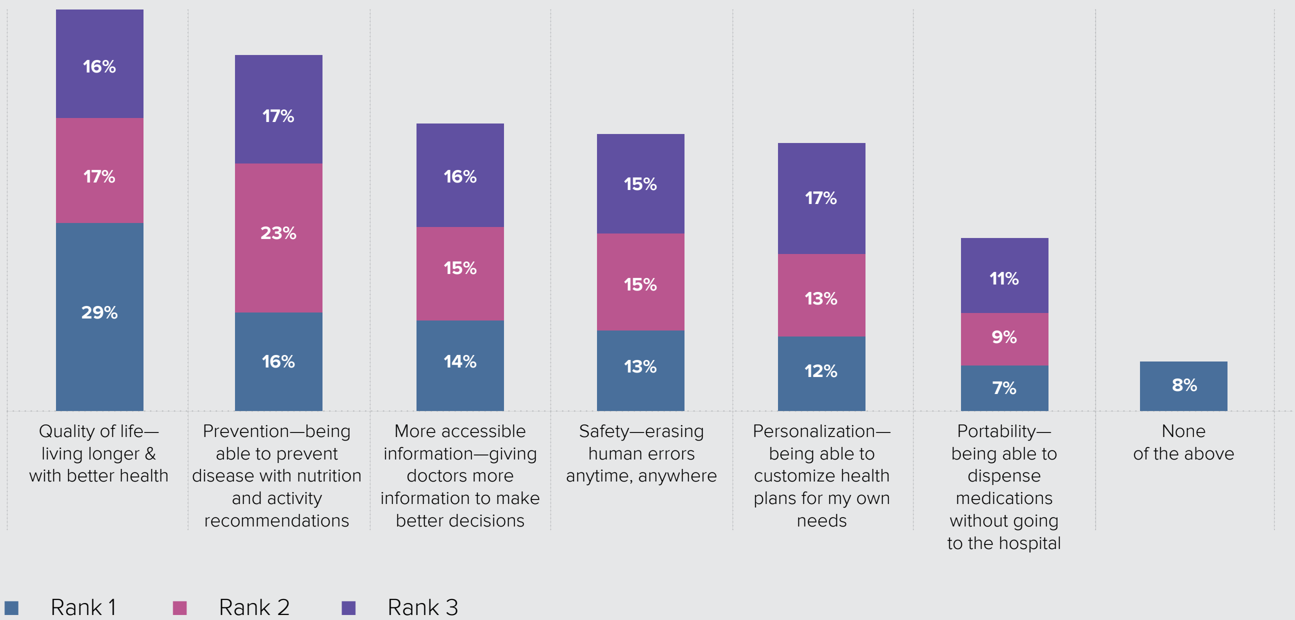
Healthcare spending in 2017 and 2022



Source: The Economist Intelligence Unit, data tool accessed on August 16, 2018.

FIGURE 7.2

Top benefits of healthcare technology, top 3 rankings



Source: Frost & Sullivan Report in partnership with Dassault Systèmes, 2019.
Notes: Participants were asked to select the top 3 benefits of having technology integrated into the healthcare system in the year 2030. Interestingly, portability is more important to younger respondents: 37% of 18- to 34-year-olds say that portability is a one of the top three benefits. Quality of life is especially important to those 55 years of age or older: 36% of the 55+ group rank this as the #1 benefit.

Healthy living and quality of life

In a fast-growing technology era, quality of life is the most important benefit citizens expect from healthcare technology breakthroughs: it is acknowledged as top 1 priority for 29% of respondents and top 3 for 62% of respondents.[7] Prevention is among the top ranking expectations as well, identified as top 3 priority for 56% of respondents. Preventive health plans are perceived as having the highest direct impact on people's health. Patients also expect higher autonomy through better information and the ability to dispense treatments at home (Figure 7.2).

This builds a strong link between health and cities. More and more cities in the world are moving towards a new "city experience", where the interactions between citizens and city services are transformed. These cities will enter into the platform era by leveraging data and technology to create more efficient living environments, improve sustainability, connect citizens to decisions by sharing information with the public, and improving the quality of government services. Achieving this goal requires a harmonious development in all dimensions of city experience: governance, education, housing, mobility, infrastructure, connectivity, innovation, energy, and healthcare—a core part of this holistic city experience. The quality, reliability, and completeness of healthcare infrastructure will be a fundamental factor for the global development of cities. As smart cities create a more valuable citizen experience, "cities of health" will become more and more attractive. In *Virtual Singapore*, intelligent 3D models were set up to improve the experience of residents, businesses, and government by capturing all aspects of the city.[8] By connecting the dots across citizens, thinking about experiences, and connecting the virtual and real world, smart cities reveal sustainable urban solutions to maintain the health of their growing and aging population. A new approach will be required to the design of cities with a new mindset for operating these cities. Mobility and transportation will be planned to preserve the health of the residents, social services will be sized based on neighborhood health indicators, and environmental exposure and air quality will be crossed with patient health to generate new insights into emerging risk factors and to trigger personalized prevention recommendations. Emerging diseases are monitored continuously to detect clusters of cases and their link with infectious agents or pollutants.

Continuous, contextual, and connected journeys

The fragmentation of the patient journey among different physicians and professionals, split across disease areas and territories, leads to "stacking" many disconnected health services to provide care to a single person. With the advent of the experience economy, value is now centered on the patient. The health industry network—from pharma to healthcare delivery—is focused on delivering effective and direct outcome for people's health. Platform approaches become necessary to solve the complexity of this health journey. The holistic model of care for citizen health will provide stakeholders with a sustainable and cost-effective model for development and innovation. The value of their collaboration on platforms of care will be patient health, rather than products. These platforms will connect physicians and care professionals to provide patient-centered experiences that are fluid and convenient.

The Internet of Experiences (IoE) connects experiences worldwide, making them accessible everywhere and anytime. This will enable a shift to remote care and monitoring, leading to more proactive therapeutic solutions with personalized recommendations. For example, healthcare-related smart home devices are designed to track and manage health at home, allowing savings of healthcare expenditures. A home health network can include services—that track vital signs, sleep quality, and other health parameters via wearables, sensors, and devices—or telehealth, which includes information services, education, and care delivery. Wearables will not only be used for continuous monitoring of health, but they will also serve as treatment dispensers. The IoE will reshape the care delivery experience through ambulatory care, telehealth, wearable devices that monitor vital signs, at-home drug delivery devices reducing in-hospital treatments, and a wide panel of online services around prevention and behavior change. Citizens will increasingly be empowered to monitor and manage their own health, reaching a new level of autonomy and harmony in their relationship with their body.

Personal and collective data intelligence

Security and privacy of health information are a top priority. Regulations on personal health data will be progressively harmonized worldwide. As the patient is positioned at the core of their own health journey, the right to access and control personal data becomes more crucial than ever.[9] At the same time, healthcare stakeholders require increased sharing of health data to build collaborative intelligence and to expand their understanding of healthcare activities. Data is shifting from the care of an individual to the care of a population and offers new opportunities for service and quality improvements. A data-enhanced platform of care enables siloed data sources to be integrated and contextualized within the health environment. Platforms, therefore, catalyze collaboration amongst diverse stakeholders and allow the setup of human patrimony in every country. Different approaches have been undertaken to collect patient data at the scale of a population. In Denmark, the entire country is a cohort scrutinized by integration of health information sources from claims, electronic health records, or genomic analysis.[10] In the US, the largest ever cohort—called "All of Us"—has been launched to gather data about more than one million people, in order to explore the potential of precision medicine while taking into account individual differences in lifestyle, environment, and biology.[11] Anonymization of data has been a key enabler for data sharing and will contribute to opening the data economy. There are no commonly accepted data sharing standards at this stage, although these will be required to build the needed trust at a societal level. A first meaningful step in this direction has been made in Europe with the European General Data Protection Regulation, which frames the definition of anonymization to reduce the risk of reidentification. Technical solutions, such as blockchain, exist but they are not sufficient by themselves to build trust. New processes and institutional approaches are needed to allow sharing of highly-sensitive data. While models of data sharing have yet to be developed, collective data intelligence will become a cornerstone for continuous learning and an improving healthcare system.

New experiences of health

As technologies will illuminate new dimensions of patient health, they create new approaches to pre-symptomatic prevention, early diagnosis, personalized treatment, and home monitoring (Figure 7.3). Invisible factors and hidden causes become more and more apparent in the routine practice of care. However, to prevent disease, virtual models and simulation are required to help practitioners turn complex data into actionable information.

New ways to prevent: While traditional decision models require a high level of expertise and include only a few clinical factors, recent advances in machine learning—when associated with proper scientific knowledge and good medical understanding—support the use of prediction models based on numerous factors, such as those generated with recent imaging and genomics. These new models may guide personalized recommendations for patients that take into account their individual risk of developing specific diseases.

New ways to diagnose: The convergence of high-definition technologies is leveraged in neurosurgery, where brain imaging is coupled with functional electro-physiology and per-surgery investigation in the operating room. Anatomic models enriched by simulation help define the pathologic zone to be resected, for instance in the case of epilepsy patients. Virtual twins of patients may help guide the surgical plan in orthopedics by predicting the functional outcome. This new way of prescribing based on a predicted patient outcome—which is nearly impossible today—will increase safety and help patients better understand medical decisions before they undergo surgery.

New ways to cure: Virtual reality is advancing as a new treatment modality—evidenced by 3D printing, which is developing to provide a range of personalized applications in the healthcare sector. Applications are currently limited to prosthetics, pre-surgery anatomical models, and custom surgical tools manufacturing. However, by 2030, the technology could be used to print prescription drugs or 3D print new tissues or organs based on a 3D model of a patient's own organs.[12] Based in Paris and Boston, Biomodex already exemplifies these new possibilities: this start-up company provides 3D printed anatomical models to help surgeons prepare for complex and difficult surgeries. The idea is that personalized 3D printed models enable physicians to gain a better understanding of the patient's unique anatomy and better plan complex procedures. Organ imaging, via an MRI or scanner, generates data that is used to create a virtual 3D model of that organ, which can then be printed using a 3D printer. While bio-printed 3D organs may emerge as a future game changer, 3D printing will first be used for the personalization of implanted medical devices, such as dental and orthopedic prostheses. The technology is not yet mature to produce an entire organ, but 3D bio-printers that use nanotechnology can already print live skin-based organs within hours and opens to powerful skin care applications. A survey shows that 71% of citizens think that on-demand 3D printed organs will directly impact their health.[13]

New ways for care at home: Patient benefits may be maximized at home by reducing the risk of various hospital-related complications, such as infection decubitus complications and loneliness. Home care delivery requires a complex infrastructure and network more easily organized in new healthcare platforms able to collect patient data, diagnose, link patients and medical professionals, and monitor treatments for safety and efficacy.

The "Living Heart" project provides a powerful example of how virtual universes will allow the radical improvement of the health experience.[14] When Dassault Systèmes' Living Heart Project was launched nearly five years ago, it was founded on the belief that a digital health transformation must have the patient playing the central role. The company reimagined a healthcare system far beyond today's paper and electronic records—instead taking the power of the virtual world to capture the best understanding of the body and combining it with a finely tuned ability to perceive subtle details in a 3D world. The project has connected leading researchers worldwide to create digital twins of a complete, beating, human heart. The model has already been used around the world to test a range of medical devices and to reproduce known disease conditions, blood flow disorders, and adverse drug effects. Combining 3D models with real-world medical data yields a powerful foundation for guiding new device designs and optimizing complex surgical procedures.

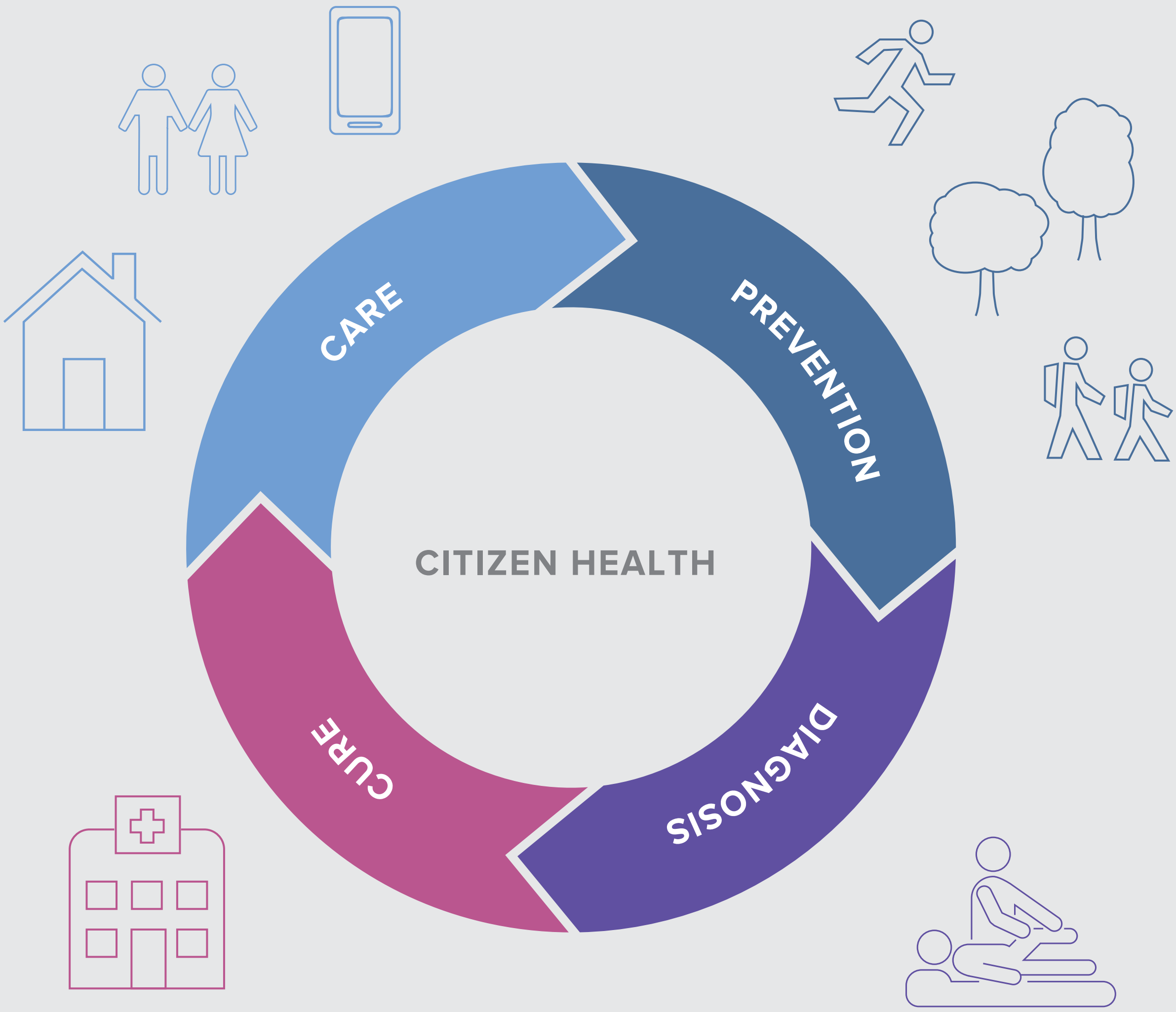
The United States Food and Drug Administration (FDA) has set a goal to create a population of **3D**EXPERIENCE twins—models which replicate the real-world experiences of a population and reveal how a group of patients will react to new devices. The hope is that, linked with a comprehensive digital assessment of safety and performance outcomes, innovation will accelerate and regulatory burden will lessen. One day, this approach may be translated into a patient record where the complexity of your clinical data is seamlessly combined with accurate virtual reality representations of your body. This data will be hosted in the cloud, securely under your control, and accessible anywhere—from your mobile phone to the offices and surgical suites of your healthcare team.

New business model calling for a new platform

"I will prevent disease whenever I can, for prevention is preferable to cure."[15] Health systems are shifting from curative medicine to preventive approaches, by enrolling citizens and professionals in value-based economic models instead of volume-based funding. The value is now the patient experience. A value-based approach requires reforming an entire model of regulation and evaluation where payments are made for activity to a system where payments are tied to patient-centered value and quality. Europe is leading this new model adoption; Sweden and the

FIGURE 7.3

Creating the continuum of care



Source: Dassault Systèmes.

United Kingdom are the only countries with high alignment between payments and value.[16] Until now, the value of health products had to be demonstrated by means of clinical trials in a pre-specified patient population. This process is long and expensive and is challenged by a high risk of failure in real life conditions. The current paradigm of clinical trials is expected to become more decentralized, more inclusive to diverse populations, and more able to rapidly adapt in real time during trials so that the right population—even in the case of small cohorts—is rapidly identified in order to deliver the highest benefit. Clinical trials are also expected to increase their validity in the real world. Real-world evidence is the clinical evidence regarding the usage and potential benefits or risks of a medical product derived from analysis of real-world data, as promoted by the U.S. FDA.[17] Real-world data are collected from various sources including, but not limited to, clinical trials, prospective and/or retrospective observational studies, medical health records, claims, and mobile and wearable devices. These data have the potential to complement clinical trials; increase knowledge for therapeutic innovations, pragmatic care, and prevention practices; lead to better designed and conducted clinical trials; and measure the real-world efficacy of a drug or a prevention. Payers will become more capable of setting price based on patient efficacy.

As precision medicine is delivered on platforms of care, individual patient value can be assessed and used to support policymaker decisions and payer engagement, leading to a new value-based model of care that moves from product to outcomes and holistic care.

Workforce of the future

The physicians, nurses, and professionals who provide direct patient care are essential to the success of the healthcare system. While nations and policymakers are developing educational programs to maintain the right number of skilled people, practicing is a key aspect of healthcare training. Pragmatic and manual skills are learned by experience, therefore, 3D and virtual worlds could play a role in scaling and extending current capacities. The increase in, and rapid evolution of, knowledge are less compatible with traditional learning materials, such as textbooks, which are being replaced by online knowledge services to access the right information at the right time. Professionals are facing less time with patients, more time for bureaucracy, and more complex care activities for dependent and aging populations with multiple concurrent pathologies. One measure of these changes is the average duration of a consultation, which is constantly decreasing. In 18 countries representing about 50% of the global population, patients spend five minutes or less with their primary care physician.[18] Fragmentation of the care processes across multiple organizations and professionals requires enablers of good communication. On the new collaborative platforms of care, every caretaker can share a holistic vision of their patients, create a relationship of listening and trust with patients, share patient-defined objectives of care, and make ethical decisions collectively. Healthcare is thus becoming a continuous and fluid journey, empowering practitioners and professionals to deliver the best health experience to patients and citizens.

Notes:

1 Hood et al., 2012.

2 Deloitte, 2019.

3 World Health Organization (WHO), 2018.

4 World Health Organization (WHO), 2018.

5 World Health Organization (WHO), 2018.

6 Quote by Marie Freifrau von Ebner-Eschenbach.

7 Frost & Sullivan Report, 2019.

8 The “Virtual Singapore” project is championed by the National Research Foundation (NRF); the Prime Minister’s Office, Singapore; the Singapore Land Authority (SLA); and the Government Technology Agency of Singapore (GovTech). It aims to transform Singapore into a “platform city” in all its dimensions. See: https://www.nrf.gov.sg/programmes/virtual-singapore

9 Mikk, 2017.

10 See for instance the “Data Saves Lives” initiative: http://www.cphhealthtech.com/data-saves-lives

11 See https://allofus.nih.gov/

12 Murphy, 2014.

13 Frost & Sullivan Report, 2014.

14 Further information about the Living Heart project is available at https://www.3ds.com/products-services/simulia/solutions/life-sciences/the-living-heart-project/

15 Hippocratic Oath. See for instance here: https://www.nlm.nih.gov/hmd/greek/greek_oath.html

16 The Economist Intelligence Unit, 2016.

17 Further information about how the FDA develops an innovative approach and policy in this domain is available at https://www.fda.gov/ScienceResearch/SpecialTopics/RealWorldEvidence/default.htm

18 Irving, 2017.

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CHAPTER 8

HOW DATA WILL IMPROVE HEALTHCARE WITHOUT ADDING STAFF OR BEDS

Kieran Murphy, GE Healthcare

Few other industries are as complex, comprehensive, and fascinating as healthcare. Three major forces are impacting the sector today: cost, which is skyrocketing at a time when governments are facing budgetary pressures; access, with 5.8 billion people unable to receive affordable healthcare across the world; and quality, which global providers have struggled to consistently offer.

A key ingredient to address all of these challenges is healthcare *data*, which exists in abundance. Today, hospitals are producing 50 petabytes of data per year.[1] This includes clinical notes, lab tests, medical images, sensor readings, genomics, and operational and financial data. Yet 97% of this information goes unanalyzed or unused. Too often, important patient data is siloed in different departments, devices, medical records or even hospitals and, as a result, the care team lacks a fully informed clinical picture.

The wealth of untapped data has created a path for *precision health*—an emerging approach to healthcare that is integrated, highly personalized to each patient, and that reduces waste and inefficiency.

More effectively integrating data and analytics across the care pathway can better support medical professionals and care providers with insights that enable predictive, individualized, and efficient care. Below I've outlined key examples of how the effective utilization of data is improving healthcare outcomes.

Improving the quality of imaging diagnosis

A staggering 90% of all healthcare data comes from imaging technology. Hospitals store hundreds of millions of digital images, and their numbers are growing as imaging scanners such as MRIs and CTs become better at capturing thinner and thinner slices of the body, and as 3D and 4D imaging become the norm.

Humans alone cannot analyze and convert that much data into useful information. Artificial Intelligence (AI)-powered medical imaging systems can help radiologists diagnose earlier and treat patients with emerging or serious conditions sooner.

Let's look at the potential of harnessing data derived from the oldest form of medical imaging, the X-ray. Just like first impressions with people, the first clinical image taken helps set the path going forward. Chest X-rays represent 40% of the 3.6 billion imaging procedures performed worldwide every year.[2] But X-ray "reject rates", the number of images that cannot be used due to poor image quality or patient positioning, can approach 25%.[3]

To address this, software engineers have developed an application that helps clinicians pinpoint the root causes of rejected images.

The app was piloted at the University of Washington Medical Center and has automated a process that once required 230 mouse clicks and nearly seven hours of work.[4] Reducing these reject rates saves time and resources while putting patients on the right path sooner.

X-rays also provide the first indicator of a potentially collapsed lung, clinically known as a pneumothorax, a life-threatening condition that strikes nearly 74,000 Americans each year,[5] which can be deadly if not diagnosed quickly and accurately.[6] A pneumothorax occurs when air leaks into the space between the lung and chest wall. This air pushes on the outside of the lung and makes it collapse. It can be caused by trauma, cigarette smoking, drug abuse, certain lung diseases, or by complications from surgery.

Today, patients who present with symptoms associated with this condition receive a chest X-ray, which can take anywhere between two and eight hours for a radiologist to read.[7] Clinicians are looking for ways to read chest X-rays faster and in a more prioritized manner to enable a quicker diagnosis.

A new X-ray algorithm uses data to identify potential pneumothorax cases at the point-of-care to enable prioritization of image review. Through simple red and green lights that flag critical cases, technologists taking the scan know whether this is a patient whose images need to be read immediately. When a suspected pneumothorax condition is identified, the point-of-care notification alerts the clinical team, enabling prioritization of image review and potentially changing the trajectory of the patient.

Helping doctors make clinical decisions across specialties

According to the International Agency for Research on Cancer, an estimated 18.1 million new cancer cases were diagnosed globally in 2018, and 9.6 million people died from the disease.[8] In oncology, speeding up diagnosis, improving accuracy, and enabling more individualized treatments offers great clinical potential for doctors, researchers, and patients.

Yet, reports show that the process of preparing for, conducting, and documenting tumor board meetings is frequently suboptimal and non-standardized,[9] with each specialist aggregating data in a silo. As a result, clinicians can develop perspectives based on an incomplete view of a patient, and meetings are spent switching back and forth between different systems and portable technologies used across each discipline. These inconsistencies and inefficiencies can lead to wasted time, decreased engagement, and could even negatively impact patient outcomes.[10]

An alliance between Roche Diagnostics and GE Healthcare aims to combine and analyze patients' in vitro diagnostic data—including genomics, tissue pathology, and biomarkers—with their in vivo medical imaging and monitoring data. When combined with the increasing availability of big data and advanced analytics, a patient can be placed quickly within the context of a broader evidence base.

Co-developed tools present a patient's in vivo and in vitro information alongside not only patient records but also medical best practices and the latest research outcomes, helping physicians make more informed, earlier, and faster diagnoses and helping them determine the most appropriate, individualized treatment for a specific patient.

Among the tools in development is cloud-based software that would fundamentally change the process of tumor board meetings that bring together clinicians from multiple disciplines to discuss the diagnosis and treatment plan for cancer patients.

Lack of effective data integration can also prevent clinicians from understanding the root cause of an illness and may hinder informed decision making when it is most crucial, including in acute situations, such as identifying the onset of sepsis. Without quick treatment, sepsis—a common but serious complication arising from an infection—can cause multiple organ failure. It is estimated to affect more than 30 million people worldwide each year, claiming the lives of 6 million patients.[11]

Roche and GE Healthcare are working to create an AI-enabled "virtual collaborator" to integrate data from electronic medical records with other hospital systems to provide insights into the status and trends of patients who are at-risk for sepsis-related deterioration. The virtual collaborator aims to highlight and integrate the detectable, but potentially undetected, data.

Giving providers the ability to access and analyze patient information across specialties through a single solution, in their existing workflow, empowers them to deliver the kind of care that is expected today—precise, data-driven, and evidence-based.

Using data to individualize precision therapies

Integrating valuable data can have transformative effects not only in a hospital or patient-facing setting but across the healthcare ecosystem. We have recently begun a partnership with Vanderbilt University Medical Center (VUMC), essentially drawing on data to enable safer, more-precise immunotherapies. Immunotherapies use the immune system to recognize and attack cancer cells and can be more effective than traditional treatments, but response rates are often low and side effects can be severe.

Together, we will retrospectively analyze and correlate the immunotherapy treatment response of thousands of VUMC cancer patients with their anonymized demographic, genomic, tumor, cellular, proteomic, and imaging data. We will then develop AI-powered apps that draw on this data to help physicians identify the most suitable treatment for each individual patient.

Not only will these techniques help predict the efficacy of an immunotherapy treatment but also its adverse effects for a specific patient, before the therapy is administered. This would allow physicians to better target immunotherapies to the right patients and avoid potentially damaging, ineffective, and costly courses of treatments.

Addressing capacity, safety, and quality

In the 1960s, airports started using air traffic control technology that allowed them to swiftly transition from scheduling a few hundred flights a day to managing thousands. Now, many airports handle millions of passengers every day. Despite the vast complexity of such a logistical challenge, the airline industry also became significantly safer and more efficient along the way.

This "air traffic control" concept soon spread to other industries. Online retailers use data and technology to predict when customers need their next batch of vitamins. Brick-and-mortar businesses and restaurants use it to track busy times and appropriately staff those periods.

Now the healthcare industry is implementing its own "air traffic control". A small but growing number of hospitals are implementing NASA-style Command Centers, designed to serve as a central mission control across a hospital's functions and services. The goal: address the capacity, safety, quality, and wait-time issues that have plagued healthcare.

A Command Center constantly pulls in streams of data from multiple systems at a hospital. Using simulation, algorithms, and AI, the system will generate predictive analytics that will help staff recognize patterns in real-time and predict what will happen in the next 24 to 48 hours. Advanced algorithms help staff anticipate and resolve bottlenecks in care-delivery before they occur, recommending actions to enable faster, more responsive patient care and better allocation of resources. The data is displayed not only on the Command Center screens but also on tablets and mobile devices. All of this allows the staff to prioritize and focus on delivering care rather than organizing it.

Johns Hopkins Hospital in Baltimore, Maryland was an early adopter of the Command Center, which helped them transfer patients to other hospitals 60% faster, reduce wait times in the Emergency Department by 25%, and decrease time spent waiting in the operating room for a post-surgical bed by 70%.

Industry experts say that this type of digitization is not only inevitable but is just the beginning. Deloitte's Center for Health Solutions report cites centralized digital centers to enable decision-making as one of the major changes the hospital of the future will need to implement to function in a world of evolving technologies, demographic shifts, and economic changes.[12]

According to the report, AI can continuously monitor the data to alert hospital operators and caregivers, enabling more efficient care and better outcomes. Through big-data analytics, machine learning, and AI, patient harm—or unintended consequences—can be predicted before it occurs and suggested interventions can be fed to caregivers. For example, using data on admissions, inter-facility transfers, and predictive analytics on possible days for discharge, command centers can help staff manage patient flow and improve care delivery, better manage lengths of stay, and enhance the discharge process.

Catalyzing the transformation of healthcare

Even though these techniques will change the interaction between doctors and patients and change how care is delivered, they should not be overtly noticed but rather they should seamlessly integrate the existing care continuum—embedded into workflows, processes, applications, and devices already in use today.

This won't happen overnight, but opportunities to deliver precision health already exist throughout the global healthcare ecosystem, from integrated digital diagnostics and AI-based clinical decision support to precision therapeutics like immunotherapies and 3D printing for treatment planning, telehealth, and remote patient monitoring. These are just the beginning.

These tools will quickly feel natural, making way for a more personal doctor-to-patient experience.

Conclusion

To deliver better quality healthcare at a lower cost to more people, healthcare needs to become more personalized, more digitally integrated, and more collaborative. Effective integration of useful data is the key to this transformation. Advanced analytics teams have made significant progress over the past few years, and we are already seeing the impact in pockets of healthcare. The potential is exciting, but there is a lot of work to be done.

Harnessed effectively, data and analytics can increase the efficiency of health systems, offer insights to support clinical decisions, better organize care, and even help to predict future health events. Ultimately this all means more effective, precise, and individualized healthcare with better outcomes for patients, providers, physicians, and healthcare staff.

Notes:

1 EMC MC with Research & Analysis by IDC, 2014.

2 World Health Organization, 2016.

3 Little et al., 2017.

4 GE Healthcare, 2018.

5 Bintcliffe et al., 2014.

6 Morjaria et al., 2014.

7 Rachh et al., 2017.

8 Bray et al., 2018.

9 Patkar et al., 2011.

10 Foster et al., 2016.

11 Fleischmann et al., 2016.

12 Deloitte Center for Health Solution, 2017.

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CHAPTER 9

CASE OF IAMYIAM—INNOVATING IN PREVENTIVE HEALTH DELIVERY

Lorena Puica, iamYiam
Jack Bauersachs, University of Applied Sciences Deggendorf

Innovation in health delivery has long been associated with technical advances in curative care. While this has brought improvements in treatment outcomes, it has yet to deliver meaningful progress in mitigating the rapid growth in preventable non-communicable diseases (NCDs)—which reflect global trends in the way we work, eat, and live.[1]

Not only are lifestyle diseases the leading cause of death in developing countries, but they also account for, including mental health, 90% of public and private health expenditures in developed economies.[2] Moreover, they reduce the meaningfulness of progress made in increasing life expectancy. Half of a retiree's remaining years of life will be significantly impacted by one or more lifestyle-related illnesses, reducing the quality of life and adding treatment costs.[3]

To address this growing issue, lifestyle enhancement and prevention research has expanded and matured significantly over the last three decades. There are now over 1.8 million published studies evaluating the effects of lifestyle, diet, traditional therapies, and personal biology on health outcomes.[4] With an emphasis on daily lifestyle interventions, these sustainable health approaches are proven to reduce disease burden, resulting in lower overall costs and higher impact.[5] Over the past decade, this research has translated into a call for action in medical and health provider communities and also spawned over 300,000 start-ups focused on prevention by enhancing lifestyle.[6]

These include preventive activity booking platforms, such as BookRetreats; interpreters of biological wellness markers from saliva and blood samples, such as 23&me and WellnessFX; and digital engagement gadgets, such as fitness watches and phone apps that influence behavior by providing real-time feedback about miles walked, calories burned, or sleep quantity and inferred quality. There are also digital coaching platforms, like *Omada*, that seek to prevent pre-diabetics from requiring medical interventions.

Growing recognition that prevention is the key instrument for tackling health care costs is driving governments, insurers, corporations, and healthcare providers to actively seek new frameworks, as well as innovations and partnerships to foster widespread adoption of healthier lifestyles. In the United Kingdom (U.K.), the Department of Health and Social Care has prioritized spending on new approaches to prevention in order to reach the government's mission of enabling its people to enjoy five additional, healthy, and independent years of life.[7] An Asian insurance company, AIA, introduced a platform to create incentives for members via product discounts and other rewards to engage in preventive activities such as quitting smoking.[8] Fullerton Healthcare has made a long-term commitment to bring prevention innovations to its millions of members across Asia Pacific through its recent partnership with iamYiam. Moreover, Discovery Health Medical Scheme offers its South African members a gamified prevention program called Vitality,[9] using inputs from fitness wearables, while Bupa healthcare targets corporate culture in Australia with its multipronged wellness programs.[10]

Nevertheless, prevention is still viewed mainly through the lens of curative medicine. For many, the entry point for engagement with preventive measures follows a medical diagnosis of mental or physical symptoms. As a consequence, the medical community has been the primary recipient of health policy initiatives focused on prevention, even though there may be more effective channels. Institutions that already seek to influence the actions of their constituencies, like schools, employers, and social communities,[11] may be in a better position to promote activities associated with a healthier lifestyle. Moreover, investment capital earmarked for "preventive" innovations flows primarily toward technologies that aim to reduce or revert the progression of chronic disease and pre-morbidity conditions—such as elevated blood sugar, blood pressure, or cholesterol—rather than toward technologies that sustain health in the broader, asymptomatic population.

Viewing health as merely the absence of ailments continues to drive the "repair shop" model that dominates institutionalized health delivery—fixing what is broken. At its core, this paradigm is reactive, allocating substantial resources to finding fixes for problems when their burden becomes unmanageable for the individual and the system itself. Nearly a century ago smoking was linked by researchers to disease, yet restrictions on advertising, sales to minors, and product warnings were initiated decades later—after the burden on public health could no longer be ignored.[12] Similarly, mental health has become a focus of health policy now that costs from treatment and lost productivity are skyrocketing; by 2030 depression is expected to be the leading cause of the global disease burden.[13] Centered on medical treatment rather than the individual's lifestyle and environment, reactive healthcare has proven itself unsustainable as it fails to keep pace with the alarming growth in chronic and debilitating diseases linked directly to unhealthy lifestyles.

This suggests the need for a pre-emptive model that focuses on enhancing an individual's lifestyle and environment to support health in a sustainable manner—every day and lifelong. Such a model would align with what was commonly considered preventive for most of written history. Prior to the antiseptic and public hygiene revolutions in the late 19th century and the development of antibiotics in the early 20th century, models for obtaining and maintaining health were holistic and, by necessity, activity-based—eating, exercising, resting, and thinking right.[14]

Building on this view, this chapter focuses on how a creative start-up designed a framework for prevention that leverages both the time-tested preventive model of health delivery and cutting edge artificial intelligence (AI) technology to provide an accessible, sustainable, and affordable solution. This example traces the development of iamYiam and the challenges faced in designing and bringing to life this framework. Following an overview of the vision and concept behind creating and delivering scalable prevention, we discuss how advances in machine learning, genomics, plus heightened privacy concerns led to essential shifts in iamYiam's market development strategy, delivery platform, and business model. We extend the discussion to look at the impact of regulation on health delivery start-ups. In the final segment, we reflect on the key lessons for entrepreneurs and policymakers engaging with preventive health.

Necessity—the mother of invention

iamYiam was launched in 2016 to provide the most efficient path for achieving optimal health—personalized to the individual. The idea for the company grew out of the experience of the founder, Lorena Puica, in overcoming her own debilitating health condition: "Doctors in Germany, as well as in the U.K., recommended a course of action—thyroidectomy—that I disagreed with due to the severity of the implications for my overall wellbeing. I started researching what the most effective courses of non-medical action for my condition were and, after a year and a half of experimenting with everything from yoga, meditation, acupuncture, massage, nutrition, etc., I achieved a sustainable state of health without any medication or other form of medical intervention. What baffled me was that, while the path to a science-based medical solution was straightforward, an analogous approach to non-medical, preventive alternatives for my challenges did not yet exist. I decided to get involved so that no one else would need to take a random walk among anecdotal advice, internet searches, and experimentation to find the best preventive solution."

Lorena learned through her research that emotions, social connections, career success, financial security, purposeful action, and environmental impact are interrelated with biological and mental health and—for health to be sustainable—must be integrated into a new framework. As a former investment industry professional, she viewed health as an optimization problem analogous to portfolio theory and investment decision-making. Just as an optimal investment portfolio achieves its goals by allocating capital efficiently among a mix of asset classes, optimal health is the result of an efficient allocation of time, energy, and nutrients based on an individual's biological, environmental, and psychological idiosyncrasies. Prevention stems mainly from how one allocates the hours of the day to various activities ranging from sleep to mental processes and physical exertion, as well as how one thinks, eats, and acts. At the same time, active measures—including traditional and modern nonmedical interventions, such as acupuncture and cognitive behavioral therapy—can also be regarded as preventive activities.

To implement this concept, a team was formed to develop a research base and build a digital platform to provide evidence-based recommendations personalized to one's biology and preferences. A marketplace was also offered where vetted practitioners and nutrition providers could offer members access to tools, therapies, classes, meal plans, and other resources that appear in some recommendations—such that individual health information, personalized recommendations, and resources are accessible in one health account with lifetime access.

A technical approach to quality of life

The key technological innovation the company developed is a comprehensive framework for understanding an individual's life context and goals. It combines biological (genetic), behavioral, and environmental factors in a predictive model that guides members to their maximum potential by tracking their progress toward optimizing the quality of their life. This is modeled by a life quality index (LQI) composed of nine interrelated dimensions, ranging from the environment to physical health.

At the heart of the platform is an AI agent referred to as *See Yourself Differently* (Syd), which acts as an optimal controller. Syd estimates the current state of being of a person in relation to their goals and uses platform-wide observations to optimize specific guidance for reaching one's desired outcomes. Over 200,000 published research papers were referenced to create the baseline for the predictions that Syd continuously improves upon via its internal model and interactions with all members. Progress in an individual's journey to better health is tracked and displayed in the member's LQI as Syd becomes a life partner—and an accurate, adaptive representation of the member's state of being.

For example, an individual with a goal of better sleep may have genetic traits that predict poor caffeine metabolism. Through analysis of the behavioral, environmental and biological data across the platform, Syd might determine that others with similar genetics, environmental, and personal characteristics—such as the same postal code, satisfaction with their careers, and low screen time—might sleep better if caffeine consumption is followed by five minutes of brisk walking. The individual's response to this guidance updates the LQI score and serves as input for Syd to further personalize recommendations.

Challenges of going to market

A key challenge of bringing this innovation to market was the product's complexity. While there had been rapid growth in the number of adults engaging in preventive activities, few were actively seeking an all-encompassing system for delivering qualified guidance on activities tied to their biology and personality. The goal was to target the market segment that most severely felt the need for timely and effective advice on what steps to take and how to easily access what would work best for them.

iamYiam.com was launched with a focus on professionals who were aware of, or had already previously engaged with, preventive practices. The messaging initially focused on the platform's efficiency: "We believe that experiencing natural health must be simpler." Subsequent customer feedback pointed toward highlighting evidence-based guidance and other benefits. During the first year, a significant increase in consumer-oriented genetic testing websites offering ancestry, health risks, and other tests went to market. This exacerbated the need for a sharper positioning of iamYiam as an adaptive model for preventive health delivery—especially to limit comparison with genetic testing companies.

This same messaging challenge also applied to fundraising. The amount of time to develop and test the AI-driven algorithms meant the company was similar to a pharma start-up—requiring substantial investment for testing and development before the product was complete. Accordingly, market penetration and ROI were expected to lag the development phase. Venture capitalists tended to relegate the company to a predefined narrow category for lack of one with a better fit—either a genetics services business, a digital health application, or a two-sided marketplace. Anticipating this challenge, the company aimed its capital raising efforts at investment angels with a shared passion for the company's mission.

To smooth the market penetration strategy, the product was positioned as an everyday, lifelong companion to support one's health, offering evidence-based guidance at every step of the way. A broader market analysis also revealed that employers would respond favorably to the company's offering, as many were actively seeking a single comprehensive preventive solution for their rising healthcare costs.

Market expansion into business-to-consumer (B2C)

During 2017, iamYiam laid the groundwork for taking its offering directly to corporations. Employers were becoming acutely aware that rising rates of obesity and impaired mental health were dragging down productivity and raising health insurance premiums. Depression, which the platform addresses, was increasingly becoming a significant cause of absenteeism and lost productivity.

While most corporations that were approached had already implemented one or several preventive programs, these were not tailored to the specific health issues individual employees faced. Moreover, the expected results were neither based on scientific evidence nor measured in a way that aided decision-making. Companies were interested in assessing the health risks they faced and getting an overall picture of the state of health of their employees. An executive dashboard was developed to demonstrate the potential risk mitigation and return on investment (ROI) from deploying the platform. Besides calculating ROI, it presented insights and risks for employee health as a group by pairing preventive activities with productivity, absenteeism, and other outcomes. What initially began as a means to demonstrate the platform's effectiveness became key features within the iamYiam corporate offering: custom dashboards, employee memberships, and member support.

Regulatory impact

The platform's AI engine does not perform disease diagnosis. This allows the company to operate in the prevention space rather than the medical industry, enabling a faster path to market. Such an approach is efficient for addressing the current market while remaining open to future collaborations with innovators in disease treatment if, as anticipated, the prevailing medical model becomes more integrated. Recent research supports the view that preventive activities play an important role in life quality during and after treatment for disease.[15] A new emphasis in medicine on life quality over disease treatment may lead to innovations in treatment models that combine a patient's historical lifestyle data with treatment protocols to deliver better health risk predictions and a higher quality of life. The personalized analysis provided by Syd could well become a useful input for collaborators developing new diagnostic methods or treatments that adjust medical measures to LQI scores or other information from the platform's data analysis. In such a case, the genetic tests that many members undertake to further personalize the guidance they receive about their activities may trigger more intense regulation as the data use crosses the line between wellness and clinical use.

Regulation proves to be more of a challenge for data protection—however, not for the reasons one would expect. Coinciding with the product launch, new data protection requirements were being planned by European and U.K. policymakers. From inception, personal privacy has been an overarching goal in developing the iamYiam and Syd platform. The company made extensive efforts to find the most reliable technologies available to protect the privacy of personal data and formed a board composed of thought leaders in ethics to provide oversight on the collection and use of data. As a result, the company has been well positioned to meet the challenge of navigating a continuously changing landscape of regulation leading up to the recently issued General Data Protection Regulation (GDPR) and the U.K. Data Protection Act.

Lessons learned

The unpredictability of how policymakers will interpret what is in the best interests of consumers results in resources wasted on contingency planning. Health start-ups, in particular, must not only comply with established medical regulations and new interpretations—driven by genetics evaluation and other evolving methodologies—but also predict the impact of recent regional directives in data privacy and copyright protections. Local differences in regulations compel start-ups to weigh possible compliance stumbling blocks when choosing whether to relocate operations to maintain their speed of development. Ideally, policymakers will not only consider the intent of the regulations but the long-term implications for innovators in the digital health space. Addressing their concerns early on would avoid penalizing them with excessive costs and delays in delivering impact in their markets.

Start-ups can also prepare for changes in rules governing data and privacy protection by not second-guessing regulators. A better strategy is to keep the interests of their customers—the rightful owners of data and intellectual property—in mind by putting themselves in their customers' shoes at every step of the product development process. If there is something you would not enjoy in terms of security, privacy, or data sharing, your customers will reach the same conclusion sooner or later.

Lessons for policymakers: sustainable health vs. early diagnosis

Prevention strategies and digital technologies need to be at the forefront of long-term planning. Some national health agencies, such as those in Singapore and the U.K., are focusing their strategies on these two areas. Singapore is also an example of a country ready to partner with health innovators. For instance, the Singapore Ministry of Health partnered with the U.K. start-up Tictak to motivate its citizens to improve their lifestyles by interpreting information collected from fitness wearables, such as Apple Watch.[16]

In the U.K., the National Health Service (NHS) is taking the lead in partnering with digital health start-ups to accelerate the innovation process.[17] In that role, the NHS actively solicits the input of innovators, like iamYiam, on the future of prevention and how to deliver affordable, accessible health outcomes.

Much more attention is still needed to create innovative public policies that target prevention where it is most effective—before one requires medical diagnosis or treatment. Public policy would benefit from being primarily directed at sustainable health. This translates into teaching people and providing the means for them to access activities that enhance their lifestyle and environment—as well as rewarding innovators who create the tools and systems for this purpose. One example of an agency that directly targets sustainability is Singapore's Health Promotion Board, which rewards employers, builders, and landlords for finding innovative ways to prevent obesity in young workers before it creates serious health issues.[18]

Rising costs have pushed large corporations to try new models that more effectively deliver health to their employees. One prominent example of an innovative model is the cooperative arrangement formed by JP Morgan, Amazon, and Berkshire Hathaway to self-insure. This nonprofit venture focuses on improving care for its one million employees—and eventually making their innovations available to the 150 million Americans who get their health insurance through work.[19] However, policies that nudge companies to create new models for healthier work environments are still needed, which means addressing all dimensions of their employees' lifestyle, ranging from financial security to social interactions.

In closing, although lifestyle improvement is where the highest return on expenditures is possible, nearly all preventive initiatives by government services still focus on the "repair shop" medical model of health delivery—taking action after one is diagnosed to be at risk for diabetes, heart disease, depression, etc. Preventive technologies have become increasingly sophisticated for addressing health issues at the pre-chronic and treatment stages, yet they are more burdensome in monetary and societal terms than other approaches aimed at root causes. Policymakers who make a concerted effort to reposition the fundamental health delivery model as an integrated model with a core focus on the relationship between health and lifestyle can also effect an improved social climate, beyond the substantial cost savings. Technologies are rapidly evolving to support this model with tools and systems to guide individuals to make healthier choices. To ensure that policies do not hamper innovation, greater dialogue is needed between governments and those in the vanguard of innovation. Policies that promote long-term investments encourage innovation in systemic solutions that have long development cycles.

The potential benefits of getting prevention policy right far outweigh the costs of promoting innovation. Poor lifestyle choices drive health risks that drive chronic disease and health care costs. Governments are uniquely positioned to encourage change by shining a light on unhealthy behaviors and empowering the innovators of tomorrow to bring their solutions to global audiences.

Notes:

1 World Health Organization, 2018.

2 Centers for Disease Control and Prevention, 2019.

3 Salive, 2013.

4 Google Scholar, 2019.

5 Minich et al., 2013.

6 Global Entrepreneurship Monitor (GEM), 2019. The authors made their own estimates based on the data in the GEM Global Report.

7 UK Department for Business, Energy, and Industrial Strategy, 2018.

8 Further information about AIA's corporate wellness program is available at https://vitality.aia.com.sg/en/vitality/home.html

9 Further information about Discovery's Vitality application is available at https://www.discovery.co.za/vitality/vitality-active

10 Further information about Bupa's workplace programs is available at https://www.bupahealthierworkplaces.com.au/solution/creating-healthier-cultures-social-connection-packs/

11 Ivbijaro, 2012.

12 Bachinger et al., 2007.

13 World Health Organization (WHO), 2011.

14 Petersen et al., 1996.

15 Segal et al., 2017.

16 McEleny, 2018.

17 UK Department of Health and Social Care, 2018.

18 Health Promotion Board, 2019.

19 Tracer, 2018.

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CHAPTER 10

HOW PARTICLE PHYSICS RESEARCH AT CERN CONTRIBUTES TO MEDICAL INNOVATION

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Since the discovery of X-rays at the end of the 19th century, physics has been having a tremendous impact on modern medicine. Physics phenomena underpin many advanced techniques and technologies that are routinely used in hospitals for both diagnosis and treatment of diseases. Radiotherapy for cancer treatment, radiopharmaceuticals, magnetic resonance imaging (MRI), and positron emission tomography (PET) imaging are just some examples. In addition, many of the state-of-the-art technologies behind these healthcare innovations were initially developed for particle physics research. Some have been pushed well beyond the industrial know-how by the stringent requirements of frontier instruments, like the particle accelerator Tevatron at Fermilab,[1] or the Large Hadron Collider (LHC) at CERN,[2] as well as the detectors used in these machines. Particle detectors and particle accelerators are not only found at CERN and other particle physics laboratories but are ubiquitous in hospitals. Accelerators are the core of radiotherapy devices, while PET scanners contain photon detectors. Computer simulations of how particles interact with matter are also widely used to model the effects of radiation on biological tissues. More recently, the healthcare sector has become interested in artificial intelligence techniques. Personalized medicine, an increasingly data-hungry discipline, is a major driver of this trend, which in turn is triggering an interest in the data analytics techniques being developed by particle physicists to deal with their large data sets.

There is a giant leap between a bespoke 27-kilometer long accelerator like the LHC and an off-the-shelf room-sized medical accelerator. Understanding how the transfer of technologies and know-how from particle physics to the medtech industry and medical research happens is a challenge. This knowledge can offer keys to improve the process and to maximize the impact of basic science on societally relevant topics, such as healthcare.

This article mainly focuses on the example of knowledge transfer from CERN, the world's largest particle physics laboratory. Some of the strategic issues described are relevant for the broad community of particle physics research and for "big science" in general. However, CERN also faces some specific challenges due to it being a publicly funded international organization with a core mission of fundamental research.

The impact of basic research

Beyond scientific achievements, the search for answers to fundamental questions often leads to major technological breakthroughs. However, measuring the worth of basic research is not a simple cost-benefit analysis. Often, the impact of basic research on the medtech market is indirect and difficult to track. One such case is particle physics' contribution to modern medical imaging technology. Today, MRI scanners deliver amazingly detailed images of the human body thanks to powerful magnets engineered with coils of a superconducting material called niobium-titanium. In the early seventies when the MRI technique was in its infancy, this material was industrially available only in small quantities, so the first scanners were built using conventional magnets. At the same time, particle physics was in dire need of niobium-titanium to build the strong magnets necessary for the Tevatron particle accelerator at Fermilab.[3] This is where the role of big science in pushing technologies beyond state-of-the-art becomes manifest: Fermilab bought the raw material in quantities that were orders of magnitude larger than standard orders for niobium-titanium and worked alongside manufacturers to achieve the perfect coils for the Tevatron. This paved the way for commercial use of niobium-titanium in MRI machines and, later, in medical accelerators.

A similar pattern can be found in the history of technology for PET scanners, often quoted as the epitome of the cross-fertilization between particle physics detectors and imaging tools. Experiments at the Stanford Linear Accelerator Center and CERN pioneered the large-scale use of detectors that are now ubiquitous in PET scanners. The mammoth scale of these next-generation experiments fueled the development of state-of-the-art photon-sensitive devices—which are used in the latest commercial PET scanners.

In some cases, there can be a direct transfer of a technology developed for particle physics research to medical applications. A recent successful example is a breakthrough application of a chip developed at CERN by the Medipix3 Collaboration for LHC experiments. Members of the Medipix3 collaboration founded a company, MARS Bioimaging Ltd., which has been granted a license to exploit the chip for spectral computed tomography imaging—X-Ray imaging in color. In 2018, the company developed a scanner based on the Medipix3 technology and managed to take the first 3D color X-ray images of human body parts.[4] However, such a direct transfer is not common—particularly in laboratories or institutions like CERN, which have a mandate of pure basic research. In such places, technologies are developed to satisfy the needs of upcoming or on-going projects and are often tailored to the end use in a particle physics environment.

International collaborations play a vital role also in providing fertile ground for the application of technologies developed for basic research to other fields. For example, the Geant4 computing simulation toolkit is developed and maintained by a world-wide collaboration of scientists and software engineers.[5] Today it is adopted by thousands of users worldwide for application in a variety of domains, including the study of the radiation environment on the International Space Station as well as radiation effects on possible future manned space missions to the Moon or Mars.

Success stories of medtech applications of CERN technology

CERN is the world's largest particle physics laboratory, located at the border between France and Switzerland. Its core mission is fundamental research in particle physics. As a publicly funded laboratory, it also has a remit to ensure that its technology and expertise deliver immediate and tangible benefits to society wherever possible. Other physics research laboratories and institutes were early adopters of CERN technologies, thanks to the highly collaborative nature of particle physics. Since its creation in 1954, CERN has also been active in transferring its technology and expertise outside particle physics. The most known example is the invention of the World Wide Web by CERN scientist Tim Berners-Lee in 1989, but the laboratory has contributed to applications in many other fields, from medical and biomedical technologies to aerospace applications, safety, "Industry 4.0", cultural heritage, and emerging technologies (Figure 10.1).

Applications of CERN technologies and know-how to the health domain represent one of the most relevant knowledge transfer opportunities in terms of potential impact on society.

At CERN, early activities with pertinence to medical applications date back to the 1970s. At that time, knowledge transfer happened—mostly serendipitously—through specific initiatives of individual researchers. CERN physicist Georges Charpak not only opened a new era for particle physics with the detector he conceived in 1968, for which he earned the 1992 Nobel Prize in Physics, but also strived to ensure that his invention could be applied in medicine. Charpak's detector has found important applications in biology, radiology, and nuclear medicine. He was a firm believer in entrepreneurship as a tool to transfer technologies from basic research to society—the company he founded in 1989 is still active in the field of medical imaging, with a system based on his original detector.[6]

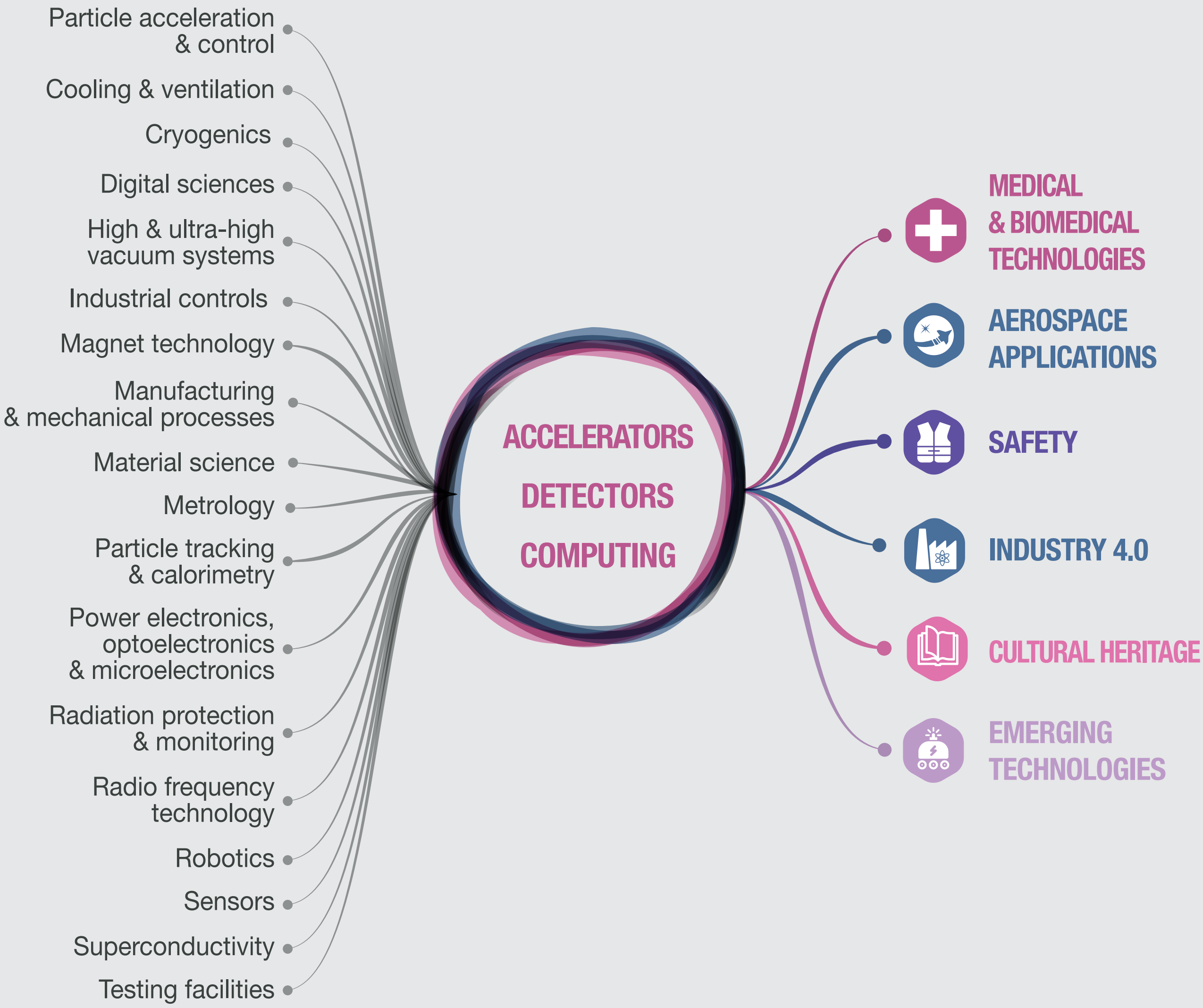
In 1975, CERN physicists David Townsend and Alan Jeavons had the idea of using a version of Charpak's detector for PET imaging, by looking at the work of a group in Berkeley and University of California, San Francisco (UCSF). Townsend developed software to reconstruct the data from Jeavons' detectors and, in 1977, they took the first mouse image, with the participation of radiobiologist Marilena Streit-Bianchi. PET was not invented at CERN, but the work carried out by Jeavons and Townsend made a major contribution to its early development.[7]

After these individual efforts, CERN acted in the 1990s as a catalyst for collaborative endeavors spanning beyond particle physics: the Crystal Clear and Medipix international collaborations aimed at developing particle physics detectors and exploring their applications to other fields, including healthcare.[8] Such collaborative efforts often provide the much-needed support to bridge the gap between CERN R&D and the end-user application. Given CERN's focus on fundamental research, it is not surprising that there are a limited number of cases of direct transfer to the healthcare sector, where a technology developed for particle physics is used "as-is" in a medical device. One example is the color X-ray scanner mentioned above. Another recent case is a compact, modular, low-cost linear accelerator manufactured by CERN, which capitalizes on the skills and expertise developed while designing the laboratory's latest linear accelerator.[9] The compact accelerator is suitable for medical applications and has been licensed to a company, ADAM, that is building a next-generation machine for hadron therapy, an advanced form of cancer radiation therapy that uses protons or other ions to treat cancer. Simulation codes initially developed for particle physics have also become crucial to modeling the effects of radiation on biological tissues for a variety of applications in the medical field. The FLUKA simulation package, jointly developed by CERN and the Istituto Nazionale di Fisica Nucleare (INFN), is licensed to various medtech companies.

A major asset to institutions like CERN is their human capital—scientists, engineers, and technicians who have the expertise to develop and maintain innovative technologies and complex technical systems. For example, in the 1990s, CERN leveraged this expertise by contributing to a collaborative design study for a next-generation cancer treatment center that would use

FIGURE 10.1

From CERN knowledge to society



Source: CERN/Geoffrey Dorne.
Notes: Through the laboratory's main technology pillars—Accelerators, Detectors, and Computing—CERN has developed expertise (left) that have found applications in many fields outside particle physics (right). These represent fields where a meaningful knowledge transfer has happened.

both protons and carbon ions.[10] This study provided the technical background for building two of the four European centers providing cancer therapy with protons and carbon ions—the National Centre of Oncological Hadrontherapy (CNAO), Italy,[11] and MedAustron, Austria.[12] CNAO's design was based on the original study, improved by the Foundation for Oncological Hadrontherapy (TERA foundation) and realized with seminal contributions from the INFN—all based in Italy. MedAustron was later constructed using the CNAO design. Beyond the initial design study, CERN had an ongoing agreement with both treatment centers to provide expertise in accelerators, magnets, and training of personnel.

CERN also has unique infrastructures that attract the interest of medtech companies and medical researchers. One example is the CERN-MEDICIS facility that, since 2018, has been producing innovative isotopes for medical and biomedical research by hospitals and other institutes.[13]

Challenges of knowledge transfer from fundamental research

Particle physics has an important role to play in contributing to medical innovation and healthcare technologies. Maximizing the societal impact of basic research requires setting up a number of knowledge transfer strategies and being aware of the challenges ahead. Many of the hurdles faced when trying to apply CERN technologies to the medical and biomedical fields provide important clues for how to optimize these strategies in other application domains, as well as in other fundamental research environments.

As discussed earlier, basic research centers develop technologies primarily for their internal needs. Such technologies are honed and fine-tuned to meet demanding specifications and adapting them to a different application is often not straightforward—and might even require rolling back to an earlier, less customized version. These adaptions may require collaboration with visionary companies who are willing to engage in medium- to long-term partnerships. Even companies with the right mindset and spirit might have difficulty funding such endeavors—when the technology is so disruptive that the market application won't be realized for years and hence does not fit the current market strategy. Funding schemes to bridge the gap between in-house development and market application would catalyze public-private collaborations. Most of the available schemes either fund the initial R&D (proof-of-concept and first prototyping) or the development of a market-ready medical device. However, between prototype and final product, several years of technical developments in close collaboration with clinicians and industry are often needed, and more funding should be made available for this stage. One pioneering initiative is the ATTRACT funding scheme, which is supported by the European Commission's Horizon 2020 Programme and aimed at creating a co-innovation ecosystem for fundamental research and industrial communities to develop breakthrough detection and imaging technologies for scientific and commercial uses.[14]

There is also a need to bridge the cultural gap between companies and the particle physics community. For example, companies do not always know what to expect from a collaboration with scientists and engineers working in big-science endeavors like the Large Hadron Collider. Scientists and engineers not only develop innovative technologies but also have an in-depth understanding of how these technologies work and can be adapted to harsh and challenging environments—ultra-high vacuum, high radiation exposure, superconductivity, superfluidity, and other extreme phenomena. In addition, they are familiar with facing complex problems related to integrating technologies and systems. This unique blend of technical competences and experience in a highly collaborative and interactive environment would be ideal for assisting companies in overcoming their technical challenges.

At the same time, the particle physics community needs to sharpen its efforts: when a potential application for a technology is identified, it is essential to evaluate whether this development would fill an existing need in the medical market or whether the application is trying to solve a problem that is not perceived as such by healthcare professionals. While blue-sky R&D is what drives basic research forward and allows building the experiments of the future, it is important to understand market needs when trying to adapt a given technology to a medical application. A dialogue with all the relevant players on the healthcare side—doctors, medical physicists, and medtech companies—is key to properly assess the potential of a given technology for a specific application, and hence to be able to focus the efforts on the most promising cases. A particularly relevant example is CERN's competences in the data analytics and machine learning domains; as discussed earlier, these competences are essential to harness the full potential of large data sets for personalized medicine. While the LHC experiments generate a vast amount of data, the technical challenges are not the same as those of the healthcare communities. In addition, the computing tools developed at CERN are often highly specialized and only usable by highly skilled scientists. The expectations of end users, such as medical researchers and companies operating in medical and biomedical technologies, may be far from the reality of the computing tools developed at CERN. It would be unrealistic to expect turnkey solutions without further technical developments due to the very different nature of the data sets available in high-energy physics and the medtech field. This makes it crucial to ensure an early dialogue between CERN and potential external partners, as realistic expectations are more likely to result in effective collaborations.

Knowledge transfer at CERN

While a lot of the above can be applied, with some variations, to most laboratories dedicated to fundamental research, a set of challenges is explicitly connected to the CERN environment. For example, the industrial culture at CERN is not as strong as in other research institutions, and therefore it is not always easy to motivate busy scientists to work with a company on the development of a medical device. The nature of CERN as an international organization that is funded by 23 Member States also has implications for the knowledge-transfer process. CERN is bound by its mandate of basic research and cannot become an applied laboratory, meaning that its technologies must be brought to the market by industrial partners. At the same time, CERN being publicly funded implies that companies from all Member States should be given equal opportunities to exploit CERN's technologies. A strategy document outlining knowledge transfer from CERN for the benefit of medical applications sets clear boundaries for these activities.

The knowledge created by CERN's community has the potential to lead to innovation in fields beyond particle physics. This innovation can happen organically, as proved by the early examples of transfer from CERN to medical technologies, but actively investing in the process can also boost its impact and reach. The CERN Knowledge Transfer (KT) group provides advice, support, training, networks and infrastructure to ease the transfer of CERN's know-how to industry and society.[15]

Intellectual property (IP) lies at the core of successful knowledge transfer at CERN. It enables CERN to claim being at the origin of a novel technology, making it possible to share its knowledge and create societal impact. CERN's policy is to disseminate its technologies as widely as possible to industrial and institutional partners within its Member States, however, patenting represents only a tiny part of CERN's approach to IP. CERN will only consider patenting where it might help mitigate the financial risks of investing further in the development of a technology. CERN's patent portfolio currently comprises 34 patent families, a number significantly lower than organizations of a similar size. In addition to its technology portfolio, CERN also has a wealth of scientific and technical competence across areas of expertise, which is accessible through collaboration and consultancy agreements.

Open innovation has been part of CERN's DNA since its inception. Several CERN software technologies are developed with open collaboration in mind. The CERN laboratory is also contributing to many open source projects, small and large, that promote collaboration within the larger community, not only the scientific world. The CERN Open Hardware License, drafted and published by the CERN KT group, was born out of the wish to openly disseminate CERN's hardware designs. The license fosters the dissemination of schematics, hardware documentation, and improvements made to the hardware. The license itself can be used by anyone and is a good example of how CERN's work can have surprising benefits for society—even the availability of open hardware worldwide.

One of the main challenges in the knowledge-transfer sphere is to make it as easy as possible for scientists and other specialists to turn their research into innovations, and CERN invests much effort in such activities. Launched in 2011, the CERN KT Fund bridges the gap between research and industry by awarding grants to projects proposed by CERN personnel where there is a high potential for positive impact on society. Since its creation, 40 projects have been funded, each receiving grants with a value between 15,000 and 240,000 Swiss francs (CHF) over one or several years. In 2016, two European Commission funded projects, AIDA-2020 and ARIES, incorporated a proof-of-concept fund modeled on CERN's KT Fund. CERN also provides a limited amount of seed funding for projects aimed at transferring its technologies and know-how to the medical field. Between 2014 and 2017, 25 projects have been funded with an average grant of about CHF 64,000 per project.

Since the early days of technology transfer at CERN, one main focus has been on knowledge transfer through people—especially early career scientists who work in industry following their contracts at CERN or who start their own company. Over the last 20 years, CERN has continued to build a general culture of entrepreneurship within the organization through many avenues. There are currently over 20 start-ups and spin-offs that use CERN technologies in their business. To assist entrepreneurs and small technology businesses in taking CERN technologies and expertise to the market, the CERN laboratory has also established a network of ten Business Incubation Centres (BICs) throughout its Member States where companies can directly express their interest in adopting a CERN technology. The BIC managers provide office space, expertise, business support, access to local and national networks, and support in accessing funding. Every year since 2008, students from the School of Entrepreneurship (NSE) at the Norwegian University of Science and Technology (NTNU) spend a week at CERN to evaluate the business potential of CERN technologies. Three of the students attending the CERN-NTNU screening week in 2012 started TIND, a spin-off based on CERN's open-source software, Invenio.

Getting the next generation of scientists into the habit of thinking about their research in terms of impact is vital for knowledge transfer to thrive. In 2015, the CERN KT group launched a series of Entrepreneurship Meet-Ups (EM-Us) to foster entrepreneurship within the CERN community. The CERN KT group, with the support of the CERN & Society foundation, also launched the CERN Entrepreneurship Student Programme (CESP), bringing together graduate students from all around the world for 5-weeks of practical and theoretical training at CERN. In 2018, CERN organized the CERN Medical Technology Hackathon (CERN MedTech:Hack) to explore new ways of developing viable applications of CERN technologies in the medical field. The CERN MedTech:Hack took place over three days, during which international teams of students competed to solve topical problems pitched by healthcare organizations and industry partners in the medical field.

Conclusions

Basic research in particle physics is an effective driving force for major technological advances. Bringing such disruptive technologies on the medtech scene is a non-trivial exercise, often because the actual market needs are too far away in time and it is difficult for companies to invest resources in developments outside of their current business plan. CERN and other basic research laboratories should hone their tools and strategies to maximize the impact of their technologies and expertise on societally relevant topics such as healthcare. Understanding what challenges are involved in transferring knowledge from particle physics to the medical field and what lies behind successful cases can offer keys to improving and streamlining the process.

Projects like the LHC can only happen through large-scale international cooperation based on mutual trust. This successful model should be of inspiration when it comes to knowledge transfer, where it is essential for different communities of experts—from academia, industry, and other disciplines—to be in contact and to know and trust each other. When a possible application of a technology is identified, it is essential to evaluate whether this development would fill an existing need in the medical market or whether one is trying to solve a problem that is not perceived as such by healthcare professionals. The scale, complexity, and unprecedented technology needs of such basic science projects require human capital with unique competences. Scientists and engineers from CERN and other research institutes are at the heart of knowledge transfer, as they collaborate with industry while remaining involved in fundamental research, move to the private sector, or start their own business. Getting the next generation of scientists into the habit of thinking about their research in terms of impact is vital for knowledge transfer to thrive.

Fundamental research has a priceless goal: knowledge for the sake of knowledge. Even though the lead times from basic scientific discoveries to practical applications are often long, it is thanks to knowledge that humankind has got to where it stands today. The theories of relativity and quantum mechanics were considered abstract and almost esoteric when they were developed; a century later, we owe them, respectively, the remarkable precision of GPS systems and the transistors that are the foundation of the electronics-based world we live in. Beyond this, particle physics research acts as a trailblazer for disrupting technologies in the fields of particle accelerators, detectors, and computing; these technologies have already greatly contributed to the advances of modern medicine, although their impact is often difficult to track as it is indirect and diffused over time. Supporting the knowledge-transfer process from particle physics to medical research and the medtech industry is a promising avenue to boost healthcare innovation and provide solutions to present and future health challenges. CERN will certainly continue its efforts to maximize the impact of our laboratory's know-how and technologies on society, including—but not limited to—the medical sector.

Notes:

1 Further information about Fermilab is available at www.fnal.gov/

2 Further information about CERN is available at https://home.cern

3 Cofield, 2008.

4 Muller, 2018.

5 Further information about Geant4 is available at http://cern.ch/geant4

6 Illés et al., 2012.

7 Raynova, 2017; Bressan, 2005.

8 Further information is available about the Crystal Clear Collaboration at http://cern.ch/crystalclear and about Medipix at http://cern.ch/medipix

9 Del Rosso, 2015.

10 Bryant, 2000.

11 Further information about CNAO is available at http://fondazionecnao.it

12 Further information about MedAustron is available at https://www.medaustron.at/en

13 CERN, 2017.

14 Further information about ATTRACT is available at https://attract-eu.com

15 Further information about the CERN Knowledge Transfer group is available at http://kt.cern

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CHAPTER 11

OVERCOMING BARRIERS TO MEDICAL INNOVATIONS FOR LOW-RESOURCE SETTINGS

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Advancing health equity by improving health outcomes of those living in the lowest resource settings is a defining moral imperative of our current epoch. By identifying and overcoming barriers to health equity, individuals, families, and communities benefit from lifelong opportunities to improve well-being and increase economic development and security. A key determinant in achieving health equity in low- and middle-income countries is the successful development, introduction, and uptake of essential biologics, drugs, and vaccines—referred to herein as essential medicines—as well as diagnostics, devices, and health systems and services designed for the specific contexts and needs of those living in low-resource settings.

Developing and increasing access to health technologies for use in low-resource settings presents multi-dimensional challenges. For the subset of health innovations known as essential medicines, these challenges are even greater, and additional interventions are required due to the lack of robust and compelling market-based financial incentives that historically drive innovation and uptake of new technologies. Despite clear and present unmet health needs, innovation in essential medicines and other health technologies for disenfranchised populations has historically remained stagnant. Evolving traditional models of—and/or creating new paradigms for—product development, approval, and access are critical to reduce uncertainties and risks and to create sustainable incentives for public, private, and local stakeholders to significantly improve the pace of development and impact of new health technologies.

Three types of challenges to innovation

Challenges to product development for low-resource settings present in myriad ways throughout the product life cycle. Often, analyses of these challenges focus disproportionately on intellectual property and price, while important drivers of access, affordability, and availability of generic options alone are not sufficient to ensure widespread access and uptake of new health products.

A more holistic and systematic approach to identifying barriers and solutions to innovation and successful multisector collaboration reveals diverse opportunities to develop new products or significantly improve access to health technologies in low- and middle-income countries (LMICs). These barriers can be divided into three main categories.

1. **Biological uncertainties:** include biological hurdles or host response limitations imposed by the target disease or population that create uncertainties or currently insurmountable barriers to the development of new health technologies. For example, available scientific evidence may suggest it is biologically implausible to develop a universal, durably protective vaccine of sufficient safety and efficacy for a given disease. Increased investment in product development activities or changes to regulations or policies will have little to no impact on traversing these biological barriers absent further scientific advances or insights.

2. **Technical uncertainties or risks:** refer to challenges related to processes and/or attributes of health technologies in development or inherent in existing products that limit their production, safety, efficacy, or quality. Such issues include, but are not limited to, manufacturing, formulation, product analytics, stability, bioavailability, or half-life of a product candidate as well as dosing schedules and processes for conducting clinical trials. For example, an effective compound may have a complex and costly synthesis process, rendering production expensive and presenting a barrier for uptake in low-resource settings.

   Some technical challenges can be overcome with increased investment. In many cases, effective therapies exist for diseases present in low-resource settings, but in formulations that are resource intensive or burdensome to store or administer. For example, pulmonary surfactant for the treatment of infant respiratory distress syndrome (IRDS) is generally affordable and available. But it requires advanced healthcare infrastructure, such as ventilation equipment, to administer and monitor the treatment, which limits its suitability in low-resource settings. In such cases, reformulations or innovations to existing products may be the optimal investment to overcome an access barrier.

3. **Human-controlled uncertainties and risks:** relate to recommendations and decisions that drive approvals, investments, or allocation of resources that support product development, accessibility, availability, affordability, acceptability, or sustainability of health technologies. Such decisions can significantly create or overcome barriers to medical innovations in all settings. Political will, appropriate and relevant incentives, sufficient or insufficient allocation of financial and human resources, cost- and risk-sharing—or lack thereof—and favorable or unfavorable ethical, regulatory, and policy decisions can either advance or stall innovation. Evidence-driven shifts in the collective understanding of what is truly impeding access in low-resource settings today and more comprehensive analyses of the value proposition that a particular health technology brings to advancing health equity are needed to overcome these human-controlled uncertainties and risks.

Understanding human-controlled uncertainties and risks

Human-controlled factors act as barriers to innovation and access to new health products—especially those considered essential medicines—throughout the various stages of the product life cycle.

Meta challenges

While some challenges to innovation or access are primarily present at a particular point in the life cycle of a product, this section highlights two challenges—funding and political will—that are omnipresent, manifesting in various ways at each stage.

Funding

Funding for product research and development, implementation and outcomes research, and market analyses for uses of health technologies in low-resource settings remain insufficient. Global funding for basic research and product development for neglected diseases in 2017 was just below US$3.6 billion, with over two-thirds directed to HIV/AIDS, malaria, and tuberculosis (TB),[1] leaving roughly $1 billion remaining for product development for all other neglected diseases. It is estimated that the funding gap between current investment and what is needed to launch one of each of 18 key missing neglected disease essential medicine products in the next five years is at least $1.5 to $2.8 billion annually.[2] This shortage of funding creates and exacerbates challenges throughout every stage of the product development life cycle.

Weak or absent profit incentives for new products for use in LMICs make it difficult to engage private-sector partners and secure their financial investment, capital infrastructure, and human resource capabilities for these products. Product developers are often able to secure partners who provide expertise and resources for work early in the product development life cycle. However, as a product progresses into later and more expensive stages of development and introduction, it becomes harder to secure private-sector funding to advance products. For context, a phase 3 vaccine trial conducted to standards that would suffice for WHO Listed Authorities who perform at a Maturity Level 3 or 4 (WLA-ML 3-4)[3] can cost $200 million or more.[4]

Funding to develop products for low-resource settings comes primarily from a rather short list of donor governments and foundations, such as the Bill & Melinda Gates Foundation (Gates Foundation). This puts product development for specific use in low-resource settings at a severe resource disadvantage as compared to for-profit product development. For perspective, in 2017, the Gates Foundation invested nearly $1.3 billion on global health,[5] but for-profit pharmaceutical developers now spend an average of $2.6 billion per drug.[6]

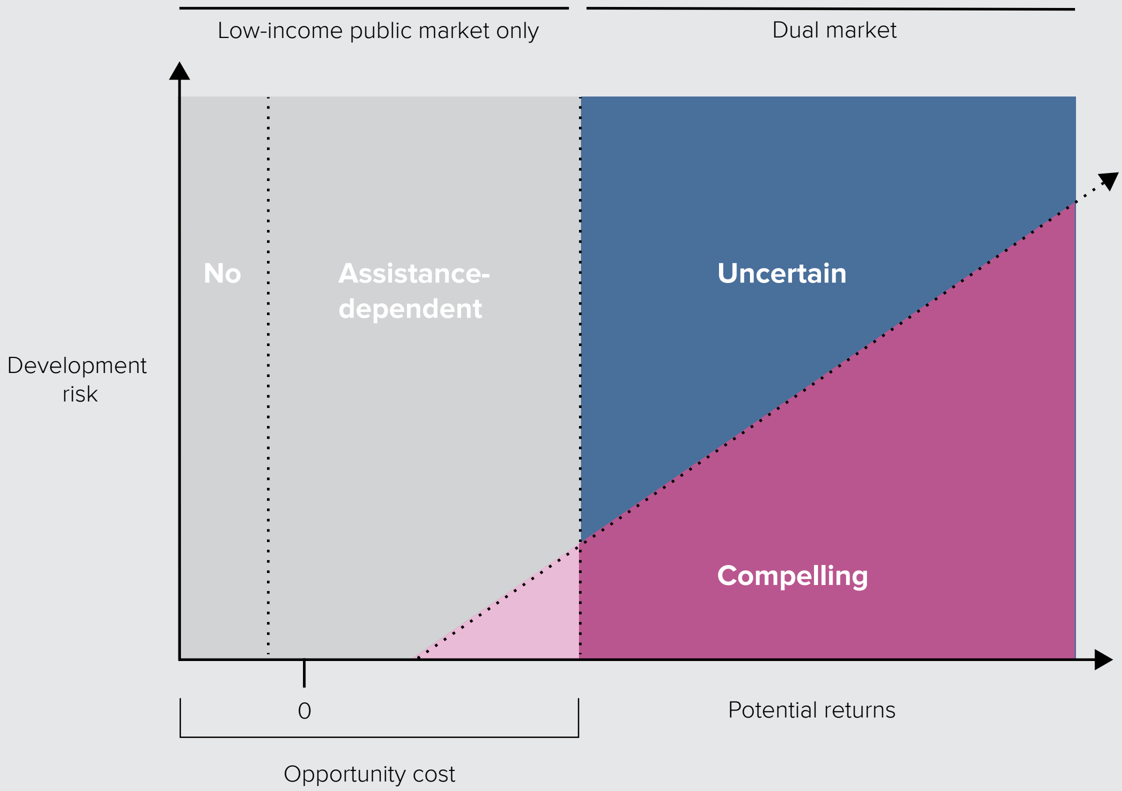
The complexity of challenges related to supporting product development for use in low-resource settings is further complicated by nuanced, but important, differences in the business cases for those products. For example, a product may have use in dual markets—both LMICs and high-income countries (HICs) and both private and public markets—or may have use only in LMIC public markets. Depending on the business case, different solutions have been, or could be, applied to provide sufficient incentives to drive development and introduction investments. Figure 10.1 illustrates these differences. The type of intervention and the epidemiology of the disease also can significantly impact the types of challenges and incentives most applicable to a particular product.

Insufficient donor and health-related funding also impacts health systems and creates challenges specific to research, evaluation, procurement, and administration of health technologies. For example, a consortium of research and development

FIGURE 11.1

Four vaccine business cases

Compelling—Uncertain—Assistance—No



Assistance-dependent business case

(LMIC only; Outbreak)

(e.g., LMIC: cholera, malaria, meningitis A, Shigella; Outbreak: Ebola, MERS, Nipah, Lassa fever)

Solutions:
Public funding
Priority review vouchers
LMIC manufacturers
Push and pull mechanisms

Uncertain business case

(LMIC ↔ HIC)

(e.g., group A strep, group B strep, TB)

Solutions:
Reverse tiered pricing
Push and pull mechanisms

Compelling business case

(HIC → LMIC)

(e.g., HBV, HiB, HPV, PCV, RSV, rotavirus)

Solutions:
Tiered pricing
Push and pull mechanisms

Source: PATH/David Kaslow.
Note: Four vaccine business cases determine the types of incentives and partners most appropirate to advance a product.

organizations, including PATH, identified the lack of support for implementation research as a formidable barrier which reduces access to and impact of new health technologies.[7]

At the same time, government budgets and healthcare systems may not have sufficient funds to procure or administer all the drugs on Essential Medicines Lists (EMLs), nor to train local healthcare providers to use new technologies, nor to provide the infrastructure needed to maintain supply and delivery of products—all of which impact access.

Political Will

The challenge of building political will to fully recognize health inequity as both a moral imperative and a barrier to social and economic development also impacts many facets of access to health technologies at the global and local level. When assessing competing funding priorities, both donors and governments may operate in an evidence- or awareness-scarce space on health's broader impact on national and global economies, security, and stability. This scarcity isolates and restricts resources, and it limits potential for innovative cross-sector collaboration to overcome challenges to product development and access.

Pre-approval challenges

This section focuses on the many challenges that exist in the process of developing and getting new health technologies approved for use in a particular market. Developing products designed specifically for use in LMICs poses unique research, development, regulatory, policy and financing challenges.

Regulatory practice

When developing or reformulating health technologies, strong regulatory systems are integral to protect patient safety and privacy and to ensure favorable benefit-risk profiles and quality of interventions. Challenges—related to consistency and suitability of regulatory practice for products designed specifically for LMICs—manifest in several ways that cause delays and increase the cost of product development.

Undefined regulatory or impractical development pathways

Registering a product for dual use (i.e., HIC and LMIC) often begins with regulatory approval from an influential WLA-ML 4 regulatory authority, most commonly the United States Food and Drug Administration (FDA) or the European Medicines Agency (EMA). Development of a product for low-resource setting use only, may also start with regulatory review (e.g., U.S. FDA review of an investigational new drug (IND) application) by a prominent WLA-ML 4 regulatory authority, and may also include a comprehensive evaluation of the quality, safety, and efficacy of certain medicinal products for use intended exclusively for markets outside their jurisdiction—for example, the EMA Article 58 procedural advice. Reviews by these or other WLA-ML 3 or 4 authorities significantly assist approval in many low-income countries that lack the capacity and resources to conduct comprehensive independent regulatory reviews.

While WLA-ML 4 regulatory authorities may assist other countries' registration and adoption of new products, the WLA-ML 4 regulatory authority's mandates are typically legislated to ensure quality, safety, and efficacy of products to be used in their own jurisdiction. Although there are mechanisms for evaluation of candidates in other jurisdictions (e.g., see U.S. FDA *Guidance for Industry: General Principles for the Development of Vaccines to Protect Against Global Infectious Diseases*[8]), HIC national regulatory authority standards may not reflect the specific population needs, local infrastructural and administration limitations, or various other context-specific dynamics of products designed for use in LMICs. As noted above, EMA's scientific opinion procedure was designed to apply EMA's scientific review capabilities and the local epidemiology and disease expertise of WHO and national regulators to provide a development and assessment pathway for products intended for use in LMICs. This procedure facilitates both WHO Prequalification (PQ) and local approval.[9] Yet challenges remain.

As an example, during the development of tribendimidine (TrBD) to control soil-transmitted helminth (STH) infections in LMICs, FDA registration standards originally called for the product to be evaluated for efficacy against the U.S. approved standard of care—which is a multi-dose, multi-day, licensed product regimen designed for individual-based treatment of active gastrointestinal infection. This is feasible to implement in HICs, however, TrBD is intended for use in LMICs where single-dose, mass drug administration for periodic presumptive treatment (PPT) is the most feasible approach for treating and controlling STH infections in an entire population. A mass drug administration campaign is not a licensed regimen in the United States. After a specific request to re-evaluate the acceptability of a PPT indication, U.S. FDA did recognize PPT as a new indication acceptable for approval. However, the development pathway for a registration of a PPT indication was complex from financial, regulatory, and scientific perspectives, which placed the project goal out of reach.

Multiple national regulatory authorities with differing regulations

Each regulatory system presents distinct logistical and technical requirements. The need for researchers and manufacturers to navigate multiple systems to register the same health products across multiple countries results in delays and increased cost to product access.

Gaps in regulatory capacity in LMICs

Gaps in regulatory capacity in many LMICs can lead to delays in accessing new health technologies. In situations where a product is intended solely for use in LMICs, first-in-human studies are often conducted in the United States or the European Union, with subsequent research often conducted locally. Reduced regulatory capacity means reviews may be longer and/or iterative, and the development pathway may be delayed or require more trials than in WHA-ML 3 or 4 settings. Some national regulatory authority (NRA) systems have insufficient capacity to efficiently regulate across all phases of development and licensure and provide adequate pharmacovigilance, or quality assurance, for products once marketed.

Resource-limited NRAs result in delays in other ways as well. For example, WHA-ML 4 NRAs have created mechanisms whereby product candidates for certain indications can obtain:

1) Accelerated approval based on a surrogate or intermediate clinical endpoint reasonably likely to predict a clinical benefit, followed by post-approval phase 4 confirmatory trials to verify clinical benefit (e.g., U.S. FDA accelerated approval pathway); or

2) Conditional approval, renewable annually, based on meeting certain specific requirements, including that the benefit to public health of the immediate availability of the product outweighs the risks due to a need for further data. This later pathway requires completion of ongoing or new studies and, in some cases, additional activities to provide comprehensive data confirming that the benefit-risk balance is positive.

Many LMIC NRAs do not have similar mechanisms and/or their healthcare systems are not able to provide the monitoring and standards stipulated as required for earlier access to essential medicines and health technologies. For products with markets and use cases in both HICs and LMICs, LMICs may have to wait for the confirmatory studies in HICs to be completed before LMICs approve access to these new health technologies.

Post-approval challenges

Once a product is developed, it must reach those it is intended to benefit to have an impact. This section highlights challenges that exist in the process of ensuring a newly developed and approved product achieves optimal use at scale.

Appropriate essential medicines lists at local levels

The WHO EML serves as a model for the development of national and institutional essential medicines lists. The most current WHO EML includes 433 products deemed essential for addressing the most important public health needs globally. Most countries have national lists and some have provincial or state lists as well. National lists of essential medicines guide the procurement and supply of medicines in the public sector, schemes that reimburse medicine costs, medicine donations, and local medicine production.[10]

Given the realities of budget limitations, it is often not possible for national or district health systems to procure an adequate supply of all medicines with WHO EML designation. Countries also may lack the data or expertise to assess their needs and prioritize their lists and supply accordingly.

Lack of workforce capacity and training

Widespread and responsible implementation of health technologies requires local healthcare providers who accept the value of new products and are appropriately trained and licensed in their use. Local healthcare workers may not have the specialized skills or licenses to administer the product. For example, local regulations in some countries preclude classes of health workers from administering injections. Program resources needed to support local capacity, product acceptance, and training around new products can be large and expensive. The process of scaling such programs can be lengthy, slowing uptake of new products.

Fragile markets

Market dynamics for many health technologies, particularly essential medicines, are not driven by traditional market forces and therefore may be fragile and require considerable additional efforts and interventions to shape and sustain them. The long-term availability of health technologies relies on sustainable markets for product manufacturers.

A product's price must be low enough to be affordable to the health system(s) or patients who must purchase it. However, if prices are pushed too low, manufacturers will exit the market, reducing competition and threatening supply security.

In the case of the live Japanese encephalitis vaccine (JEV), which PATH contributed to bringing to market, a single manufacturer, Chengdu Institute of Biological Products, is responsible for over three-quarters of the JEV global supply. The product is currently affordable and available, but any significant disruption in JEV supply from one manufacturer, including force majeure, could threaten global availability of this product, negatively impacting public health and increasing the threat of outbreaks of Japanese encephalitis.

Infrastructure maintenance

An often-neglected component of sustainable supply for essential medicines and other health technologies is ongoing maintenance and quality improvement in the infrastructure and capacity for production. Facilities that produce, store, and transport existing and future products must be rigorously maintained and routinely updated to new and evolving quality standards. Manufacturing facilities that produce low-margin essential medicines for low-resource settings face constant threats to their long-term sustainability. Without sufficient margins or other mechanisms to ensure access to low-cost capital and resources for maintaining or replacing aging facilities, sustainable supply and administration of health products is threatened.

Policy recommendations

Addressing barriers to access of health technologies, including essential medicines, in low-resource settings requires innovation and strengthening of systems throughout the product life cycle, as well as engagement from stakeholders at all levels and from various sectors and governmental agencies. The following is a list of recommendations to support and accelerate access to innovative health technologies for use in low-resource settings and further enable the multisector collaboration needed to tackle the complex and diverse challenges previously discussed.

1. Resources and commitment: Increase financial investment and political will to prioritize global health product development and access

The lack of adequate financial resources to drive the product development and access pipelines for new health technologies for poverty-related and neglected diseases impacts every challenge discussed. Unlocking greater funding for this work requires innovations to be valued not just on their direct, individual health benefits but also on indirect, population-based social and economic benefits. Funding to support this work must break out of silos, such as solely Ministry of Health or Department of Health budgets. A more holistic approach could enable new resource streams to sustainably fund innovation. Activities to support this shift include:

- Existing funders should continue to support research to further establish the evidence base and business case for investment in innovation of health technologies. This research should include cross-disciplinary work that frames the value of new products beyond individual health benefits and presents evidence of the positive impact health technology investment can have on other priorities like poverty prevention, security, global development, agriculture, education, and technology. Funders and thought leaders should highlight this research using high-visibility platforms to build political will and cultivate champions.
- More fit-for-purpose incentives and innovative financing mechanisms to support product development and provide incentives for private-sector participation are needed throughout the product life cycle. To ensure impact, each of these mechanisms need a focused and clearly understood scope to accomplish stated goals and limit unintended outcomes. Mechanisms should be deliberately coordinated such that there is a clear line-of-sight across development and introduction, with minimal gaps or delays during transitions in financing mechanisms. Both push (funding greater input) and pull (rewarding output) mechanisms are needed.

2. Regulatory affairs: expand efforts to converge regulatory standards across agencies and regions and support innovative initiatives to strengthen regulatory capacity in LMICs

Addressing regulatory challenges could simplify and clarify the development and regulatory pathways required for registration of health technologies (including essential medicines), facilitating quicker adoption and uptake, and increasing public health impact. A more convergent and/or integrated regional or even global regulatory system would reduce the cost and time of product development, as fewer country-specific clinical studies or chemistry, manufacturing, and control activities would have to be performed.

Efforts across regions to pool resources and expertise is a critical way to strengthen capacity and converge/integrate standards and processes. A recent PATH report, *Making the Case: How Regulatory Harmonisation Can Save Lives in Africa*, shows that harmonization of regulatory approvals for just two medicines could contribute to more than 23,000 lives saved in eastern and southern Africa. Initiatives such as the *African Medicines Regulatory Harmonisation* (AMRH) are advancing these goals and having an impact.[11] However, these efforts have only been piloted at a small scale and require further support. Activities to support strengthening regulatory systems include:

- Regulatory agencies should clearly and consistently communicate regulatory and licensure requirements to help clarify paths for developers and manufacturers.
- Regulatory convergence and ongoing harmonization initiatives should receive financial and political support, with a focus on building capacity and streamlining processes in LMICs.
- Regulatory convergence should create opportunities for third parties with experience developing and evaluating products in low-resource settings to help facilitate regional regulatory convergent/integrated processes. These opportunities include, but are not limited to, standardizing methodologies for evaluation, forms and filing protocol, review scheduling, and decision reporting systems.

3. Local capacity: Invest in growing local capacity to support the introduction, appropriate and responsible use, and sustainable supply of the most impactful health technologies

Public health impact is not achieved until those in need of interventions receive and benefit from them. Ensuring medical products are reliably delivered, consistently available, and appropriately and responsibly administered requires reliable and robust health systems. These health systems must include informed decision-makers, well-trained and resourced care providers, and anti-fragile infrastructure to support manufacturing, storage, and delivery. Activities to strengthen the capacity of local workforces, and systems to implement innovative health solutions, must include sufficient resources from donors and national governments to:

- Strengthen public health systems and aspire to achieve universal healthcare, which will enable widespread and responsible use of new health technologies.
- Develop national and provincial Essential Medicines Lists that ensure countries are selecting, prioritizing, and procuring the products necessary and appropriate for their health context and making these decisions based on current relevant evidence from real-life implementation of stated treatment standards.
- Address issues of deteriorating manufacturing infrastructure of legacy essential medicines (e.g., vaccine factories that are reaching the end of their useful life) and ensure the supply of essential medicines—particularly those with two or fewer manufacturers—remains secure. To stimulate competition and provide incentives or funding for the maintenance of infrastructure needed for manufacture, storage, and delivery, products in need of manufacturer diversity and repair of markets should be proactively identified. Such efforts should include actively seeking and supporting local manufacturers and investing in their capacity to produce essential medicines, to increase local product acceptance, promote consistent and sustainable local product supply, and achieve sustainable and affordable product prices.

Innovation is critical to driving gains in health equity and social and economic development around the world. However, product development is only the first step. A holistic approach that creates and supports the financial, economic, regulatory, and human resources to create an anti-fragile environment is needed to sustainably advance the development, approval, widespread adoption, and effective and responsible use of health technologies in LMICs.

Notes:

1 Chapman et al., 2019.

2 Young et al., 2018.

3 World Health Organization (WHO), n.d.-a.

4 Young et al., 2018.

5 Bill & Melinda Gates Foundation, 2017.

6 DeMasi, 2018.

7 PATH, 2018.

8 United States Food and Drug Administration (FDA), 2011.

9 European Medicines Agency (EMA), n.d.

10 World Health Organization (WHO), n.d.-b.

11 New Partnership for Africa's Development (NEPAD), n.d.

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CHAPTER 12

LIFE IS TOO SHORT WITH HCV AND NCDs—100 MILLION HEALTHY LIVES INITIATIVE

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Global healthcare is moving towards implementing medical innovations through automation and digital transformation of e-health strategies and applications. Digital health supports the application of universal health coverage (UHC), which ensures no one is excluded from obtaining health and medical services due to financial hardship.[1] Strengthening information and communication technologies (ICT) changes the shape of service delivery and improves individual and public health. E-health helps to ensure that health information is provided to the right person at the appropriate time and place.[2]

Leadership enables these changes—especially on the national level—ensuring alignment with strategic health goals. In 2018, Egypt's highest level of authority started to show commitment towards digital health by establishing automation and digital transformation units in all ministries. Shortly thereafter, the Ministry of Health and Population (MoHP) started addressing and enhancing the health information system (HIS) through assessment and definition of specific objectives. The primary focus of the MoHP is to assess health risks using population surveys. Using these evidence-based surveys ensures that resources are allocated efficiently and allows for effective decision-making.

The two main health risks in need of assessment in Egypt are hepatitis C virus (HCV) and non-communicable diseases (NCDs). An estimated 84% of all deaths in Egypt are NCD-related. Statistics from 2008 show that Egypt had the highest HCV prevalence worldwide,[3] with an estimated 6.8 million patients between the ages of 15 and 59 diagnosed with the virus.[4] The prevalence of HCV decreased by 30% from 2008 to 2015 but, despite this decrease,[5] Egypt still had the highest prevalence globally—a reported 7% or roughly 4.5 million patients.[6] The use of population surveys as an assessment tool for health risks has yielded moderate results. To strengthen the influence and impact of these surveys, further action needs to be taken to improve data governance, transparency, population coverage, fraud detection, and instant monitoring. These matters can only be enhanced through digital technologies.

Methodology

From October 2018 to April 2019, the MoHP ran a large-scale HCV and NCD screening and treatment program for Egyptians aged 18 years and older. Egypt is known to be the country with the highest prevalence of HCV and the highest number of mortalities due to the complications of NCDs. Despite this, the MoHP did not have precise records for the incidence and prevalence of HCV and NCDs. In addition, the MoHP had neither comparison with other countries nor the peripheral distribution between provinces. This initiative—named *100 Million Healthy Lives*—was launched under the patronage of the Egyptian president. The aim of this program is to eliminate hepatitis C by 2020 and to assess the prominence of NCDs in the country. It includes early detection, referral, and treatment for HCV and NCDs. The cross-sectional screening had three phases and covered 27 governorates representing the country. Over seven months, screening teams consisting of 60,057 medical professionals and data entry staff worked in 5,716 screening sites, such as primary healthcare (PHC) units, government hospitals, mobile clinics, and youth centers.[7] Over 49.8 million people were screened and tested for NCDs and HCV, 2.2 million were referred for polymerase chain reaction (PCR) tests, and 0.9 million started their first dose of HCV treatment. Monitoring and evaluation of the program, in collaboration with the World Health Organization (WHO) Egypt Country Office, took place in two parts—field visits during the screening and a verification process to ensure the quality of the screened data.[8]

The process flow of the patient cycle was divided into technical and medical. The technical side of the cycle focused on data collection to create patient profiles at the beginning of the process and to record medical results and assessments at the end of the process. Based on the personal data collected at the beginning of the cycle, the system determined whether tests for NCDs and/or HCV were required. Trained health professionals—mainly physicians, dentists, and/or pharmacists—performed the necessary medical tests following pre-defined standards. The health professionals were also responsible for completing the technical side of the cycle by providing medical data as input for the system. In the case of negative results, the patient file was closed. If results were positive, the patient proceeded to a second phase where further testing was conducted and medical professionals established patient specific treatment plans.

Findings

1. Instant monitoring of the process

The MoHP developed software solution offers a holistic approach to the screening, referral, and treatment process. It provides instant reports derived from the data entries at every registered site. The system updates every ten minutes. It is able to detect which screening units did not make any data entries for patients within the last fifteen minutes. This enables monitoring officers to overcome any obstacle or challenge that may be faced within these locations, such as technical issues related to the database, code debugging, internet accessibility, or even lack of workforce motivation. All of these challenges can be solved once detected.

Between 2011 and 2015, rapid political changes affected the health system. Short-term wins were created to demonstrate power, while long-term programs lacked political commitment. This eventually led to duplication of services through parallel programs. Now the system enables standardization between different entities, centralized around the patient. This system enables the medical team to determine—during the screening process—whether the patient is insured or not. If possible, the patient is referred directly to a nearby hospital that belongs to their health insurance organization (HIO). If not insured, the patient is referred to a hospital with administrative ties to the curative sector in the MoHP. In this case, the patient gets financial coverage from another insurance scheme. The referral place and time of the patient's next visit are provided during the screening, enabling the patient to understand the next steps before leaving the screening site. Having the system accessible at each referral site enables all patient information—from screening, treatment, and results—to be entered, stored, and easily tracked.[9]

The software produces updates every ten minutes and can provide instant reports about screenings across the country. The system generates a targeted number of screenings for each site per day and compares that to the actual screened population. It also analyzes the population per gender, shows the highest contribution by age group, and is capable of identifying the peak screening time within a day or peak times throughout the screening process. Its enormous capacity allows access to 20,000 users at the same time, captures 750,000 screening transactions per day, and captures 47 screening transactions per second.

2. Evidence-based decision-making

Limited resources are usually the main challenge facing public health interventions. Resource mobilization driven by data is the optimum solution to overcome this obstacle. A well-developed software solution offers multilayer output. This approach starts from a national level and narrows to regions, governorates, districts, cities, and villages—eventually reaching a population covered by a primary healthcare unit. This multilayer approach clarifies which screening centers have covered the targeted population numbers and which centers have not. This targeting is followed by behavioral change and awareness campaigns, using messages sent to targeted citizens in a specific geographical area to motivate them to undertake the screening.

The system produces data, such as the total number of screened cases and their results, on all layers from the national level to villages and specific areas. This aids in placing targeted interventions in the needed areas. The system also shows correlation between diseases and related risk factors. For example, the data shows a strong correlation between hypertension and obesity, a decrease in the incidence of hypertension with increased physical activity and lifestyle management, a higher prevalence of hypertension in males, and a higher prevalence of diabetes in females.

3. Data governance and transparency

Lack of data governance can raise security and management issues, while lack of transparency may decrease trust and cause decisions based on incomplete information. Data governance aims to establish evidence-based decision-making. It aims to distribute responsibility and authority across the Ministry of Health. The system effectively connects campaign senior management, tactical teams, and operational managers. Policies and rules for the medical and technical teams are utilized to ensure the best governance. The system has built-in data validation rules to ensure the integrity and consistency of all data. This creates a closed-loop system for the screening process that includes data security, privacy, operation, analysis, and decision-making. The system encapsulates processes and procedures and defines them as implementable operational steps. It promotes consistency, data flows, data analytics, and data mining. Training for operational teams, managerial teams, and steering committees enabled each group to understand the system, manage data, and make decisions. Finally, audits are in place to ensure data quality.

Transparency was achieved through a verification report on the data quality, performed by WHO, Egypt. Data verification and transparency strengthened the results from the population surveys. Results of the screening are displayed on public billboards for citizens and other parties to see. Reports are under development to share the results of this large-scale screening. Media campaigns are also being used to communicate why the general public should undertake the screening.

4. Population coverage and health mapping

Population coverage—using a multilayer approach—is a key measure that defines the success of Egypt's population-based survey. Data mining and analytics based on the most critical cases, such as hypertension over 180/110 mmHg and diabetes over 600mg/dL, will lead to a health map matrix that can inform communication campaigns and treatment. The data will be analyzed for correlations between the screened diseases and geographical areas. For instance, four governorates from phase one have double the prevalence of hypertension compared to the rest of the governorates. This enables defining the risk factors by governorates and narrowing further to focus on small areas and villages. Other risk factors are also taken into consideration, such as gender, age group, distribution between rural and urban, and profession. In addition to the health mapping matrix, the analytics will be used to produce various reports and research articles. Finally, the software produces a dashboard that offers a strategic overview of the mass screening.

5. Cost-effective approaches, fraud detection, and financial sustainability

The economic burden of diseases is critical, as it increases out of pocket and catastrophic health expenditures. Wise decisions must be adopted to decrease the financial load on the population. The fragmentation of the Egyptian health system makes it difficult to detect service duplication, standardize services across different entities, or stabilize pricing for services. However, the technology system has capabilities that enable integrating the different entities, detecting fraud, and ensuring efficient interventions.

The National Committee for Control of Viral Hepatitis (NCCVH) is the governmental entity that develops strategy for the screening, prevention, and treatment process. In the past, this was a long process, which included time-consuming and costly paperwork and accounted for 65% of the out of pocket cost to patients. Now, the process of approval is completely electronic and confirms the treatment regimen with no financial burden on the patient. The screening is free of charge and has eliminated out of pocket and catastrophic expenditures.

Conclusion and recommendations

The case study of the Egyptian presidential initiative, called *100 Million Healthy Lives*, set a few goals, which include improving the public health status of 100 million Egyptians, eliminating HCV from Egypt by 2030, and assessing the situation of NCDs. The objective of this mass screening was to screen 50 million citizens above 18 years old and connect them to treatment through a proper referral system. This initiative was successful due to the digital health application. It generated an enormous amount of data that can be easily transformed into useful information for wise decision-making.

Automation and digital transformation of public health interventions ensure prompt evaluation and provide clear evidence for decision-making, governance modalities, health metrics, and the best economic approaches. The health system in Egypt is fragmented due to unintegrated health services and complex vertical programs and silos. The only solution for fixing this issue is through connecting all the services and the institutions together to prohibit duplication of services, define the needed services, and ensure transparency. Data mining and analytics are cost-effective approaches to mobilizing resources toward the most crucial health needs.

Egypt is the chair of the African Union in 2019. The sister countries have similar health system challenges regarding health informatics. This has motivated policymakers to support other countries through knowledge and technology transfer. Currently, some countries are adopting the lessons learned and building on Egypt's experience, according to their status and needs. Requirements for each of the nominated member states is currently being assessed through field visits. The approach will then be modified and tailored to satisfy the specific needs of member states.

There is a critical need in science and public health in Egypt to develop more effective medicines and medical devices and to ensure that they are available and accessible for all who need them. A solution to this problem is under development through enterprise resource planning (ERP)—business process management software that includes supply chain management, inventory management, documentation management, and human resources management. This system will integrate various applications that digitize back-office processes and procedures and will be utilized for all governmental bodies, not only MoHP.

Notes:

1 WHO, 2016.

2 WHO, 2012.

3 WHO, 2017.

4 Kandeel et al., 2017.

5 Talaat et al., 2019.

6 Kouyoumjian et al., 2018.

7 WHO, 2019.

8 WHO, 2019.

9 Additional information is available at http://stophcv.eg/upload/end-note-weblink-2-pager.pdf

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CHAPTER 13

INNOVATIONS IN HEALTH-CARE AFFORDABILITY AND DELIVERY—AN INDIAN PERSPECTIVE

Devi Shetty, Narayana Health

With a population of more than 1.3 billion,[1] just a shade less than China's 1.4 billion, India faces enormous challenges ensuring quality healthcare for all of its citizens. Although a relatively young nation, with 50% of the population below 25 years of age and 65% below 35 years,[2] India still has a large aging population which needs access to medical facilities to lead a healthy life.

Improvement in life expectancy over the years, which is 69.04 years as of 2018,[3] implies that the types of healthcare challenges faced by the country today are quite different from what they were thirty or forty years back. In earlier years, high rates of infant mortality, infectious diseases, and population control were the major concerns. Today, healthcare problems—such as hypertension, diabetes, and coronary heart disease, which has emerged as the leading cause of death in India—are more related to lifestyle.[4]

In this chapter we focus on healthcare in India, innovating in healthcare delivery, and increasing healthcare affordability through increased capacity.

Healthcare in India—an overview

Indian healthcare has made substantial progress, especially in the last decade. The Government of India has been trying to improve public health delivery through significant investments in the healthcare infrastructure. With limited resources and a large population to take care of, the Indian government requires innovative ways to provide quality healthcare facilities for all. It spends roughly 1.15% of gross domestic product (GDP) on the public healthcare system,[5] which badly suffers from an insufficient number of trained health professionals. In addition, disparity in healthcare coverage between urban and rural areas does not meet the needs of the population. The private sector has stepped in to fill this gap in India, but healthcare facilities remain beyond the reach of a large percentage of the population due to their prohibitive costs. Although the government has primary, secondary, and tertiary care facilities, it is the private sector that runs a majority of super specialty hospitals—hospitals with expertise in multiple specialized areas. However, private facilities are concentrated in and around tier 1 and 2 cities. The healthcare market in India is expected to reach US$372 billion by 2022.[6] India has attracted foreign direct investment (FDI) worth US$6 billion in the healthcare sector between April 2000 and June 2018.[7] However, there is great disparity in the availability of skilled resources between rural and urban areas. On the positive side, India is currently among the top 20 global medical device markets and the 4th largest medical device market in Asia. Medical tourist arrivals in India have also increased by over 50% to 200,000 in 2016 from 130,000 in 2015—and are expected to double in the near future.

Across the world, government spending on healthcare is expected to reach US$10 trillion by 2022,[8] which is the largest expense for any service in the world. Even today, less than 20% of the world's population has access to secondary and tertiary level healthcare.[9] In order to meet the healthcare needs of citizens and increase access to affordable healthcare, the Indian government created the centrally sponsored Ayushman Bharat scheme.

Ayushman Bharat initiative by the government promises to provide affordable access to healthcare services. Launched in 2018, the scheme is the world's largest universal health coverage program with a goal to provide medical insurance worth US$7,100 each to 100 million families every year.[10] While it is similar to other health insurance schemes, the Indian government pays the insurance premium to health insurance providers on behalf of its citizens. The entire healthcare infrastructure is now being geared up to meet the demands and massive scale of Ayushman Bharat. India's medical educational infrastructure has grown rapidly in the last 26 years: the number of medical colleges in India has increased from 314 in FY11 to 476 in FY18.

The government has increased health expenditure by 370% between 2000 and 2014, making the efficient management of expenditures and the creation of mechanisms that ensure benefits reach the needy essential.

Healthcare delivery—the need for innovation

While developing countries continue to focus on controlling malaria, tuberculosis, and HIV, which combined kill 3.8 million people annually,[11] adequate attention is needed to save nearly 17 million lives lost due to the absence of proper facilities for basic procedures and surgeries. The statistics reveal that out of the 313 billion surgeries done across the world, only 6% are performed in the areas where nearly half the world population lives. These are not complex surgeries of the heart, brain, or for cancer but basic surgeries, called bellwether procedures, that include an emergency cesarean section for obstructed delivery, laparotomy for a burst appendix, and surgery for compound fractures.

The infrastructure created for malaria, tuberculosis, and HIV cannot be used to perform surgeries, but the infrastructure and expertise built for performing surgeries can be used to treat malaria, tuberculosis, and HIV with virtually no additional cost. Essentially, what is needed is investment in innovations aimed at the delivery of healthcare.

Indian healthcare organizations are gradually increasing investment in artificial intelligence (AI), the internet of things (IoT), and robotics. With telemedicine becoming a fast-growing sector in India, major hospitals adopting telemedicine services, and hospitals entering into public-private partnerships (PPPs), the telemedicine market in India is expected to reach US$32 million by 2020. This would help bridge the rural-urban divide in terms of medical facilities, extending low-cost consultation and diagnostic facilities to the remotest of areas via high-speed communication links.

As hospitals "go paperless"—by digitizing and relaying information electronically rather than on paper—consultations, access to inpatient reports, and communication within and outside the hospitals can be revolutionized. The impact of technology can be much more significant than any pill or medical equipment in reducing preventable deaths in the country. Adoption of technologies, such as less invasive diagnostics, patient-centric mobile apps, remote monitoring solutions, digital platform integration, surgical robotic tools, smaller implants, AI, and 3D printing, shall provide the necessary impetus towards achieving the vision of a connected healthcare ecosystem.

One of the first steps towards this transformation will be to use technology to leverage a digital healthcare ecosystem. Rising adoption of AI-based applications will ensure better connectivity among physicians, patients, hospitals, and the overall healthcare industry. Developments in information technology and integration with medical electronics have made it possible to provide high-quality medical care at home—at affordable prices—enabling consumers to save from 20 to 50 percent of the cost.

Capacity building—critical aspects

Rural Health Statistics 2017 show that there is an 81.6% shortage of medical specialists in government-run hospitals in India.[12] We do not have adequate specialists to fill the vacant positions in government-run hospitals. Infectious diseases are no longer a cause for concern, as they can be treated by doctors with undergraduate degrees. But degenerative diseases, which are responsible for most illnesses, cannot be treated legally by a doctor with only an undergraduate degree. It is essential for a doctor to have a graduate qualification to treat such illnesses. According to the Medical Council of India, while 63,850 seats are offered for undergraduate admissions in medical colleges across India, availability of seats for graduate studies numbers only 25,000.[13] Of this, admissions for clinical specialties are around 14,500 and the rest are for paraclinical specialties. This gap between undergraduate and graduate seats has created 200,000 undergraduate, or MBBS, doctors who are either unutilized or underutilized in the nation's healthcare delivery. The problem can be addressed by equalizing the number of seats at the undergraduate and graduate levels in medical colleges. This will also ensure the availability of specialists in the rural and remote areas.

Over the years, education in the healthcare sector in India has become an elitist affair. It costs over US$60 million to build a medical college that can train 100 doctors per year. In this process, the cost of education has increased beyond the means of the working class and the poor. Interestingly, many esteemed doctors across the world generally come from deprived backgrounds. In India, the problem could be addressed by converting 763 district hospitals into medical, nursing, and paramedical institutions,[14] which will cost roughly US$15 million. About 5% of the seats in these colleges could be reserved for local students, which would enable them to study in their own region and improve the quality of service in their home districts.

Across the world, especially in the United States of America (U.S.) and Europe, any practicing medical specialist with over five years of experience is able to become a medical teacher who can train doctors, nurses, and paramedics. As per guidelines from the Medical Council of India, a medical practitioner must work for more than 10 years in a medical college hospital to be considered as a medical teacher.

There are medical colleges in the Caribbean region that have low overhead costs using small rental spaces to train medical students that will work in the United States. Many pre-medical students and medical residents undergoing specialist training programs in the United States are from one of these Caribbean medical colleges. If India adopts these norms for training medical students, the overall cost of medical education will decrease significantly.

Healthcare is poised to become one of the largest employers and carries huge potential for foreign exchange earnings through medical tourism. With a large youth population, India could also become a skilled health workforce provider for the aging and shrinking population of the developed countries. Policymakers must carefully consider all of these aspects to build a balanced program for education.

Healthcare—improving affordability in India

While a heart surgery in India used to cost US$3,500 about 30 years ago, it is performed for less than US$1,500 today. This drastic cost reduction has been possible because of physician and hospital entrepreneurship. To achieve further reductions in the cost of healthcare, we need to dramatically change the way doctors, nurses, and medical technicians are trained and also how hospitals are built and managed.

While the developed world focuses more on cutting-edge research, we in India have a unique opportunity to develop innovative processes to democratize healthcare.

To foster a culture of research and excellence, specialized research—in robotics-led remote surgeries, basic medicine, and provisions—should be encouraged and incentivized to reward innovators for their time and effort.

More than innovation in products, India needs process innovations and a major change in regulations to embrace technology in healthcare. Technology enables a specialist anywhere in the world to instantly access patient reports, view monitors attached at the patient's bedside, and take clinical decisions immediately.

Despite the benefits that the adoption of technology offers, there are additional costs that will extend the time it takes for these technologies to become a reality. There are no clear-cut guidelines related to technology-led healthcare delivery in India. For example, a doctor cannot issue an electronic medical prescription because they are limited by regulations. Updating regulations, encouraging technology adoption, and mandating minimum standards for healthcare delivery, electronic medical records, and exchange of clinical data are some of the important changes needed in the country.

Once technology adoption becomes widespread, remote monitoring of patients using telehealth devices will become the norm. Hospitals will do away with wards and have 90% of beds for intensive care and 10% of beds for emergency or trauma. The healthcare delivery model will undergo a change where patients who would have otherwise been in hospitals will be tended to in patient care centers by nurses and remotely monitored by specialists.

Conclusion

Like Uber and Airbnb, information technology enabled services (ITES) will become the largest healthcare provider. There is already Microsoft's Kaizala platform, which allows patients to save their medical records on their phone and to have a Skype conversation with a doctor from any part of the world. Such platforms can dramatically change the way patient-doctor interaction happens, resulting in a significant cost reduction of healthcare.

Adoption of such technologies will lead to better care, which will not only reduce re-admissions but also improve the average length of stay. Due to the volume of patients that a healthcare delivery center can handle, enhanced efficiency in the system will bring down the costs.

The Government of India has embarked on an ambitious target of providing broadband connectivity to every village. Such high-speed data links would revolutionize the communication process—patients' pathological, radiographic, and other test data collected at primary health centers could be quickly shared with super specialty hospitals to enable the specialists to decide on diagnosis and treatment protocol. The aforesaid tech-enabled healthcare delivery models would transform the healthcare services sector in the country. In addition, the Indian Government's health coverage program will boost healthcare services. Such initiatives will pave the way for better access and affordability of quality care—the grand vision of any universal healthcare program.

Notes:

1 United Nations, n.d.

2 Government of India,Vice President's Secretariat, 2018.

3 Knoema, n.d.

4 World Health Organization, 2018.

5 National Health Systems Resource Centre, 2016.

6 India Brand Equity Foundation, 2018.

7 India Brand Equity Foundation, 2019.

8 Deloitte, 2019.

9 Meara et al., 2015.

10 National Portal of India, n.d.

11 Meara et al., 2015.

12 Ministry of Health and Family Welfare, 2018.

13 Seats offered for undergraduate admissions are 63,850 whereas graduate admissions are 25,000 across India. Further information about the number of seats for the said admissions is available at https://www.mciindia.org/CMS/information-desk/college-and-course-search

14 Ministry of Health and Family Welfare, 2016.

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CHAPTER 14

A BRAZILIAN OUTLOOK ON HEALTH AND MEDICAL INNOVATION

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This chapter looks at the challenges and opportunities for Brazil in the health sector—one of the most thriving sectors in the world. First, we consider global health trends in innovation and how Brazil is performing. Second, we outline the role of the National Confederation of Industry–Brazil (CNI), Social Service of Industry (SESI), National Service for Industrial Training (SENAI), Euvaldo Lodi Institute (IEL), and the Brazilian Micro and Small Business Support Service (SEBRAE) in shaping the future of health innovation in the country. Finally, we present recommendations for the Brazilian government to build a more innovative ecosystem in the country.

Global health trends and the Brazilian outlook

Global health trends

One of the main factors driving health innovations worldwide is an aging population. This has led to increased research into diseases that most commonly affect the elderly, such as neurodegenerative diseases like Parkinson's and Alzheimer's. Another effect of population aging is the increase in health costs. Health spending as a share of global GDP has steadily grown in recent years, from 8.6% to almost 10% between 2000 and 2015; in higher income economies it reaches up to 17% of GDP.[1]

However, the growing availability of health data may help mitigate rising health costs and increase the potential for using information and communication technologies (ICT), which can revolutionize health services.[2] The application of ICT to healthcare ranges from telemedicine to the use of artificial intelligence (AI) as an auxiliary tool in diagnosing diseases and the development of medicines through the management of health systems. Several ICT-based technologies are among recent significant innovations in health.[3] Among them are telemedicine, artificial intelligence, the increased use of monitoring devices, virtual reality, and the use of social networks to improve health services. Specialists also mention immunotherapy—the activation or suppression of the immune system—as a tool to combat certain diseases and as one of the most promising new technologies for the treatment of cancer.[4]

A recent study by IEL, 2027 Industry: Risks and Opportunities for Brazil in the Face of Disruptive Innovations, mentions several of these trends as relevant for Brazilian Industry.[5] The novelties are numerous, but the scope of these changes is still unclear. However, the conditions for the development of new technologies have not changed as much as the technologies themselves. In any field, innovating requires qualified people, adequate infrastructure for conducting research and product development, and a stimulating environment. In addition to this, innovation in healthcare and medicine has specific and more complex characteristics than any other sector.[6]

Creating new health products—especially medicine—requires more scientific research than practically any other sector of economic activity. Before developing medicine, medical equipment, or medical devices, it is necessary to understand the human body in relation to how diseases affect the individual—namely its mechanisms, causes, and effects. This is usually the purpose of scientific research conducted in universities and research institutions. Health innovations are also typically expensive and take time to reach patients. The development of a new drug, for example, can take about 10 years from the basic research stage to preclinical and clinical tests. Even

TABLE 14.1

Participation (% of total scientific publications) of health-related scientific areas in Brazilian and worldwide scientific publications (2017)

Academic field	Health-related publications as a percent of Brazilian scientific publications	Health-related publications as a percent of worldwide scientific publications	Brazil's health-related publications as a percent of worldwide health-related publications
Biology and agriculture	11.6%	4.4%	6.5%
Biochemistry, genetics, and molecular biology	6.8%	6.4%	2.6%
Odontology	1.6%	0.3%	11.8%
Immunology and microbiology	2.5%	1.5%	4.0%
Medicine	17.9%	16.9%	2.6%
Neuroscience	1.6%	1.5%	2.6%
Nursing	1.3%	1.0%	3.1%
Pharmacology, toxicology, and pharmaceutics	2.2%	1.8%	3.1%
Total	**45.3%**	**33.7%**	**2.4%**

Source: Ministry of Science, Technology, Innovation and Communications (MCTIC).
Notes: This table shows the participation of scientific areas related to health in Brazilian and world publications, as well as the participation of Brazilian science in the world. When the participation of the area in Brazilian publications is greater than its respective participation in world publications, it means that Brazil has advantages in these areas.

innovation in software, equipment, and devices take time to meet regulatory requirements before they are released to patients. Furthermore, the development of a new health product is a risky activity. Estimates indicate that the percent of drugs that reach the market after starting clinical trials vary between 6% and 13.8%.[7]

Brazilian outlook

Brazil has over 200 million inhabitants and one of the largest public healthcare systems in the world, called the Unified Health System (SUS). The SUS provides healthcare, from basic treatments to complex transplants, to over 100 million people, free of charge. According to the Brazilian Institute of Geography and Statistics (IBGE), in 2015 the total costs of health-related goods and services in Brazil amounted to around 9.1% of GDP, approximately US$180 billion today.[8] These numbers show that Brazil has a significant market for health. Rising health costs, together with the fiscal problems faced by the country, also make the SUS an excellent pilot to test technologies capable of reducing health costs, especially through ICTs.

While the size of the market is an important advantage for the development of new technologies in health and medicine, it is also important to note that Brazil has pertinent scientific competences in health-related areas as shown in Table 14.1.

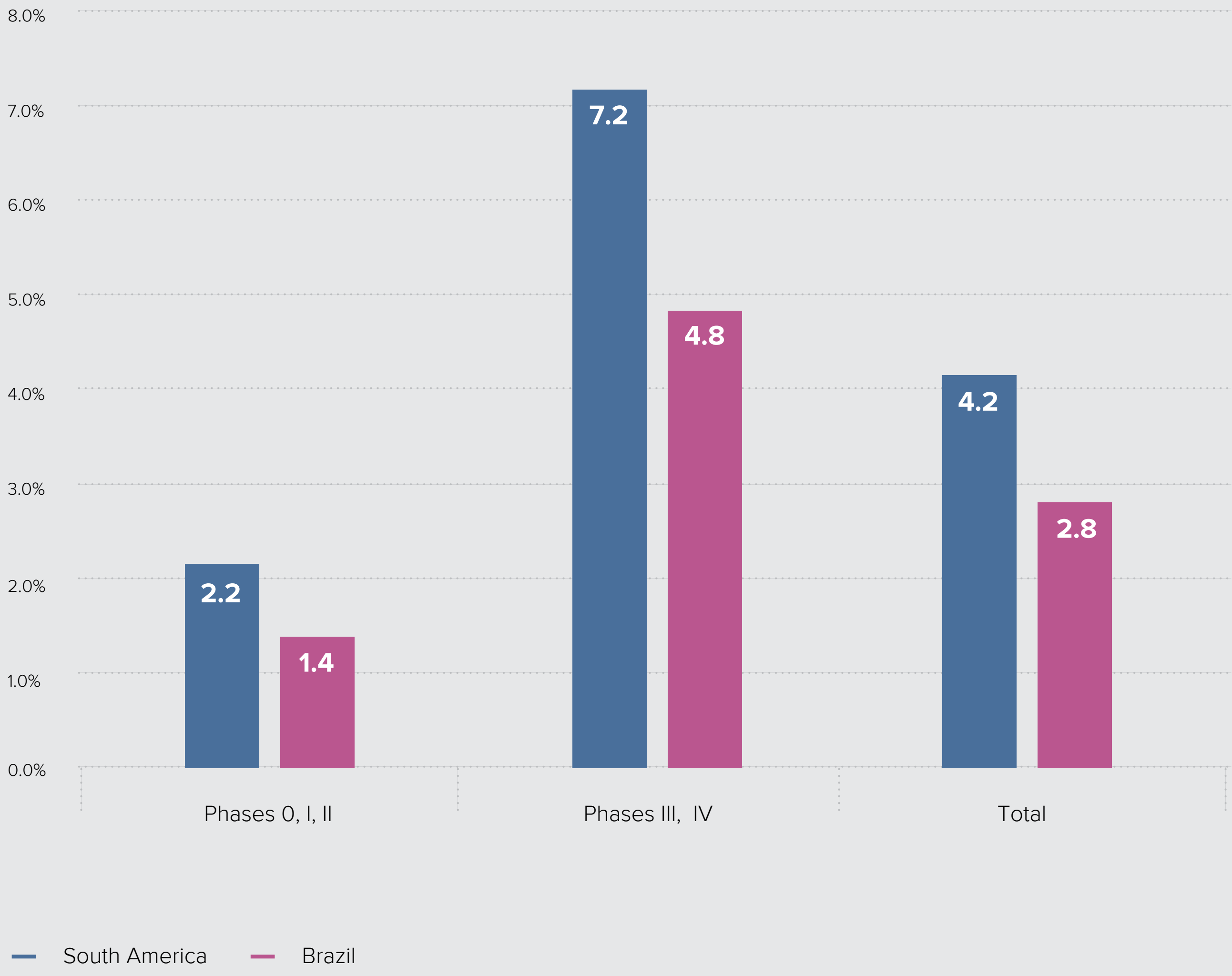
Across all scientific areas, not just health-related areas, Brazil accounts for 1.8% of worldwide scientific publications. In the health-related scientific areas detailed in the table, Brazil's participation is 2.4% overall and much greater in specific areas. For example, Brazil accounts for almost 7% of worldwide scientific publications in biological and agrarian sciences, close to 12% in odontology, and precisely 4% in immunology and microbiology. This shows that Brazil has important scientific expertise in these areas (Figure 14.1).

When it comes to translating research into new drug production, however, there is room for the country to move forward. Evidence of this is Brazil's participation in clinical trials, the final stage of a long research and developmnet (R&D) process that starts in the laboratory of a university or research center and ends with testing on humans. At this stage, fundamental research from universities and research institutions moves to the laboratories of large pharmaceutical companies, which are primarily responsible for conducting clinical trials. Brazil accounts for less than 3% of worldwide clinical trials, and this participation is lower in phases 0, I, and II, which are the most knowledge intensive. An increase in clinical trials will help establish the country within global networks of knowledge production in medicines and health products, especially in areas where Brazilian comparative advantages are relevant.

This is the case for biopharmaceuticals, an area that has grown the most in recent years and accounts for about 20% of the world's pharmaceutical market. A recent study conducted by researchers from the Massachusetts Institute of Technology (MIT), as part of a program sponsored by SENAI, argues

FIGURE 14.1

South American and Brazilian share in worldwide clinical trials (phases 0 to IV) initiated between January 2000 and January 2018



Source: De Negri, 2018.

that Brazil has the conditions to be more than a follower in biopharmaceuticals because of its scientific competences and the potential of its biodiversity.[9] The 2027 Industry study conducted by IEL has reached the same conclusions.[10] However, biopharmaceuticals—which are more expensive than pharmochemicals—can burden health systems. For this reason, a resolution of the National Health Surveillance Agency (Anvisa) regulated the biosimilar market—drugs that are the equivalent to approved, but not patented, biopharmaceuticals—in 2010. By regulating this market, it is possible to increase patients' access to biological drugs without causing significant increases in drug costs. Nevertheless, according to the MIT study, by focusing solely on biosimilars, Brazil risks falling further behind the rapidly expanding science-based innovation frontier, meaning that the regulation of biosimilars is not enough to put Brazil on the path of innovative countries in biopharmaceuticals. By choosing the path of biosimilars and generics, Brazil has taken an important step towards facilitating access to cheaper medicines, but this is not enough for the country to be more than follower in this field. Pursuing a leadership strategy requires larger R&D investments from businesses in the health sector. Today, the Brazilian pharmaceutical industry invests around 2.4% of its revenues on R&D, according to the IBGE's Technological Innovation Survey (PINTEC).[11] This level of investment makes the sector one of the most R&D intensive in the country. However, this is far from worldwide R&D investment in the pharmaceutical sector, which is 10% to 15% of revenues.[12]

Yet, health innovation does not only relate to medicines. There is potential for Brazil to use ICT in health, since there is a significant ecosystem of start-ups and researchers in this area.[13] In addition, the SUS, one of the largest public health systems in the world, could improve management and efficiency using ICTs. A recent study has mapped out about 200 start-ups that offer solutions in ICTs applied to health, all of which are in operation and own proprietary technologies.[14] These companies are involved in telemedicine, wearables, internet of things (IoT), medical devices, electronic medical records management, AI, and big data. A significant Brazilian medical innovation is an application developed by researchers at the Federal University of Rio Grande de Norte who, through analysis of a user's speech, help in the diagnosis of patients with schizophrenia.[15]

Brazil is just beginning to participate in other technological trends, such as precision medicine. Nevertheless, important initiatives—such as the Brazilian Initiative on Precision Medicine (BIPMed), which brings together five research centers supported by the São Paulo Research Foundation (FAPESP)—facilitate the sharing of a genomic database. The Albert Einstein Hospital in São Paulo, in partnership with a genomics company, has created a center for personalized medicine. This center aims to use genetics to improve the diagnostic accuracy of serious and complex diseases while administering an assertive prevention plan and adopting an individualized approach for each patient.

Prognosis and the role of the CNI, SESI, SENAI, IEL, and SEBRAE

Despite the challenges, the prospects for Brazil in terms of innovation in health and medicine are promising. SEBRAE, SENAI, SESI, IEL, and CNI all play a relevant role in the health area.

The role of SENAI

SENAI has contributed significantly to innovation in Brazil, through training and the provision of technical services. To address innovation challenges, SENAI has created a network of innovation centers called the SENAI Innovation Institutes (ISI), equipped to develop innovative projects in several transversal areas, including health and medicine. To date, 10 of the 26 ISIs have developed over 43 R&D projects related to health, in partnership with companies and other research institutions. Some examples are:

1. The ISI for Microelectronics, in Manaus, Brazil, is leading R&D of medical devices, in partnership with the Oswaldo Cruz Research Foundation (Fiocruz) based in Rio de Janeiro, Brazil. The first project aimed to design and produce a low-cost device capable of conducting isothermal reactions to assist in the diagnosis of infections such as tuberculosis, leprosy, malaria, and dengue.
2. In Pernambuco, Brazil, the ISI for Information and Communication Technologies is focusing R&D on a radiology imaging transmission system, a virtual reality solution to train Paralympic athletes, and portable equipment to use for retinal diagnosis.
3. The ISI specializing in polymer engineering, in Rio Grande do Sul, Brazil, tests materials, orthoses, and breast prostheses, in addition to developing health instruments.

Several additional SENAI Innovation Institutes undertake R&D in health and medicine, such as the ISIs for Advanced Materials and Nanocomposites, Advanced Manufacturing in São Paulo, Microfabrication in São Paulo, Byosinthetics in Rio de Janeiro, and Automation of Production in Bahia. Before the end of 2019, SENAI expects to launch the ISI for Biotechnology in São Paulo, whose R&D efforts will focus on the development and optimization of bioprocesses and biomolecules, engineering genetics, and the development of intelligent products with a biological basis.

The role of SEBRAE

SEBRAE aims to foster development and to support micro and small companies in areas such as technological prospection, intellectual property consulting, business modeling, market positioning, investor relations, consulting, and business and financial management. One SEBRAE initiative, for example, is to promote events where inventors and investors present market trends and business opportunities to small companies.

In the health sector, SEBRAE initiates participation from innovation professionals in areas such as biotechnology, nanotechnology, bioinformatics, and artificial intelligence. For example, through SEBRAE, start-ups and innovators have the opportunity to present their solutions to solve specific health challenges to investors.

The role of SESI

SESI focuses on, and promotes innovation in, health and safety at work. This contributes to business competitiveness by reducing costs, reducing work-related accidents, and improving workers' well-being. To face the challenges of safety and health at work, SESI has implemented nine innovation centers aimed at identifying challenges and developing solutions in several areas: prevention of disability, health and safety economics, ergonomics, lifestyle and health, longevity and productivity, health and safety management systems, psychosocial factors, occupational hygiene, and healthcare technologies.

For example, the SESI Innovation Center for Health Care Technologies developed a gamification solution to encourage users to adopt healthy habits. The solution facilitates monitoring and data visualization of personal habits that need to change for a healthier lifestyle. This and other examples of innovations developed by the SESI Innovation Centers are publicly available on the web in the National Platform of Innovations.[16]

The role of CNI and IEL

CNI manages SENAI, SESI, and IEL. Together, state federations and employers' trade unions form the Industry System, a national private network responsible for initiatives to support the Brazilian industrial sector.

From the demands identified in the companies by the industrial federations and unions, the System offers basic education, professional training, business training, and technical and technological solutions to industries. It also develops socio-educational programs that contribute in an effective way to improve safety and health conditions in the workplace.

The Innovation Directory of CNI/IEL also supports innovative companies in the health and medical sector through management consulting and training. The program Inova Talentos, in partnership with the National Council for Scientific and Technological Development (CNPq), encourages fellows to participate in innovation projects, such as validating biomarkers discovered through metabolomics and development, or validating tools to aid molecular diagnosis in precision oncology.

Finally, CNI hosts the Entrepreneurial Mobilization for Innovation (MEI) in Brazil. One of MEI's initiatives—carried out through an agreement between CNI, SESI, SENAI, and SEBRAE—is the publication *Business Innovation Cases*, which aims to inspire companies to innovate.

These are just a few examples of how the CNI, SENAI, SESI, IEL, and SEBRAE can collaborate in the development of new technologies in health and medicine in Brazil. Brazil has enormous opportunities ahead, and the research and business support infrastructures provided by the aforementioned institutions will play an essential role in realizing these opportunities.

Key challenges and recommendations for health innovation in Brazil

Despite the country's scientific expertise and potential in some aspects of healthcare and medicine, developing more technologies in these areas requires us to overcome regulatory, financial, and institutional constraints.

One significant constraint is the discontinuity in public policies and research funding, which undermines the country's scientific infrastructure and expertise. Although companies account for a significant portion of R&D investment in health, public investment is still the primary source of scientific research in the area worldwide. In Brazil, discontinuities in public funding for science and technology (S&T) lead to *brain drain*—training gaps for qualified staff—and obsolescence of equipment and laboratories, which need to be continuously updated if the country wishes to produce relevant scientific knowledge in this area.

Therefore, one of the most important recommendations for Brazilian government is to set up a transparent and stable strategy for innovation in healthcare and medicine, which should consist of long-term investments in infrastructure and research. This strategic plan should also address institutional constraints that hamper innovation in the country.

Regulation is one constraint that partially explains the low participation of the country in world clinical trials. According to companies, the time required by ANVISA to approve clinical trials is one of the regulatory problems, and a study by the Brazilian Development Bank (BNDES) showed that these time requirements are higher than the world average.[17] Since many studies are conducted concomitantly in several countries, delays in the approval process may limit Brazilian participation in those studies.

One reason for this delay may be the existence of multiple requests for approval for clinical trials. Each research institution has its own research ethics committee, which is not always expeditious in analyzing tests. In some cases, this approval still needs to go to the National Ethics Research Council, where the process can take up to six months to complete.[18]

In addition, entrepreneurs and studies point out that the cost of clinical research in Brazil as an impediment to growth.[19] This cost comes, in part, from regulatory standards, such as the need to supply medicine to trial participants after the study ends.

One possible solution to these issues lies in a bill currently under discussion in the Congress. This bill establishes standards for clinical research in human beings and creates a national system of ethics and research, which will improve and give consistency to the regulation of clinical research in the country.

Intellectual property is also a major challenge for innovation in Brazilian industry. Specifically, in the health sector, intellectual property rights are the main tool to reward the innovator for the risk incurred in innovating. In Brazil, the registration of a patent can take up to 11 years, which hampers innovation in the country. Therefore, one important recommendation of CNI is to increase the efficiency of the National Patent Office (INPI) in evaluating patents, which requires more evaluators, better management, and the use of international collaborative schemes.

An example of a good international collaborative scheme is the Budapest treaty, aimed at advancing the protection of microorganisms, which allows deposits of microorganisms at an international depositary authority for patent procedure. CNI considers that Brazil becoming a member of the Budapest treaty would be an important step for the development of the biopharma industry in the country.

With regard to advancing the use of ICT in health, there are some relevant bottlenecks related to legislation and the availability of information. One example is the adoption of the electronic medical record in the Unified Health System network. For this to be feasible, it is necessary to provide basic infrastructure for public health units across the country and to establish interoperability protocols among several health service providers. Government and regulatory agencies need to develop standards and protocols for medical records to widen its use, which could benefit both the public and private health system and its patients.

The recently passed General Data Protection Act, due to come into force in 2020, introduces a new element to this scenario. From this, any use of personal data—especially sensitive information such as health—will require the consent of the owner. Two factors requiring clarification are whether the law is expected to protect people and their personal information from indiscriminate and unauthorized use, and if the Act will impact health research, especially using big data and AI. Therefore, the CNI will follow the developments of this law and its impact on innovation in health in Brazil.

Brazil has immense potential to innovate in health and medicine. These are merely a few recommendations that could help the country overcome challenges and build a more dynamic health innovation ecosystem, thus benefiting Brazilian society with improved and more affordable healthcare. The Brazilian industry is committed to these ideas and to the goal of transforming the country into a hub of innovation in health.

Notes:

1 The World Bank, 2019.

2 The Economist, 2018.

3 Deloitte, 2016.

4 Deloitte, 2016.

5 Instituto Evaldo Lodi, 2018.

6 De Negri, 2018.

7 Cross, 2018

8 IBGE, 2017.

9 Reynolds et al., 2016.

10 Instituto Euvaldo Lodi, 2018.

11 IBGE, 2016.

12 OECD, 2015.

13 Revista Exame, 2018.

14 Distrito, 2018.

15 Prêmio Abril Dasa de Inovação Médica, 2018.

16 Plataforma Nacional de Soluções SESI, 2019.

17 Gomes et al., 2012.

18 Gomes et al., 2012.

19 Reynolds et al., 2016.

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CHAPTER 15

INTEGRATION OF HEALTH AND MEDICAL INNOVATIONS IN RWANDA TO PROMOTE HEALTH EQUITY

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While ministries and health departments around the globe face disparate health concerns, they often share a vision of improving equitable access to quality healthcare—particularly from a gender and age-specific lens—for their constituents. Although this vision is ubiquitous, the procedures involved in bringing it to fruition remain arcane. Nevertheless, Rwanda has made tremendous progress in the area of universal health coverage, advancing the county's health equity agenda.

One of the key catalysts propelling Rwanda's progress in providing equitable access to healthcare is the country's eagerness to adopt technological innovations and swiftly integrate them into the health system. Innovations range from utilizing drones to deliver blood to citizens in the most remote corners of the country to using mobile phones to transmit critical health information collected at the community level to a central database. The innovations in Rwanda's health system ensure the equitable distribution of health services, as well as consistent and reliable information about critical health information at all levels of the health system. Many health policy experts suggest that the synergy of political will and the aforementioned health innovations have fostered Rwanda's health sector achievements.

Health innovations

1. Drones

In Rwanda, as well as many other parts of the world, a considerable portion of the population living in rural areas have limited access to essential medical products, such as blood and vaccines, due to onerous landscapes and gaps in infrastructure.[1] In past years, when essential medical supplies were required to save lives, healthcare providers would either dispatch an ambulance to transport the patient to a health facility with higher capacity or dispatch a car and driver to the central blood bank to retrieve blood. These processes are especially precarious in situations where the central blood bank is five hours from the health facility. The protracted process of awaiting land vehicles to transport vital medical supplies to patients in critical condition hampered doctors' abilities to save the lives of those patients. The ineffectiveness of this approach encouraged health policymakers to create a novel strategy to quickly deliver lifesaving medical supplies to patients in critical condition.

Through an emphasis on building strong public-private partnerships, the Rwanda Ministry of Health has begun using medical drones to supply lifesaving medical supplies to 21 district hospitals throughout the country. These medical drones ensure that blood products are instantly accessible to the nearly 12 million citizens of Rwanda.[2]

Since October 2016, the Rwanda Ministry of Health has collaborated with Zipline to integrate drones into the medical-supply infrastructure. Before drones were integrated into the health system, donated blood stored in blood banks in Rwanda would often expire. Rwanda was likely spending over US$50,000 for the disposal of blood products annually. As a result of this new, comprehensive blood-delivery system, medical doctors are now able to place orders online and receive blood from the distribution center within 30 minutes.[3] According to Zipline, blood deliveries to hospitals by drone resulted in blood banks having zero units of expired blood. This highlights several benefits of integrating drones into Rwanda's medical-supply infrastructure.

2. Mobile health (mHealth) as a digital health solution

In addition to the integration of cutting-edge technology to promote health equity, phones are also used as an alternative technological innovation to provide quick, affordable, quality resolutions to ailing citizens. With over 2 million registered users—roughly 30% of the adult population in Rwanda—and over 280,000 consultations performed, digital healthcare through Babyl Rwanda is expanding the provision of healthcare services to individuals throughout the country. Clients must follow three simple steps to access heathcare through Babyl: 1) send an SMS to a specific phone number to request an appointment, 2) transmit a payment using e-transactions with mobile money services, and 3) complete a short consultation with a triage nurse before scheduling a follow-up appointment with the Babyl senior nurse or general practitioner. This digital health solution offered through Babyl Rwanda is promoting access to healthcare in a convenient and cost-effective system.

With an average waiting time to see an emergency center physician of 30-60 minutes in Rwanda, Babyl Rwanda diminishes the time wasted in long queues by providing immediate access to healthcare professionals.[4] The long waiting times are, in part, a result of the doctor to patient ratios that lie below international recommendations. Given these low ratios, the artificial intelligence (AI) component of Babyl Rwanda becomes extremely valuable. Babyl Rwanda is integrating AI into the Babyl call center, health posts, and health centers. The AI system will serve as a commensurable substitute to in-person consultations with physicians given AI will have the capacity of an expert medical doctor's brain.[5] The development and expansion of AI technology will serve as an extraordinary tool to support the task sharing and task shifting approaches that are in place to mitigate the shortage of highly skilled health professionals. In addition to reducing time wasted awaiting consultations and assuaging congested waiting areas, Babyl Rwanda will also ensure that healthcare services are affordable to the Rwandan population. As Babyl Rwanda's consultations are quick and convenient, illnesses can be diagnosed and treated earlier—before the patient's symptoms worsen and create a need for extensive and costly medical treatment.

While Babyl Rwanda predominantly promotes healthcare-seeking behaviors in patients, RapidSMS serves as another mHealth innovation that, in contrast, focuses on health service outreach. In 2010, Community Health Workers (CHWs) adopted RapidSMS, a mobile-based process for transferring vital health information about vulnerable community members to a central database to be monitored by doctors and central level staff. Through RapidSMS, the 58,298 CHWs in Rwanda ensure that community members, pregnant women, and infants, in particular, receive the swift healthcare services they require. Additionally, RapidSMS serves as a notification system to ensure that medical professionals are immediately alerted when life-threatening complications arise. With the recent upsurge of malaria cases, severe malaria was added to the RapidSMS system to accelerate referral processes and reduce mortality. Malaria alerts demonstrate that RapidSMS has the flexibility to accommodate conditions that require a specific focus.

Some of the most significant barriers to achieving optimum maternal and child health indexes point to the low reach, quality, and utilization of services. Low reach is largely due to a shortage of human resources needed to expand the coverage of health services. Low coverage for maternal and child health services results in late identification of pregnancy and labor complications, slow response to poor newborn health, and inadequate monitoring of child development.[6] The integration of the RapidSMS into CHWs' daily work facilitates the expeditious communication between CHWs and medical professionals. This ensures that CHWs can access the clinical information needed to increase the effectiveness of their work, expedite the interventions they are implementing, and improve their confidence in securing the health of their community members (Figure 15.1).

3. Online learning

As the health sector is ever evolving with innovative tools and policies to expand access to high-quality care, there is a need to provide standardized, high-quality trainings to the health workforce to ensure they are prepared to adopt these innovations. To address this need, the Rwandan Ministry of Health developed the health sector e-learning system in January 2018, which combines online distance learning with curtailed virtual face-to-face sessions to offer learners the optimal learning experience.[7] The online learning affords the health sector workforce the flexibility to build their skills and knowledge at home, during breaks at work, or anywhere an individual has an internet connection, as courses can be taken even on smartphones.

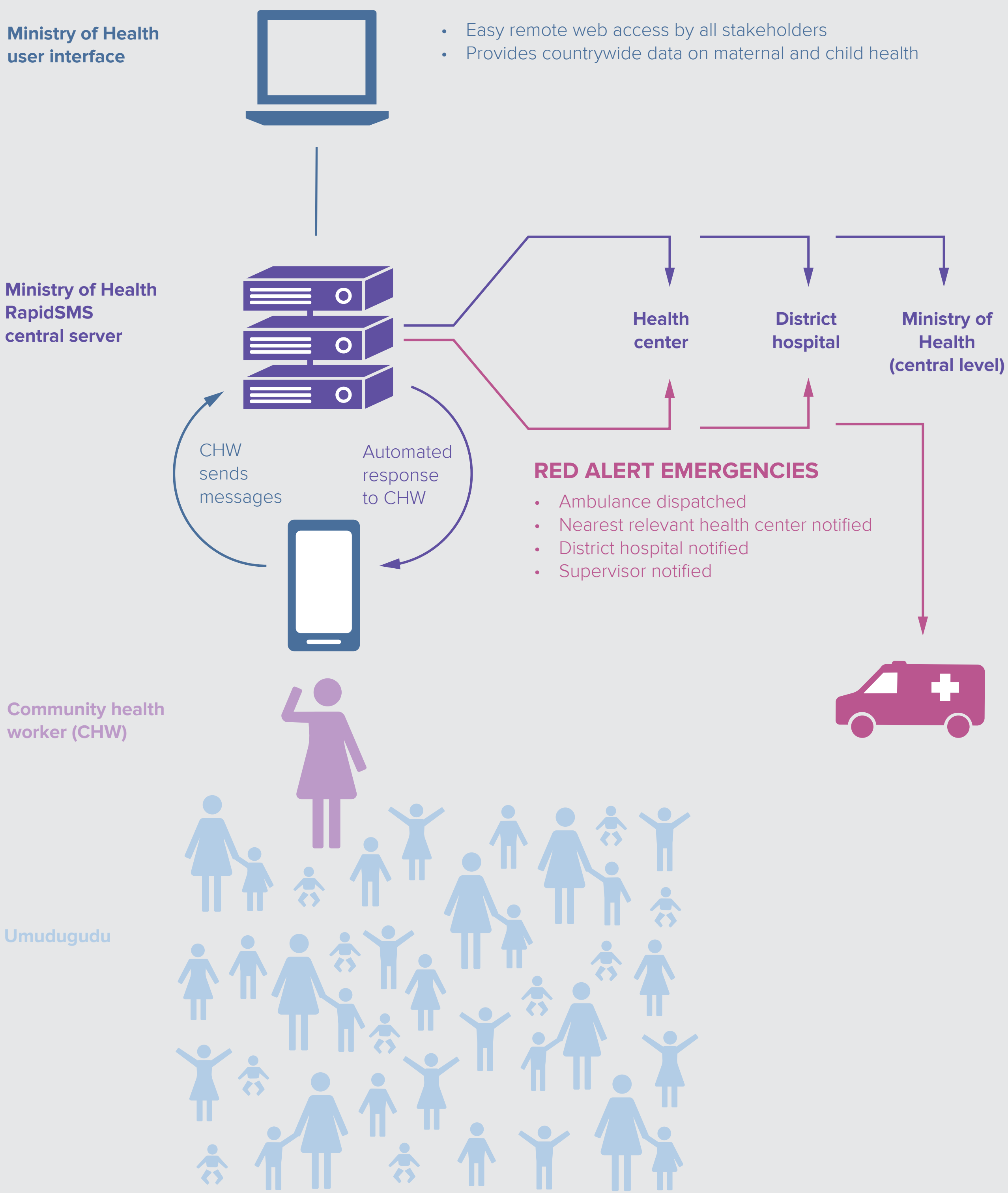
Online training—which offers flexibility in the time, location, and pace that health workers consume new information—averts the absenteeism that is typically associated with health workers' attendance at traditional face-to-face training. A study examining the causes of low health worker performance and outputs in low-income countries recognized that traditional, in-service training was associated with reduced productivity because it served as an authorized absence for staff.[8]

Furthermore, e-learning aims to ensure that the entire population is afforded high-quality health services by providing training to healthcare workers in even the most remote areas of the country. The most recently launched e-learning course was offered to district and private hospital data managers. Data managers, monitoring staff, and evaluation staff—representing all public and several private hospitals throughout the country—enrolled in the course. Through this online training, the Rwanda Ministry of Health was able to ensure that all 60 participants received consistent, high-quality training and were equipped to integrate leading data quality mechanisms into their daily work practices.

A meta-analysis conducted by the United States Department of Education discovered that e-learning users performed modestly better, on average, than students learning the same material through traditional face-to-face instruction.[9] This improvement in learning outcomes and evidence regarding the cost-effectiveness of online learning have encouraged policymakers to integrate e-learning into their educational initiatives.[10]

FIGURE 15.1

RapidSMS Rwanda information flowchart



Source: Scaling Up Nutrition, 2016.

Impact of innovations on the quality of health services

The aforementioned innovations propel the continued strengthening of healthcare services offered in the country. Rwanda is a country that promotes evidence-based innovation and is eager to adopt blockchain, genomics, and precision medicine. The country's leadership ensures that all of these innovations serve the common denominator of equitable access to high-quality healthcare for the entire population. The integration of blood and vaccine delivering drones, mHealth, and online learning into the health system have served to expand equitable access to healthcare across the Rwandan population in the most cost-effective manner.

The blood and vaccine delivering drones, for example, are not only cost-effective in preventing the wastage of blood supplies, but a study found that emergency shipments by drones could be more cost-effective than the use of common transport means (ground ambulances and motorcycles). The analysis not only includes cost savings but also suggests that there is a time-saving element to using drones.[11] Rwanda's blood delivering drones also contribute to the country's aspirations of providing healthcare services to the population as the cold-chain capabilities of the drones preserve the quality of vaccines and blood that reach their intended clients.

RapidSMS is the most well-documented innovation because of its contribution to improving the quality of health services in Rwanda. As one of mHealths' digital health solutions, the RapidSMS has contributed to the country's improvements in maternal and child healthcare. As postnatal care is essential for safeguarding the health of newborns and mothers, the introduction of RapidSMS has led to an increase in the total number of postnatal care visits.[12] This increase is significant given that over 50% of pregnant women had not received postnatal care checkups according to the 2014/2015 Demographic and Health Survey.[13] As RapidSMS assists in the expansion of healthcare services, several stakeholders also suggest that the system contributed to improvements in the quality of services provided both in the community and in health facilities.[14] One example of this includes the testimonies received from district- and community-level healthcare personnel who found that RapidSMS helped them reach their targets for care provision.[15] A less studied mHealth solution is Babyl—Rwanda's largest health service provider.[16] While this innovation is fairly new, the formative evaluations that have been conducted suggest that this innovation is a time-saving solution for both the individuals seeking care and the health system. Mobile consultations are afforded to thousands of Babyl Rwanda users through the medical AI agent that mimics the thought processes of an expert medical doctor's brain which enables it to provide quick and reliable healthcare to Babyl Rwanda's clients.[17]

The last health innovation which contributes to health service quality improvement is Rwanda's Health Sector e-Learning System. This system safeguards the equitable distribution of high-quality training to healthcare workers throughout the country. Preliminary results from course evaluations and pre- and post-training assessments completed by e-learning participants suggest that a majority of participants gain critical knowledge and skills upon completion of these courses and gain confidence in their ability to carry out their daily work responsibilities. As healthcare providers acquire new skills and knowledge through standardized training and experience a boost in confidence in their ability to provide quality healthcare, the healthcare services offered throughout the country will similarly improve.

Main challenges and opportunities

While e-learning has it's benefits—such as ensuring the health workforce is properly trained on innovations integrated into the health system—the blended learning approach that is used in the health sector e-learning system may still increase the time healthcare workers spend away from their patients. Additionally, capacity building in areas, such as service delivery, requires numerous practical sessions. These sessions should be complemented through—not replaced by—e-learning courses.

The integration of technology into the health system also requires greater investment in infrastructure. As new systems—such as the delivery of medical supplies by drones—are integrated into the health infrastructure, new policies must be developed to regulate the services and maintain a standard of quality in service delivery. Additionally, the health system in Rwanda must continue to foster strong partnerships with private sector experts to ensure that technology interventions are effectively integrated into health service delivery.

Finally, given the increasing cost of healthcare—caused by an increase in healthcare utilization, life expectancy, and non-communicable diseases—it is of paramount importance to find cost effective ways of providing the best and safest care to all. For example, the Joint United Nations Programme on HIV and AIDS (UNAIDS) noted a substantial decrease in AIDS funding from 13 governments in 2016.[18] Several innovations have been integrated into health systems around the world to reduce the transmission of HIV, such as pre-exposure prophylaxis and HIV self-sampling kits. It is essential that these efforts continue to be funded to ensure countries that have been successful in reducing the incidence of HIV transmission, such as Rwanda, can reach the goal of ending AIDS as a public health threat by 2030.

Conclusion

Rwanda's receptiveness to, and interest in, the adoption of innovative solutions to public health challenges has led to the country's remarkable progress—both in enhancing health equity and towards achieving universal health coverage. As one of the first countries in the world to utilize drones as a method of equitably distributing health products to citizens throughout the country, Rwanda has embraced the idea of integrating technology into the health system to provide high-quality, equitable services to the population.

Furthermore, the country's adoption of mHealth—to deliver quick and effective health services, reduce waiting room congestion at health facilities, and communicate the health emergencies which occur in the community to medical experts in the capital—safeguards the equitable distribution of high-quality services to the entire population. As the health sector's effective use of drones and mobile devices are used for delivering high-quality services, the proper uses of these health innovations require high-quality training. The adoption of innovations such as an e-learning system targeting the health workforce ensures that healthcare professionals are proficient in utilizing these innovations countrywide.

While the health sector may encounter challenges in the implementation of these health innovations, the amalgamation of strong political will and good governance involving the contributions of other sectors in Rwanda enables the health sector to push forward and find solutions to those challenges. Some of the contributions from other sectors include:

- collaboration with the Republic of Rwanda Ministry of Infrastructure, which includes the civil aviation mandate to ensure the availability of well-established regulations for blood and vaccine delivering drones to operate in Rwanda;
- the country's mobile phone penetration, which crept up to 76.1% in February 2018, driving the expansion and success of mHealth services;[19] and
- significant investment in expanding internet connectivity, especially fiber optic telecommunication networks across the country, ensuring the feasibility of the e-learning system.

Beyond the technological innovations, the contributions from other sectors suggest that health technology is not the sole force driving the expansion of health equity throughout the country. The Ministry of Health's appetite for reaching across sectors to improve collaboration, coordination, and communication has made immeasurable contributions to the health sector's success in implementing these technological innovations. The commitment of CHWs and the private sector to use technology to reach citizens in even the most remote areas of the country suggests that partnerships between internal and external actors are essential to providing affordable, effective, and high-quality health care to the population.

The Government of Rwanda's readiness to partner with technology experts from the private sector further propels their success in integrating technology innovations into the health system. Technological progress does not always equate to health equity; however, the Government of Rwanda remained mindful of its intention to integrate technology that furthers equitable access to high-quality services into the health system. This has driven its success in using technological innovations to achieve inclusive and equitable health for the population.

Notes:

1 Zipline, n.d.

2 Ackerman et al, 2018.

3 Glauser, 2018.

4 Pascasie et al., 2013.

5 Kantengwa, 2017.

6 Mwendwa, 2016.

7 Lyle et al., 2018.

8 Dovlo, 2005.

9 U.S. Department of Education, 2010.

10 Bartley et al., 2014.

11 Würbel, 2017.

12 Würbel, 2017.

13 National Institute of Statistics Rwanda, 2016.

14 Ruton et al., 2016.

15 Musabyimana et al., 2018.

16 Babyl, n.d.

17 Rwanda Guide, 2018.

18 UNAIDS, 2016.

19 The New Times, 2018.

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CHAPTER 16

IRAN'S EXPERIENCE IN DEVELOPING HIGH-TECH MEDICAL INNOVATIONS AND THE PATH AHEAD

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Over the last two decades, the Islamic Republic of Iran has made significant progress in the health and medical sector, expanding both in market size and coverage. The ever-growing medical innovation ecosystem is supported by ongoing policy framework developments, incentives, and regulatory bodies. In addition, the emergence and development of the biopharma sector in Iran, which is a complex, high-tech sector, hosts several successful local export firms.

The focus of this chapter is the evolving pro-innovation ecosystem of the health sector in Iran. This ecosystem has achieved effective policy and regulatory synergies and has supported the supply- and demand-side of medical innovation. Demand-side innovation has paved the way for advanced endogenous medical innovations in Iran while, historically, conventional medical solutions were not easily accessible due to sanctions or affordability.

The chapter provides policy- and firm-level recommendations to highlight common success factors of medical innovation, based on the mentioned case studies and field interviews conducted with firms and policymakers. In addition, we discuss ways to mitigate impediments to further innovation.

Advancing health coverage, research, and innovation

Iran's improvement in health-related indicators has been consistent and promising. According to the Human Development Index (HDI), the mean years of life expectancy in Iran has increased dramatically from 51.1 in 1980 to 76.2 in 2018, an approximate 25-year increase over the past three decades.[1]

From a science, technology, and innovation (STI) perspective, Iran has boosted scientific production in areas such as nano-tech, biotechnology (biotech), biomedical engineering, bioengineering, biomaterials, and biophysics. For instance, rankings have improved from either non-existent or around 60th position in the late 20th century to 4th in nano-tech, 12th in biomedical engineering, 9th in bioengineering, and 8th in biomaterials, in 2017.[2]

STI efforts to transform the medical and health sector resulted in synergies between human capital supply, technological regime, and the innovation ecosystem. In addition, state-of-the-art medical innovation continues to advance through expanding medical education, support for university- and firm-level research and development (R&D), and the creation of an evolving pro-innovation, medical policy framework. The medical innovation ecosystem—supported by over 19,300 faculty members from medical universities and research institutes, and responsible for roughly 37,450 scientific papers and 1,589 patent applications in 2018—has the capacity to host various research activities.[3]

In 2018, the National Medical Device Directorate (NMDD) reported that the Iranian medical equipment market was worth US$2.5 billion, of which 30% belonged to over 1,000 domestic firms.[4] On a global scale, 56% of 500,000 medical equipment items available in the world market have Iranian-made versions.[5] In pharmaceuticals, around 70% of Iran's US$4.5 billion market is domestic products and, in 2018, 97% of pharmaceuticals consumed in the country were manufactured locally.[6] Furthermore, in 2018, 67% of the active pharmaceutical ingredients (APIs) used to produce drugs in Iran were made locally.[7]

Boosting the medical innovation ecosystem through policy framework

Medical innovation policy framework

Iran has integrated its healthcare system with medical education to improve health conditions. Sixty-five medical universities, responsible for both health services and medical higher education, constitute a decentralized network of provincial healthcare bodies that are managed centrally by the Ministry of Health (MOH). This network has contributed to the creation of a strong healthcare system characterized by extensive and convenient access to medical services, both in rural and urban areas. In each province, public medical universities provide medical services, administer vaccinations, and assist in fighting local diseases. Because of countrywide distribution, the network has the ability to undertake endogenous research and innovation and train medical cadres based on local demands and epidemic situations.

Since the early 1990s, the MOH has followed a five-year national development plan (FYDP), revised in five-year intervals, as the principal policy framework for enhancing Iran's health sector.[8] In 2014, during the 5th FYDP, the MOH initiated and funded the Health Transformation Plan (HTP), which has resulted in a sharp decrease in the share of medical expenses paid by patients—from an initial out-of-pocket expense of 37% of overall patient health costs to 5% for rural citizens and 10% for urban citizens. The key health policy for the 6th FYDP (2016 to 2021), is dedicated to providing universal health coverage using coordinated public insurance schemes governed by the MOH. According to the MOH, 100% of urban and 98% of rural areas in Iran now have access to at least primary medical services.[9]

Policies supporting the supply side of medical innovations: In the 1980s, lack of access to foreign drugs and medical equipment became a threat to national health and well-being in Iran. For this reason, Iran adopted import substitution policies and promoted local production. In 2011, the Food and Drug Administration of Iran, under the MOH, introduced a set of regulations to support the supply of local medical equipment and pharmaceutical products. These regulations ban or limit the import of foreign drugs and medical equipment to 10% of market share when a similar local product becomes available. When local products are available, public health insurances do not cover the costs of foreign drugs for patients, but they do cover from 90 to 100 percent of the total cost of the domestic equivalent.[10]

Imposing high tariffs on foreign drugs and/or medical equipment, when an equivalent is locally produced and developed to meet domestic demand, is also a tool to support medical innovation. In cases where the domestic equivalent is not available, low tariffs of 4% are set on foreign products. However, when the domestic equivalent is available and verified by the MOH, these tariffs increase from 4 percent to between 32 to 45 percent, and public health insurances will no longer cover patient medical expenses for these products.[11] Supporting the local production of drugs has successfully promoted domestic product share in the national pharmaceutical market, from 63.4% in 2009 to 78.6% in 2018.[12]

But, this approach will not guarantee the success of medical innovations in the long run. Policymakers and firms are aware of the possible harmful consequences of import substitution on future medical innovation.[13] Hence, exporting medical innovations is strongly encouraged by recent policies, such as the law for supporting knowledge-based firms (KBFs). This law, approved by Parliament in 2010, was introduced as a mechanism to encourage the supply side of technology and innovation in high-tech firms, benefitting the health sector.[14] The Vice-Presidency for Science and Technology (VPST) administers this law and the Innovation and Prosperity Fund (IPF) channels funds to the innovative and technological activities of eligible KBFs. Eligible firms include private entities that produce high-tech products, require in-house R&D and skilled employees, are high value-added, and are difficult to imitate. In early 2019, US$85 million had been allocated in the form of low-interest rate loans to fund 474 medical innovation projects by the IPF. Additionally, the VSPT supports 4,300 KBFs, of which approximately 1,100 KBFs are private health and medical sector firms.[15]

Policies supporting the demand side of medical innovations: Policy efforts are also in play to push medical innovation on the demand side (Figure 16.1). One example is the Iran Lab Expo (ILE), initiated by the VPST in 2012 to promote technology & innovation (T&I) development by private firms.[16] Depending on the depth of domestic capabilities to design and manufacture independently as well as the technological complexities of the lab equipment and/or device, public buyers, such as universities and hospitals, are entitled to a VPST subsidy of between 10 and 40 percent of total cost. To encourage and stimulate demand from private buyers, the ILE grants low-rate, medium-term loans of up to US$120,000.[17] In addition, the Heyat Omana Arzi (HOA) plays a critical role, on behalf of the MOH, to procure and supply medical disposables, devices, and equipment to public hospitals and medical centers. The HOA also provides patients with prerequisites for domestic treatment, minimizing dependency on foreign treatment and medical expenditure.[18]

Medical innovation ecosystem and its key actors

A community of vibrant young entrepreneurs in Iran has pioneered state-of-the-art medical innovations. Their efforts are reinforced by evolving government support in the form of tariff barriers, tax exemption, and guaranteed purchase. The law for supporting KBFs has played a key role in empowering the medical innovation ecosystem. There are 4 dedicated S&T parks, 78 incubators, and 739 research centers in a variety of medical fields affiliated with the MOH.[19] Furthermore, 68 incubators and 27 S&T parks, under the supervision of the Ministry of Science Research and Technology (MSRT), specialize in supporting medical and pharmaceutical sectors.[20] As of February 2019, medical related KBFs—approximately 1,100

FIGURE 16.1

Key policies and actors supporting medical innovation in Iran

- **Food and Drug Administration**—certifies all foods and drugs for consumers
- **National Medical Device Directorate**—responsible for certifying local and imported medical equipment/devices
- **Iranian National Standards Organization**—certifying all foods, medical equipment when applicable

- **Ministry of Health**
  - **Health Technology Council**—supports technology and innovation development in health sector
  - **Food and Drug Administration**—sets high tariffs and limits market share of imported drug and medical equipment when domestically produced options are available
- **Vice-Presidency for Science and Technology**—supports knowledge-based firms by offering instruments such as tax and duty exemptions; funding and supporting major health sector innovative projects called mega projects
- **Ministry of Industry, Mines and Trade**—imposes import tariffs on drugs and medical equipment in coordination with Ministry of Health, upon availability of domestic products

- **Research and technology funds and VCs**—21 S&T funds and 9 VCs such as Innovation and Prosperity Fund; Biotech Fund; Medical Equipment Fund; Tehran Health Fund
- **CVCs**—PersisGen in biopharma founded by CinnaGen
- **National IP office; IP offices in universities**
- **Innovation centers**—79 centers
- **Accelerators**—29 accelerators
- **S&T parks and incubators**
- **Health techmarts**

- **Medical equipment & pharmaceutical firms**—about 1100 firms
- **Commercial firms**—importing drugs and medical equipment and providing after-sale customer services

- **Research centers**—such as Pasteur Institute, Razi Institute, National Institute of Genetic Engineering and Biotechnology; 739 university research centers
- **Universities**—such as biotech, pharmacy, science, medical engineering, chemistry, and other relevant faculties in both medical and conventional universities

- **Ministry of Health**
  - **Health Technology Council**—strengthening university-industry collaborations in health sector
  - **Heyat Omana Arzi**—procuring aggregated medical equipment and drugs for MOH leveraged to support medical innovation and made-in-Iran products
- **Vice-Presidency for Science and Technology**—subsidizes lab equipment/devices for public hospitals and universities and grants loan to private buyers by Iran Lab Expo initiative
  - **Biotech Council**—coordinates and supports development of biotech-related technologies and products, including biopharma
- **National Medical Device Directorate**—encourages export of medical equipment; pushing local firms to acquire local and international standards such as CE/ISO

■ Regulators ■ Supply side ■ Intermediaries ■ Demand side

Sources: Ministry of Health and Medical Education, 2019; Institute for Trade Studies and Research, 2017a,b; UNCTAD, 2016.
Note: Data extracted from information provided by actors on their websites and available periodical reports.

FIGURE 16.2

Iran's biopharma evolution and key products

2003	CinnaGen started collobaration with Fraunhofer to develop interferon beta-1a
2006	Production of CinnoVex® (interferon beta-1a) by CinnaGen for MS treatment (3rd country in the world to produce); Introduction of PDpoetin® (erythropoietin) by Pooyesh Darou for hemodialysis patients
2008	ReciGen® (interferon beta-1a) produced by CinnaGen for enhancing immune cell activities; γ-Immunex® (interferon gamma-1b) by ExirPharma for improving immune system produced
2012	Production of CinnoRA® (adalimumab) by CinnaGen for rheumatology treatment; recombinant activated human blood coagulation factor VIIa, with the trade name AryoSeven™, developed by AryoGen for hemophilia treatment; Herceptin (trade name for trastuzumab) introduced for fighting breast cancer
2013	Production of PegaGen® (pegylated filgrastim) by CinnaGen for fighting cancer
2014	Glatiramer (trade name Osvimer®) and deferasirox (trade name Osveral®) developed by Osvah Pharma for multiple sclerosis treatment
2016	CinnaGen produced: CinnoPar® (teriparatide) for osteoporosis treatment; CinnaTropin® (somatropin) to enhance growth of bones and muscles and increase metabolism; Cinnal-f® (follitropin alfa) for infertility treatment; CinnoRA® (adalimumab) for autoimmune diseases
2019	Saman daroo 8 produced human recombinant factor VIII (hr FVIII) under trade name Safacto (SD8) for hemophilia patients

Source: Institute for Trade Studies and Research, 2017a.
Note: Data in this figure have been partially extracted from the information provided on websites and periodical reports of Iranian biopharma firms.

firms—are engaged in T&I development, including 200 biotech firms, 255 advanced pharmaceutical firms, and 175 medical equipment firms.

Accelerators and innovation centers are the most recent mechanisms used by the government and, in particular, the VPST to expand and increase the efficiency of KBFs. To date, 29 accelerators and 79 innovation centers are operational and open to medical innovators and entrepreneurs. PersisGen, established in 2016 by CinnaGen, is an example of a medical accelerator—perhaps the most successful and prominent in Iran—which provides corporate venture capital (CVC).[21] As of February 2019, PersisGen had hosted 15 teams to work on 20 advanced biopharma innovations, of which 4 teams had reached the final product.

The major funding institution, IPF, supports medical innovation mainly by granting loans—US$85 million to date—to facilitate KBF efforts in developing medical equipment, biotech, and advanced drugs. Another active funding body, the Iran Biotech Fund (IBT), was founded in 2015 by the Biotech Development Council, an affiliate to VPST, and is supported by joint investment from the private sector.[22] At the end of 2017, IBT had invested US$4 million in venture capital (VC) in 24 innovative ideas and, from its inception, has granted 350 loans—total of US$11.7 million—to a wide range of innovative biotech ideas and projects.

Biopharma in Iran: a unique and advanced sector

Over the last two decades, Iran's STI efforts, accompanied by policy support, in biotechnology and pharmaceuticals has resulted in a rapid increase in biotechnology scientific publications—ranking 9th in bioengineering, 9th in applied microbiology and biotechnology, and 13th in biotechnology in 2017.[23]

Iran's history in biopharma dates back to the 1920s when the Pasteur and Razi Institutes, initially specializing in producing vaccines and then biotechnology, gradually diversified into biopharma. In the 1980s, the National institute of Genetic Engineering and Biotechnology and the Iranian Red Crescent boosted biopharma development. The turning point, in the 1990s, came when the government supported and collaborated with foreign countries, including Cuba, to train Iranian scientists and researchers. Shortly after, trainees, along with other ambitious scientists and researchers, formed an inner circle of Iranian biotechnology and biopharma pioneers that revolutionized biopharma in Iran by founding firms such as CinnaGen, ExirPharma,[24] Ronak Daru,[25] Pooyesh Darou,[26] Osvah Pharmaceutical,[27] Saman daroo 8,[28] Zist Daru Danesh,[29] and AryoGen.[30] International collaboration and STI linkages in biopharma have been instrumental to the success of medical innovation in this sector, but global collaboration barriers, such as sanctions, remain a challenge. Key events in the course of biopharma development in Iran are shown in Figure 16.2.

Currently, there are 20 Iranian biopharma firms, 7 of which are KBFs supported by the VPST. Of the 22 drugs that these firms produce, at least 10 are considered state of the art. The local development of biopharma products has resulted in savings of US$980 million annually, created over 4000 quality jobs for Iranian scientist and researchers, and is accountable for roughly US$60 million of Iran's pharmaceutical exports—of which a sizeable share is exported to Europe.[31]

Although the quantity of biopharma products sold in the local market is not comparable to conventional drugs, three of the top five pharmaceutical manufacturers—in terms of total sales in 2017—are CinnaGen, ExirPharma, and AryoGen. These three manufacturers hold 11.2% of the pharmaceutical market share. In the same vein, AryoTrust™ (Trastuzumab for breast cancer treatment), Cinnovex® (interferon beta-1a for multiple sclerosis treatment),[32] and Zytux™ (Rituximab for fighting cancer and autoimmune diseases developed by AryoGen) are among the top 10 drugs sold in 2017.[33]

Cases of advanced medical innovations in Iran

The increasing and developing market for pharmaceuticals and medical equipment—fueled by local technological and innovative efforts, continued public support, and an influx of interested young medical entrepreneurs—reflects the dynamics of medical innovation in Iran. Three noteworthy cases of advanced medical innovations are explored below, whilst looking at the main drivers of success and challenges as well as the barriers to further innovation.

Medical devices and equipment incubator (MDEI)[34]**:** The MDEI, based at the Imam Khomeini hospital in Iran, hosts several promising firms that are equipped to design and manufacture advanced medical equipment and develop cutting-edge technologies.[35] One of these firms, Sina Robotics and Medical Innovators Co, a KBF, develops Sina—a robotic telesurgery system which assists surgeons in sophisticated surgeries.[36] A guaranteed purchase order by the government in 2009 drove Sina's development, which had commenced in the early 2000s, and by 2013, the first generation of Sina became available.[37] The improved Sina, equipped with added force feedback capability and more, has advantages over similar products on the market and has gained significant international interest.

With over 30 patents registered on Sina, the drivers of its success include: the government order, which overcame sanctions that had made the system locally inaccessible; internal R&D capabilities; the availability and dedication of qualified and talented human resources; and the proximity to clinical practice. Sina creators have faced lack of interest from private investors and delays in allocating public support funds.[38]

Tanin Pardaz Pasargad (TPP)[39]**:** TPP, a KBF, specializes in designing and manufacturing the external unit of the cochlear implant system (CDS) called TAPPS+.[40] Established as a company in 2013, the founders began research efforts almost two decades earlier. After several generations of prototypes, TAPPS+ was introduced in 2016 with the expectation of release to the public in 2019. TPP is one of five firms in the world offering a similar product and interest from leading firms to collaborate on TAPPS+ is growing.

One complementary asset to TAPPS+ is executing the transtympanic promontory stimulation test (TPST) using the ETT device.[41] TPST is a tool used to evaluate the effectiveness of cochlear implant surgeries, especially in patients with weak auditory nerves and those who have been deaf for a prolonged period. Another significant innovative product by TPP uses *deafness recognition by baby crying*, which offers free and efficient evaluation of infant cry signals to detect deafness in babies.[42]

Although TPP provides a number of innovative products, a few challenges inhibit TPP's ability to realize its efforts. For example, complying with local standards is a complicated and lengthy process. Moreover, there is a need to implement a proactive marketing strategy and to increase stakeholder involvement—in particular, sales representatives of foreign CDSs.[43]

Behyaar Sanaat Sepahan (Behyaar)[44]: Behyaar, founded in 2003, is a KBF specializing in radiotherapy and radiography solutions.[45] In 2010, the founder—a young engineer active in linear accelerator (LINAC) maintenance in Isfahan hospitals—decided to build a locally made LINAC. Given Iran's need to produce 240 LINACs by 2025—almost three times the available amount—it was a wise decision. In 2017, relying on in-house R&D, Behyaar built the OMID 6MV, a medical linear accelerator which puts Iran among roughly 10 countries involved in building medical LINACs. Furthermore, LINAC design and development led Behyaar to develop the first Iranian-made cargo inspection system, called Sayyad, designed to inspect loaded trucks, containers, and vehicles at ports, airports, and borders. It uses a dual energy LINAC that penetrates up to 320 millimeters in steel.

Despite numerous failed attempts owing to product complexity and lack of available expertise, Behyaar transformed from a company that used to build simple hospital beds to one designing optical lenses, 3D water phantoms, X-ray systems, image viewing systems, and U-arm ceiling radiology systems. Overcoming these challenges required persistence, risk-taking and in-house R&D. Yet, Behyaar faces a barrier to further innovation and commercialization—the prolonged process to acquire approvals for equipment using radiation. This process can be longer than the product development period itself.[46]

Conclusions and policy recommendation to strengthen medical innovations

Over the past two decades, several domestic firms have pursued medical innovations, some of which are more advanced and user-friendly than world-leading products—particularly in the biopharma and medical equipment sectors. These innovations were driven by the necessity to fulfill local demand for drugs and medical equipment when international solutions were neither accessible nor affordable. Providing all citizens with affordable universal healthcare and medical services that are recognized by government and firms encourages the realization of medical innovations.

National necessity, foreign currency saving, self-reliance, ambition, public incentives, and public policies have afforded Iranian medical researchers and entrepreneurs the opportunity to design and develop medical equipment and advanced drugs. Despite the sizeable share of local medical products in the Iranian market, further domestic innovation requires economies of scale that cannot be attained solely by tariff barriers and market protection. To achieve economies of scale, local firms must export their products. It is imperative that the government systematically continues to facilitate and monitor the export of medical products.[47]

Even with many successes, Iranian firms face barriers to continued innovation, such as lack of customized public support, branding, international acceptance, and standards. Overcoming these barriers would require establishing a coordinated policy framework and creating synergies between current policies. Several policy recommendations to strengthen medical innovation and increase economic impact include:

- The scale of the domestic health market is not large enough to justify the development of costly and long-lasting medical innovations. To deter exclusive reliance on the domestic market, strong policy measures should be established to encourage local firms to export their products. The export process can be lengthy, which suggests that enhancing accreditation infrastructure and standardization facilities would encourage exports more than, for example, access to low-rate loans.
- Government support of local firms has proved to be beneficial; therefore, government should increasingly trust and encourage local firms to engage in high-end medical innovations.
- As leading firms play an important role in the economy, the government should adequately support them in the development of medical innovations and the creation of a dynamic knowledge regime. This would entail enforcing fewer formalities on leading firms, facilitating medical exports, and assisting with the import of raw materials and production equipment. To this end, the Vice-Presidency for Science and Technology has devised *Pioneer KBFs*, a direct communication line to gather information about the needs and challenges of leading firms and to address these in the shortest time possible. The Ministry of Health is encouraged to adopt a similar approach to facilitate and support leading firms.
- According to local firms, some foreign firms that import medical equipment do not face the same difficulties experienced by locals, specifically in obtaining permissions and certifications needed to launch their product in the market. Giving procurement and tender priority to domestic products and firms over the foreign equivalent should be reinforced by the Ministry of Health. In other words, government should take measures to limit foreign medical imports, especially products of lower quality, as a means to encourage local firms to engage in medical research and innovation, as is the case with many other countries.
- Current funding systems that support medical innovation are largely risk-averse. Although institutional mechanisms—

such as the Iran Biotech Fund and the Innovation and Prosperity Fund—have helped to mitigate innovation risks, there is a need to enhance efficiency and availability of funding, particularly venture capital. Formulating a comprehensive technology and innovation funding system in the health sector by socializing some of the inherent risks—for example, through guaranteed public procurements and grants in the medical innovation process—could be the starting point to attract more private funding.[48]

Notes:

1 United Nations Development Programme, 2018.

2 StatNano, 2019; Scimago, 2017.

3 Ministry of Health and Medical Education, 2019.

4 Masaeli, 2018a.

5 Masaeli, 2019.

6 Food and Drug Organization, 2017; Food and Drug Organization, 2018; Pirsalehi, 2019.

7 Pirsalehi, 2019.

8 The five-year development plan (FYDP), revised in five-year intervals, is the main national policy to steer Iran's economic development, involving all national sectors, including the health sector.

9 Ministry of Health and Medical Education, 2019.

10 Institute for Trade Studies and Research, 2017a; Institute for Trade Studies and Research, 2017b.

11 Institute for Trade Studies and Research, 2017a; Institute for Trade Studies and Research, 2017b.

12 Jahanpoor, 2019.

13 Negotiation for ascension to the WTO is in progress; Iran may eventually have to let go its support for import substitution by wall of tariffs according to page 49 of UNCTAD, 2016.

14 UNCTAD, 2016.

15 Information on KBFs and their fields of activity can be found at https://pub.daneshbonyan.ir/ (Accessed in March 2019; In Persian)

16 More information about ILE procedures and statistics can be found at http://iranlabexpo.ir/index.php?lang=2

17 Iran Vice-Presidency for Science and Technology, 2019.

18 More information can be found at http://hoa-ir.com/en/Page/2677/About-Us.html

19 Vatanpour, 2017.

20 Ministry of Science, Research and Technology, 2018. By February 2019, 195 incubators and 44 S&T parks are under the supervision of the Ministry of Science, Research and Technology.

21 More information about CinnaGen and PersisGen can be found at http://persisgen.com/en and https://www.cinnagen.com/

22 More information on IBT approach and initiatives can be found at http://en.biotechfund.ir/

23 Scimago, 2017.

24 More information can be found at http://www.exir.co.ir/index.php/en/

25 More information can be found at http://ronakpharm.com/

26 More information can be found at https://pooyeshdarou.com/

27 More information can be found at http://www.osvahpharma.com/en

28 More information can be found at http://samandaroo.com/english/

29 More information can be found at http://zistdaru.ir/?lang=en

30 More information can be found at http://www.aryogen.com/EN/index.html

31 Institute for Trade Studies and Research, 2017a.

32 Multiple sclerosis, or MS, is a long-lasting disease that can affect brain, spinal cord, and the optic nerves in eyes. It can cause problems with vision, balance, muscle control, and other basic body functions. MS insulates covers of nerve cells in the brain and spinal cord are damaged.

33 Food and Drug Organization, 2017; Food and Drug Organization, 2018.

34 More information on the incubator activities can be found at http://ic-med.tums.ac.ir/

35 Imam Khomeini hospital is a medical institution affiliated to Tehran University of Medical Sciences

36 More information about Sina Robotics and Medical Innovators can be found at http://sinamed.ir/

37 PARSISS Integrated Company, established in 2006, is another competent firm located at the MDEI. PARSISS has successfully developed the Parseh surgical navigation system (SNG) that was introduced in 2011. Thanks to Parseh, Iran is among only seven countries in the world manufacturing SNG. Parseh market share in Iran is about 80 percent and its market price is between 30 and 50 percent of foreign SNGs. The main success factors of Parseh are building trust between PARSISS team and surgeons, mastering SNG core technologies by in-house R&D, and proximity to clinical practice; based on Interview with PARSISS business development manager, Mr. Javad Hasani, conducted by authors in 30 January 2019.

38 Interview with the CEO of Sina Robotics and Medical Innovators, Mr. Alireza Mirbagheri, conducted by authors in 27 January 2019.

39 More information about TPP can be found at http://taninpardazco.com/en-us/

40 More details on TAPPS+ can be found at http://taninpardazco.com/en-us/Products/Tapps

41 More details on ETT can be found at http://taninpardazco.com/en-us/Products/ETT

42 More information on baby crying test can be found at http://taninpardazco.com/en-us/Activities/Hearing-Detection/BabyCrying

43 Interview with Tanin Pardaz Pasargad CEO, Ms. Samira Kooshkestani, conducted by authors in 28 January 2019;. Interview with Tanin Pardaz Pasargad founder, Mr. Hamed Sajedi, conducted by authors in 28 January 2019.

44 More information about Behyaar is available at http://www.behyaar.com/en/

45 More details on Behyaar products is available at http://www.behyaar.com/?page_id=3299

46 Interview with Behyaar's CEO, Mr. Navid Nejatbakhs, conducted by authors in 23 January 2019.

47 Masaeli, 2018b.

48 Mazzucato, 2015.

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CHAPTER 17

SOCIAL AND ECONOMIC ASPECTS OF HEALTH AND MEDICAL INNOVATION IN THAILAND

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Innovation has long been recognized as a driving engine of economic growth. After the global financial crisis, Thailand turned its attention to an innovation-driven growth strategy, instead of an export-oriented growth strategy—and recently became an upper-middle-income economy. According to the Tenth National Economic and Social Development Plan, which covers the period from 2007 to 2011, the strategy was deployed nationwide with a focus on economic development and competitiveness. Since adopting this strategy, the concept of innovation has evolved and been broadly adopted as a means toward sustainable development. Presently the focus has been expanded in the Twelfth Plan, covering the period from 2017 to 2021, to include all aspects of development. Health and medical innovation are playing a crucial role.

As the country is experiencing transitions in demography and epidemiology—with an increase in life expectancy and a decrease in fertility—the health and medical system has had profound impacts on economic, social, and health service development. At a glance, Thailand's life expectancy has increased steadily, from 71.1 years in 2000 to 75.5 years in 2016.[1] Also, the rate of fertility and mortality is declining. In 2010, it was reported that around 11.9% of the Thai population, or 68 million people, are aging over 60 years; this is expected to reach 25% in 2030.[2] Moreover, the population—which was predominantly rural and poor—has recently changed to the one that is almost equally balanced between urban and rural populations. While urbanization offers many opportunities, including potential access to better health service, it also introduces health challenges relating to the environment, non-communicable diseases (NCDs), unhealthy diets, and physical inactivity.

On the other hand, Thai medical services are recognized globally as having an outstanding medical foundation, including premium medical services, qualified healthcare specialists, and various internationally accredited medical facilities. With over 50,573 well-trained physicians and more than 1,000 public and 300 private hospitals nationwide, a diverse range of treatments and world-class facilities are offered.[3] Thailand was ranked first in top destinations for medical tourism, and the number of foreign patients receiving treatment reached 2.35 million people in 2014.[4] This is the result of long-term developments in medical education. Nevertheless, the demand for doctors, medical personnel, and healthcare service in the country still cannot be met.

Given these challenges and opportunities, innovation is considered to be a means toward sustainable health and medical transformations. However, a broad range of benefits and impacts of innovation could be induced in two main aspects—social and economic. Various forms of innovation have been introduced into the health and medical system, ranging from policy innovation to technological innovation. In order to develop a comprehensive understanding of how innovation has affected the reform of the Thai health and medical system, we will focus on two aspects of innovation—health policies and the medical industry.

Innovation in health policies

Demographic changes, through an aging population, affected the rising cost of medical care, the quality of care, and health security for individuals;[5] consequently, the health system needed to be reformed. Through government policies, the reforms aimed to shape the context of the health system in terms of efficiency, effectiveness, quality, safety, and affordability—which is not only limited to healthcare services but also extends to processes, systems, policies, and organizational structures for the purpose of creating new value for patients.

The health system reform in Thailand has employed the concept of a Participatory Public Policy Process (PPPP). Three main sectors were identified to participate in the reform to promote healthy public policy:[6]

1. Knowledge or technical sectors, which includes scholars, professionals, and policy researchers in all relevant areas of both public and private institutes;

2. Social sectors that open opportunities for everyone, from individuals, groups, civil society organizations, mass media, non-governmental organizations, and private sector agencies; and

3. Political and civil service sectors, which includes state agencies, political organizations, and local government organizations.

The fundamentals of health reform have started with reframing the health system from “ill-health oriented” to “good-health oriented”.[7] The concepts of health promotion and health prevention have become part of the reforms to the Thai health system.[8] Also, healthcare financing must be developed to ensure accessibility to adequate and quality healthcare for all. All of these concepts lead to innovation in Thailand health policies such as financing for health promotion, universal health coverage providing all Thai people access to health services, and participation from related sectors to develop public health policies in the National Health Assembly.

Financing for health promotion—ThaiHealth

In the last few decades, Thailand has been facing the double burden of communicable and non-communicable diseases. NCDs—such as cardiovascular disease, cancer, diabetes, and chronic respiratory diseases—have emerged as a leading cause of disease burden. Fundamentally, these diseases share similar risk factors to tobacco use, alcohol consumption, dietary imbalances, and insufficient physical activity. Although health promotion and disease prevention have been recognized as cost-effective investments that can improve lifestyles and society, the majority of health expenditures from the Ministry of Public Health focus on curative services. Therefore, the concept of innovative and sustainable funding for health promotion has been explored and implemented.[9]

After the long process of national policy development and health system reform, Thai parliament enacted the Health Promotion Foundation Act in 2001. This act established the Thai Health Promotion Foundation (ThaiHealth) as a state agency with annual revenue around US$120 million—derived from a “sin tax” or excise tax of 2% on tobacco and alcohol.[10] ThaiHealth was established to manage the health promotion fund and to support health promotion activities at both the individual and organizational level in all areas relevant to health promotion, including a healthy society and environment. As an autonomous agency, ThaiHealth coordinates with partners in both public and private sectors. ThaiHealth also provides a dedicated infrastructure for health promotion, offering several advantages such as flexibility, financial security, and effective strategy. ThaiHealth employs a “Tri-Power Model”—which not only supports direct activities but also supports knowledge development related to evidence-based action and policy, the social movement to raise public awareness and action, and the goal of fortifying political authority involvement (Figure 17.1).[11]

Achievement and challenges—The initiation of ThaiHealth is regarded as the most important landmark signifying the strength of health promotion in Thailand. For example, one of the campaigns against smoking, conducted during the previous decade, changed the perception and social norm related to secondhand smoke. Additionally, there have been several successful campaigns to promote physical activity and improve emotional and spiritual health, such as the “Bike for Mom” project and the campaign to stop drunk-driving. ThaiHealth introduced an innovative and sustainable financing system for health promotion. This system provides sustainable financial resources and also accelerates, supports, and promotes health promotion activities.

However, this financing system still has some challenges. As a new concept, it took time to build up a clear understanding of the concept and its indirect benefits to the public and key stakeholders. Furthermore, some campaigns for health promotion might be against some industries and businesses, which makes it challenging to secure political support to counter any opposition. To overcome the challenges, ThaiHealth must develop an understanding of health promotion to the public and key stakeholders at large, as well as improve the evaluation and effectiveness of health promotion at project, program, and strategic levels.

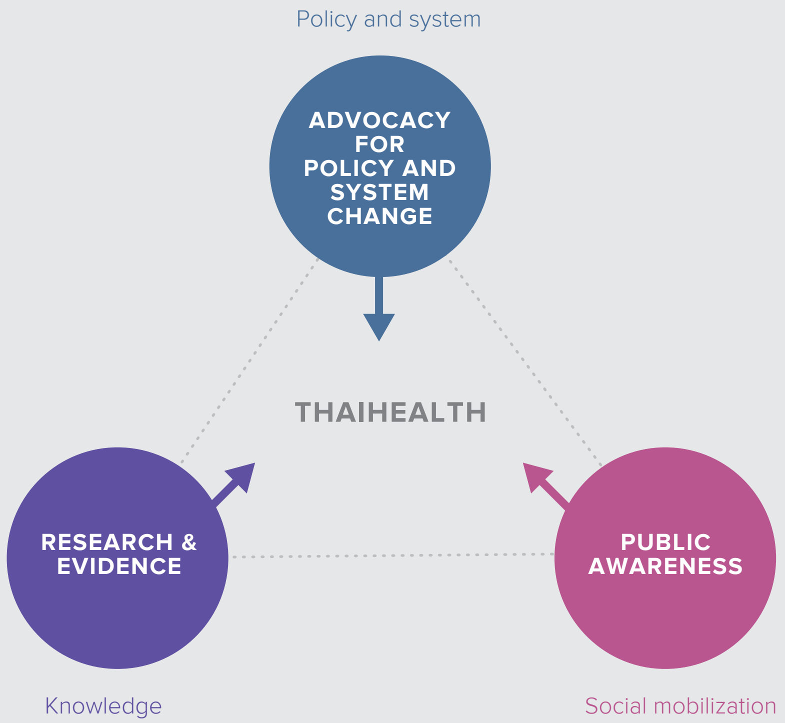
Universal health coverage for Thailand’s health security

Thailand has been recognized as a developing country that has been successful in implementing universal health coverage (UHC). In 2002, the National Health Security Act established the National Health Security Office (NHSO). Universal health coverage contributes to the health security of the Thai population, allowing access to necessary health services without catastrophic healthcare expenditures—particularly for poor people or vulnerable groups. In other words, the UHC provides public health security to the Thai people who do not have coverage from any health insurance scheme. As a result, more than 90% of the Thai population is presently covered by three public health insurance schemes—the Civil Servant Medical Benefit Scheme (CSMBS) for civil servants and their dependents, the Social Health Insurance Scheme (SHI) for private sector employees, and UHC for the rest of the population.

Achievement and challenges—Apart from improving health security for Thai people, the UHC also contributes to the quality of healthcare services because of the scale of the program. The purchaser, in particular the NHSO, can negotiate with the service providers on both price and quality of care. Strategic

FIGURE 17.1

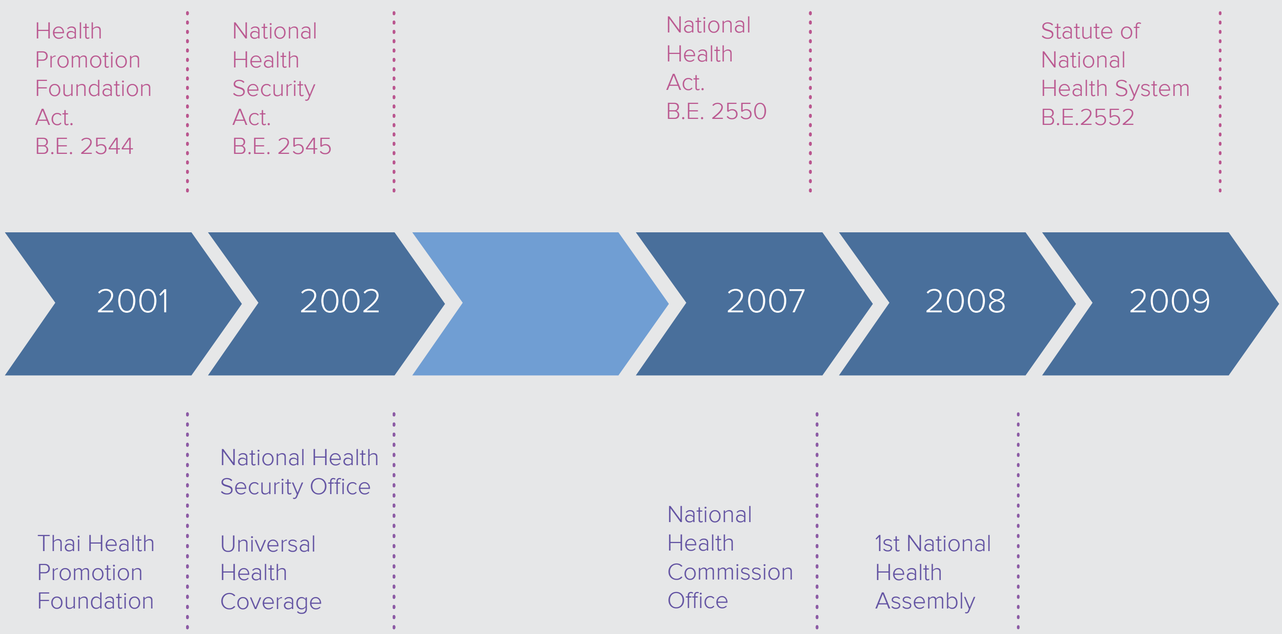
“Tri-Power Model” of ThaiHealth



Source: Adapted from Wasi, 2000 and Sopitarchasak et al., 2017.

FIGURE 17.2

Timeline of innovation in health policies



Source: Adapted from Rajan et al., 2017.

purchasing by NHSO resulted in improved and equitable access to certain high cost interventions, such as open-heart surgery, renal replacement therapy, and antiretroviral therapy. Improvement in the quality of hospital care is indicated by an increase in the number of hospitals that meet the standard requirements for hospital accreditation and a reduction in hospital standardized mortality ratio. However, there are a couple of future challenges for the UHC, for example, harmonizing the three public health insurance schemes and the equitable distribution of financial and human resources.[12] To overcome these challenges, policy recommendations have been suggested for future development. For example, on the issue of harmonizing the three public health insurance schemes, the government needs to streamline operations by standardizing common features—for example, the benefits package, the information system, and the payment method. At the same time, inequities in benefits and level of expenditure need to be reduced and inefficiencies across the schemes addressed.[13] Working towards achieving a more equitable distribution of human resources across the country must be planned and developed—and include capacity development in the health workforce.

Sectors driving public health policies in the National Health Assembly

The National Health Assembly (NHA) is a platform for public policy development. The platform encourages participation of public and key stakeholders throughout the process of health policy development—including agenda setting, resolution drafting, stakeholder and public consultation, resolution adoption, implementation, monitoring, and evaluation. It is a year-round policy process, not just a onetime event, to assure that public health policies will be developed sustainably.

In Thailand, there are three types of health assemblies: area-based health assemblies, issue-based health assemblies, and the National Health Assembly (NHA). The health assemblies emphasize participatory democracy and promote active multisectoral involvement in the formulation of public health policies. At the provincial and regional level, area-based health assemblies identify local health issues and concerns and raise them to the national level. Issue-based health assemblies convene on topics based on specific health issues and concerns. All concerns and comments from area-based health assemblies and issue-based health assemblies are collected and drafted into NHA resolutions. The NHA encourages the engagement of representatives from the government, academia, and local communities, in order to finalize and bring the resolution to actions.

Achievement and challenges—The NHA has an impact on public policymaking in Thailand. The consensus-based resolutions of the NHA are submitted to the National Health Commission and further to the Cabinet of Thailand. Presently, 81 resolutions from 11 assemblies have been implemented, including resolutions on NCDs, such as childhood obesity management; national strategies on antibacterial resistance; health promotion, such as illegal advertisement of drugs and health products; daily cycling; waste management; and housing. Moreover, six issues have been generated by the issue-based health assemblies: development of the national health information system, a bill on reproductive health protection, traditional medicine strategy, nanotechnology strategy for safety and ethics, health workforce educational reform, and a national strategic plan on health promotion at the end of life.[14]

With regard to the achievements above, there are a couple of challenges that need to be explored and addressed. Although the NHA is open for all sectors to participate, it is limited to active groups, rather than the whole society. In this sense, the question of whether the voices of participants—groups or networks—adequately reflect the real needs of the country has been raised. In addition, due to the nature of the resolutions implemented—which are voluntary rather than compulsory—it is difficult to evaluate the outcome and impact of the resolutions.

In conclusion, the reform of Thailand's health system has been significantly impacted by innovation in health policies. The most influential aspect of reform has been the public participation concept—where civil society organizations have been participating in health issues and learning about resolutions and initiatives implemented. The Health Promotion Foundation Act, enacted in 2001, led to establishing the Thai Health Promotion Foundation. This extended the concept of health beyond the physical to also include mental, social, and spiritual aspects of health. Additionally, innovation health financing has been introduced to build sustainable funding to support health promotion. In 2002, the National Health Security Act was legislated and universal health coverage (UHC) implemented, which contributed to health security and access to necessary services for the Thai population—particularly poor people and vulnerable groups. Moreover, one year after the National Health Act was legislated in 2007, formal "space" for the public to participate was introduced. The National Health Act conceived the National Health Commission Office (NHCO) with a mandate to convene the National Health Assembly, which is a health policy platform for the public—from the grass roots to civil society, academic institutions, departments, and ministries—to engage in the same place (Figure 17.2).[15]

Innovation in Thailand's medical industry

Thailand has given the medical industry top priority as one of the driving engines for economic development. A range of policies have been deployed to utilize the existing medical foundation to its highest potential, strengthen competitiveness of the industry, and improve the quality of life for Thai citizens. Innovation is considered as a means towards these goals. Support and incentives are provided to create opportunities for continual success in related fields, including medical technologies, digitalization in healthcare services, and investment incentives.

Medical technologies

The medical device sector in Thailand is considered a high-value industry. Despite unfavorable economic conditions, the sector gains advantages from a national medical hub policy that encourages foreigners to travel to Thailand for medical purposes. Since 2003, this medical hub policy has helped to support continuous growth in medical tourism. The number of foreign patients arriving in Thailand has soared to 2.5 million patients annually—and is continuing to grow.[16] Additionally, the Thai medical device industry has expanded continuously—both domestically and internationally. Although there are a wide variety of medical devices being manufactured domestically, concentration is on relatively low-end product categories, while a substantial number of high-end and sophisticated medical devices are being imported.[17] To upgrade the local production of medical devices, long-term and systematic development of local capabilities, knowledge, and innovation are required.

To accelerate the growth of the sector, the Thai government provides investment and support through research funding, public-private partnerships, and granting for prototype development. As a result, the technological progress in academic research creates tremendous opportunities for new investment in the medical device sector, such as medical diagnosis kits, medical robotics, and implanted medical devices. The following are examples of how the support could be used for leveraging the sector's transformation:[18]

- The Biomedical Technology Research Unit of the Faculty of Associated Medical Sciences, Chiang Mai Universities, developed a more convenient, less expensive, and highly accurate test kit for alpha thalassemia carrier screening. The device has been licensed to a private company for commercialization.

- The Thailand Center of Excellence for Life Sciences (TCELS) has established the Center for Advanced Medical Robotics, to broaden Thailand's research base through advanced medical robotics projects. With an extensive network of researchers, the sector is able to develop their own technological capabilities. Specialized medical robots have been prototyped and commercialized, including Dindow, an elderly care robot by CT Asia Robotics, Co., Ltd., and Sensible Tab, an arm rehabilitation robot by TMGO Co., Ltd.

- Chulalongkorn University and TCELS have completed the development of a unipolar modular hip prosthesis, which is more compatible with the anatomy of Asians, and they have secured funding to undergo standard testing in accordance with ISO 7206, ASTM 2009, ASTM 1875 and ISO 10993.

Digitalization in healthcare services

There are great challenges and opportunities for digital technologies in the healthcare system. On the one hand, digital technologies will improve equality and convenience of Thai people in getting healthcare services. On the other hand, adoption of digital technologies to the healthcare system, in particular at a national level, is very challenging for the country—for example, in terms of digital transformation and digital literacy. Moreover, access to medical records and data is important for enabling effective collaboration between patients and healthcare providers. With awareness of these challenges, the Ministry of Public Health (MoPH) deployed the eHealth Strategy in 2017 to serve as a mechanism for the development of the national health system. The strategy includes reform of digital technology operations, innovation in medical product manufacturing, and innovation in health services. However, this strategy is a long-term development plan that needs to be coordinated with Thailand's digital landscape and digital development plan.

The case of Bangkok Metropolitan Administration (BMA) highlights the impact of digitalization on healthcare service. BMA is using technology to enable the elderly to have more convenient access to healthcare. Similar to many other cities across the region, Bangkok is facing an increasing number of elderly people and a declining birth rate; among Bangkok's registered 10 million people, around 16% are over 60 years old. The growing elderly population is increasing the burden on the city's working population, as people must juggle full-time jobs with caring for their elderly relatives. In addition, Bangkok is a large and crowded city with traffic conditions that make hospital visits inconvenient.

One solution is to bring care to the homes of the elderly. The Home Ward Referral Center, a new BMA unit, has been set up in order to provide home care for the elderly, improve the utilization of digital technology in public hospitals, and improve the accessibility of healthcare services to patients with difficulties in mobilization. Utilization of technologies is at the center of this innovative healthcare service, as sharing patients' medical records and personal data could enhance the capability of the center to provide healthcare staff and healthcare volunteers to check on elderly and disabled patients. Additionally, the updated data from the visits can also be shared with public hospitals so that doctors and nurses can better coordinate care. This could improve the patient experience, as patients don't have to repeatedly provide the same information to doctors—whether at home visits or hospitals. The BMA has also launched a pilot to introduce electronic patient records in 10 public hospitals. This is a crucial platform that is required for the city's public health system to use more advanced technologies, like analytics and artificial intelligence, in the future.

Investment incentives

As government support of knowledge and innovation increases the potential growth of the sector, it seems that foreign direct investment in manufacturing facilities, global supply chain, and knowledge is required to strengthen linkages to the global market. To encourage foreign investment and business partnerships, the Board of Investment (BOI) offers various types of investment incentives, including import duty exemption, tax breaks, and land ownership rights to both foreign and Thai investors seeking to manufacture medical equipment in Thailand. On top of that, the manufacture of medical equipment receives the maximum 8-year corporate income tax exemption, regardless of location.[19]

Alongside investment incentives, several types of support are also provided by other government agencies to encourage collaboration in research and development (R&D) of new medical technologies, medical products, and services. Agencies include the:

- National Science and Technology Development Agency (NSTDA), a leading public research institute which provides channels of communication between Thai research institutions and the private sector;
- Thailand Science Park (TSP), a technology and innovation hub that includes R&D and innovation development for private sectors, providing services ranging from technology transfer to financial assistance and business incubation; and
- National Innovation Agency (NIA), a granting agency for innovation development, which supports up to 75% funding for prototype or pilot scale projects, and which also provides interest-free loans for up to 3 years to assist in the commercial operations of innovation projects.

In summary, Thailand's medical industry has responded to the economic development policy to strengthen the competitiveness of Thailand in this high-value sector. As the industry advances through knowledge and technologies, bridging the supply-side knowledge and the demand-side market becomes very important. Supports and incentives also need to be in place to facilitate the flow of technical knowledge from research institutes to innovative companies—and to encourage investments and partnerships. Digitalization is a crucial enabling tool for the effective collaboration between stakeholders and partners. Its deployment at the national level would significantly enhance the transformation of healthcare services at large. To elevate the medical industry, the government plays a crucial role in boosting knowledge creation and stimulating collaboration between supply-side and demand-side partners, through the provision of supports and incentives.

Conclusion and policy recommendations

With regard to the two different aspects of health and medical innovation in Thailand, which are health policies and the medical industry, it is noticeable that innovation has a crucial role in health and medical transformations of the country. The health and medical system serve the country—as a profound public service for society and a growth engine for the economy. Innovation, therefore, requires integration of broad and comprehensive viewpoints, especially from policymakers, civil society, industries, entrepreneurs, and technology providers. On the one hand, innovation at the policy level is necessary for preparing the country to deal with structural reforms and future changes. In essence, it shifts the paradigm of thought, which greatly affects society. On the other hand, the development of health- and medical-related industries could strengthen Thailand's competitiveness and bring opportunities for economic growth. The support of the government makes Thailand fertile ground for medical industry investment. Yet, technological and knowledge infrastructure—both medical and digital—require investment. The health and medical system is driven by knowledge-intensive activities and reliable services. Contextualization and inclusive engagement are imperative to the success of both upstream and downstream development.

Notes:

1 World Health Organization, 2018.

2 Tejativaddhana et al., 2018.

3 Tejativaddhana et al., 2018.

4 Thailand Board of Investment, 2019.

5 Wasi, 2000; Bureau of Policy and Strategy, 2011.

6 Wasi, 2000; Bureau of Policy and Strategy, 2011.

7 Adulyanon, 2012.

8 Wasi, 2000; Bureau of Policy and Strategy, 2011.

9 Damrongplasit and Melnick, 2009.

10 ThaiHealth.

11 Adulyanon, 2012.

12 Evans et al., 2012.

13 Evans et al., 2012.

14 Rajan et al., 2017.

15 Rajan et al., 2017.

16 Hanvoravongchai, 2013.

17 Tunpaiboon, 2018.

18 Thailand Board of Investment, 2019.

19 Thailand Board of Investment, 2019.

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APPENDICES

APPENDIX I

THE GLOBAL INNOVATION INDEX (GII) CONCEPTUAL FRAMEWORK

The rationale for the Global Innovation Index

The Global Innovation Index (GII) project was launched by Professor Dutta in 2007 during his tenure at INSEAD. The goal was to find and determine metrics and methods that could better capture the richness of innovation in society, going beyond the traditional measures of innovation such as the number of research articles and the level of research and development (R&D) expenditures.[1]

There were several motivations for setting this goal. First, innovation is important for driving economic progress and competitiveness—both for developed and developing economies. Many governments are putting innovation at the center of their growth strategies. Second, the definition of innovation has broadened—it is no longer restricted to R&D laboratories and to published scientific papers. Innovation could be and is more general and horizontal in nature, including social, business model, and technical innovation. Last, but foremost, recognizing and celebrating innovation in emerging markets is critical for inspiring people—especially the next generation of entrepreneurs and innovators.

Now in its 12th edition, the GII helps to create an environment in which innovation factors are under continual evaluation. It provides a key tool for decision-makers and a rich database of detailed metrics for refining innovation policies.

The GII is not meant to be the ultimate and definitive ranking of economies with respect to innovation. Measuring innovation outputs and its impact remains difficult, hence great emphasis is placed on measuring the climate and infrastructure for innovation and on assessing related outcomes.

Although the end results take the shape of several rankings, the GII is more concerned with improving the "journey" to better measurement, understanding innovation, and in identifying targeted policies, good practices, and other levers that foster innovation. The rich data metrics, at index, sub-index, or indicator level, can be used to monitor performance over time and to benchmark developments against economies within the same region or income group classification.

Drawing on the expertise of the GII's Knowledge Partners and its prominent Advisory Board, the GII model is continually updated to reflect the improved availability of statistics and our understanding of innovation. This year the model continues to evolve, although its mature state now requires only minor updates (Appendix IV).

An inclusive perspective on innovation

The GII adopts a broad notion of innovation, originally elaborated in the *Oslo Manual* developed by the European Communities and the Organisation for Economic Co-operation and Development (OECD). In its fourth edition, the Oslo Manual 2018 introduces a more general definition of innovation:[2]

An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).

This update of the *Oslo Manual* also introduces a series of definitions associated with innovation in business activities and for different types of innovation firms.[3] In this context, innovation translates as improvements made to outcomes in the form of either new goods or services or any combination of these. While the GII focuses on a more general definition of innovation, it is important to highlight how these definitions capture the evolution of the way innovation has been perceived and understood over the last two decades.[4]

Economists and policymakers previously focused on R&D-based technological product innovation, largely produced in-house and mostly in manufacturing industries. Innovation of this nature was executed by a highly educated labor force in R&D-intensive companies. The process leading to such innovation was conceptualized as closed, internal, and localized. Technological breakthroughs were necessarily "radical" and took place at the "global knowledge frontier". This characterization implied the existence of leading and lagging economies, with low- or middle-income economies only playing "catch up".

Today innovation capability is increasingly seen as the ability to exploit new technological combinations; it embraces the notion of incremental innovation and "innovation without research". Non-R&D innovative expenditure is an important component of reaping the rewards of technological innovation. Interest in understanding how innovation evolves in low- and middle-income economies is increasing, along with an awareness that incremental forms of innovation can impact development. Furthermore, the process of innovation itself has changed significantly. Investment in innovation-related activity has consistently intensified at the firm, economy, and global levels, adding both new innovation actors from outside high-income economies and non-profit actors. The structure of knowledge production activity is more complex and geographically dispersed than ever.

A key challenge is to find metrics that capture innovation as it actually happens in the world today.[5] Direct official measures that quantify innovation outputs remain extremely scarce.[6] For example, there are no official statistics on the amount of innovative activity—defined as the number of new products, processes, or other innovations—for any given innovation actor, let alone for any given country (GII 2013, Chapter 1, Annex 1, Box 1). Most measurements also struggle to appropriately capture the innovation outputs of a wider spectrum of innovation actors, such as the services sector or public entities. This includes innovation surveys, which have contributed greatly to the measurement of innovation activities, but that fail to provide a good and reliable sense of cross-economy innovation output performance, and that are often not applicable to developing economies where innovation is often informal.[7]

The GII aims to move beyond the mere measurement of such simple innovation metrics. To do so will require the integration of new variables, with a trade-off between the quality of the variable on the one hand and achieving good economy coverage on the other. A key priority is to improve the measurement of innovation in the field of knowledge-intensive services, user and public sector innovation, including policy support to innovative entrepreneurship and venture capital, innovation linkages (in particular international ones) and innovation outputs and impacts more generally.[8]

The timeliest possible indicators are used for the GII: 37.3% of data obtained are from 2018, 33.3% are from 2017, 9.3% are from 2016, 4.8% from 2015, and the small remainder of 5.3% from earlier years.[9]

The GII conceptual framework

The GII is an evolving project that builds on its previous editions, while incorporating newly available data, and is inspired by the latest research on the measurement of innovation. This year the GII model includes 129 countries/economies, which represent 91.8% of the world's population and 96.8% of the world's GDP in purchasing power parity current international dollars. The GII relies on two sub-indices—the Innovation Input Sub-Index and the Innovation Output Sub-Index—each built around pillars. Three measures are calculated (Figure A-I.1):[10]

Innovation Input Sub-Index: Five input pillars capture elements of the national economy that enable innovative activities.

Innovation Output Sub-Index: Innovation outputs are the result of innovative activities within the economy. Although the Output Sub-Index includes only two pillars, it has the same weight in calculating the overall GII scores as the Input Sub-Index.

The overall GII score is the average of the Input and Output Sub-Indices.

Each pillar is divided into three sub-pillars, each of which is composed of individual indicators, a total of 80 this year (Figure A-I.1). The GII pays special attention to presenting a scoreboard for each economy that includes strengths and weaknesses and makes the data series accessible (Appendix II); providing data sources and definitions (Appendix III); and providing detailed technical notes and adjustments to the GII framework, including a detailed analysis of the factors influencing year-on-year changes (Appendix IV). In addition, since 2011 the GII has undergone an independent statistical audit performed by the Joint Research Centre of the European Union (Appendix V).

The Innovation Input Sub-Index

The first sub-index of the GII, the Innovation Input Sub-Index, has five enabler pillars: Institutions, Human capital and research, Infrastructure, Market sophistication, and Business sophistication. Enabler pillars define aspects of the environment conducive to innovation within an economy.

Pillar 1: Institutions

Nurturing an institutional framework that attracts business and fosters growth by providing good governance and the correct levels of protection and incentives is essential to innovation. The Institutions pillar captures the institutional framework of an economy.

The Political environment sub-pillar includes two indices: the first is the political, legal, operational or security risk index that replaces the political stability and safety indicator, reflecting more on the likelihood and severity of political, legal, operational or security risks impacting business operations; the second reflects the quality of public and civil services, policy formulation, and implementation.

The Regulatory environment sub-pillar draws on two indices aimed at capturing perceptions on the ability of the government to formulate and implement cohesive policies that promote the development of the private sector and at evaluating the extent to which the rule of law prevails (in aspects such as contract enforcement, property rights, the police, and the courts). The third indicator evaluates the cost of redundancy dismissal as the sum, in salary weeks, of the cost of advance notice requirements added to severance payments due when terminating a redundant worker.

FIGURE A-I.1

Framework of the Global Innovation Index 2019

Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2019.

The Business environment sub-pillar expands on two aspects that directly affect private entrepreneurial endeavors by using the World Bank indices on the ease of starting a business and the ease of resolving insolvency (based on the recovery rate recorded as the cents on the dollar recouped by creditors through reorganization, liquidation, or debt enforcement/foreclosure proceedings).

Pillar 2: Human capital and research

The level and standard of education and research activity in an economy are prime determinants of the innovation capacity of a nation. This pillar tries to gauge the human capital of economies.

The first sub-pillar includes a mix of indicators aimed at capturing achievements at the elementary and secondary education levels. Education expenditure and school life expectancy are good proxies for coverage. Government funding per pupil, secondary, gives a sense of the level of priority given to secondary education by the state (excluding funding from abroad). The quality of education is measured through the results to the OECD Programme for International Student Assessment (PISA), which examines 15-year-old students' performances in reading, mathematics, and science, as well as the pupil-teacher ratio.

Higher education is crucial for economies to move up the value chain beyond simple production processes and products. The sub-pillar on tertiary education aims at capturing coverage (tertiary enrolment); priority is given to the sectors traditionally associated with innovation (with a series on the percentage of tertiary graduates in science, engineering, manufacturing, and construction); and the inbound and mobility of tertiary students, which plays a crucial role in the exchange of ideas and skills necessary for innovation.

The last sub-pillar, on R&D, measures the level and quality of R&D activities, with indicators on researchers (full-time equivalence), gross expenditure, the R&D expenditures of top global R&D spenders, and the quality of scientific and research institutions as measured by the average score of the top three universities in the QS World University Ranking of 2018. The R&D expenditures of the top three firms in a given economy looks at the average expenditure of these three firms that are part of the top 2,500 R&D spenders worldwide. The QS university rankings indicator gives the average scores of the economy's top three universities that belong to the top 700 universities worldwide. These indicators are not aimed at assessing the average level of all institutions within an economy.

Pillar 3: Infrastructure

The third pillar includes three sub-pillars: Information and communication technologies (ICTs), General infrastructure, and Ecological sustainability.

Good and ecologically friendly communication, transport, and energy infrastructures facilitate the production and exchange of ideas, services, and goods and feed into the innovation system through increased productivity and efficiency, lower transaction costs, better access to markets, and sustainable growth.

The ICTs sub-pillar includes four indices, each on ICT access, use, online service by governments, and online participation of citizens.

The sub-pillar on general infrastructure includes the average of electricity output in kWh per capita; a composite indicator on logistics performance; and gross capital formation, which consists of outlays on additions to the fixed assets and net inventories of the economy, including land improvements (fences, ditches, drains); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.

The sub-pillar on ecological sustainability includes three indicators GDP per unit of energy use (a measure of efficiency in the use of energy), the Environmental Performance Index of Yale and Columbia Universities, and the number of certificates of conformity with standard ISO 14001 on environmental management systems issued.

Pillar 4: Market sophistication

The availability of credit and an environment that supports investment, access to the international market, competition, and market scale are all critical for businesses to prosper and for innovation to occur. The Market sophistication pillar has three sub-pillars structured around market conditions and the total level of transactions.

The Credit sub-pillar includes a measure on the ease of getting credit aimed at measuring the degree to which collateral and bankruptcy laws facilitate lending by protecting the rights of borrowers and lenders, as well as the rules and practices affecting the coverage, scope, and accessibility of credit information. Transactions are given by the total value of domestic credit and, to make the model more applicable to emerging markets, by the gross loan portfolio of microfinance institutions.

The Investment sub-pillar includes the ease of protecting minority investors index as well as two indicators on the level of transactions. The Investment sub-pillar includes the ease of protecting minority investors index as well as two indicators on the level of transactions. These two indicators look at whether market size is matched by market dynamism and provide a hard data metric on venture capital deals.

The last sub-pillar tackles trade, competition, and market scale. The market conditions for trade are given in the first indicator measuring the average tariff rate weighted by import shares. The second indicator is a survey question that reflects the intensity of competition in local markets. Efforts made at finding hard data on competition remain unsuccessful so far. Domestic market scale, as measured by an economy's GDP, was incorporated in 2016, so the last sub-pillar takes into consideration the impact that the size of an economy has on its capacity to introduce and test innovations in the marketplace.

Pillar 5: Business sophistication

The last enabler pillar tries to capture the level of business sophistication to assess how conducive firms are to innovation activity. The Human capital and research pillar (pillar 2) made the case that the accumulation of human capital through education, particularly higher education and the prioritization of R&D activities, is an indispensable condition for innovation to occur. That logic is taken one step further here with the assertion that businesses foster their productivity, competitiveness, and innovation potential with the employment of highly qualified professionals and technicians.

The first sub-pillar includes four quantitative indicators on knowledge workers: employment in knowledge-intensive services; the availability of formal training at the firm level; R&D performed by business enterprise (GERD) as a percentage of GDP (i.e., GERD over GDP); and the percentage of total gross expenditure of R&D that is financed by business enterprise. In addition, the sub-pillar includes an indicator related to the percentage of females employed with advanced degrees. This indicator, in addition to providing a glimpse into the gender labor distributions of nations, offers more information about the degree of sophistication of the local human capital currently employed.

Innovation linkages and public/private/academic partnerships are essential to innovation. In emerging markets, pockets of wealth have developed around industrial or technological clusters and networks, in sharp contrast to the poverty that may prevail in the rest of the territory. The Innovation linkages sub-pillar draws on both qualitative and quantitative data regarding business/university collaboration on R&D, the prevalence of well-developed and deep clusters, the level of gross R&D expenditure financed by abroad, and the number of deals on joint ventures and strategic alliances. In addition, the total number of Patent Cooperation Treaty (PCT) and national office published patent family applications filed by residents in at least two offices proxies for international linkages. The GII team has been evaluating various hard data-based indicators to measure innovation linkages in an economy. Measuring innovation linkages adequately remains challenging, if not to say, impossible based on existing innovation metrics.

In broad terms, pillar 4 on Market sophistication makes the case that well-functioning markets contribute to the innovation environment through competitive pressure, efficiency gains, and economies of transaction and by allowing supply to meet demand. Markets that are open to foreign trade and investment have the additional effect of exposing domestic firms to best practices around the globe, which is critical to innovation through knowledge absorption and diffusion, which are considered in pillars 5 and 6. The rationale behind sub-pillars 5.3 on Knowledge absorption (an enabler) and 6.3 on Knowledge diffusion (a result)—two sub-pillars designed to mirror each other as much as possible—is precisely that together they will reveal how good economies are at absorbing and diffusing knowledge.

Sub-pillar 5.3 includes five metrics that are linked to sectors with high-tech content or are key to innovation: intellectual property payments as a percentage of total trade (three-year average); high-tech imports as a percentage of total imports; imports of communication, computer and information services as a percentage of total trade; and net inflows of foreign direct investment (FDI) as a percentage of GDP (three-year average). To strengthen the sub-pillar, the percentage of research talent in business was added in 2016 to provide a measurement of professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, including business management.

The Innovation Output Sub-Index

Innovation outputs are the results of innovative activities within an economy. Although the Output Sub-Index includes only two pillars, it has the same weight in calculating the overall GII scores as the Input Sub-Index. There are two output pillars: Knowledge and technology outputs and Creative outputs.

Pillar 6: Knowledge and technology outputs

This pillar covers all those variables that are traditionally thought to be the fruits of inventions and/or innovations. The first sub-pillar refers to the creation of knowledge. It includes five indicators that are the result of inventive and innovative activities: patent applications filed by residents both at the national patent office and at the international level through the PCT; utility model applications filed by residents at the national office; scientific and technical published articles in peer-reviewed journals; and an economy's number of articles (H) that have received at least H citations.

The second sub-pillar, on Knowledge impact, includes statistics representing the impact of innovation activities at the micro- and macro-economic level or related proxies: increases in labor productivity (three-year average), the entry density of new firms, spending on computer software, the number of certificates of conformity with standard ISO 9001 on quality management systems issued, and the measure of high- and medium-high-tech industrial output over total manufactures output.

The third sub-pillar, on Knowledge diffusion, mirrors the Knowledge absorption sub-pillar of pillar 5, except for indicators 5.3.2 (no longer net imports) and 5.3.5 (on research talent). It includes four statistics all linked to sectors with high-tech content or that are key to innovation: intellectual property receipts as a percentage of total trade (three-year average); high-tech net exports as a percentage of total exports; exports of ICT services as a percentage of total trade; and net outflows of FDI as a percentage of GDP (three-year average).

Pillar 7: Creative outputs

The role of creativity for innovation is still largely underappreciated in innovation measurement and policy debates. Since its inception, the GII has always emphasized measuring creativity as part of its Innovation Output Sub-Index. The last pillar, on Creative outputs, has three sub-pillars.

The first sub-pillar on intangible assets includes statistics on trademark applications by residents at the national office; industrial designs included in applications at a regional or national office; and two survey questions regarding the use of ICTs in business and organizational models—new areas that are increasingly linked to process innovations in the literature.

The second sub-pillar on Creative goods and services includes proxies to get at creativity and the creative outputs of an economy. In 2014, to include broader sectoral coverage, a global entertainment and media output composite was added. In addition, that same year, the indicator on audio-visual and related services exports was renamed Cultural and creative services exports, and expanded to include information services, advertising, market research and public opinion polling, and other, personal, cultural and recreational services (as a percentage of total trade). These two indicators complement the remainder of the sub-pillar, which measures national feature films produced in a given economy (per capita count), printing and other media output (as a percentage of total manufactures output), and creative goods exports (as a percentage of total trade), all of which are aimed at providing an overall sense of the international reach of creative activities in an economy.

The third sub-pillar on Online creativity includes four indicators: generic and economy/country-code top level domains, average yearly edits to Wikipedia, all scaled by population aged 15 through 69 years old and mobile app creation, which is scaled by GDP (bn PPP US$). The indicator on mobile app creation was improved this year to capture more precisely the downloads of apps by origin of the headquarters of the developer/firm. This improvement aims to offer more insight into how innovation, production and trade of digitized creative products and services are evolving in an innovation-based economy.

Notes:

1 For a detailed introduction to the Global Innovation Index, see the GII 2011.

2 Eurostat and OECD, 2018.

3 The manual uses the term “innovation activities” to refer to processes while the term “innovation” is limited to outcomes. Business innovation is defined as a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm. Business processes include all core activities by the firm to produce products as well as all auxiliary or supporting activities. A product innovation is a new or improved good or service that differs significantly from the firm’s previous goods or services and that has been introduced on the market. A business process innovation is a new or improved business process for one or more business functions that differs significantly from the firm’s previous business processes and that has been brought into use in the firm.

The innovation status of a firm is defined based on its engagement in innovation activities and its introduction of one or more innovations over the observation period of a data collection exercise. There are three categories of innovative and innovation-active firms: innovative, non-innovative, and innovation-active firms.

4 OECD, 2010; INSEAD, 2011; and WIPO, 2011.

5 INSEAD, 2011; OECD Scoreboard, 2013; WIPO, 2011

6 INSEAD, 2011; OECD, 2011; WIPO, 2011.

7 Elahi et al, 2013.

8 See OECD Blue Sky Forum on Science and Innovation Indicators. http://www.oecd.org/innovation/blue-sky.htm

9 For completeness, 1.6% of data points are from 2014, 1.4% from 2013, 0.4% from 2012, 0.6% from 2011, 0.7% from 2010, 0.3% from 2009 and 2008, and a few exceptions from 2007 (0.01%), 2006 (0.03%), 2003 (0.01%), and 2002 (0.01%). In addition, the GII is calculated based on 9,300 data points (compared to 10,320 with complete series), implying that 9.9% of data points are missing. The Data Tables (Appendix II) include the reference year for each data point and mark missing data as not available (n/a).

10 This year the GII introduces an alternative to study of the connection between innovation inputs and outputs replacing the Efficiency Ratio (see Chapter 1, Figure 1.8 and relevant segment).

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ECONOMY PROFILES & DATA TABLES

Economy profiles

The following tables provide detailed profiles for each of the 129 economies in the Global Innovation Index 2019. They are constructed around three sections.

1 The top section provides the overall Global Innovation Index (GII) rank for each economy.

2 The next section provides eight key metrics to put the economy into context. They present the Innovation Output Sub-Index rank, Innovation Input Sub-Index rank, the income group to which the economy belongs, its geographical region,[1] population in millions,[2] GDP in billion PPP US$, and GDP per capita in PPP US$.[3] The last metric provides the GII 2018 rank for the economy.

Because of economies dropping or entering the GII, and because of adjustments made to the GII framework and other technical factors not directly related to actual performance (missing data, updates of data, etc.), the GII rankings are not directly comparable from one year to the next. Please refer to Appendix IV for details.

All scores at the sub-index, pillar, sub-pillar, and indicator level are normalized in the 0 to 100 range. The Innovation Input Sub-Index score is the average of the scores in the first five pillars, while the Innovation Output Sub-Index is the average of the scores in the last two pillars. Each sub-index rank is computed based on these scores for each economy.

3 Pillars are identified by an icon, sub-pillars by two-digit numbers, and indicators by three-digit numbers. For example, indicator: *1.3.1 Ease of starting a business* appears under sub-pillar: *1.3, Business environment*, which in turn appears under pillar: *1 Institutions.* Throughout the report the pillars are identified by their respective icons or names, and the sub-pillars and indicators by their respective numbers.

The 2019 GII includes 80 indicators and three types of data. Composite (or index) indicators are identified with an asterisk (*), survey questions from the World Economic Forum's Executive Opinion Survey are identified with a dagger (†), and the remaining indicators are all hard data series.

For hard data, the original value is provided (except for indicators in sub-pillar 7.3, for which the raw data were provided under the condition that only the normalized scores be published). Normalized scores in the 0 to 100 range are provided for everything else (index and survey data, sub-pillars, pillars, and indices).

When data are either not available or out of date, 'n/a' is used. (see Appendix IV for more details). The year used for each data point is indicated in the Data Table (Appendix II). To the right of the indicator title, a clock symbol indicates that the economy's data for that indicator are older than the base year. (Appendix II)

For further details, see Appendix III, Sources and Definitions, and Appendix IV, Adjustments to the Global Innovation Index Framework, Year-on-Year Comparability of Results, and Technical Notes.

4 To the far right of each column, strengths of the economy in question are indicated by a solid circle (●), weaknesses by a hollow circle (○). Strengths within the economy's income group are indicated with a solid diamond (◆), weaknesses by a hollow diamond (◇). The only exceptions to the income group strengths and weaknesses are the top 25 high-income economies, where these strengths and weaknesses are computed within the top 25 group.[4]

All ranks of 1, 2, and 3 are highlighted as strengths, except in particular instances at the sub-pillar level where strengths and weaknesses are not signaled when the desired minimum indicator coverage (DMC) is not met for that sub-pillar.[5] For the remaining indicators, strengths and weaknesses of a particular economy are based on the percentage of economies with scores that fall below its score (i.e., percent ranks).

- For a given economy, strengths (●) are those scores with percent ranks greater than the 10th largest percent rank among the 80 indicators in that economy.
- For that economy, weaknesses (○) are those scores with percent ranks lower than the 10th smallest percent rank among the 80 indicators in that economy.
- Similarly, for a given economy, income group strengths (◆) are those scores that are above the income group average plus the standard deviation within the group.
- For an economy, weaknesses (◇) are those scores that are below the income group average minus the standard deviation within the group.

In addition, economies with a sub-pillar that does not meet the DMC will show the score for that sub-pillar within brackets. Those that have more than one sub-pillar that fails to meet the DMC in the same pillar will also show the ranks of the pillar where these are located within brackets. For these pillars and sub-pillars, strengths/weaknesses are not signaled.

Percent ranks embed more information than ranks and allow for comparisons of ranks of series with missing data and ties in ranks. Examples from the Russian Federation and Zambia illustrate this point:

1. Strengths for Russia are all indicators with percent ranks equal to or above 0.83 (10th largest percent rank for Russia); weaknesses are all indicators with percent ranks equal to or below 0.27 (Russia's 10th smallest percent rank).
2. Russia ranks 22nd out of 129 economies in 6.1.5, Citable documents H-Index, with a percent rank of 0.84; this indicator is a strength for Russia.
3. Russia ranks 29th in 1.3.1, Ease of starting a business, but with a percent rank of 0.78, this indicator is not a strength for Russia.
4. The rank of 77 (percent rank of 0.01) in 4.2.3, Venture capital deals loans, is a weakness for Russia. By contrast, the similar rank of 78 for Zambia in 1.3.1, Ease of starting a business is a strength for Zambia (with a percent rank of 0.40, this is above the cut-off for strengths for Zambia, which is 0.37).

Percent ranks are not reported in the Economy Profiles but they are presented in the Data Tables (Appendix II).

Data tables

This appendix provides a description of the tables for each of the 80 indicators that make up the Global Innovation Index 2019. These can be found online at https://globalinnovationindex.org.

Structure

Each table is identified by indicator number, with the first digit representing the pillar, the second representing the sub-pillar, and the final digit representing the indicator within that particular sub-pillar. For example, the table for indicator shows results for indicator 5.1.4, GERD financed by business enterprise, which is the fourth indicator of sub-pillar 5.1, Knowledge workers, within pillar 5, Business sophistication.

The sub-heading text provides a detailed description of each indicator and includes information on the units of each variable, the scaling factor (if any), the question asked (for survey questions), and the most frequent year for which data were available

For each indicator for each economy, the most recent value within the period 2009 to 2018 was used (with a few exceptions, which are further explained in Appendix III). In instances where this base year does not correspond to the most frequent year reported in the sub-heading, the year of the value appears in parentheses after the economy name. These instances are noted in the Economy Profiles after the indicator name with a clock symbol.

A total of 57 variables are hard data. A total of 18 variables are composite indicators and 5 are survey questions from the World Economic Forum's Executive Opinion Survey.

The source of each indicator is indicated at the bottom of the page; details for each can be found in Appendix III: Sources and Definitions.

Explanation of scores

The tables list the economies by their rank order, with the best performers at the top. After the rank comes the economy name, the original value of the specific indicator for that economy (in the units specified in the sub-heading), the normalized score in the 0 to 100 range, and the percentage of economies with scores that fall below the normalized score (i.e., percent ranks). To the far right of each column, a solid circle indicates that an indicator is a strength for the economy in question, and a hollow circle indicates that it is a weakness.

- Strengths (●) are all ranks of 1, 2, and 3, as well as all scores with percent ranks greater than the 10th highest percent rank among the 81 indicators in a specific economy.

- Weaknesses (○) are all scores with percent ranks lower than the 10th smallest percent rank among the 80 indicators in a specific economy.

For four hard data series (7.3.1, 7.3.2, 7.3.3, and 7.3.4), the raw data were provided under the condition that only the normalized scores be published and therefore the original value equals the normalized score. For indicators 1.3.1, 1.3.2, 2.3.4, 3.3.2, 4.1.1, and 4.2.1, the range for both measures is the same, 0 to 100, and therefore both measures are also identical.

Details on the computation methodology can be found in Appendix IV.

Notes:

1 Countries/economies are classified according to the World Bank Income Group (July 2018; see https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups) and special classification based on the online version of the United Nations publication *Standard Country or Area Codes for Statistical Use*, originally published as Series M, No. 49, and now commonly referred to as the M49 standard (April 2018; see https://unstats.un.org/unsd/methodology/m49/). These are: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

2 Data are from the United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2017 Revision*.

3 Data for GDP and GDP per capita are from the International Monetary Fund World Economic Outlook 2018 database.

4 As the only non-high-income economy in the top 25, China's income group strengths and weaknesses are computed within the non-top 25 group.

5 Data stringency requirements are used in the attribution of strengths and weaknesses at the sub-pillar level. These levels were revised in 2019. When economies do not meet a data minimum coverage (DMC) requirement at the sub-pillar level (for sub-pillars with two indicators, the DMC is 2; for three it is 2; for four it is 3; and for five it is 4), they are not attributed a strength or weakness at the sub-pillar either. Furthermore, if the economy in question does not meet the DMC requirements at the sub-pillar level, but it still obtains a ranking higher than or equal to 10 or a ranking equal to or lower than 100 at the sub-pillar level, for caution this rank is put in brackets. This procedure is to ensure that incomplete data coverage does not lead to erroneous conclusions about strengths or weaknesses, or particularly about strong or weak sub-pillar rankings.

Index of economy profiles

ALBANIA

GII 2019 rank

83

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
93	70	Upper middle	EUR	2.9	38.3	13,344.5	83

		Score/Value	Rank	
	INSTITUTIONS	**65.8**	**56**	
1.1	**Political environment**	**56.8**	**63**	
1.1.1	Political and operational stability*	73.7	50	
1.1.2	Government effectiveness*	48.4	66	
1.2	**Regulatory environment**	**61.1**	**79**	
1.2.1	Regulatory quality*	47.9	60	
1.2.2	Rule of law*	35.7	85	
1.2.3	Cost of redundancy dismissal, salary weeks	20.8	88	
1.3	**Business environment**	**79.5**	**35**	● ◆
1.3.1	Ease of starting a business*	91.6	44	
1.3.2	Ease of resolving insolvency*	67.4	36	●
	HUMAN CAPITAL & RESEARCH	**22.7**	**88**	
2.1	**Education**	**40.1**	**85**	
2.1.1	Expenditure on education, % GDP	4.0	80	
2.1.2	Government funding/pupil, secondary, % GDP/cap	9.8	98	○ ◇
2.1.3	School life expectancy, years	15.2	48	
2.1.4	PISA scales in reading, maths, & science	415.2	57	
2.1.5	Pupil-teacher ratio, secondary	11.6	45	
2.2	**Tertiary education**	**26.7**	**76**	
2.2.1	Tertiary enrolment, % gross	57.0	51	
2.2.2	Graduates in science & engineering, %	19.2	69	
2.2.3	Tertiary inbound mobility, %	1.5	81	
2.3	**Research & development (R&D)**	**1.2**	**103**	
2.3.1	Researchers, FTE/mn pop. ◷	156.1	82	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.2	94	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**46.2**	**66**	
3.1	**Information & communication technologies(ICTs)**	**63.8**	**72**	
3.1.1	ICT access*	53.1	82	
3.1.2	ICT use*	52.8	69	
3.1.3	Government's online service*	73.6	57	
3.1.4	E-participation*	75.8	59	
3.2	**General infrastructure**	**26.6**	**94**	
3.2.1	Electricity output, kWh/mn pop.	2,702.1	67	
3.2.2	Logistics performance*	27.9	85	
3.2.3	Gross capital formation, % GDP	21.7	78	
3.3	**Ecological sustainability**	**48.2**	**38**	● ◆
3.3.1	GDP/unit of energy use	14.1	16	● ◆
3.3.2	Environmental performance*	65.5	36	● ◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.9	48	
	MARKET SOPHISTICATION	**53.4**	**42**	●
4.1	**Credit**	**30.9**	**89**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	35.0	88	
4.1.3	Microfinance gross loans, % GDP ◷	0.5	31	
4.2	**Investment**	**71.7**	**[8]**	
4.2.1	Ease of protecting minority investors*	71.7	24	●
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**57.6**	**77**	
4.3.1	Applied tariff rate, weighted avg., %	0.9	7	●
4.3.2	Intensity of local competition†	67.4	72	
4.3.3	Domestic market scale, bn PPP$	38.3	107	◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**24.0**	**105**	
5.1	**Knowledge workers**	**24.5**	**97**	
5.1.1	Knowledge-intensive employment, %	17.4	85	
5.1.2	Firms offering formal training, % firms	23.8	66	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, % ◷	3.3	85	◇
5.1.5	Females employed w/advanced degrees, %	9.9	66	
5.2	**Innovation linkages**	**17.9**	**108**	
5.2.1	University/industry research collaboration†	38.8	73	
5.2.2	State of cluster development†	34.3	112	◇
5.2.3	GERD financed by abroad, % ◷	7.4	53	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	68	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**29.5**	**85**	
5.3.1	Intellectual property payments, % total trade	0.5	66	
5.3.2	High-tech imports, % total trade	1.5	128	○ ◇
5.3.3	ICT services imports, % total trade	1.5	42	●
5.3.4	FDI net inflows, % GDP	8.4	16	● ◆
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**12.2**	**114**	
6.1	**Knowledge creation**	**2.2**	**121**	○
6.1.1	Patents by origin/bn PPP$ GDP	0.6	75	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	0.0	62	○
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.2	98	
6.1.5	Citable documents H-index	1.5	122	○
6.2	**Knowledge impact**	**23.3**	**109**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-1.6	104	◇
6.2.2	New businesses/th pop. 15-64	1.4	62	
6.2.3	Computer software spending, % GDP	0.1	88	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.8	39	●
6.2.5	High- & medium-high-tech manufactures, %	0.0	99	○ ◇
6.3	**Knowledge diffusion**	**10.9**	**99**	
6.3.1	Intellectual property receipts, % total trade	0.1	53	
6.3.2	High-tech net exports, % total trade	0.0	125	○
6.3.3	ICT services exports, % total trade	2.0	56	
6.3.4	FDI net outflows, % GDP	0.0	116	
	CREATIVE OUTPUTS	**24.4**	**74**	
7.1	**Intangible assets**	**30.1**	**107**	
7.1.1	Trademarks by origin/bn PPP$ GDP	34.2	71	
7.1.2	Industrial designs by origin/bn PPP$ GDP ◷	0.4	87	
7.1.3	ICTs & business model creation†	51.3	100	
7.1.4	ICTs & organizational model creation†	39.5	113	◇
7.2	**Creative goods & services**	**30.7**	**29**	● ◆
7.2.1	Cultural & creative services exports, % total trade	1.2	22	●
7.2.2	National feature films/mn pop. 15-69 ◷	3.3	54	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	3.4	5	● ◆
7.2.5	Creative goods exports, % total trade ◷	0.2	89	
7.3	**Online creativity**	**6.6**	**59**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	6.6	48	
7.3.2	Country-code TLDs/th pop. 15-69	2.4	63	
7.3.3	Wikipedia edits/mn pop. 15-69 ◷	16.0	57	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ALGERIA

GII 2019 rank

113

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
118	100	Upper middle	NAWA	42.0	660.8	15,439.9	110

		Score/Value	Rank	
	INSTITUTIONS	**51.1**	**106**	◇
1.1	**Political environment**	**38.3**	**111**	◇
1.1.1	Political and operational stability*	50.9	121	◇
1.1.2	Government effectiveness*	32.1	103	◇
1.2	**Regulatory environment**	**51.2**	**109**	◇
1.2.1	Regulatory quality*	9.8	126	○ ◇
1.2.2	Rule of law*	23.5	116	◇
1.2.3	Cost of redundancy dismissal, salary weeks	17.3	71	
1.3	**Business environment**	**63.7**	**88**	
1.3.1	Ease of starting a business*	78.1	112	
1.3.2	Ease of resolving insolvency*	49.2	68	
	HUMAN CAPITAL & RESEARCH	**27.9**	**74**	
2.1	**Education**	**37.7**	**[90]**	
2.1.1	Expenditure on education, % GDP ⊙	4.3	69	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years ⊙	14.3	65	
2.1.4	PISA scales in reading, maths, & science	361.7	69	○
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**40.6**	**36**	●
2.2.1	Tertiary enrolment, % gross	47.7	62	●
2.2.2	Graduates in science & engineering, %	31.1	9	● ◆
2.2.3	Tertiary inbound mobility, %	0.6	94	
2.3	**Research & development (R&D)**	**5.3**	**78**	
2.3.1	Researchers, FTE/mn pop.	820.8	54	●
2.3.2	Gross expenditure on R&D, % GDP	0.5	58	●
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**42.1**	**81**	
3.1	**Information & communication technologies(ICTs)**	**35.3**	**115**	◇
3.1.1	ICT access*	53.1	83	
3.1.2	ICT use*	46.3	75	
3.1.3	Government's online service*	21.5	125	○ ◇
3.1.4	E-participation*	20.2	123	◇
3.2	**General infrastructure**	**54.8**	**10**	● ◆
3.2.1	Electricity output, kWh/mn pop.	1,748.3	82	
3.2.2	Logistics performance*	18.0	107	◇
3.2.3	Gross capital formation, % GDP	50.6	2	● ◆
3.3	**Ecological sustainability**	**36.1**	**74**	
3.3.1	GDP/unit of energy use	10.3	47	●
3.3.2	Environmental performance*	57.2	77	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	123	
	MARKET SOPHISTICATION	**34.1**	**122**	◇
4.1	**Credit**	**9.8**	**125**	◇
4.1.1	Ease of getting credit*	10.0	126	○ ◇
4.1.2	Domestic credit to private sector, % GDP	24.8	107	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**35.0**	**[99]**	
4.2.1	Ease of protecting minority investors*	35.0	123	◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**57.6**	**78**	
4.3.1	Applied tariff rate, weighted avg., %	9.4	110	◇
4.3.2	Intensity of local competition†	55.0	121	◇
4.3.3	Domestic market scale, bn PPP$	660.8	34	●

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**18.1**	**126**	○ ◇
5.1	**Knowledge workers**	**19.0**	**110**	◇
5.1.1	Knowledge-intensive employment, %	17.9	81	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.0	75	
5.1.4	GERD financed by business, %	6.7	77	◇
5.1.5	Females employed w/advanced degrees, %	8.1	79	
5.2	**Innovation linkages**	**13.8**	**122**	◇
5.2.1	University/industry research collaboration†	26.9	117	◇
5.2.2	State of cluster development†	40.6	91	
5.2.3	GERD financed by abroad, %	0.0	102	○ ◇
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	94	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	89	
5.3	**Knowledge absorption**	**21.4**	**117**	◇
5.3.1	Intellectual property payments, % total trade	0.4	73	
5.3.2	High-tech imports, % total trade	8.3	53	●
5.3.3	ICT services imports, % total trade	0.7	91	
5.3.4	FDI net inflows, % GDP	0.5	120	◇
5.3.5	Research talent, % in business enterprise	0.5	82	◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**12.3**	**113**	
6.1	**Knowledge creation**	**6.0**	**90**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	91	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	87	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.6	83	
6.1.5	Citable documents H-index	8.0	79	
6.2	**Knowledge impact**	**24.5**	**107**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.5	50	●
6.2.2	New businesses/th pop. 15–64 ⊙	0.6	82	
6.2.3	Computer software spending, % GDP	0.0	125	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.7	115	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.0	94	◇
6.3	**Knowledge diffusion**	**6.4**	**126**	○ ◇
6.3.1	Intellectual property receipts, % total trade	0.0	100	◇
6.3.2	High-tech net exports, % total trade	0.0	126	○
6.3.3	ICT services exports, % total trade	0.3	109	
6.3.4	FDI net outflows, % GDP	0.0	107	
	CREATIVE OUTPUTS	**14.3**	**117**	◇
7.1	**Intangible assets**	**27.8**	**111**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	12.9	99	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.9	53	●
7.1.3	ICTs & business model creation†	46.7	114	◇
7.1.4	ICTs & organizational model creation†	41.3	110	◇
7.2	**Creative goods & services**	**1.0**	**125**	◇
7.2.1	Cultural & creative services exports, % total trade	0.0	108	
7.2.2	National feature films/mn pop. 15–69	0.4	97	
7.2.3	Entertainment & Media market/th pop. 15–69	1.3	55	◇
7.2.4	Printing & other media, % manufacturing ⊙	0.3	99	○ ◇
7.2.5	Creative goods exports, % total trade	0.0	124	
7.3	**Online creativity**	**0.8**	**102**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.5	108	
7.3.2	Country-code TLDs/th pop. 15–69	0.1	116	
7.3.3	Wikipedia edits/mn pop. 15–69	3.7	90	
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	94	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ARGENTINA

GII 2019 rank

73

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
75	**72**	**High**	**LCN**	**44.7**	**918.6**	**20,537.1**	**80**

		Score/Value	Rank	
	INSTITUTIONS	**56.7**	**86**	◇
1.1	**Political environment**	**57.0**	**62**	◇
1.1.1	Political and operational stability*	70.2	61	◇
1.1.2	Government effectiveness*	50.4	61	◇
1.2	**Regulatory environment**	**51.5**	**106**	○ ◇
1.2.1	Regulatory quality*	34.1	92	◇
1.2.2	Rule of law*	39.9	75	◇
1.2.3	Cost of redundancy dismissal, salary weeks	30.3	116	○ ◇
1.3	**Business environment**	**61.6**	**95**	◇
1.3.1	Ease of starting a business*	82.0	99	◇
1.3.2	Ease of resolving insolvency*	41.2	92	◇

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**38.7**	**42**	
2.1	**Education**	**57.9**	**31**	
2.1.1	Expenditure on education, % GDP	5.6	25	●
2.1.2	Government funding/pupil, secondary, % GDP/cap	21.8	42	
2.1.3	School life expectancy, years	17.6	15	●
2.1.4	PISA scales in reading, maths, & science	468.9	39	
2.1.5	Pupil-teacher ratio, secondary ⊙	12.2	50	
2.2	**Tertiary education**	**29.7**	**70**	◇
2.2.1	Tertiary enrolment, % gross ⊙	89.1	7	●
2.2.2	Graduates in science & engineering, %	16.1	81	○ ◇
2.2.3	Tertiary inbound mobility, %	2.5	70	
2.3	**Research & development (R&D)**	**28.6**	**38**	
2.3.1	Researchers, FTE/mn pop. ⊙	1,232.6	47	◇
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.5	59	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	46.3	34	
2.3.4	QS university ranking, average score top 3*	41.9	29	●

		Score/Value	Rank	
	INFRASTRUCTURE	**45.8**	**69**	◇
3.1	**Information & communication technologies(ICTs)**	**68.1**	**62**	◇
3.1.1	ICT access*	73.1	55	◇
3.1.2	ICT use*	61.8	53	◇
3.1.3	Government's online service*	75.0	56	
3.1.4	E-participation*	62.4	84	◇
3.2	**General infrastructure**	**32.1**	**75**	◇
3.2.1	Electricity output, kWh/mn pop.	3,346.1	59	
3.2.2	Logistics performance*	38.5	60	◇
3.2.3	Gross capital formation, % GDP	23.7	57	
3.3	**Ecological sustainability**	**37.3**	**69**	◇
3.3.1	GDP/unit of energy use	9.2	62	
3.3.2	Environmental performance*	59.3	65	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.6	54	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**37.9**	**111**	○ ◇
4.1	**Credit**	**20.1**	**117**	○ ◇
4.1.1	Ease of getting credit*	55.0	77	
4.1.2	Domestic credit to private sector, % GDP	16.1	113	○ ◇
4.1.3	Microfinance gross loans, % GDP	0.0	75	○
4.2	**Investment**	**32.2**	**111**	○ ◇
4.2.1	Ease of protecting minority investors*	61.7	54	
4.2.2	Market capitalization, % GDP	12.7	68	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	59	
4.3	**Trade, competition, & market scale**	**61.3**	**61**	
4.3.1	Applied tariff rate, weighted avg., %	7.9	103	○ ◇
4.3.2	Intensity of local competition†	55.4	120	○ ◇
4.3.3	Domestic market scale, bn PPP$	918.6	28	●

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**32.6**	**57**	◇
5.1	**Knowledge workers**	**41.2**	**53**	
5.1.1	Knowledge-intensive employment, %	17.6	84	◇
5.1.2	Firms offering formal training, % firms ⊙	63.6	5	● ◆
5.1.3	GERD performed by business, % GDP ⊙	0.1	58	◇
5.1.4	GERD financed by business, %	18.2	69	◇
5.1.5	Females employed w/advanced degrees, %	14.2	44	
5.2	**Innovation linkages**	**18.0**	**106**	○ ◇
5.2.1	University/industry research collaboration†	37.6	83	◇
5.2.2	State of cluster development†	39.1	95	◇
5.2.3	GERD financed by abroad, %	6.3	57	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	96	○ ◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	62	
5.3	**Knowledge absorption**	**38.4**	**42**	
5.3.1	Intellectual property payments, % total trade	2.9	7	● ◆
5.3.2	High-tech imports, % total trade	12.1	18	●
5.3.3	ICT services imports, % total trade	1.5	39	
5.3.4	FDI net inflows, % GDP	1.5	97	
5.3.5	Research talent, % in business enterprise ⊙	8.1	65	◇

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**19.2**	**78**	◇
6.1	**Knowledge creation**	**13.2**	**60**	
6.1.1	Patents by origin/bn PPP$ GDP	0.4	78	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	0.2	43	
6.1.4	Scientific & technical articles/bn PPP$ GDP	6.8	65	◇
6.1.5	Citable documents H-index	26.2	36	
6.2	**Knowledge impact**	**28.0**	**101**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	-1.2	102	○ ◇
6.2.2	New businesses/th pop. 15-64 ⊙	0.4	89	○
6.2.3	Computer software spending, % GDP	0.2	78	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.0	47	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**16.3**	**73**	
6.3.1	Intellectual property receipts, % total trade	0.2	33	
6.3.2	High-tech net exports, % total trade	1.8	56	
6.3.3	ICT services exports, % total trade	2.5	41	
6.3.4	FDI net outflows, % GDP	0.2	87	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**24.0**	**77**	◇
7.1	**Intangible assets**	**37.9**	**80**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	64.7	32	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.1	65	
7.1.3	ICTs & business model creation†	53.0	93	◇
7.1.4	ICTs & organizational model creation†	50.6	79	◇
7.2	**Creative goods & services**	**14.6**	**69**	◇
7.2.1	Cultural & creative services exports, % total trade	1.1	24	●
7.2.2	National feature films/mn pop. 15-69	7.4	24	●
7.2.3	Entertainment & Media market/th pop. 15-69	10.2	35	◇
7.2.4	Printing & other media, % manufacturing ⊙	1.0	67	
7.2.5	Creative goods exports, % total trade	0.1	98	
7.3	**Online creativity**	**5.4**	**63**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	3.0	62	◇
7.3.2	Country-code TLDs/th pop. 15-69	4.5	55	
7.3.3	Wikipedia edits/mn pop. 15-69	12.1	61	◇
7.3.4	Mobile app creation/bn PPP$ GDP	5.8	48	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ARMENIA

GII 2019 rank

64

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
50	85	Upper middle	NAWA	2.9	30.7	10,176.1	68

		Score/Value	Rank	
	INSTITUTIONS	**63.2**	**64**	
1.1	**Political environment**	**50.5**	**81**	
1.1.1	Political and operational stability*	63.2	86	
1.1.2	Government effectiveness*	44.2	77	
1.2	**Regulatory environment**	**69.1**	**55**	
1.2.1	Regulatory quality*	49.5	57	
1.2.2	Rule of law*	42.3	69	
1.2.3	Cost of redundancy dismissal, salary weeks	13.0	42	
1.3	**Business environment**	**70.1**	**65**	
1.3.1	Ease of starting a business*	96.2	8	● ◆
1.3.2	Ease of resolving insolvency*	44.0	85	
	HUMAN CAPITAL & RESEARCH	**16.9**	**107**	◇
2.1	**Education**	**26.9**	**[112]**	
2.1.1	Expenditure on education, % GDP	2.8	111	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap. ⊙	14.5	85	
2.1.3	School life expectancy, years ⊙	13.0	81	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**22.1**	**87**	
2.2.1	Tertiary enrolment, % gross	52.2	54	
2.2.2	Graduates in science & engineering, %	14.7	88	○ ◇
2.2.3	Tertiary inbound mobility, %	4.3	48	
2.3	**Research & development (R&D)**	**1.6**	**97**	
2.3.1	Researchers, FTE/mn pop	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	0.2	86	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**40.2**	**85**	
3.1	**Information & communication technologies(ICTs)**	**60.1**	**78**	
3.1.1	ICT access*	76.7	36	● ◆
3.1.2	ICT use*	50.7	70	
3.1.3	Government's online service*	56.3	95	
3.1.4	E-participation*	56.7	97	
3.2	**General infrastructure**	**26.7**	**93**	
3.2.1	Electricity output, kWh/mn pop	2,496.6	71	
3.2.2	Logistics performance*	25.4	87	
3.2.3	Gross capital formation, % GDP	22.5	68	
3.3	**Ecological sustainability**	**33.9**	**82**	
3.3.1	GDP/unit of energy use	7.8	80	
3.3.2	Environmental performance*	62.1	56	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	120	○
	MARKET SOPHISTICATION	**50.1**	**55**	
4.1	**Credit**	**31.2**	**86**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	51.5	66	
4.1.3	Microfinance gross loans, % GDP	0.0	60	
4.2	**Investment**	**63.3**	**[17]**	
4.2.1	Ease of protecting minority investors*	63.3	48	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**55.9**	**86**	
4.3.1	Applied tariff rate, weighted avg., %	2.2	56	
4.3.2	Intensity of local competition†	73.6	36	
4.3.3	Domestic market scale, bn PPP$	30.7	113	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.3**	**89**	
5.1	**Knowledge workers**	**36.5**	**[66]**	
5.1.1	Knowledge-intensive employment, %	29.4	46	
5.1.2	Firms offering formal training, % firms	16.2	82	○ ◇
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	14.9	42	
5.2	**Innovation linkages**	**20.0**	**88**	
5.2.1	University/industry research collaboration†	36.3	89	
5.2.2	State of cluster development†	46.0	69	
5.2.3	GERD financed by abroad, %	1.7	82	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	47	
5.3	**Knowledge absorption**	**22.4**	**114**	○ ◇
5.3.1	Intellectual property payments, % total trade ⊙	0.0	120	○ ◇
5.3.2	High-tech imports, % total trade	4.8	109	
5.3.3	ICT services imports, % total trade	0.5	102	
5.3.4	FDI net inflows, % GDP	2.4	74	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**25.0**	**54**	
6.1	**Knowledge creation**	**22.6**	**37**	
6.1.1	Patents by origin/bn PPP$ GDP	3.9	29	●
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	50	
6.1.3	Utility models by origin/bn PPP$ GDP	1.4	18	●
6.1.4	Scientific & technical articles/bn PPP$ GDP	25.2	13	● ◆
6.1.5	Citable documents H-index	9.8	69	
6.2	**Knowledge impact**	**35.3**	**70**	
6.2.1	Growth rate of PPP$ GDP/worker, %	6.2	2	● ◆
6.2.2	New businesses/th pop. 15–64	1.7	55	
6.2.3	Computer software spending, % GDP	0.1	84	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.0	107	
6.2.5	High- & medium-high-tech manufactures, %	0.0	96	○ ◇
6.3	**Knowledge diffusion**	**17.2**	**67**	
6.3.1	Intellectual property receipts, % total trade ⊙	0.0	109	○ ◇
6.3.2	High-tech net exports, % total trade	0.6	77	
6.3.3	ICT services exports, % total trade	4.3	15	● ◆
6.3.4	FDI net outflows, % GDP	0.3	77	
	CREATIVE OUTPUTS	**32.2**	**48**	
7.1	**Intangible assets**	**43.2**	**55**	
7.1.1	Trademarks by origin/bn PPP$ GDP	94.7	18	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.9	52	
7.1.3	ICTs & business model creation†	54.2	88	
7.1.4	ICTs & organizational model creation†	52.8	67	
7.2	**Creative goods & services**	**22.4**	**49**	
7.2.1	Cultural & creative services exports, % total trade	0.6	41	
7.2.2	National feature films/mn pop. 15–69	12.5	11	● ◆
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.5	33	
7.2.5	Creative goods exports, % total trade	0.6	55	
7.3	**Online creativity**	**19.8**	**34**	● ◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	3.0	64	
7.3.2	Country-code TLDs/th pop. 15–69	4.6	53	
7.3.3	Wikipedia edits/mn pop. 15–69	102.5	6	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	2.5	60	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

AUSTRALIA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
31	15	High	SEAO	24.8	1,318.6	52,373.5	20

		Score/Value	Rank	
	INSTITUTIONS	**88.8**	**13**	
1.1	**Political environment**	**85.7**	**14**	
1.1.1	Political and operational stability*	89.5	15	
1.1.2	Government effectiveness*	83.8	15	
1.2	**Regulatory environment**	**93.1**	**12**	
1.2.1	Regulatory quality*	93.7	5	●
1.2.2	Rule of law*	90.9	13	
1.2.3	Cost of redundancy dismissal, salary weeks	12.0	38	
1.3	**Business environment**	**87.7**	**11**	
1.3.1	Ease of starting a business*	96.5	7	●
1.3.2	Ease of resolving insolvency*	78.9	19	
	HUMAN CAPITAL & RESEARCH	**57.7**	**10**	●
2.1	**Education**	**61.0**	**19**	
2.1.1	Expenditure on education, % GDP	5.3	32	
2.1.2	Government funding/pupil, secondary, % GDP/cap	17.2	69	○ ◇
2.1.3	School life expectancy, years	22.1	1	● ◆
2.1.4	PISA scales in reading, maths, & science	502.3	19	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**50.6**	**13**	
2.2.1	Tertiary enrolment, % gross	113.8	2	● ◆
2.2.2	Graduates in science & engineering, % ⊙	17.6	76	○ ◇
2.2.3	Tertiary inbound mobility, %	17.5	9	
2.3	**Research & development (R&D)**	**61.4**	**14**	
2.3.1	Researchers, FTE/mn pop. ⊙	4,539.5	16	
2.3.2	Gross expenditure on R&D, % GDP ⊙	1.9	18	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	68.1	20	
2.3.4	QS university ranking, average score top 3*	80.9	5	●
	INFRASTRUCTURE	**60.9**	**19**	
3.1	**Information & communication technologies(ICTs)**	**89.0**	**13**	
3.1.1	ICT access*	80.4	26	
3.1.2	ICT use*	80.2	15	
3.1.3	Government's online service*	97.2	7	●
3.1.4	E-participation*	98.3	5	●
3.2	**General infrastructure**	**49.1**	**20**	
3.2.1	Electricity output, kWh/mn pop.	10,432.2	13	
3.2.2	Logistics performance*	79.0	18	
3.2.3	Gross capital formation, % GDP	24.3	50	
3.3	**Ecological sustainability**	**44.5**	**45**	
3.3.1	GDP/unit of energy use	8.5	67	○
3.3.2	Environmental performance*	74.1	21	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	3.2	30	
	MARKET SOPHISTICATION	**68.3**	**8**	●
4.1	**Credit**	**79.5**	**5**	● ◆
4.1.1	Ease of getting credit*	90.0	7	● ◆
4.1.2	Domestic credit to private sector, % GDP ⊙	142.5	13	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**46.4**	**51**	
4.2.1	Ease of protecting minority investors*	60.0	61	○
4.2.2	Market capitalization, % GDP	102.3	11	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	19	
4.3	**Trade, competition, & market scale**	**78.9**	**10**	●
4.3.1	Applied tariff rate, weighted avg., %	0.9	9	●
4.3.2	Intensity of local competition†	79.2	11	
4.3.3	Domestic market scale, bn PPP$	1,318.6	20	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**46.1**	**26**	◇
5.1	**Knowledge workers**	**67.5**	**11**	
5.1.1	Knowledge-intensive employment, % ⊙	46.0	14	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ⊙	1.0	21	
5.1.4	GERD financed by business, % ⊙	61.9	11	
5.1.5	Females employed w/advanced degrees, % ⊙	22.6	17	
5.2	**Innovation linkages**	**34.6**	**39**	◇
5.2.1	University/industry research collaboration†	53.1	35	◇
5.2.2	State of cluster development†	53.8	40	◇
5.2.3	GERD financed by abroad, % ⊙	1.6	84	○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.2	7	●
5.2.5	Patent families 2+ offices/bn PPP$ GDP	1.0	28	◇
5.3	**Knowledge absorption**	**36.2**	**50**	◇
5.3.1	Intellectual property payments, % total trade	1.3	24	
5.3.2	High-tech imports, % total trade	10.5	26	
5.3.3	ICT services imports, % total trade	1.0	71	○ ◇
5.3.4	FDI net inflows, % GDP	3.3	50	
5.3.5	Research talent, % in business enterprise ⊙	27.9	44	◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**31.6**	**36**	◇
6.1	**Knowledge creation**	**38.0**	**21**	
6.1.1	Patents by origin/bn PPP$ GDP	2.0	43	◇
6.1.2	PCT patents by origin/bn PPP$ GDP	1.4	26	◇
6.1.3	Utility models by origin/bn PPP$ GDP	0.8	29	
6.1.4	Scientific & technical articles/bn PPP$ GDP	26.9	10	●
6.1.5	Citable documents H-index	65.2	10	●
6.2	**Knowledge impact**	**44.1**	**30**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.4	77	○
6.2.2	New businesses/th pop. 15-64	15.5	7	● ◆
6.2.3	Computer software spending, % GDP	0.3	53	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	9.7	32	
6.2.5	High- & medium-high-tech manufactures, %	0.3	39	
6.3	**Knowledge diffusion**	**12.6**	**88**	○ ◇
6.3.1	Intellectual property receipts, % total trade	0.3	29	◇
6.3.2	High-tech net exports, % total trade	1.7	58	◇
6.3.3	ICT services exports, % total trade	1.0	83	○
6.3.4	FDI net outflows, % GDP	0.1	97	○ ◇
	CREATIVE OUTPUTS	**41.1**	**29**	◇
7.1	**Intangible assets**	**48.7**	**40**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	64.3	33	
7.1.2	Industrial designs by origin/bn PPP$ GDP	2.3	48	
7.1.3	ICTs & business model creation†	70.7	30	◇
7.1.4	ICTs & organizational model creation†	67.3	25	◇
7.2	**Creative goods & services**	**27.5**	**35**	
7.2.1	Cultural & creative services exports, % total trade	0.4	56	
7.2.2	National feature films/mn pop. 15-69	3.2	56	○
7.2.3	Entertainment & Media market/th pop. 15-69	67.0	7	
7.2.4	Printing & other media, % manufacturing	2.3	14	◆
7.2.5	Creative goods exports, % total trade	0.6	54	
7.3	**Online creativity**	**39.5**	**16**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	63.1	10	●
7.3.2	Country-code TLDs/th pop. 15-69	50.9	14	
7.3.3	Wikipedia edits/mn pop. 15-69	47.2	28	
7.3.4	Mobile app creation/bn PPP$ GDP	12.1	37	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

AUSTRIA

GII 2019 rank

21

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
25	19	High	EUR	8.8	464.0	52,137.4	21

		Score/Value	Rank	
	INSTITUTIONS	**86.0**	**17**	
1.1	**Political environment**	**83.9**	**17**	
1.1.1	Political and operational stability*	87.7	18	
1.1.2	Government effectiveness*	82.0	16	
1.2	**Regulatory environment**	**93.7**	**10**	●
1.2.1	Regulatory quality*	80.5	18	
1.2.2	Rule of law*	94.3	9	●
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**80.3**	**32**	
1.3.1	Ease of starting a business*	83.2	91	○ ◇
1.3.2	Ease of resolving insolvency*	77.5	20	
	HUMAN CAPITAL & RESEARCH	**60.2**	**8**	●
2.1	**Education**	**60.7**	**22**	
2.1.1	Expenditure on education, % GDP	5.5	28	
2.1.2	Government funding/pupil, secondary, % GDP/cap	27.3	17	◆
2.1.3	School life expectancy, years	16.3	28	
2.1.4	PISA scales in reading, maths, & science	492.2	25	
2.1.5	Pupil-teacher ratio, secondary	9.3	20	◆
2.2	**Tertiary education**	**61.7**	**3**	● ◆
2.2.1	Tertiary enrolment, % gross	86.3	12	●
2.2.2	Graduates in science & engineering, %	30.3	12	◆
2.2.3	Tertiary inbound mobility, %	16.3	10	●
2.3	**Research & development (R&D)**	**58.1**	**18**	
2.3.1	Researchers, FTE/mn pop.	5,439.8	9	●
2.3.2	Gross expenditure on R&D, % GDP	3.2	6	●
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	55.4	25	
2.3.4	QS university ranking, average score top 3*	42.0	28	
	INFRASTRUCTURE	**61.4**	**17**	
3.1	**Information & communication technologies(ICTs)**	**82.3**	**26**	
3.1.1	ICT access*	85.2	13	
3.1.2	ICT use*	74.7	29	◇
3.1.3	Government's online service*	86.8	32	
3.1.4	E-participation*	82.6	45	◇
3.2	**General infrastructure**	**51.3**	**14**	
3.2.1	Electricity output, kWh/mn pop.	7,666.0	27	
3.2.2	Logistics performance*	91.8	4	●
3.2.3	Gross capital formation, % GDP	25.6	41	
3.3	**Ecological sustainability**	**50.5**	**28**	
3.3.1	GDP/unit of energy use	11.5	37	
3.3.2	Environmental performance*	79.0	8	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.6	37	
	MARKET SOPHISTICATION	**52.8**	**44**	◇
4.1	**Credit**	**47.3**	**39**	
4.1.1	Ease of getting credit*	55.0	77	○
4.1.2	Domestic credit to private sector, % GDP	84.1	34	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**38.8**	**81**	○ ◇
4.2.1	Ease of protecting minority investors*	68.3	30	
4.2.2	Market capitalization, % GDP	30.8	48	○ ◇
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	38	○ ◇
4.3	**Trade, competition, & market scale**	**72.4**	**28**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	78.8	13	
4.3.3	Domestic market scale, bn PPP$	464.0	43	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**53.8**	**18**	
5.1	**Knowledge workers**	**65.0**	**17**	
5.1.1	Knowledge-intensive employment, %	41.6	25	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	2.2	6	●
5.1.4	GERD financed by business, %	54.0	21	
5.1.5	Females employed w/advanced degrees, %	17.2	35	◇
5.2	**Innovation linkages**	**50.8**	**11**	●
5.2.1	University/industry research collaboration†	65.2	16	
5.2.2	State of cluster development†	66.7	14	
5.2.3	GERD financed by abroad, %	16.0	24	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	31	◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	4.5	12	●
5.3	**Knowledge absorption**	**45.6**	**26**	
5.3.1	Intellectual property payments, % total trade	0.8	49	
5.3.2	High-tech imports, % total trade	8.2	54	○
5.3.3	ICT services imports, % total trade	2.3	18	
5.3.4	FDI net inflows, % GDP	-1.9	127	○
5.3.5	Research talent, % in business enterprise	62.2	9	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**36.7**	**25**	◇
6.1	**Knowledge creation**	**41.3**	**18**	
6.1.1	Patents by origin/bn PPP$ GDP	9.7	13	
6.1.2	PCT patents by origin/bn PPP$ GDP	3.2	11	
6.1.3	Utility models by origin/bn PPP$ GDP	1.0	23	
6.1.4	Scientific & technical articles/bn PPP$ GDP	22.0	20	
6.1.5	Citable documents H-index	43.4	17	
6.2	**Knowledge impact**	**43.6**	**33**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.9	65	○
6.2.2	New businesses/th pop. 15–64	0.6	80	○ ◇
6.2.3	Computer software spending, % GDP	0.6	15	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	8.4	36	
6.2.5	High- & medium-high-tech manufactures, %	0.4	15	
6.3	**Knowledge diffusion**	**25.1**	**40**	◇
6.3.1	Intellectual property receipts, % total trade	0.6	24	
6.3.2	High-tech net exports, % total trade	7.5	21	
6.3.3	ICT services exports, % total trade	3.0	33	
6.3.4	FDI net outflows, % GDP	-1.2	124	○ ◇
	CREATIVE OUTPUTS	**41.4**	**25**	
7.1	**Intangible assets**	**51.2**	**30**	
7.1.1	Trademarks by origin/bn PPP$ GDP	53.3	45	
7.1.2	Industrial designs by origin/bn PPP$ GDP ◷	7.3	17	
7.1.3	ICTs & business model creation†	72.6	27	
7.1.4	ICTs & organizational model creation†	64.9	29	◇
7.2	**Creative goods & services**	**27.1**	**38**	
7.2.1	Cultural & creative services exports, % total trade	1.2	23	
7.2.2	National feature films/mn pop. 15–69	7.1	28	
7.2.3	Entertainment & Media market/th pop. 15–69	65.3	8	
7.2.4	Printing & other media, % manufacturing	1.3	42	○
7.2.5	Creative goods exports, % total trade	0.9	45	
7.3	**Online creativity**	**36.2**	**22**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	36.0	19	
7.3.2	Country-code TLDs/th pop. 15–69	57.9	11	●
7.3.3	Wikipedia edits/mn pop. 15–69	54.2	20	
7.3.4	Mobile app creation/bn PPP$ GDP	14.4	33	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

AZERBAIJAN

GII 2019 rank

84

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
90	**77**	**Upper middle**	**NAWA**	**9.9**	**178.5**	**18,075.9**	**82**

		Score/Value	Rank	
	INSTITUTIONS	**64.5**	**59**	
1.1	**Political environment**	**51.2**	**77**	
1.1.1	Political and operational stability*	68.4	71	
1.1.2	Government effectiveness*	42.6	82	
1.2	**Regulatory environment**	**62.4**	**73**	
1.2.1	Regulatory quality*	35.4	89	
1.2.2	Rule of law*	31.7	96	
1.2.3	Cost of redundancy dismissal, salary weeks	13.7	53	
1.3	**Business environment**	**80.0**	**33**	● ◆
1.3.1	Ease of starting a business*	96.1	9	● ◆
1.3.2	Ease of resolving insolvency*	63.8	42	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**17.0**	**106**	◇
2.1	**Education**	**21.1**	**[123]**	
2.1.1	Expenditure on education, % GDP	2.9	103	◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**27.5**	**74**	
2.2.1	Tertiary enrolment, % gross	27.1	87	◇
2.2.2	Graduates in science & engineering, %	23.6	38	
2.2.3	Tertiary inbound mobility, %	2.1	74	
2.3	**Research & development (R&D)**	**2.5**	**90**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	0.2	90	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	3.7	72	

		Score/Value	Rank	
	INFRASTRUCTURE	**45.3**	**70**	
3.1	**Information & communication technologies(ICTs)**	**65.9**	**68**	
3.1.1	ICT access*	67.0	64	
3.1.2	ICT use*	55.5	63	
3.1.3	Government's online service*	72.9	63	
3.1.4	E-participation*	68.0	77	
3.2	**General infrastructure**	**30.8**	**83**	
3.2.1	Electricity output, kWh/mn pop.	2,556.7	70	
3.2.2	Logistics performance*	n/a	n/a	
3.2.3	Gross capital formation, % GDP	25.0	45	
3.3	**Ecological sustainability**	**39.3**	**61**	
3.3.1	GDP/unit of energy use	10.8	44	
3.3.2	Environmental performance*	62.3	52	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	92	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**56.5**	**31**	● ◆
4.1	**Credit**	**29.5**	**95**	
4.1.1	Ease of getting credit*	80.0	20	●
4.1.2	Domestic credit to private sector, % GDP	22.2	109	◇
4.1.3	Microfinance gross loans, % GDP	0.0	66	
4.2	**Investment**	**81.7**	**[1]**	
4.2.1	Ease of protecting minority investors*	81.7	2	● ◆
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**58.4**	**74**	
4.3.1	Applied tariff rate, weighted avg., % ◷	5.2	89	
4.3.2	Intensity of local competition†	61.3	102	◇
4.3.3	Domestic market scale, bn PPP$	178.5	66	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**24.5**	**103**	
5.1	**Knowledge workers**	**29.4**	**83**	
5.1.1	Knowledge-intensive employment, %	23.3	62	
5.1.2	Firms offering formal training, % firms	20.2	74	◇
5.1.3	GERD performed by business, % GDP	0.0	82	○
5.1.4	GERD financed by business, %	32.0	56	
5.1.5	Females employed w/advanced degrees, % ◷	12.9	52	
5.2	**Innovation linkages**	**21.4**	**79**	
5.2.1	University/industry research collaboration†	54.2	32	● ◆
5.2.2	State of cluster development†	55.7	33	● ◆
5.2.3	GERD financed by abroad, %	0.1	100	○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	84	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	79	
5.3	**Knowledge absorption**	**22.9**	**113**	◇
5.3.1	Intellectual property payments, % total trade ◷	0.1	105	
5.3.2	High-tech imports, % total trade	2.8	124	○ ◇
5.3.3	ICT services imports, % total trade	0.5	106	
5.3.4	FDI net inflows, % GDP	8.8	15	● ◆
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**14.9**	**101**	
6.1	**Knowledge creation**	**3.9**	**109**	
6.1.1	Patents by origin/bn PPP$ GDP ◷	1.1	60	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	67	
6.1.3	Utility models by origin/bn PPP$ GDP ◷	0.1	53	
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.5	96	
6.1.5	Citable documents H-index	3.9	104	
6.2	**Knowledge impact**	**21.4**	**111**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-1.6	105	○ ◇
6.2.2	New businesses/th pop. 15-64	1.0	70	
6.2.3	Computer software spending, % GDP	0.1	95	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.2	104	
6.2.5	High- & medium-high-tech manufactures, %	0.1	79	
6.3	**Knowledge diffusion**	**19.4**	**51**	
6.3.1	Intellectual property receipts, % total trade ◷	0.0	108	○ ◇
6.3.2	High-tech net exports, % total trade	0.1	115	○
6.3.3	ICT services exports, % total trade	0.4	107	
6.3.4	FDI net outflows, % GDP	6.4	10	● ◆

		Score/Value	Rank	
	CREATIVE OUTPUTS	**22.8**	**84**	
7.1	**Intangible assets**	**38.7**	**76**	
7.1.1	Trademarks by origin/bn PPP$ GDP ◷	16.7	91	
7.1.2	Industrial designs by origin/bn PPP$ GDP ◷	0.1	110	○
7.1.3	ICTs & business model creation†	65.9	48	◆
7.1.4	ICTs & organizational model creation†	63.4	35	● ◆
7.2	**Creative goods & services**	**8.7**	**92**	
7.2.1	Cultural & creative services exports, % total trade	0.1	75	
7.2.2	National feature films/mn pop. 15-69	7.2	27	● ◆
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	0.7	82	
7.2.5	Creative goods exports, % total trade	0.0	122	○
7.3	**Online creativity**	**5.0**	**66**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.0	94	
7.3.2	Country-code TLDs/th pop. 15-69	1.2	76	
7.3.3	Wikipedia edits/mn pop. 15-69	26.2	41	●
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	93	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BAHRAIN

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
87	69	High	NAWA	1.6	75.2	50,056.5	72

		Score/Value	Rank	
	INSTITUTIONS	**66.0**	**54**	◇
1.1	**Political environment**	**57.4**	**60**	◇
1.1.1	Political and operational stability*	70.2	61	◇
1.1.2	Government effectiveness*	51.0	60	◇
1.2	**Regulatory environment**	**73.5**	**39**	●
1.2.1	Regulatory quality*	53.1	53	◇
1.2.2	Rule of law*	58.2	44	◇
1.2.3	Cost of redundancy dismissal, salary weeks	13.6	51	
1.3	**Business environment**	**67.1**	**75**	◇
1.3.1	Ease of starting a business*	89.6	56	
1.3.2	Ease of resolving insolvency*	44.6	83	◇

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**24.4**	**85**	◇
2.1	**Education**	**40.5**	**83**	◇
2.1.1	Expenditure on education, % GDP	2.3	115	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	17.5	66	
2.1.3	School life expectancy, years	15.3	46	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	10.1	32	●
2.2	**Tertiary education**	**30.1**	**67**	◇
2.2.1	Tertiary enrolment, % gross	45.5	65	◇
2.2.2	Graduates in science & engineering, %	15.6	85	◇
2.2.3	Tertiary inbound mobility, %	13.1	12	●
2.3	**Research & development (R&D)**	**2.7**	**89**	◇
2.3.1	Researchers, FTE/mn pop. ⊙	368.9	72	◇
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.1	107	○ ◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	4.5	70	◇

		Score/Value	Rank	
	INFRASTRUCTURE	**51.6**	**45**	
3.1	**Information & communication technologies(ICTs)**	**78.8**	**34**	●
3.1.1	ICT access*	82.5	19	●
3.1.2	ICT use*	73.2	30	●
3.1.3	Government's online service*	79.9	45	
3.1.4	E-participation*	79.8	53	
3.2	**General infrastructure**	**47.7**	**27**	●
3.2.1	Electricity output, kWh/mn pop.	19,937.1	3	● ◆
3.2.2	Logistics performance*	40.8	58	◇
3.2.3	Gross capital formation, % GDP	24.0	54	
3.3	**Ecological sustainability**	**28.2**	**106**	◇
3.3.1	GDP/unit of energy use	4.3	114	○ ◇
3.3.2	Environmental performance*	55.2	81	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.9	50	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**45.3**	**79**	◇
4.1	**Credit**	**39.7**	**56**	
4.1.1	Ease of getting credit*	45.0	94	
4.1.2	Domestic credit to private sector, % GDP ⊙	73.7	43	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**43.9**	**60**	
4.2.1	Ease of protecting minority investors*	66.7	35	
4.2.2	Market capitalization, % GDP	61.2	28	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	24	●
4.3	**Trade, competition, & market scale**	**52.4**	**100**	◇
4.3.1	Applied tariff rate, weighted avg., %	7.8	102	◇
4.3.2	Intensity of local competition†	70.1	60	
4.3.3	Domestic market scale, bn PPP$	75.2	88	◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**27.1**	**83**	◇
5.1	**Knowledge workers**	**26.0**	**[96]**	
5.1.1	Knowledge-intensive employment, % ⊙	21.9	69	◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ⊙	0.0	79	◇
5.1.4	GERD financed by business, % ⊙	21.8	64	◇
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**37.7**	**33**	●
5.2.1	University/industry research collaboration†	45.4	50	
5.2.2	State of cluster development†	60.3	26	●
5.2.3	GERD financed by abroad, % ⊙	12.4	34	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.2	6	● ◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	75	
5.3	**Knowledge absorption**	**17.7**	**127**	○ ◇
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade ⊙	4.7	110	
5.3.3	ICT services imports, % total trade	0.4	111	◇
5.3.4	FDI net inflows, % GDP	0.8	109	
5.3.5	Research talent, % in business enterprise ⊙	0.4	83	○ ◇

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.9**	**92**	◇
6.1	**Knowledge creation**	**2.1**	**123**	○ ◇
6.1.1	Patents by origin/bn PPP$ GDP	0.2	100	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	92	◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.8	114	○ ◇
6.1.5	Citable documents H-index	2.4	116	○ ◇
6.2	**Knowledge impact**	**35.7**	**69**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.6	72	
6.2.2	New businesses/th pop. 15-64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.3	39	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	5.7	54	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	85	◇
6.3	**Knowledge diffusion**	**9.8**	**103**	◇
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade ⊙	0.1	110	◇
6.3.3	ICT services exports, % total trade	3.0	32	●
6.3.4	FDI net outflows, % GDP	-2.7	125	○ ◇

		Score/Value	Rank	
	CREATIVE OUTPUTS	**22.8**	**83**	◇
7.1	**Intangible assets**	**36.1**	**90**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	3.6	119	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.4	90	
7.1.3	ICTs & business model creation†	66.8	42	
7.1.4	ICTs & organizational model creation†	58.2	51	
7.2	**Creative goods & services**	**14.8**	**[67]**	
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15-69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15-69	9.3	37	◇
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade ⊙	1.5	35	●
7.3	**Online creativity**	**4.0**	**69**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	4.7	55	
7.3.2	Country-code TLDs/th pop. 15-69	0.4	96	◇
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	16.2	55	
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	87	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BANGLADESH

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
108	**117**	**Lower middle**	**CSA**	**166.4**	**758.2**	**4,619.8**	**116**

		Score/Value	Rank	
	INSTITUTIONS	**45.5**	**124**	○ ◇
1.1	**Political environment**	**37.2**	**116**	◇
1.1.1	Political and operational stability*	54.4	111	
1.1.2	Government effectiveness*	28.7	115	◇
1.2	**Regulatory environment**	**44.7**	**118**	
1.2.1	Regulatory quality*	20.3	116	◇
1.2.2	Rule of law*	28.6	102	
1.2.3	Cost of redundancy dismissal, salary weeks	31.0	118	
1.3	**Business environment**	**54.5**	**119**	◇
1.3.1	Ease of starting a business*	80.8	105	
1.3.2	Ease of resolving insolvency*	28.2	123	○ ◇
	HUMAN CAPITAL & RESEARCH	**8.8**	**127**	○ ◇
2.1	**Education**	**15.9**	**127**	○ ◇
2.1.1	Expenditure on education, % GDP	1.5	118	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	10.2	97	
2.1.3	School life expectancy, years	11.2	98	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	34.0	110	○ ◇
2.2	**Tertiary education**	**6.6**	**118**	◇
2.2.1	Tertiary enrolment, % gross	17.6	97	
2.2.2	Graduates in science & engineering, %	11.3	98	○ ◇
2.2.3	Tertiary inbound mobility, % ⊙	0.1	109	○
2.3	**Research & development (R&D)**	**4.0**	**[81]**	
2.3.1	Researchers, FTE/mn pop	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	8.0	66	
	INFRASTRUCTURE	**40.0**	**86**	
3.1	**Information & communication technologies(ICTs)**	**53.3**	**90**	
3.1.1	ICT access*	35.7	109	◇
3.1.2	ICT use*	18.7	111	◇
3.1.3	Government's online service*	78.5	51	● ◆
3.1.4	E-participation*	80.3	51	● ◆
3.2	**General infrastructure**	**36.6**	**58**	●
3.2.1	Electricity output, kWh/mn pop	394.8	109	
3.2.2	Logistics performance*	24.0	94	
3.2.3	Gross capital formation, % GDP	33.7	14	●
3.3	**Ecological sustainability**	**30.0**	**96**	
3.3.1	GDP/unit of energy use	13.3	19	● ◆
3.3.2	Environmental performance*	29.6	126	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	113	
	MARKET SOPHISTICATION	**41.1**	**96**	
4.1	**Credit**	**32.7**	**78**	
4.1.1	Ease of getting credit*	25.0	122	○ ◇
4.1.2	Domestic credit to private sector, % GDP	47.6	73	
4.1.3	Microfinance gross loans, % GDP	3.0	9	●
4.2	**Investment**	**31.0**	**117**	
4.2.1	Ease of protecting minority investors*	55.0	84	
4.2.2	Market capitalization, % GDP	34.5	43	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	73	
4.3	**Trade, competition, & market scale**	**59.5**	**70**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	10.7	116	◇
4.3.2	Intensity of local competition†	67.5	71	
4.3.3	Domestic market scale, bn PPP$	758.2	30	●

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**20.0**	**120**	◇
5.1	**Knowledge workers**	**15.7**	**[116]**	
5.1.1	Knowledge-intensive employment, %	8.3	102	
5.1.2	Firms offering formal training, % firms	21.9	72	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	1.3	105	
5.2	**Innovation linkages**	**21.0**	**82**	
5.2.1	University/industry research collaboration†	26.5	120	○
5.2.2	State of cluster development†	46.8	60	●
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	78	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**23.3**	**111**	
5.3.1	Intellectual property payments, % total trade	0.1	103	
5.3.2	High-tech imports, % total trade ⊙	8.0	58	●
5.3.3	ICT services imports, % total trade	0.2	120	◇
5.3.4	FDI net inflows, % GDP	1.1	104	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**16.1**	**91**	
6.1	**Knowledge creation**	**6.7**	**[86]**	
6.1.1	Patents by origin/bn PPP$ GDP	0.1	111	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	2.2	110	
6.1.5	Citable documents H-index	10.4	63	
6.2	**Knowledge impact**	**32.9**	**83**	
6.2.1	Growth rate of PPP$ GDP/worker, %	4.5	12	●
6.2.2	New businesses/th pop. 15–64 ⊙	0.1	101	
6.2.3	Computer software spending, % GDP	0.2	75	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.6	117	◇
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	81	
6.3	**Knowledge diffusion**	**8.6**	**114**	
6.3.1	Intellectual property receipts, % total trade	0.0	103	
6.3.2	High-tech net exports, % total trade ⊙	0.2	93	
6.3.3	ICT services exports, % total trade	1.1	78	
6.3.4	FDI net outflows, % GDP	0.0	106	
	CREATIVE OUTPUTS	**15.0**	**115**	◇
7.1	**Intangible assets**	**29.4**	**108**	
7.1.1	Trademarks by origin/bn PPP$ GDP	13.4	98	
7.1.2	Industrial designs by origin/bn PPP$ GDP	2.3	49	●
7.1.3	ICTs & business model creation†	50.2	103	
7.1.4	ICTs & organizational model creation†	42.1	107	
7.2	**Creative goods & services**	**0.8**	**126**	○ ◇
7.2.1	Cultural & creative services exports, % total trade	0.1	86	
7.2.2	National feature films/mn pop. 15–69	0.3	101	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	0.2	101	○ ◇
7.2.5	Creative goods exports, % total trade ⊙	0.1	107	
7.3	**Online creativity**	**0.4**	**110**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.4	112	
7.3.2	Country-code TLDs/th pop. 15–69	0.1	117	
7.3.3	Wikipedia edits/mn pop. 15–69	1.0	104	
7.3.4	Mobile app creation/bn PPP$ GDP	0.5	68	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BELARUS

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
95	**50**	**Upper middle**	**EUR**	**9.5**	**190.8**	**20,003.0**	**86**

		Score/Value	Rank	
	INSTITUTIONS	**57.7**	**83**	
1.1	**Political environment**	**48.8**	**87**	
1.1.1	Political and operational stability*	70.2	61	
1.1.2	Government effectiveness*	38.1	91	
1.2	**Regulatory environment**	**51.3**	**107**	○ ◇
1.2.1	Regulatory quality*	22.2	113	○ ◇
1.2.2	Rule of law*	24.7	112	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	21.7	92	
1.3	**Business environment**	**73.0**	**54**	
1.3.1	Ease of starting a business*	93.4	26	
1.3.2	Ease of resolving insolvency*	52.6	66	
	HUMAN CAPITAL & RESEARCH	**41.6**	**39**	◆
2.1	**Education**	**60.8**	**20**	◆
2.1.1	Expenditure on education, % GDP	4.8	53	
2.1.2	Government funding/pupil, secondary, % GDP/cap	35.9	8	● ◆
2.1.3	School life expectancy, years	15.4	43	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	8.2	11	● ◆
2.2	**Tertiary education**	**54.8**	**9**	● ◆
2.2.1	Tertiary enrolment, % gross	86.7	11	● ◆
2.2.2	Graduates in science & engineering, %	33.2	6	● ◆
2.2.3	Tertiary inbound mobility, %	4.2	51	
2.3	**Research & development (R&D)**	**9.1**	**61**	
2.3.1	Researchers, FTE/mn pop	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	0.6	54	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	14.8	57	
	INFRASTRUCTURE	**48.2**	**60**	
3.1	**Information & communication technologies(ICTs)**	**77.9**	**37**	◆
3.1.1	ICT access*	80.8	23	◆
3.1.2	ICT use*	68.8	37	◆
3.1.3	Government's online service*	73.6	57	
3.1.4	E-participation*	88.2	33	
3.2	**General infrastructure**	**31.7**	**79**	
3.2.1	Electricity output, kWh/mn pop	3,529.5	57	
3.2.2	Logistics performance*	23.9	97	◇
3.2.3	Gross capital formation, % GDP	26.6	36	
3.3	**Ecological sustainability**	**35.2**	**78**	
3.3.1	GDP/unit of energy use	6.2	99	○ ◇
3.3.2	Environmental performance*	65.0	40	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.9	51	
	MARKET SOPHISTICATION	**50.0**	**56**	
4.1	**Credit**	**21.8**	**115**	○ ◇
4.1.1	Ease of getting credit*	55.0	77	
4.1.2	Domestic credit to private sector, % GDP	26.4	104	○
4.1.3	Microfinance gross loans, % GDP	0.0	81	○ ◇
4.2	**Investment**	**63.3**	**[17]**	
4.2.1	Ease of protecting minority investors*	63.3	48	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**64.8**	**54**	
4.3.1	Applied tariff rate, weighted avg., %	1.5	15	●
4.3.2	Intensity of local competition†	n/a	n/a	
4.3.3	Domestic market scale, bn PPP$	190.8	64	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**32.6**	**56**	
5.1	**Knowledge workers**	**61.3**	**23**	◆
5.1.1	Knowledge-intensive employment, %	39.2	27	◆
5.1.2	Firms offering formal training, % firms	51.1	19	
5.1.3	GERD performed by business, % GDP	0.4	41	
5.1.4	GERD financed by business, %	43.0	41	
5.1.5	Females employed w/advanced degrees, %	32.6	1	● ◆
5.2	**Innovation linkages**	**11.4**	**[126]**	
5.2.1	University/industry research collaboration†	n/a	n/a	
5.2.2	State of cluster development†	n/a	n/a	
5.2.3	GERD financed by abroad, %	14.1	29	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	100	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	60	
5.3	**Knowledge absorption**	**25.1**	**101**	
5.3.1	Intellectual property payments, % total trade	0.4	70	
5.3.2	High-tech imports, % total trade	5.1	104	
5.3.3	ICT services imports, % total trade	0.7	93	
5.3.4	FDI net inflows, % GDP	2.6	63	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**25.5**	**51**	
6.1	**Knowledge creation**	**17.5**	**52**	
6.1.1	Patents by origin/bn PPP$ GDP	3.1	30	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	61	
6.1.3	Utility models by origin/bn PPP$ GDP	2.2	10	●
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.3	78	
6.1.5	Citable documents H-index	9.7	70	
6.2	**Knowledge impact**	**40.1**	**48**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.5	35	
6.2.2	New businesses/th pop. 15-64	1.1	69	
6.2.3	Computer software spending, % GDP	0.0	107	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	22.2	14	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.3	45	
6.3	**Knowledge diffusion**	**18.7**	**55**	
6.3.1	Intellectual property receipts, % total trade	0.1	59	
6.3.2	High-tech net exports, % total trade	1.8	57	
6.3.3	ICT services exports, % total trade	4.0	19	● ◆
6.3.4	FDI net outflows, % GDP	0.2	89	
	CREATIVE OUTPUTS	**10.8**	**126**	○ ◇
7.1	**Intangible assets**	**8.0**	**[127]**	
7.1.1	Trademarks by origin/bn PPP$ GDP	24.8	81	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.0	68	
7.1.3	ICTs & business model creation†	n/a	n/a	
7.1.4	ICTs & organizational model creation†	n/a	n/a	
7.2	**Creative goods & services**	**5.0**	**101**	◇
7.2.1	Cultural & creative services exports, % total trade	0.2	69	
7.2.2	National feature films/mn pop. 15-69 ⊙	0.1	105	○ ◇
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	0.5	90	○
7.2.5	Creative goods exports, % total trade	0.4	63	
7.3	**Online creativity**	**22.1**	**31**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.7	83	
7.3.2	Country-code TLDs/th pop. 15-69	5.2	47	
7.3.3	Wikipedia edits/mn pop. 15-69	22.2	47	
7.3.4	Mobile app creation/bn PPP$ GDP	66.5	6	● ◆

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BELGIUM

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
24	21	High	EUR	11.5	549.7	48,244.7	25

		Score/Value	Rank	
	INSTITUTIONS	**82.0**	**21**	
1.1	**Political environment**	**77.0**	**28**	◇
1.1.1	Political and operational stability*	80.7	35	◇
1.1.2	Government effectiveness*	75.2	24	◇
1.2	**Regulatory environment**	**80.4**	**30**	
1.2.1	Regulatory quality*	75.3	24	
1.2.2	Rule of law*	81.9	21	
1.2.3	Cost of redundancy dismissal, salary weeks	19.7	81	○
1.3	**Business environment**	**88.5**	**9**	●
1.3.1	Ease of starting a business*	93.0	30	
1.3.2	Ease of resolving insolvency*	83.9	8	●
	HUMAN CAPITAL & RESEARCH	**55.0**	**13**	●
2.1	**Education**	**68.6**	**5**	● ◆
2.1.1	Expenditure on education, % GDP	6.6	14	
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	24.5	26	
2.1.3	School life expectancy, years	19.7	2	● ◆
2.1.4	PISA scales in reading, maths, & science	502.5	18	
2.1.5	Pupil-teacher ratio, secondary ⊙	9.1	18	◆
2.2	**Tertiary education**	**37.2**	**44**	
2.2.1	Tertiary enrolment, % gross ⊙	75.9	22	
2.2.2	Graduates in science & engineering, %	17.1	78	○ ◇
2.2.3	Tertiary inbound mobility, %	12.0	13	
2.3	**Research & development (R&D)**	**59.2**	**16**	
2.3.1	Researchers, FTE/mn pop.	4,905.5	14	
2.3.2	Gross expenditure on R&D, % GDP	2.6	11	●
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	66.8	21	
2.3.4	QS university ranking, average score top 3*	54.2	16	
	INFRASTRUCTURE	**57.2**	**29**	◇
3.1	**Information & communication technologies(ICTs)**	**77.1**	**38**	◇
3.1.1	ICT access*	81.5	21	
3.1.2	ICT use*	75.6	27	
3.1.3	Government's online service*	75.7	55	◇
3.1.4	E-participation*	75.8	59	○ ◇
3.2	**General infrastructure**	**50.5**	**16**	
3.2.1	Electricity output, kWh/mn pop.	7,496.2	29	
3.2.2	Logistics performance*	92.4	3	●
3.2.3	Gross capital formation, % GDP	24.9	47	
3.3	**Ecological sustainability**	**44.1**	**46**	
3.3.1	GDP/unit of energy use	8.5	68	○
3.3.2	Environmental performance*	77.4	15	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.0	47	
	MARKET SOPHISTICATION	**55.3**	**37**	
4.1	**Credit**	**47.8**	**36**	
4.1.1	Ease of getting credit*	65.0	54	○
4.1.2	Domestic credit to private sector, % GDP	66.3	46	◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**45.0**	**56**	
4.2.1	Ease of protecting minority investors*	61.7	54	
4.2.2	Market capitalization, % GDP	86.9	17	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	21	
4.3	**Trade, competition, & market scale**	**73.2**	**25**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	78.6	14	
4.3.3	Domestic market scale, bn PPP$	549.7	37	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**54.1**	**17**	
5.1	**Knowledge workers**	**73.1**	**7**	●
5.1.1	Knowledge-intensive employment, %	47.6	9	●
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	1.8	11	
5.1.4	GERD financed by business, % ⊙	58.6	12	
5.1.5	Females employed w/advanced degrees, %	25.0	11	●
5.2	**Innovation linkages**	**46.0**	**19**	
5.2.1	University/industry research collaboration†	68.7	12	●
5.2.2	State of cluster development†	64.9	16	
5.2.3	GERD financed by abroad, % ⊙	16.5	22	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	26	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	2.8	16	
5.3	**Knowledge absorption**	**43.2**	**31**	
5.3.1	Intellectual property payments, % total trade	0.8	46	
5.3.2	High-tech imports, % total trade	7.4	67	○
5.3.3	ICT services imports, % total trade	2.3	20	
5.3.4	FDI net inflows, % GDP	-1.3	126	○
5.3.5	Research talent, % in business enterprise	54.1	21	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**40.8**	**21**	
6.1	**Knowledge creation**	**49.1**	**14**	●
6.1.1	Patents by origin/bn PPP$ GDP	6.0	19	
6.1.2	PCT patents by origin/bn PPP$ GDP	2.4	15	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	23.1	18	
6.1.5	Citable documents H-index	53.4	14	●
6.2	**Knowledge impact**	**43.1**	**39**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.2	83	○
6.2.2	New businesses/th pop. 15–64	3.7	34	
6.2.3	Computer software spending, % GDP	0.7	7	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	5.9	53	
6.2.5	High- & medium-high-tech manufactures, %	0.4	29	
6.3	**Knowledge diffusion**	**30.2**	**31**	
6.3.1	Intellectual property receipts, % total trade	0.9	20	
6.3.2	High-tech net exports, % total trade	8.1	20	
6.3.3	ICT services exports, % total trade	3.0	34	
6.3.4	FDI net outflows, % GDP	-0.1	119	○ ◇
	CREATIVE OUTPUTS	**38.5**	**33**	◇
7.1	**Intangible assets**	**49.1**	**38**	
7.1.1	Trademarks by origin/bn PPP$ GDP	45.8	55	
7.1.2	Industrial designs by origin/bn PPP$ GDP	2.4	47	
7.1.3	ICTs & business model creation†	74.9	18	
7.1.4	ICTs & organizational model creation†	72.2	16	
7.2	**Creative goods & services**	**30.9**	**27**	
7.2.1	Cultural & creative services exports, % total trade	1.4	18	
7.2.2	National feature films/mn pop. 15–69	10.9	14	
7.2.3	Entertainment & Media market/th pop. 15–69	53.9	14	
7.2.4	Printing & other media, % manufacturing ⊙	1.3	38	
7.2.5	Creative goods exports, % total trade	1.6	34	
7.3	**Online creativity**	**24.9**	**29**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	21.2	27	
7.3.2	Country-code TLDs/th pop. 15–69	56.0	13	●
7.3.3	Wikipedia edits/mn pop. 15–69	30.7	39	
7.3.4	Mobile app creation/bn PPP$ GDP	1.8	62	○ ◇

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BENIN

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
125	114	Low	SSF	11.5	27.5	2,426.5	n/a

		Score/Value	Rank	
	INSTITUTIONS	**56.6**	**87**	
1.1	**Political environment**	**42.3**	**98**	
1.1.1	Political and operational stability*	64.9	79	
1.1.2	Government effectiveness*	30.9	109	
1.2	**Regulatory environment**	**62.0**	**74**	●
1.2.1	Regulatory quality*	29.3	102	
1.2.2	Rule of law*	29.8	98	
1.2.3	Cost of redundancy dismissal, salary weeks	11.6	37	●
1.3	**Business environment**	**65.6**	**80**	
1.3.1	Ease of starting a business*	90.6	52	●
1.3.2	Ease of resolving insolvency*	40.7	97	
	HUMAN CAPITAL & RESEARCH	**21.1**	**92**	◆
2.1	**Education**	**36.8**	**96**	
2.1.1	Expenditure on education, % GDP	4.0	79	
2.1.2	Government funding/pupil, secondary, % GDP/cap	10.8	93	
2.1.3	School life expectancy, years	12.6	85	◆
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	11.0	38	● ◆
2.2	**Tertiary education**	**26.4**	**78**	◆
2.2.1	Tertiary enrolment, % gross ⊙	12.9	101	
2.2.2	Graduates in science & engineering, % ⊙	20.7	59	●
2.2.3	Tertiary inbound mobility, %	8.3	24	● ◆
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**27.7**	**118**	
3.1	**Information & communication technologies(ICTs)**	**31.1**	**118**	
3.1.1	ICT access*	31.4	115	
3.1.2	ICT use*	8.9	124	○ ◇
3.1.3	Government's online service*	47.2	108	
3.1.4	E-participation*	37.1	114	
3.2	**General infrastructure**	**32.5**	**72**	●
3.2.1	Electricity output, kWh/mn pop	32.7	119	○
3.2.2	Logistics performance*	32.1	75	● ◆
3.2.3	Gross capital formation, % GDP	28.4	25	●
3.3	**Ecological sustainability**	**19.5**	**125**	
3.3.1	GDP/unit of energy use	4.8	110	
3.3.2	Environmental performance*	38.2	120	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	126	○
	MARKET SOPHISTICATION	**32.1**	**124**	
4.1	**Credit**	**25.7**	**106**	
4.1.1	Ease of getting credit*	30.0	115	
4.1.2	Domestic credit to private sector, % GDP	22.7	108	
4.1.3	Microfinance gross loans, % GDP	2.2	11	●
4.2	**Investment**	**40.0**	**[72]**	
4.2.1	Ease of protecting minority investors*	40.0	114	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**30.7**	**126**	○ ◇
4.3.1	Applied tariff rate, weighted avg., %	17.8	128	○ ◇
4.3.2	Intensity of local competition†	63.2	89	
4.3.3	Domestic market scale, bn PPP$	27.5	117	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**19.9**	**[121]**	
5.1	**Knowledge workers**	**15.2**	**[118]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms	20.0	75	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	0.8	109	
5.2	**Innovation linkages**	**19.5**	**[90]**	
5.2.1	University/industry research collaboration†	30.8	104	
5.2.2	State of cluster development†	33.4	114	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**24.9**	**104**	
5.3.1	Intellectual property payments, % total trade	0.0	118	○
5.3.2	High-tech imports, % total trade	3.6	121	
5.3.3	ICT services imports, % total trade	1.1	63	●
5.3.4	FDI net inflows, % GDP	1.8	87	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**5.6**	**126**	○ ◇
6.1	**Knowledge creation**	**6.2**	**89**	
6.1.1	Patents by origin/bn PPP$ GDP	0.1	108	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	8.6	55	● ◆
6.1.5	Citable documents H-index	3.5	109	
6.2	**Knowledge impact**	**3.9**	**[124]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15-64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.1	100	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.6	95	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**6.6**	**125**	
6.3.1	Intellectual property receipts, % total trade ⊙	0.0	107	
6.3.2	High-tech net exports, % total trade	0.1	105	
6.3.3	ICT services exports, % total trade	0.1	120	
6.3.4	FDI net outflows, % GDP	0.3	82	
	CREATIVE OUTPUTS	**13.1**	**124**	
7.1	**Intangible assets**	**26.0**	**118**	
7.1.1	Trademarks by origin/bn PPP$ GDP	7.0	109	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	107	
7.1.3	ICTs & business model creation†	49.9	105	
7.1.4	ICTs & organizational model creation†	39.2	114	
7.2	**Creative goods & services**	**0.1**	**[128]**	
7.2.1	Cultural & creative services exports, % total trade ⊙	0.0	111	
7.2.2	National feature films/mn pop. 15-69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.0	128	○ ◇
7.3	**Online creativity**	**0.4**	**111**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	0.6	103	◆
7.3.2	Country-code TLDs/th pop. 15-69	0.0	125	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	0.9	106	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BOLIVIA (PLURINATIONAL STATE OF)

GII 2019 rank

110

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
113	102	Lower middle	LCN	11.2	89.4	7,476.9	117

		Score/Value	Rank	
	INSTITUTIONS	**36.8**	**128**	○ ◇
1.1	**Political environment**	**41.1**	**100**	
1.1.1	Political and operational stability*	49.1	122	○ ◇
1.1.2	Government effectiveness*	37.1	94	
1.2	**Regulatory environment**	**16.1**	**129**	○ ◇
1.2.1	Regulatory quality*	17.8	122	○ ◇
1.2.2	Rule of law*	14.4	124	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	n/a	n/a	
1.3	**Business environment**	**53.3**	**121**	◇
1.3.1	Ease of starting a business*	64.3	127	○ ◇
1.3.2	Ease of resolving insolvency*	42.3	90	
	HUMAN CAPITAL & RESEARCH	**26.5**	**[79]**	
2.1	**Education**	**51.7**	**[54]**	
2.1.1	Expenditure on education, % GDP ⊙	7.3	8	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	18.1	61	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	20.6	91	
2.2	**Tertiary education**	**n/a**	**[n/a]**	
2.2.1	Tertiary enrolment, % gross	n/a	n/a	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**1.2**	**101**	
2.3.1	Researchers, FTE/mn pop. ⊙	166.0	81	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.2	93	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**35.1**	**102**	
3.1	**Information & communication technologies(ICTs)**	**51.1**	**93**	
3.1.1	ICT access*	48.4	92	
3.1.2	ICT use*	42.0	85	
3.1.3	Government's online service*	56.3	95	
3.1.4	E-participation*	57.9	93	
3.2	**General infrastructure**	**21.2**	**114**	
3.2.1	Electricity output, kWh/mn pop.	864.0	98	
3.2.2	Logistics performance*	13.8	115	◇
3.2.3	Gross capital formation, % GDP	21.5	80	
3.3	**Ecological sustainability**	**32.9**	**84**	
3.3.1	GDP/unit of energy use	8.1	75	
3.3.2	Environmental performance*	56.0	79	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.7	77	
	MARKET SOPHISTICATION	**49.7**	**59**	
4.1	**Credit**	**54.9**	**26**	● ◆
4.1.1	Ease of getting credit*	35.0	110	◇
4.1.2	Domestic credit to private sector, % GDP	64.5	49	●
4.1.3	Microfinance gross loans, % GDP	28.2	1	● ◆
4.2	**Investment**	**40.0**	**[72]**	
4.2.1	Ease of protecting minority investors*	40.0	114	◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**54.1**	**91**	
4.3.1	Applied tariff rate, weighted avg., %	6.1	95	
4.3.2	Intensity of local competition†	63.8	85	
4.3.3	Domestic market scale, bn PPP$	89.4	83	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**24.1**	**104**	
5.1	**Knowledge workers**	**34.7**	**71**	
5.1.1	Knowledge-intensive employment, %	15.8	89	
5.1.2	Firms offering formal training, % firms	49.9	21	●
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, % ⊙	5.2	80	
5.1.5	Females employed w/advanced degrees, %	8.5	77	
5.2	**Innovation linkages**	**12.3**	**125**	○ ◇
5.2.1	University/industry research collaboration†	27.0	116	
5.2.2	State of cluster development†	31.1	118	◇
5.2.3	GERD financed by abroad, % ⊙	1.9	78	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	93	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**25.3**	**99**	
5.3.1	Intellectual property payments, % total trade	0.9	40	● ◆
5.3.2	High-tech imports, % total trade	9.1	41	●
5.3.3	ICT services imports, % total trade	0.9	78	
5.3.4	FDI net inflows, % GDP	1.5	96	
5.3.5	Research talent, % in business enterprise ⊙	0.4	84	○
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**14.5**	**105**	
6.1	**Knowledge creation**	**3.8**	**110**	
6.1.1	Patents by origin/bn PPP$ GDP	0.7	71	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	51	
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.6	118	
6.1.5	Citable documents H-index	5.8	91	
6.2	**Knowledge impact**	**30.3**	**93**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.8	45	●
6.2.2	New businesses/th pop. 15–64	0.5	83	
6.2.3	Computer software spending, % GDP	0.3	51	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.8	79	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	89	
6.3	**Knowledge diffusion**	**9.2**	**108**	
6.3.1	Intellectual property receipts, % total trade	0.2	34	●
6.3.2	High-tech net exports, % total trade	0.2	100	
6.3.3	ICT services exports, % total trade	0.6	94	
6.3.4	FDI net outflows, % GDP	0.2	92	
	CREATIVE OUTPUTS	**15.7**	**111**	
7.1	**Intangible assets**	**25.0**	**121**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	41.7	62	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	103	
7.1.3	ICTs & business model creation†	39.0	122	○ ◇
7.1.4	ICTs & organizational model creation†	31.7	122	○ ◇
7.2	**Creative goods & services**	**11.7**	**79**	
7.2.1	Cultural & creative services exports, % total trade	0.1	89	
7.2.2	National feature films/mn pop. 15–69	0.9	84	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	1.0	64	
7.2.5	Creative goods exports, % total trade	1.3	39	●
7.3	**Online creativity**	**1.2**	**100**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.8	80	
7.3.2	Country-code TLDs/th pop. 15–69	0.5	95	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	3.5	92	
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	88	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BOSNIA AND HERZEGOVINA

GII 2019 rank

76

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
79	71	Upper middle	EUR	3.5	47.3	13,491.0	77

		Score/Value	Rank	
	INSTITUTIONS	**58.9**	**79**	
1.1	**Political environment**	**44.3**	**94**	◇
1.1.1	Political and operational stability*	63.2	86	
1.1.2	Government effectiveness*	34.9	96	◇
1.2	**Regulatory environment**	**68.7**	**59**	
1.2.1	Regulatory quality*	37.9	82	
1.2.2	Rule of law*	40.8	73	
1.2.3	Cost of redundancy dismissal, salary weeks	9.2	24	●
1.3	**Business environment**	**63.7**	**87**	
1.3.1	Ease of starting a business*	59.6	128	○ ◇
1.3.2	Ease of resolving insolvency*	67.8	34	● ◆
	HUMAN CAPITAL & RESEARCH	**42.0**	**37**	◆
2.1	**Education**	**92.2**	**[1]**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	9.3	21	●
2.2	**Tertiary education**	**29.7**	**71**	
2.2.1	Tertiary enrolment, % gross	n/a	n/a	
2.2.2	Graduates in science & engineering, %	20.3	64	
2.2.3	Tertiary inbound mobility, %	7.1	31	◆
2.3	**Research & development (R&D)**	**4.1**	**79**	
2.3.1	Researchers, FTE/mn pop	463.9	70	
2.3.2	Gross expenditure on R&D, % GDP	0.2	89	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	7.0	67	
	INFRASTRUCTURE	**35.3**	**100**	◇
3.1	**Information & communication technologies(ICTs)**	**50.1**	**95**	
3.1.1	ICT access*	65.8	66	
3.1.2	ICT use*	48.1	74	
3.1.3	Government's online service*	43.1	112	○ ◇
3.1.4	E-participation*	43.3	109	◇
3.2	**General infrastructure**	**25.5**	**99**	
3.2.1	Electricity output, kWh/mn pop	5,047.4	43	
3.2.2	Logistics performance*	34.8	71	
3.2.3	Gross capital formation, % GDP	17.2	108	○
3.3	**Ecological sustainability**	**30.4**	**92**	◇
3.3.1	GDP/unit of energy use	5.6	102	◇
3.3.2	Environmental performance*	41.8	117	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	5.5	20	●
	MARKET SOPHISTICATION	**49.3**	**62**	
4.1	**Credit**	**34.3**	**71**	
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	54.4	59	
4.1.3	Microfinance gross loans, % GDP	0.8	25	
4.2	**Investment**	**58.3**	**[22]**	
4.2.1	Ease of protecting minority investors*	58.3	68	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**55.1**	**88**	
4.3.1	Applied tariff rate, weighted avg., %	2.5	60	
4.3.2	Intensity of local competition†	61.9	97	◇
4.3.3	Domestic market scale, bn PPP$	47.3	97	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.5**	**88**	
5.1	**Knowledge workers**	**37.8**	**59**	
5.1.1	Knowledge-intensive employment, %	22.1	68	
5.1.2	Firms offering formal training, % firms	52.4	16	●
5.1.3	GERD performed by business, % GDP	0.1	67	
5.1.4	GERD financed by business, %	29.1	62	
5.1.5	Females employed w/advanced degrees, %	6.9	81	
5.2	**Innovation linkages**	**21.9**	**72**	
5.2.1	University/industry research collaboration†	27.2	114	○ ◇
5.2.2	State of cluster development†	37.4	97	
5.2.3	GERD financed by abroad, %	16.4	23	●
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	58	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**19.8**	**125**	○ ◇
5.3.1	Intellectual property payments, % total trade	0.1	97	
5.3.2	High-tech imports, % total trade	5.0	106	
5.3.3	ICT services imports, % total trade	0.6	101	
5.3.4	FDI net inflows, % GDP	2.2	79	
5.3.5	Research talent, % in business enterprise	7.2	66	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**21.8**	**65**	
6.1	**Knowledge creation**	**8.2**	**79**	
6.1.1	Patents by origin/bn PPP$ GDP	1.9	46	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	66	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	8.0	58	
6.1.5	Citable documents H-index	3.3	111	○
6.2	**Knowledge impact**	**42.0**	**41**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.7	15	●
6.2.2	New businesses/th pop. 15-64	1.1	67	
6.2.3	Computer software spending, % GDP	0.1	92	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	25.4	8	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.2	64	
6.3	**Knowledge diffusion**	**15.3**	**76**	
6.3.1	Intellectual property receipts, % total trade	0.2	42	◆
6.3.2	High-tech net exports, % total trade	2.4	50	
6.3.3	ICT services exports, % total trade	1.8	60	
6.3.4	FDI net outflows, % GDP	0.4	75	
	CREATIVE OUTPUTS	**19.0**	**99**	
7.1	**Intangible assets**	**27.2**	**115**	○ ◇
7.1.1	Trademarks by origin/bn PPP$ GDP	16.5	92	
7.1.2	Industrial designs by origin/bn PPP$ GDP	2.4	46	
7.1.3	ICTs & business model creation†	44.0	116	○ ◇
7.1.4	ICTs & organizational model creation†	39.0	115	○ ◇
7.2	**Creative goods & services**	**13.2**	**74**	
7.2.1	Cultural & creative services exports, % total trade	0.0	96	
7.2.2	National feature films/mn pop. 15-69	7.3	26	● ◆
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.2	53	
7.2.5	Creative goods exports, % total trade	0.4	67	
7.3	**Online creativity**	**8.3**	**56**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	2.7	69	
7.3.2	Country-code TLDs/th pop. 15-69	2.3	64	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	41.7	34	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	80	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BOTSWANA

GII 2019 rank

93

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
117	80	Upper middle	SSF	2.3	41.8	17,965.4	91

		Score/Value	Rank	
	INSTITUTIONS	**65.7**	**58**	
1.1	**Political environment**	**66.0**	**43**	◆
1.1.1	Political and operational stability*	84.2	25	● ◆
1.1.2	Government effectiveness*	56.8	46	◆
1.2	**Regulatory environment**	**69.0**	**56**	
1.2.1	Regulatory quality*	54.4	47	
1.2.2	Rule of law*	60.0	41	◆
1.2.3	Cost of redundancy dismissal, salary weeks	20.6	85	
1.3	**Business environment**	**62.1**	**93**	
1.3.1	Ease of starting a business*	76.2	116	○
1.3.2	Ease of resolving insolvency*	48.0	73	
	HUMAN CAPITAL & RESEARCH	**28.2**	**73**	
2.1	**Education**	**67.5**	**[7]**	
2.1.1	Expenditure on education, % GDP	9.6	1	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	36.4	6	● ◆
2.1.3	School life expectancy, years	12.2	89	◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**13.8**	**102**	◇
2.2.1	Tertiary enrolment, % gross	23.0	89	◇
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	2.7	69	
2.3	**Research & development (R&D)**	**3.4**	**85**	
2.3.1	Researchers, FTE/mn pop.	179.5	80	
2.3.2	Gross expenditure on R&D, % GDP	0.5	57	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**35.2**	**101**	◇
3.1	**Information & communication technologies(ICTs)**	**32.4**	**116**	○ ◇
3.1.1	ICT access*	52.5	84	
3.1.2	ICT use*	36.8	94	◇
3.1.3	Government's online service*	20.8	126	○ ◇
3.1.4	E-participation*	19.7	125	○ ◇
3.2	**General infrastructure**	**34.0**	**68**	
3.2.1	Electricity output, kWh/mn pop.	1,194.7	91	◇
3.2.2	Logistics performance*	n/a	n/a	
3.2.3	Gross capital formation, % GDP	28.3	26	●
3.3	**Ecological sustainability**	**39.2**	**62**	
3.3.1	GDP/unit of energy use	13.3	19	●
3.3.2	Environmental performance*	51.7	92	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	93	
	MARKET SOPHISTICATION	**49.0**	**63**	
4.1	**Credit**	**34.0**	**73**	
4.1.1	Ease of getting credit*	55.0	77	
4.1.2	Domestic credit to private sector, % GDP	31.4	93	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**56.7**	**[27]**	
4.2.1	Ease of protecting minority investors*	56.7	79	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**56.3**	**85**	
4.3.1	Applied tariff rate, weighted avg., %	1.1	11	●
4.3.2	Intensity of local competition†	61.7	100	◇
4.3.3	Domestic market scale, bn PPP$	41.8	104	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.2**	**91**	
5.1	**Knowledge workers**	**34.4**	**73**	
5.1.1	Knowledge-intensive employment, %	17.8	82	
5.1.2	Firms offering formal training, % firms	51.9	17	●
5.1.3	GERD performed by business, % GDP	0.1	61	
5.1.4	GERD financed by business, %	17.7	71	
5.1.5	Females employed w/advanced degrees, %	9.1	71	
5.2	**Innovation linkages**	**24.3**	**68**	
5.2.1	University/industry research collaboration†	34.7	94	
5.2.2	State of cluster development†	34.5	108	◇
5.2.3	GERD financed by abroad, %	21.7	17	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	67	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**19.8**	**123**	○ ◇
5.3.1	Intellectual property payments, % total trade	0.1	94	
5.3.2	High-tech imports, % total trade	3.6	122	○
5.3.3	ICT services imports, % total trade	1.0	70	
5.3.4	FDI net inflows, % GDP	2.6	66	
5.3.5	Research talent, % in business enterprise	1.0	76	◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**13.7**	**107**	
6.1	**Knowledge creation**	**4.1**	**105**	
6.1.1	Patents by origin/bn PPP$ GDP	0.1	117	○
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	52	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.9	71	
6.1.5	Citable documents H-index	4.5	98	
6.2	**Knowledge impact**	**25.9**	**[105]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64	18.4	3	● ◆
6.2.3	Computer software spending, % GDP	0.1	85	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.5	121	○
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**11.0**	**98**	
6.3.1	Intellectual property receipts, % total trade	0.0	93	
6.3.2	High-tech net exports, % total trade	0.8	71	
6.3.3	ICT services exports, % total trade	0.3	110	
6.3.4	FDI net outflows, % GDP	1.7	36	●
	CREATIVE OUTPUTS	**14.3**	**118**	○ ◇
7.1	**Intangible assets**	**27.4**	**114**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	11.9	100	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.3	93	
7.1.3	ICTs & business model creation†	49.4	107	◇
7.1.4	ICTs & organizational model creation†	41.9	108	◇
7.2	**Creative goods & services**	**1.6**	**[118]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	106	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.2	86	
7.3	**Online creativity**	**0.8**	**101**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.1	93	
7.3.2	Country-code TLDs/th pop. 15–69	1.2	77	
7.3.3	Wikipedia edits/mn pop. 15–69	0.4	110	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BRAZIL

GII 2019 rank

66

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
67	60	Upper middle	LCN	210.9	3,370.6	16,154.3	64

		Score/Value	Rank	
	INSTITUTIONS	**58.9**	**80**	
1.1	**Political environment**	**48.6**	**88**	
1.1.1	Political and operational stability*	66.7	74	
1.1.2	Government effectiveness*	39.6	87	
1.2	**Regulatory environment**	**63.8**	**72**	
1.2.1	Regulatory quality*	38.9	76	
1.2.2	Rule of law*	38.9	78	
1.2.3	Cost of redundancy dismissal, salary weeks	15.4	62	
1.3	**Business environment**	**64.4**	**83**	
1.3.1	Ease of starting a business*	80.2	106	○
1.3.2	Ease of resolving insolvency*	48.5	69	
	HUMAN CAPITAL & RESEARCH	**36.0**	**48**	
2.1	**Education**	**50.1**	**59**	
2.1.1	Expenditure on education, % GDP	6.2	18	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	21.7	44	
2.1.3	School life expectancy, years ⏲	15.3	44	
2.1.4	PISA scales in reading, maths, & science	395.0	64	○
2.1.5	Pupil-teacher ratio, secondary ⏲	16.6	73	
2.2	**Tertiary education**	**22.3**	**85**	
2.2.1	Tertiary enrolment, % gross ⏲	50.5	56	
2.2.2	Graduates in science & engineering, %	17.7	75	
2.2.3	Tertiary inbound mobility, %	0.2	105	○ ◇
2.3	**Research & development (R&D)**	**35.6**	**32**	◆
2.3.1	Researchers, FTE/mn pop. ⏲	881.4	53	
2.3.2	Gross expenditure on R&D, % GDP ⏲	1.3	28	● ◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	61.5	22	● ◆
2.3.4	QS university ranking, average score top 3*	43.0	25	● ◆
	INFRASTRUCTURE	**46.8**	**64**	
3.1	**Information & communication technologies(ICTs)**	**77.9**	**36**	◆
3.1.1	ICT access*	61.9	72	
3.1.2	ICT use*	60.2	57	
3.1.3	Government's online service*	92.4	22	● ◆
3.1.4	E-participation*	97.2	12	● ◆
3.2	**General infrastructure**	**24.4**	**102**	○
3.2.1	Electricity output, kWh/mn pop.	2,787.8	64	
3.2.2	Logistics performance*	43.1	55	
3.2.3	Gross capital formation, % GDP	16.1	115	○ ◇
3.3	**Ecological sustainability**	**38.2**	**65**	
3.3.1	GDP/unit of energy use	10.0	52	
3.3.2	Environmental performance*	60.7	62	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.9	68	
	MARKET SOPHISTICATION	**44.2**	**84**	
4.1	**Credit**	**25.8**	**105**	○
4.1.1	Ease of getting credit*	50.0	87	
4.1.2	Domestic credit to private sector, % GDP	59.7	56	
4.1.3	Microfinance gross loans, % GDP	0.0	74	○
4.2	**Investment**	**36.8**	**91**	
4.2.1	Ease of protecting minority investors*	65.0	45	
4.2.2	Market capitalization, % GDP	38.6	40	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	61	○
4.3	**Trade, competition, & market scale**	**70.1**	**33**	
4.3.1	Applied tariff rate, weighted avg., %	8.6	104	○ ◇
4.3.2	Intensity of local competition†	68.2	67	
4.3.3	Domestic market scale, bn PPP$	3,370.6	8	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**37.6**	**40**	◆
5.1	**Knowledge workers**	**46.3**	**42**	
5.1.1	Knowledge-intensive employment, %	23.1	65	
5.1.2	Firms offering formal training, % firms ⏲	42.2	30	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	45.0	35	
5.1.5	Females employed w/advanced degrees, %	12.5	55	
5.2	**Innovation linkages**	**25.0**	**66**	
5.2.1	University/industry research collaboration†	42.5	58	
5.2.2	State of cluster development†	49.7	50	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	82	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	55	
5.3	**Knowledge absorption**	**41.7**	**36**	◆
5.3.1	Intellectual property payments, % total trade	2.3	10	● ◆
5.3.2	High-tech imports, % total trade	10.1	28	●
5.3.3	ICT services imports, % total trade	1.6	35	
5.3.4	FDI net inflows, % GDP	4.0	41	
5.3.5	Research talent, % in business enterprise ⏲	26.6	45	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**23.0**	**58**	
6.1	**Knowledge creation**	**19.8**	**47**	
6.1.1	Patents by origin/bn PPP$ GDP	1.7	50	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	53	
6.1.3	Utility models by origin/bn PPP$ GDP	0.9	25	
6.1.4	Scientific & technical articles/bn PPP$ GDP	9.7	50	
6.1.5	Citable documents H-index	36.3	24	● ◆
6.2	**Knowledge impact**	**31.9**	**86**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.3	96	○
6.2.2	New businesses/th pop. 15-64	0.1	98	○
6.2.3	Computer software spending, % GDP	0.2	74	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	5.4	58	
6.2.5	High- & medium-high-tech manufactures, % ⏲	0.3	32	
6.3	**Knowledge diffusion**	**17.4**	**66**	
6.3.1	Intellectual property receipts, % total trade	0.3	31	◆
6.3.2	High-tech net exports, % total trade	4.5	32	
6.3.3	ICT services exports, % total trade	0.9	84	
6.3.4	FDI net outflows, % GDP	0.6	63	
	CREATIVE OUTPUTS	**22.8**	**82**	
7.1	**Intangible assets**	**38.9**	**73**	
7.1.1	Trademarks by origin/bn PPP$ GDP	49.0	50	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.1	64	
7.1.3	ICTs & business model creation†	61.1	57	
7.1.4	ICTs & organizational model creation†	52.6	69	
7.2	**Creative goods & services**	**7.0**	**94**	
7.2.1	Cultural & creative services exports, % total trade	0.5	50	
7.2.2	National feature films/mn pop. 15-69	1.0	81	
7.2.3	Entertainment & Media market/th pop. 15-69	8.5	39	◆
7.2.4	Printing & other media, % manufacturing ⏲	0.6	86	○
7.2.5	Creative goods exports, % total trade	0.2	77	
7.3	**Online creativity**	**6.4**	**61**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.5	87	
7.3.2	Country-code TLDs/th pop. 15-69	7.2	44	
7.3.3	Wikipedia edits/mn pop. 15-69	6.3	71	
7.3.4	Mobile app creation/bn PPP$ GDP	12.7	36	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⏲ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BRUNEI DARUSSALAM

GII 2019 rank

71

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
120	**35**	**High**	**SEAO**	**0.4**	**35.5**	**79,529.9**	**67**

		Score/Value	Rank	
	INSTITUTIONS	**78.9**	**27**	
1.1	**Political environment**	**80.5**	**21**	●
1.1.1	Political and operational stability*	93.0	7	● ◆
1.1.2	Government effectiveness*	74.3	26	●
1.2	**Regulatory environment**	**81.2**	**27**	
1.2.1	Regulatory quality*	61.1	38	
1.2.2	Rule of law*	63.5	37	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	● ◆
1.3	**Business environment**	**75.0**	**45**	
1.3.1	Ease of starting a business*	94.9	14	●
1.3.2	Ease of resolving insolvency*	55.1	59	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**33.3**	**55**	◇
2.1	**Education**	**50.2**	**58**	
2.1.1	Expenditure on education, % GDP	4.4	63	
2.1.2	Government funding/pupil, secondary, % GDP/cap	23.8	30	
2.1.3	School life expectancy, years	14.4	64	◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	8.7	13	●
2.2	**Tertiary education**	**39.8**	**39**	
2.2.1	Tertiary enrolment, % gross	32.9	79	◇
2.2.2	Graduates in science & engineering, % ⊙	30.5	11	● ◆
2.2.3	Tertiary inbound mobility, %	3.8	56	
2.3	**Research & development (R&D)**	**9.8**	**[57]**	
2.3.1	Researchers, FTE/mn pop	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	19.6	53	

		Score/Value	Rank	
	INFRASTRUCTURE	**50.4**	**52**	◇
3.1	**Information & communication technologies(ICTs)**	**69.9**	**58**	◇
3.1.1	ICT access*	76.6	39	
3.1.2	ICT use*	70.3	33	
3.1.3	Government's online service*	72.2	67	◇
3.1.4	E-participation*	60.7	92	◇
3.2	**General infrastructure**	**41.9**	**41**	
3.2.1	Electricity output, kWh/mn pop	10,166.7	14	●
3.2.2	Logistics performance*	30.1	79	◇
3.2.3	Gross capital formation, % GDP	29.1	23	● ◆
3.3	**Ecological sustainability**	**39.3**	**60**	
3.3.1	GDP/unit of energy use	10.1	49	
3.3.2	Environmental performance*	63.6	48	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.8	71	◇

		Score/Value	Rank	
	MARKET SOPHISTICATION	**60.1**	**17**	●
4.1	**Credit**	**58.5**	**20**	●
4.1.1	Ease of getting credit*	100.0	1	● ◆
4.1.2	Domestic credit to private sector, % GDP	39.5	84	◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**65.0**	**[15]**	
4.2.1	Ease of protecting minority investors*	65.0	45	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**56.7**	**84**	◇
4.3.1	Applied tariff rate, weighted avg., %	0.0	2	● ◆
4.3.2	Intensity of local competition†	61.2	104	◇
4.3.3	Domestic market scale, bn PPP$	35.5	110	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**36.0**	**45**	
5.1	**Knowledge workers**	**60.1**	**[24]**	
5.1.1	Knowledge-intensive employment, %	40.6	26	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	12.0	59	◇
5.2	**Innovation linkages**	**21.7**	**76**	◇
5.2.1	University/industry research collaboration†	37.3	86	◇
5.2.2	State of cluster development†	41.5	87	◇
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	60	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**26.3**	**97**	◇
5.3.1	Intellectual property payments, % total trade	0.5	68	
5.3.2	High-tech imports, % total trade	6.1	92	
5.3.3	ICT services imports, % total trade	0.8	86	
5.3.4	FDI net inflows, % GDP	1.3	99	
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**8.9**	**120**	○ ◇
6.1	**Knowledge creation**	**2.7**	**117**	○ ◇
6.1.1	Patents by origin/bn PPP$ GDP	0.2	92	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	83	◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.1	102	◇
6.1.5	Citable documents H-index	1.9	119	○ ◇
6.2	**Knowledge impact**	**6.2**	**[119]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15-64	2.5	44	
6.2.3	Computer software spending, % GDP	n/a	n/a	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.2	76	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.0	101	○ ◇
6.3	**Knowledge diffusion**	**17.7**	**62**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	3.1	44	
6.3.3	ICT services exports, % total trade	0.0	128	○ ◇
6.3.4	FDI net outflows, % GDP	1.6	39	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**17.0**	**107**	◇
7.1	**Intangible assets**	**30.4**	**105**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	5.2	116	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.0	117	○ ◇
7.1.3	ICTs & business model creation†	58.0	74	◇
7.1.4	ICTs & organizational model creation†	47.5	89	◇
7.2	**Creative goods & services**	**3.3**	**[109]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	119	○ ◇
7.2.2	National feature films/mn pop. 15-69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	0.5	93	○ ◇
7.2.5	Creative goods exports, % total trade	0.2	91	
7.3	**Online creativity**	**4.0**	**68**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	7.5	45	
7.3.2	Country-code TLDs/th pop. 15-69	0.8	83	◇
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	5.7	79	◇
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BULGARIA

GII 2019 rank

40

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
38	45	Upper middle	EUR	7.0	162.7	23,155.6	37

		Score/Value	Rank	
	INSTITUTIONS	**68.3**	**48**	
1.1	**Political environment**	**58.1**	**59**	
1.1.1	Political and operational stability*	68.4	71	
1.1.2	Government effectiveness*	52.9	52	
1.2	**Regulatory environment**	**75.5**	**37**	◆
1.2.1	Regulatory quality*	58.7	43	◆
1.2.2	Rule of law*	45.3	66	
1.2.3	Cost of redundancy dismissal, salary weeks	8.6	17	●
1.3	**Business environment**	**71.5**	**60**	
1.3.1	Ease of starting a business*	85.4	76	
1.3.2	Ease of resolving insolvency*	57.5	51	
	HUMAN CAPITAL & RESEARCH	**30.6**	**62**	
2.1	**Education**	**47.0**	**68**	
2.1.1	Expenditure on education, % GDP ⊙	4.1	77	○
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	21.7	43	
2.1.3	School life expectancy, years	14.8	56	
2.1.4	PISA scales in reading, maths, & science	439.6	45	○
2.1.5	Pupil-teacher ratio, secondary ⊙	12.6	52	
2.2	**Tertiary education**	**33.1**	**58**	
2.2.1	Tertiary enrolment, % gross ⊙	71.2	26	◆
2.2.2	Graduates in science & engineering, %	19.7	67	○
2.2.3	Tertiary inbound mobility, %	4.6	44	
2.3	**Research & development (R&D)**	**11.7**	**51**	
2.3.1	Researchers, FTE/mn pop.	2,130.5	38	◆
2.3.2	Gross expenditure on R&D, % GDP	0.8	47	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	4.7	68	
	INFRASTRUCTURE	**53.7**	**39**	◆
3.1	**Information & communication technologies(ICTs)**	**74.9**	**45**	
3.1.1	ICT access*	70.3	62	
3.1.2	ICT use*	65.8	42	◆
3.1.3	Government's online service*	76.4	54	
3.1.4	E-participation*	87.1	35	
3.2	**General infrastructure**	**33.9**	**69**	
3.2.1	Electricity output, kWh/mn pop.	6,262.4	33	◆
3.2.2	Logistics performance*	45.4	51	
3.2.3	Gross capital formation, % GDP	21.5	82	○
3.3	**Ecological sustainability**	**52.2**	**21**	● ◆
3.3.1	GDP/unit of energy use	6.8	88	○
3.3.2	Environmental performance*	67.9	29	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	11.9	2	● ◆
	MARKET SOPHISTICATION	**47.5**	**66**	
4.1	**Credit**	**31.8**	**84**	○
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	50.6	67	
4.1.3	Microfinance gross loans, % GDP	0.4	32	
4.2	**Investment**	**47.1**	**46**	
4.2.1	Ease of protecting minority investors*	68.3	30	
4.2.2	Market capitalization, % GDP ⊙	15.2	64	○
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**63.7**	**56**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	65.1	81	○
4.3.3	Domestic market scale, bn PPP$	162.7	69	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**40.3**	**34**	◆
5.1	**Knowledge workers**	**48.9**	**39**	
5.1.1	Knowledge-intensive employment, %	31.4	42	◆
5.1.2	Firms offering formal training, % firms	42.7	29	
5.1.3	GERD performed by business, % GDP	0.5	38	
5.1.4	GERD financed by business, %	43.6	39	
5.1.5	Females employed w/advanced degrees, %	19.2	26	◆
5.2	**Innovation linkages**	**36.3**	**37**	◆
5.2.1	University/industry research collaboration†	40.2	69	
5.2.2	State of cluster development†	46.8	61	
5.2.3	GERD financed by abroad, %	34.2	10	● ◆
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	35	◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	44	
5.3	**Knowledge absorption**	**35.7**	**52**	
5.3.1	Intellectual property payments, % total trade	0.5	60	
5.3.2	High-tech imports, % total trade	6.7	78	○
5.3.3	ICT services imports, % total trade	1.1	65	
5.3.4	FDI net inflows, % GDP	4.0	42	
5.3.5	Research talent, % in business enterprise	43.4	29	◆
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**31.4**	**37**	◆
6.1	**Knowledge creation**	**17.8**	**51**	
6.1.1	Patents by origin/bn PPP$ GDP	1.5	54	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.4	41	
6.1.3	Utility models by origin/bn PPP$ GDP	1.7	14	●
6.1.4	Scientific & technical articles/bn PPP$ GDP	10.0	49	
6.1.5	Citable documents H-index	14.4	50	
6.2	**Knowledge impact**	**54.9**	**9**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	2.9	26	
6.2.2	New businesses/th pop. 15-64	10.9	11	● ◆
6.2.3	Computer software spending, % GDP	0.3	54	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	35.3	2	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.2	48	
6.3	**Knowledge diffusion**	**21.7**	**44**	
6.3.1	Intellectual property receipts, % total trade	0.1	44	◆
6.3.2	High-tech net exports, % total trade	3.8	38	
6.3.3	ICT services exports, % total trade	3.0	31	
6.3.4	FDI net outflows, % GDP	1.1	51	
	CREATIVE OUTPUTS	**33.8**	**41**	◆
7.1	**Intangible assets**	**49.9**	**37**	
7.1.1	Trademarks by origin/bn PPP$ GDP	98.6	12	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	8.1	15	● ◆
7.1.3	ICTs & business model creation†	58.0	75	○
7.1.4	ICTs & organizational model creation†	53.7	64	
7.2	**Creative goods & services**	**19.3**	**57**	
7.2.1	Cultural & creative services exports, % total trade	1.4	19	●
7.2.2	National feature films/mn pop. 15-69	4.8	44	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.2	48	
7.2.5	Creative goods exports, % total trade	0.8	49	
7.3	**Online creativity**	**16.0**	**40**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	22.9	25	● ◆
7.3.2	Country-code TLDs/th pop. 15-69	3.3	59	
7.3.3	Wikipedia edits/mn pop. 15-69	46.2	30	◆
7.3.4	Mobile app creation/bn PPP$ GDP	7.0	45	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BURKINA FASO

GII 2019 rank

117

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
115	111	Low	SSF	19.8	38.8	1,996.1	124

		Score/Value	Rank	
	INSTITUTIONS	**56.4**	**88**	
1.1	**Political environment**	**40.2**	**103**	
1.1.1	Political and operational stability*	56.1	105	
1.1.2	Government effectiveness*	32.3	102	
1.2	**Regulatory environment**	**64.5**	**68**	●
1.2.1	Regulatory quality*	30.0	100	
1.2.2	Rule of law*	35.7	86	
1.2.3	Cost of redundancy dismissal, salary weeks	10.5	33	●
1.3	**Business environment**	**64.5**	**81**	
1.3.1	Ease of starting a business*	88.2	64	●
1.3.2	Ease of resolving insolvency*	40.9	94	
	HUMAN CAPITAL & RESEARCH	**14.4**	**110**	
2.1	**Education**	**29.4**	**109**	
2.1.1	Expenditure on education, % GDP	4.2	73	●
2.1.2	Government funding/pupil, secondary, % GDP/cap	17.6	65	
2.1.3	School life expectancy, years	8.9	112	○
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	23.3	95	
2.2	**Tertiary education**	**12.6**	**105**	
2.2.1	Tertiary enrolment, % gross	6.0	116	○
2.2.2	Graduates in science & engineering, %	15.4	87	
2.2.3	Tertiary inbound mobility, % ⊙	2.9	65	●
2.3	**Research & development (R&D)**	**1.2**	**102**	
2.3.1	Researchers, FTE/mn pop. ⊙	47.6	91	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.2	87	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**31.2**	**110**	
3.1	**Information & communication technologies(ICTs)**	**40.8**	**103**	
3.1.1	ICT access*	32.4	114	
3.1.2	ICT use*	14.9	116	
3.1.3	Government's online service*	53.5	101	
3.1.4	E-participation*	62.4	84	◆
3.2	**General infrastructure**	**23.8**	**106**	
3.2.1	Electricity output, kWh/mn pop.	n/a	n/a	
3.2.2	Logistics performance*	26.1	86	
3.2.3	Gross capital formation, % GDP	16.3	114	
3.3	**Ecological sustainability**	**29.0**	**104**	
3.3.1	GDP/unit of energy use	n/a	n/a	
3.3.2	Environmental performance*	42.8	116	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	117	
	MARKET SOPHISTICATION	**36.2**	**116**	
4.1	**Credit**	**24.9**	**108**	
4.1.1	Ease of getting credit*	30.0	115	
4.1.2	Domestic credit to private sector, % GDP	31.3	94	
4.1.3	Microfinance gross loans, % GDP	1.8	14	●
4.2	**Investment**	**40.0**	**[72]**	
4.2.1	Ease of protecting minority investors*	40.0	114	○
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**43.7**	**122**	○
4.3.1	Applied tariff rate, weighted avg., %	9.1	108	
4.3.2	Intensity of local competition†	57.7	116	
4.3.3	Domestic market scale, bn PPP$	38.8	106	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**23.3**	**111**	
5.1	**Knowledge workers**	**18.1**	**[111]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms ⊙	24.8	65	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, % ⊙	11.9	72	◆
5.1.5	Females employed w/advanced degrees, % ⊙	0.5	112	○
5.2	**Innovation linkages**	**18.1**	**105**	
5.2.1	University/industry research collaboration†	31.9	99	
5.2.2	State of cluster development†	33.3	115	
5.2.3	GERD financed by abroad, % ⊙	1.5	86	◇
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	86	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	n/a	n/a	
5.3	**Knowledge absorption**	**33.8**	**63**	●
5.3.1	Intellectual property payments, % total trade	0.0	117	○
5.3.2	High-tech imports, % total trade	4.4	112	
5.3.3	ICT services imports, % total trade	2.2	21	●
5.3.4	FDI net inflows, % GDP	3.3	51	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.1**	**98**	
6.1	**Knowledge creation**	**4.9**	**100**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	103	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP ⊙	0.1	50	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.5	75	●
6.1.5	Citable documents H-index	4.8	95	
6.2	**Knowledge impact**	**31.1**	**90**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.5	36	●
6.2.2	New businesses/th pop. 15–64 ⊙	0.2	95	
6.2.3	Computer software spending, % GDP	0.0	114	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.6	93	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**9.3**	**106**	
6.3.1	Intellectual property receipts, % total trade	0.0	80	
6.3.2	High-tech net exports, % total trade	0.1	106	
6.3.3	ICT services exports, % total trade	1.2	74	●
6.3.4	FDI net outflows, % GDP	0.3	81	
	CREATIVE OUTPUTS	**13.5**	**120**	
7.1	**Intangible assets**	**26.3**	**117**	
7.1.1	Trademarks by origin/bn PPP$ GDP	5.7	114	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.5	84	
7.1.3	ICTs & business model creation†	50.0	104	
7.1.4	ICTs & organizational model creation†	39.5	112	
7.2	**Creative goods & services**	**1.2**	**[122]**	
7.2.1	Cultural & creative services exports, % total trade	0.1	79	
7.2.2	National feature films/mn pop. 15–69 ⊙	0.5	95	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.0	119	
7.3	**Online creativity**	**0.0**	**127**	○
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.1	124	○
7.3.2	Country-code TLDs/th pop. 15–69	0.0	124	○
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.0	125	○
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

BURUNDI

GII 2019 rank

128

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
126	128	Low	SSF	10.9	8.0	735.2	n/a

		Score/Value	Rank	
	INSTITUTIONS	**45.6**	**123**	
1.1	**Political environment**	**22.8**	**128**	○ ◇
1.1.1	Political and operational stability*	40.4	128	○
1.1.2	Government effectiveness*	14.1	128	○ ◇
1.2	**Regulatory environment**	**51.2**	**108**	
1.2.1	Regulatory quality*	19.5	118	
1.2.2	Rule of law*	9.5	128	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	15.9	66	●
1.3	**Business environment**	**62.7**	**92**	
1.3.1	Ease of starting a business*	94.8	15	● ◆
1.3.2	Ease of resolving insolvency*	30.6	117	◇
	HUMAN CAPITAL & RESEARCH	**17.7**	**103**	
2.1	**Education**	**38.7**	**88**	
2.1.1	Expenditure on education, % GDP	4.3	68	
2.1.2	Government funding/pupil, secondary, % GDP/cap. ⊙	28.0	15	●
2.1.3	School life expectancy, years	11.3	95	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	28.0	103	
2.2	**Tertiary education**	**13.8**	**101**	
2.2.1	Tertiary enrolment, % gross	6.2	115	
2.2.2	Graduates in science & engineering, %	16.2	80	
2.2.3	Tertiary inbound mobility, %	2.9	66	
2.3	**Research & development (R&D)**	**0.8**	**109**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.1	100	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**14.0**	**129**	○ ◇
3.1	**Information & communication technologies(ICTs)**	**22.9**	**126**	
3.1.1	ICT access*	24.0	122	
3.1.2	ICT use*	6.1	126	○ ◇
3.1.3	Government's online service*	30.6	119	
3.1.4	E-participation*	30.9	119	
3.2	**General infrastructure**	**0.2**	**129**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	n/a	n/a	
3.2.2	Logistics performance*	0.0	122	○ ◇
3.2.3	Gross capital formation, % GDP	6.0	124	◇
3.3	**Ecological sustainability**	**18.9**	**128**	○
3.3.1	GDP/unit of energy use	n/a	n/a	
3.3.2	Environmental performance*	27.4	127	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	108	
	MARKET SOPHISTICATION	**26.1**	**129**	○ ◇
4.1	**Credit**	**6.1**	**128**	○ ◇
4.1.1	Ease of getting credit*	10.0	126	◇
4.1.2	Domestic credit to private sector, % GDP	15.5	115	
4.1.3	Microfinance gross loans, % GDP ⊙	0.2	42	●
4.2	**Investment**	**43.3**	**[61]**	
4.2.1	Ease of protecting minority investors*	43.3	105	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**28.8**	**128**	○ ◇
4.3.1	Applied tariff rate, weighted avg., % ⊙	5.9	94	
4.3.2	Intensity of local competition†	48.5	124	◇
4.3.3	Domestic market scale, bn PPP$	8.2	129	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**29.3**	**74**	
5.1	**Knowledge workers**	**16.0**	**[115]**	
5.1.1	Knowledge-intensive employment, %	2.3	114	
5.1.2	Firms offering formal training, % firms	32.0	47	●
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	0.2	116	
5.2	**Innovation linkages**	**38.7**	**30**	●
5.2.1	University/industry research collaboration†	33.8	96	
5.2.2	State of cluster development†	35.1	106	
5.2.3	GERD financed by abroad, % ⊙	39.9	7	●
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.5	33	● ◆
5.3	**Knowledge absorption**	**33.1**	**65**	●
5.3.1	Intellectual property payments, % total trade	0.0	116	
5.3.2	High-tech imports, % total trade	9.0	44	●
5.3.3	ICT services imports, % total trade	1.6	37	●
5.3.4	FDI net inflows, % GDP	0.5	118	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**4.8**	**[127]**	◇
6.1	**Knowledge creation**	**3.8**	**[112]**	
6.1.1	Patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.3	89	
6.1.5	Citable documents H-index	0.0	128	○ ◇
6.2	**Knowledge impact**	**3.6**	**[126]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.1	96	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.5	120	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.0	97	
6.3	**Knowledge diffusion**	**7.1**	**122**	
6.3.1	Intellectual property receipts, % total trade	0.0	98	
6.3.2	High-tech net exports, % total trade	0.0	120	
6.3.3	ICT services exports, % total trade	0.6	96	
6.3.4	FDI net outflows, % GDP	0.0	113	
	CREATIVE OUTPUTS	**12.7**	**125**	
7.1	**Intangible assets**	**24.0**	**123**	
7.1.1	Trademarks by origin/bn PPP$ GDP	6.6	111	
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	37.3	123	◇
7.1.4	ICTs & organizational model creation†	33.3	121	
7.2	**Creative goods & services**	**2.6**	**[112]**	
7.2.1	Cultural & creative services exports, % total trade	0.3	66	●
7.2.2	National feature films/mn pop. 15–69	0.8	89	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.1	109	
7.3	**Online creativity**	**0.1**	**126**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.0	127	
7.3.2	Country-code TLDs/th pop. 15–69	0.1	114	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.1	122	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

CAMBODIA

GII 2019 rank

98

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
84	**104**	**Lower middle**	**SEAO**	**16.2**	**70.3**	**4,334.7**	**98**

		Score/Value	Rank	
	INSTITUTIONS	**49.6**	**112**	
1.1	**Political environment**	**45.0**	**93**	
1.1.1	Political and operational stability*	73.7	50	● ◆
1.1.2	Government effectiveness*	30.7	110	
1.2	**Regulatory environment**	**53.1**	**104**	
1.2.1	Regulatory quality*	28.5	104	
1.2.2	Rule of law*	18.4	122	◇
1.2.3	Cost of redundancy dismissal, salary weeks	19.4	80	
1.3	**Business environment**	**50.6**	**125**	○ ◇
1.3.1	Ease of starting a business*	52.8	129	○ ◇
1.3.2	Ease of resolving insolvency*	48.4	71	
	HUMAN CAPITAL & RESEARCH	**11.2**	**120**	◇
2.1	**Education**	**17.8**	**[126]**	
2.1.1	Expenditure on education, % GDP ◷	1.9	117	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years ◷	10.6	101	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**15.2**	**100**	
2.2.1	Tertiary enrolment, % gross	13.1	100	
2.2.2	Graduates in science & engineering, % ◷	15.4	86	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**0.6**	**113**	
2.3.1	Researchers, FTE/mn pop. ◷	30.4	100	○
2.3.2	Gross expenditure on R&D, % GDP ◷	0.1	102	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**26.5**	**123**	○ ◇
3.1	**Information & communication technologies(ICTs)**	**29.5**	**121**	◇
3.1.1	ICT access*	41.6	102	
3.1.2	ICT use*	34.1	96	
3.1.3	Government's online service*	25.0	123	○ ◇
3.1.4	E-participation*	17.4	126	○ ◇
3.2	**General infrastructure**	**23.9**	**105**	
3.2.1	Electricity output, kWh/mn pop.	354.9	111	
3.2.2	Logistics performance*	24.1	93	
3.2.3	Gross capital formation, % GDP	22.0	76	
3.3	**Ecological sustainability**	**26.0**	**112**	
3.3.1	GDP/unit of energy use	7.0	85	
3.3.2	Environmental performance*	43.2	115	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.7	78	
	MARKET SOPHISTICATION	**56.8**	**30**	● ◆
4.1	**Credit**	**73.6**	**8**	● ◆
4.1.1	Ease of getting credit*	80.0	20	●
4.1.2	Domestic credit to private sector, % GDP	86.7	32	● ◆
4.1.3	Microfinance gross loans, % GDP	7.5	1	● ◆
4.2	**Investment**	**50.0**	**[39]**	
4.2.1	Ease of protecting minority investors*	50.0	93	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**46.7**	**114**	◇
4.3.1	Applied tariff rate, weighted avg., % ◷	9.8	111	
4.3.2	Intensity of local competition†	59.6	108	◇
4.3.3	Domestic market scale, bn PPP$	70.3	91	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**23.5**	**109**	
5.1	**Knowledge workers**	**13.2**	**120**	◇
5.1.1	Knowledge-intensive employment, % ◷	5.3	107	◇
5.1.2	Firms offering formal training, % firms	22.2	70	
5.1.3	GERD performed by business, % GDP ◷	0.0	81	
5.1.4	GERD financed by business, % ◷	19.4	67	
5.1.5	Females employed w/advanced degrees, % ◷	1.1	107	
5.2	**Innovation linkages**	**36.9**	**35**	● ◆
5.2.1	University/industry research collaboration†	37.4	85	
5.2.2	State of cluster development†	52.2	44	●
5.2.3	GERD financed by abroad, % ◷	34.9	9	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	33	●
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**20.4**	**122**	◇
5.3.1	Intellectual property payments, % total trade	0.1	102	
5.3.2	High-tech imports, % total trade ◷	2.7	125	○ ◇
5.3.3	ICT services imports, % total trade	0.6	97	
5.3.4	FDI net inflows, % GDP	11.7	10	● ◆
5.3.5	Research talent, % in business enterprise ◷	4.3	72	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**19.6**	**[75]**	
6.1	**Knowledge creation**	**3.6**	**[114]**	
6.1.1	Patents by origin/bn PPP$ GDP ◷	0.0	121	○
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	2.3	109	
6.1.5	Citable documents H-index	4.3	99	
6.2	**Knowledge impact**	**46.0**	**[25]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	4.9	9	● ◆
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.0	115	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.4	82	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**9.1**	**109**	
6.3.1	Intellectual property receipts, % total trade	0.0	92	
6.3.2	High-tech net exports, % total trade ◷	1.1	65	
6.3.3	ICT services exports, % total trade	0.4	105	
6.3.4	FDI net outflows, % GDP	0.5	69	
	CREATIVE OUTPUTS	**19.8**	**97**	
7.1	**Intangible assets**	**37.1**	**83**	
7.1.1	Trademarks by origin/bn PPP$ GDP ◷	23.4	83	
7.1.2	Industrial designs by origin/bn PPP$ GDP ◷	0.2	106	
7.1.3	ICTs & business model creation†	60.1	66	
7.1.4	ICTs & organizational model creation†	60.6	41	● ◆
7.2	**Creative goods & services**	**4.4**	**[105]**	
7.2.1	Cultural & creative services exports, % total trade ◷	0.0	112	
7.2.2	National feature films/mn pop. 15–69	3.2	55	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade ◷	0.3	76	
7.3	**Online creativity**	**0.6**	**107**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.8	99	
7.3.2	Country-code TLDs/th pop. 15–69	0.0	121	
7.3.3	Wikipedia edits/mn pop. 15–69 ◷	1.8	100	
7.3.4	Mobile app creation/bn PPP$ GDP	0.3	74	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

CAMEROON

GII 2019 rank

115

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
106	112	Lower middle	SSF	24.7	95.1	3,828.2	111

		Score/Value	Rank	
	INSTITUTIONS	**49.6**	**111**	
1.1	**Political environment**	**36.5**	**118**	◇
1.1.1	Political and operational stability*	56.1	105	
1.1.2	Government effectiveness*	26.7	118	◇
1.2	**Regulatory environment**	**50.8**	**110**	
1.2.1	Regulatory quality*	19.9	117	◇
1.2.2	Rule of law*	19.3	120	◇
1.2.3	Cost of redundancy dismissal, salary weeks	19.9	82	
1.3	**Business environment**	**61.4**	**98**	
1.3.1	Ease of starting a business*	86.3	73	●
1.3.2	Ease of resolving insolvency*	36.6	108	
	HUMAN CAPITAL & RESEARCH	**18.8**	**98**	
2.1	**Education**	**34.5**	**98**	
2.1.1	Expenditure on education, % GDP	3.1	102	
2.1.2	Government funding/pupil, secondary, % GDP/cap. ⊙	17.4	68	
2.1.3	School life expectancy, years	12.7	82	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	19.3	85	
2.2	**Tertiary education**	**21.9**	**88**	
2.2.1	Tertiary enrolment, % gross ⊙	19.2	95	
2.2.2	Graduates in science & engineering, % ⊙	21.3	54	●
2.2.3	Tertiary inbound mobility, % ⊙	1.1	86	
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**29.9**	**113**	◇
3.1	**Information & communication technologies(ICTs)**	**31.7**	**117**	◇
3.1.1	ICT access*	34.6	112	◇
3.1.2	ICT use*	13.7	119	○ ◇
3.1.3	Government's online service*	45.8	110	
3.1.4	E-participation*	32.6	116	◇
3.2	**General infrastructure**	**31.8**	**77**	
3.2.1	Electricity output, kWh/mn pop.	357.0	110	
3.2.2	Logistics performance*	24.9	90	
3.2.3	Gross capital formation, % GDP	29.1	24	●
3.3	**Ecological sustainability**	**26.3**	**111**	
3.3.1	GDP/unit of energy use	8.3	71	
3.3.2	Environmental performance*	40.8	119	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	114	
	MARKET SOPHISTICATION	**36.4**	**115**	◇
4.1	**Credit**	**22.4**	**114**	
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	14.5	117	◇
4.1.3	Microfinance gross loans, % GDP	0.2	47	
4.2	**Investment**	**41.7**	**[65]**	
4.2.1	Ease of protecting minority investors*	41.7	108	◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**45.1**	**117**	◇
4.3.1	Applied tariff rate, weighted avg., % ⊙	12.7	125	○ ◇
4.3.2	Intensity of local competition†	63.2	88	
4.3.3	Domestic market scale, bn PPP$	95.1	79	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**23.9**	**106**	
5.1	**Knowledge workers**	**26.3**	**[94]**	
5.1.1	Knowledge-intensive employment, % ⊙	10.9	98	
5.1.2	Firms offering formal training, % firms	37.6	37	●
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	2.0	100	
5.2	**Innovation linkages**	**18.3**	**102**	
5.2.1	University/industry research collaboration†	38.4	77	
5.2.2	State of cluster development†	35.3	104	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	103	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**27.0**	**94**	
5.3.1	Intellectual property payments, % total trade	0.1	106	◇
5.3.2	High-tech imports, % total trade	5.4	101	
5.3.3	ICT services imports, % total trade	1.1	67	●
5.3.4	FDI net inflows, % GDP	2.2	78	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.7**	**93**	
6.1	**Knowledge creation**	**6.5**	**87**	
6.1.1	Patents by origin/bn PPP$ GDP	0.3	83	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	94	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	6.8	64	●
6.1.5	Citable documents H-index	6.0	89	
6.2	**Knowledge impact**	**29.9**	**94**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.0	62	● ◇
6.2.2	New businesses/th pop. 15-64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.2	76	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.7	116	◇
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.0	103	○ ◇
6.3	**Knowledge diffusion**	**10.6**	**100**	
6.3.1	Intellectual property receipts, % total trade	0.0	89	
6.3.2	High-tech net exports, % total trade	0.2	95	
6.3.3	ICT services exports, % total trade	1.9	57	●
6.3.4	FDI net outflows, % GDP	0.0	105	
	CREATIVE OUTPUTS	**16.5**	**109**	
7.1	**Intangible assets**	**27.6**	**113**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	5.9	113	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.3	95	
7.1.3	ICTs & business model creation†	52.0	99	
7.1.4	ICTs & organizational model creation†	42.4	106	
7.2	**Creative goods & services**	**10.4**	**84**	
7.2.1	Cultural & creative services exports, % total trade	0.3	61	●
7.2.2	National feature films/mn pop. 15-69 ⊙	1.9	68	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	1.3	40	●
7.2.5	Creative goods exports, % total trade	0.0	121	○
7.3	**Online creativity**	**0.5**	**108**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	0.2	117	◇
7.3.2	Country-code TLDs/th pop. 15-69	1.3	75	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	0.1	119	○
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

CANADA

GII 2019 rank

17

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
22	9	High	NAC	37.0	1,852.5	49,651.2	18

		Score/Value	Rank	
	INSTITUTIONS	**92.3**	**4**	●
1.1	**Political environment**	**92.0**	**6**	●
1.1.1	Political and operational stability*	93.0	7	
1.1.2	Government effectiveness*	91.5	6	●
1.2	**Regulatory environment**	**95.1**	**8**	
1.2.1	Regulatory quality*	92.6	6	●
1.2.2	Rule of law*	94.0	10	
1.2.3	Cost of redundancy dismissal, salary weeks	10.0	29	
1.3	**Business environment**	**89.8**	**4**	●
1.3.1	Ease of starting a business*	98.2	3	● ◆
1.3.2	Ease of resolving insolvency*	81.5	12	
	HUMAN CAPITAL & RESEARCH	**50.9**	**19**	
2.1	**Education**	**51.9**	**51**	◇
2.1.1	Expenditure on education, % GDP ⊙	5.3	33	
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	18.3	58	○ ◇
2.1.3	School life expectancy, years	16.1	33	
2.1.4	PISA scales in reading, maths, & science	523.3	5	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**41.2**	**32**	
2.2.1	Tertiary enrolment, % gross ⊙	67.0	33	
2.2.2	Graduates in science & engineering, %	21.3	55	○
2.2.3	Tertiary inbound mobility, %	11.9	14	
2.3	**Research & development (R&D)**	**59.5**	**15**	
2.3.1	Researchers, FTE/mn pop. ⊙	4,274.7	22	
2.3.2	Gross expenditure on R&D, % GDP ⊙	1.7	21	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	69.6	19	
2.3.4	QS university ranking, average score top 3*	80.2	6	●
	INFRASTRUCTURE	**58.5**	**27**	◇
3.1	**Information & communication technologies(ICTs)**	**85.0**	**21**	
3.1.1	ICT access*	80.0	29	
3.1.2	ICT use*	76.1	25	
3.1.3	Government's online service*	93.1	17	
3.1.4	E-participation*	91.0	27	
3.2	**General infrastructure**	**55.4**	**8**	
3.2.1	Electricity output, kWh/mn pop.	18,368.9	4	● ◆
3.2.2	Logistics performance*	77.8	20	
3.2.3	Gross capital formation, % GDP	23.8	56	
3.3	**Ecological sustainability**	**35.1**	**79**	○ ◇
3.3.1	GDP/unit of energy use	5.5	103	○ ◇
3.3.2	Environmental performance*	72.2	24	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.7	76	○ ◇
	MARKET SOPHISTICATION	**80.4**	**2**	● ◆
4.1	**Credit**	**85.0**	**[4]**	
4.1.1	Ease of getting credit*	85.0	11	◆
4.1.2	Domestic credit to private sector, % GDP	n/a	n/a	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**77.7**	**4**	● ◆
4.2.1	Ease of protecting minority investors*	78.3	10	◆
4.2.2	Market capitalization, % GDP	125.1	7	
4.2.3	Venture capital deals/bn PPP$ GDP	0.5	1	● ◆
4.3	**Trade, competition, & market scale**	**78.6**	**13**	
4.3.1	Applied tariff rate, weighted avg., %	1.5	16	
4.3.2	Intensity of local competition†	74.5	31	
4.3.3	Domestic market scale, bn PPP$	1,852.5	17	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**49.9**	**22**	
5.1	**Knowledge workers**	**56.4**	**28**	◇
5.1.1	Knowledge-intensive employment, % ⊙	43.7	19	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.8	24	
5.1.4	GERD financed by business, %	40.9	43	◇
5.1.5	Females employed w/advanced degrees, %	17.6	31	
5.2	**Innovation linkages**	**48.4**	**15**	
5.2.1	University/industry research collaboration†	63.0	20	
5.2.2	State of cluster development†	62.0	22	
5.2.3	GERD financed by abroad, %	10.9	36	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.3	1	● ◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	2.1	20	
5.3	**Knowledge absorption**	**44.9**	**28**	
5.3.1	Intellectual property payments, % total trade	2.2	11	
5.3.2	High-tech imports, % total trade	10.0	30	
5.3.3	ICT services imports, % total trade	0.9	77	○ ◇
5.3.4	FDI net inflows, % GDP	2.6	64	
5.3.5	Research talent, % in business enterprise ⊙	56.7	18	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**41.3**	**19**	
6.1	**Knowledge creation**	**50.5**	**13**	
6.1.1	Patents by origin/bn PPP$ GDP	2.3	38	◇
6.1.2	PCT patents by origin/bn PPP$ GDP	1.3	27	◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	20.6	22	
6.1.5	Citable documents H-index	80.0	4	● ◆
6.2	**Knowledge impact**	**41.5**	**43**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.7	68	○
6.2.2	New businesses/th pop. 15–64	0.1	104	○ ◇
6.2.3	Computer software spending, % GDP	0.7	5	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.4	73	○ ◇
6.2.5	High- & medium-high-tech manufactures, %	0.4	24	
6.3	**Knowledge diffusion**	**32.0**	**27**	
6.3.1	Intellectual property receipts, % total trade	0.8	21	
6.3.2	High-tech net exports, % total trade	4.9	31	
6.3.3	ICT services exports, % total trade	1.5	68	○
6.3.4	FDI net outflows, % GDP	5.0	12	
	CREATIVE OUTPUTS	**41.4**	**27**	
7.1	**Intangible assets**	**50.7**	**31**	
7.1.1	Trademarks by origin/bn PPP$ GDP	58.5	37	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.5	86	○ ◇
7.1.3	ICTs & business model creation†	75.7	16	
7.1.4	ICTs & organizational model creation†	77.0	11	
7.2	**Creative goods & services**	**24.7**	**45**	
7.2.1	Cultural & creative services exports, % total trade	0.8	34	
7.2.2	National feature films/mn pop. 15–69	3.5	53	
7.2.3	Entertainment & Media market/th pop. 15–69	59.4	10	
7.2.4	Printing & other media, % manufacturing	1.5	34	
7.2.5	Creative goods exports, % total trade	1.0	43	
7.3	**Online creativity**	**39.4**	**17**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	76.5	6	● ◆
7.3.2	Country-code TLDs/th pop. 15–69	29.4	19	
7.3.3	Wikipedia edits/mn pop. 15–69	49.0	25	
7.3.4	Mobile app creation/bn PPP$ GDP	18.8	24	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

CHILE

GII 2019 rank

51

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
62	**43**	**High**	**LCN**	**18.2**	**481.0**	**25,978.3**	**47**

		Score/Value	Rank	Notes
	INSTITUTIONS	**73.0**	**39**	
1.1	**Political environment**	**71.7**	**37**	
1.1.1	Political and operational stability*	80.7	35	
1.1.2	Government effectiveness*	67.2	36	
1.2	**Regulatory environment**	**72.9**	**41**	
1.2.1	Regulatory quality*	77.8	21	●
1.2.2	Rule of law*	73.1	29	
1.2.3	Cost of redundancy dismissal, salary weeks	27.4	107	○ ◇
1.3	**Business environment**	**74.5**	**50**	
1.3.1	Ease of starting a business*	89.1	58	
1.3.2	Ease of resolving insolvency*	59.9	46	

		Score/Value	Rank	Notes
	HUMAN CAPITAL & RESEARCH	**32.5**	**57**	◇
2.1	**Education**	**49.8**	**60**	
2.1.1	Expenditure on education, % GDP	5.4	30	
2.1.2	Government funding/pupil, secondary, % GDP/cap	18.2	59	
2.1.3	School life expectancy, years	16.5	20	●
2.1.4	PISA scales in reading, maths, & science	442.7	44	
2.1.5	Pupil-teacher ratio, secondary	18.4	79	○ ◇
2.2	**Tertiary education**	**34.3**	**56**	
2.2.1	Tertiary enrolment, % gross	91.5	5	● ◆
2.2.2	Graduates in science & engineering, %	20.5	62	
2.2.3	Tertiary inbound mobility, %	0.4	100	○ ◇
2.3	**Research & development (R&D)**	**13.3**	**49**	◇
2.3.1	Researchers, FTE/mn pop. ⊙	502.1	67	◇
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.4	71	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	39.5	32	

		Score/Value	Rank	Notes
	INFRASTRUCTURE	**51.0**	**50**	◇
3.1	**Information & communication technologies(ICTs)**	**76.1**	**41**	
3.1.1	ICT access*	72.8	57	◇
3.1.2	ICT use*	66.3	41	
3.1.3	Government's online service*	83.3	37	
3.1.4	E-participation*	82.0	46	
3.2	**General infrastructure**	**36.5**	**59**	
3.2.1	Electricity output, kWh/mn pop.	4,262.7	51	
3.2.2	Logistics performance*	58.6	33	
3.2.3	Gross capital formation, % GDP	22.4	71	
3.3	**Ecological sustainability**	**40.3**	**53**	
3.3.1	GDP/unit of energy use	10.1	49	
3.3.2	Environmental performance*	57.5	73	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	3.1	31	

		Score/Value	Rank	Notes
	MARKET SOPHISTICATION	**51.7**	**49**	
4.1	**Credit**	**41.4**	**51**	
4.1.1	Ease of getting credit*	55.0	77	
4.1.2	Domestic credit to private sector, % GDP	112.6	19	●
4.1.3	Microfinance gross loans, % GDP	0.9	21	◆
4.2	**Investment**	**40.3**	**71**	
4.2.1	Ease of protecting minority investors*	60.0	61	
4.2.2	Market capitalization, % GDP	89.8	15	●
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	53	
4.3	**Trade, competition, & market scale**	**73.3**	**24**	●
4.3.1	Applied tariff rate, weighted avg., %	0.5	4	● ◆
4.3.2	Intensity of local competition†	74.5	30	
4.3.3	Domestic market scale, bn PPP$	481.0	42	

		Score/Value	Rank	Notes
	BUSINESS SOPHISTICATION	**33.1**	**53**	
5.1	**Knowledge workers**	**44.4**	**47**	
5.1.1	Knowledge-intensive employment, %	26.4	53	◇
5.1.2	Firms offering formal training, % firms ⊙	57.5	10	● ◆
5.1.3	GERD performed by business, % GDP ⊙	0.1	57	
5.1.4	GERD financed by business, %	35.8	52	
5.1.5	Females employed w/advanced degrees, %	8.8	75	◇
5.2	**Innovation linkages**	**18.7**	**96**	○ ◇
5.2.1	University/industry research collaboration†	43.8	55	
5.2.2	State of cluster development†	44.1	77	◇
5.2.3	GERD financed by abroad, %	1.9	77	○ ◇
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	85	○ ◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	42	
5.3	**Knowledge absorption**	**36.3**	**49**	
5.3.1	Intellectual property payments, % total trade	2.2	12	●
5.3.2	High-tech imports, % total trade	8.5	50	
5.3.3	ICT services imports, % total trade	0.7	88	○
5.3.4	FDI net inflows, % GDP	5.3	28	
5.3.5	Research talent, % in business enterprise ⊙	29.5	42	

		Score/Value	Rank	Notes
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**22.9**	**61**	
6.1	**Knowledge creation**	**14.6**	**56**	
6.1.1	Patents by origin/bn PPP$ GDP	0.9	64	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.5	35	
6.1.3	Utility models by origin/bn PPP$ GDP	0.2	41	
6.1.4	Scientific & technical articles/bn PPP$ GDP	13.2	40	
6.1.5	Citable documents H-index	22.5	37	
6.2	**Knowledge impact**	**38.3**	**56**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.7	67	
6.2.2	New businesses/th pop. 15–64	8.9	15	●
6.2.3	Computer software spending, % GDP	0.3	43	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	9.4	33	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.2	62	
6.3	**Knowledge diffusion**	**15.8**	**74**	
6.3.1	Intellectual property receipts, % total trade	0.1	65	
6.3.2	High-tech net exports, % total trade	0.8	72	
6.3.3	ICT services exports, % total trade	0.5	102	○
6.3.4	FDI net outflows, % GDP	3.8	16	●

		Score/Value	Rank	Notes
	CREATIVE OUTPUTS	**27.2**	**66**	◇
7.1	**Intangible assets**	**45.4**	**48**	
7.1.1	Trademarks by origin/bn PPP$ GDP	70.2	28	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	105	○
7.1.3	ICTs & business model creation†	72.1	28	
7.1.4	ICTs & organizational model creation†	57.8	54	
7.2	**Creative goods & services**	**10.9**	**80**	◇
7.2.1	Cultural & creative services exports, % total trade	0.3	65	
7.2.2	National feature films/mn pop. 15–69	3.7	49	
7.2.3	Entertainment & Media market/th pop. 15–69	13.5	31	◇
7.2.4	Printing & other media, % manufacturing ⊙	1.1	59	
7.2.5	Creative goods exports, % total trade	0.2	90	○
7.3	**Online creativity**	**6.9**	**58**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	2.2	76	◇
7.3.2	Country-code TLDs/th pop. 15–69	12.2	37	
7.3.3	Wikipedia edits/mn pop. 15–69	16.2	56	
7.3.4	Mobile app creation/bn PPP$ GDP	2.4	61	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

CHINA

GII 2019 rank

14

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
5	**26**	**Upper middle**	**SEAO**	**1,415.0**	**25,313.3**	**18,109.8**	**17**

		Score/Value	Rank	
	INSTITUTIONS	**64.1**	**60**	
1.1	**Political environment**	**63.0**	**47**	◆
1.1.1	Political and operational stability*	75.4	46	
1.1.2	Government effectiveness*	56.8	47	◆
1.2	**Regulatory environment**	**54.6**	**100**	○
1.2.1	Regulatory quality*	38.0	81	
1.2.2	Rule of law*	39.4	77	
1.2.3	Cost of redundancy dismissal, salary weeks	27.4	107	○
1.3	**Business environment**	**74.7**	**48**	
1.3.1	Ease of starting a business*	93.5	25	
1.3.2	Ease of resolving insolvency*	55.8	56	
	HUMAN CAPITAL & RESEARCH	**47.6**	**25**	◆
2.1	**Education**	**63.4**	**[13]**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years ⊙	13.5	74	
2.1.4	PISA scales in reading, maths, & science	514.3	8	◆
2.1.5	Pupil-teacher ratio, secondary	13.3	59	
2.2	**Tertiary education**	**20.6**	**94**	○
2.2.1	Tertiary enrolment, % gross	51.0	55	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	0.4	101	○
2.3	**Research & development (R&D)**	**58.8**	**17**	◆
2.3.1	Researchers, FTE/mn pop.	1,234.8	46	
2.3.2	Gross expenditure on R&D, % GDP	2.1	15	◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	91.7	6	◆
2.3.4	QS university ranking, average score top 3*	82.5	3	● ◆
	INFRASTRUCTURE	**58.7**	**26**	◆
3.1	**Information & communication technologies(ICTs)**	**74.5**	**46**	
3.1.1	ICT access*	60.0	75	
3.1.2	ICT use*	61.5	55	
3.1.3	Government's online service*	86.1	34	
3.1.4	E-participation*	90.5	29	◆
3.2	**General infrastructure**	**63.8**	**2**	● ◆
3.2.1	Electricity output, kWh/mn pop.	4,487.7	48	
3.2.2	Logistics performance*	72.1	26	◆
3.2.3	Gross capital formation, % GDP	44.2	4	● ◆
3.3	**Ecological sustainability**	**37.9**	**67**	
3.3.1	GDP/unit of energy use	6.6	94	○
3.3.2	Environmental performance*	50.7	97	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	7.1	14	◆
	MARKET SOPHISTICATION	**58.6**	**21**	◆
4.1	**Credit**	**45.3**	**43**	◆
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	155.8	7	◆
4.1.3	Microfinance gross loans, % GDP	0.0	69	○
4.2	**Investment**	**42.2**	**64**	
4.2.1	Ease of protecting minority investors*	60.0	61	
4.2.2	Market capitalization, % GDP	70.2	22	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	22	◆
4.3	**Trade, competition, & market scale**	**88.2**	**2**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	3.8	73	
4.3.2	Intensity of local competition†	74.4	32	
4.3.3	Domestic market scale, bn PPP$	25,313.3	1	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**55.4**	**14**	◆
5.1	**Knowledge workers**	**84.9**	**[1]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms ⊙	79.2	1	● ◆
5.1.3	GERD performed by business, % GDP	1.7	12	◆
5.1.4	GERD financed by business, %	76.5	2	● ◆
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**27.2**	**58**	
5.2.1	University/industry research collaboration†	56.5	27	◆
5.2.2	State of cluster development†	59.6	28	◆
5.2.3	GERD financed by abroad, %	0.6	93	○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	57	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	1.0	27	◆
5.3	**Knowledge absorption**	**54.1**	**13**	◆
5.3.1	Intellectual property payments, % total trade	1.1	30	
5.3.2	High-tech imports, % total trade	23.3	4	● ◆
5.3.3	ICT services imports, % total trade	0.8	85	
5.3.4	FDI net inflows, % GDP	1.7	88	○
5.3.5	Research talent, % in business enterprise	60.7	12	◆
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**57.2**	**5**	◆
6.1	**Knowledge creation**	**68.1**	**4**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP	53.7	1	● ◆
6.1.2	PCT patents by origin/bn PPP$ GDP	2.1	17	◆
6.1.3	Utility models by origin/bn PPP$ GDP	72.4	1	● ◆
6.1.4	Scientific & technical articles/bn PPP$ GDP	11.9	42	
6.1.5	Citable documents H-index	54.2	13	◆
6.2	**Knowledge impact**	**66.6**	**1**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	7.1	1	● ◆
6.2.2	New businesses/th pop. 15-64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.4	24	◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	16.9	20	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.5	12	◆
6.3	**Knowledge diffusion**	**37.0**	**22**	◆
6.3.1	Intellectual property receipts, % total trade	0.1	56	
6.3.2	High-tech net exports, % total trade	27.9	1	● ◆
6.3.3	ICT services exports, % total trade	1.2	75	
6.3.4	FDI net outflows, % GDP	1.4	42	
	CREATIVE OUTPUTS	**48.3**	**12**	◆
7.1	**Intangible assets**	**77.6**	**1**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	238.7	1	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	26.3	1	● ◆
7.1.3	ICTs & business model creation†	61.7	56	
7.1.4	ICTs & organizational model creation†	59.7	46	◆
7.2	**Creative goods & services**	**35.2**	**15**	◆
7.2.1	Cultural & creative services exports, % total trade	0.5	49	
7.2.2	National feature films/mn pop. 15-69	0.8	87	○
7.2.3	Entertainment & Media market/th pop. 15-69	6.9	42	
7.2.4	Printing & other media, % manufacturing ⊙	0.8	79	○
7.2.5	Creative goods exports, % total trade	11.9	1	● ◆
7.3	**Online creativity**	**2.7**	**79**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	2.4	75	
7.3.2	Country-code TLDs/th pop. 15-69	5.4	46	
7.3.3	Wikipedia edits/mn pop. 15-69	0.3	111	○
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

COLOMBIA

GII 2019 rank

67

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
76	**58**	**Upper middle**	**LCN**	**49.5**	**748.6**	**14,943.5**	**63**

		Score/Value	Rank	
	INSTITUTIONS	**64.0**	**61**	
1.1	**Political environment**	**50.4**	**82**	
1.1.1	Political and operational stability*	61.4	91	○
1.1.2	Government effectiveness*	44.9	74	
1.2	**Regulatory environment**	**65.4**	**66**	
1.2.1	Regulatory quality*	51.1	55	
1.2.2	Rule of law*	36.9	83	
1.2.3	Cost of redundancy dismissal, salary weeks	16.7	69	
1.3	**Business environment**	**76.4**	**41**	
1.3.1	Ease of starting a business*	85.3	77	
1.3.2	Ease of resolving insolvency*	67.4	37	
	HUMAN CAPITAL & RESEARCH	**27.0**	**78**	
2.1	**Education**	**38.8**	**87**	
2.1.1	Expenditure on education, % GDP	4.4	64	
2.1.2	Government funding/pupil, secondary, % GDP/cap	17.5	67	
2.1.3	School life expectancy, years	14.6	59	
2.1.4	PISA scales in reading, maths, & science	410.1	59	○
2.1.5	Pupil-teacher ratio, secondary	26.0	98	○ ◇
2.2	**Tertiary education**	**32.5**	**60**	
2.2.1	Tertiary enrolment, % gross	60.4	44	
2.2.2	Graduates in science & engineering, %	23.7	37	
2.2.3	Tertiary inbound mobility, %	0.2	106	○ ◇
2.3	**Research & development (R&D)**	**9.8**	**58**	
2.3.1	Researchers, FTE/mn pop. ⊙	88.5	88	○
2.3.2	Gross expenditure on R&D, % GDP	0.2	85	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	33.2	34	
	INFRASTRUCTURE	**51.3**	**47**	◆
3.1	**Information & communication technologies(ICTs)**	**71.4**	**55**	
3.1.1	ICT access*	61.3	74	
3.1.2	ICT use*	44.2	79	
3.1.3	Government's online service*	88.2	30	◆
3.1.4	E-participation*	92.1	23	● ◆
3.2	**General infrastructure**	**28.7**	**88**	
3.2.1	Electricity output, kWh/mn pop.	1,580.8	87	
3.2.2	Logistics performance*	41.1	57	
3.2.3	Gross capital formation, % GDP	21.5	79	
3.3	**Ecological sustainability**	**53.8**	**13**	● ◆
3.3.1	GDP/unit of energy use	15.6	10	● ◆
3.3.2	Environmental performance*	65.2	38	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	4.2	27	●
	MARKET SOPHISTICATION	**50.4**	**53**	
4.1	**Credit**	**39.7**	**55**	
4.1.1	Ease of getting credit*	95.0	3	● ◆
4.1.2	Domestic credit to private sector, % GDP	49.4	70	
4.1.3	Microfinance gross loans, % GDP	0.1	53	
4.2	**Investment**	**41.2**	**70**	
4.2.1	Ease of protecting minority investors*	75.0	14	● ◆
4.2.2	Market capitalization, % GDP	34.9	42	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	66	○
4.3	**Trade, competition, & market scale**	**70.2**	**32**	
4.3.1	Applied tariff rate, weighted avg., %	4.4	78	
4.3.2	Intensity of local competition†	75.0	28	● ◆
4.3.3	Domestic market scale, bn PPP$	748.6	31	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**32.6**	**58**	
5.1	**Knowledge workers**	**46.8**	**41**	
5.1.1	Knowledge-intensive employment, % ⊙	16.7	86	
5.1.2	Firms offering formal training, % firms ⊙	65.1	4	● ◆
5.1.3	GERD performed by business, % GDP	0.1	60	
5.1.4	GERD financed by business, %	49.3	29	
5.1.5	Females employed w/advanced degrees, %	13.7	49	
5.2	**Innovation linkages**	**17.7**	**109**	○
5.2.1	University/industry research collaboration†	41.9	60	
5.2.2	State of cluster development†	45.1	75	
5.2.3	GERD financed by abroad, %	0.5	96	○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	75	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	59	
5.3	**Knowledge absorption**	**33.1**	**64**	
5.3.1	Intellectual property payments, % total trade	0.9	44	
5.3.2	High-tech imports, % total trade	13.2	16	●
5.3.3	ICT services imports, % total trade	1.4	51	
5.3.4	FDI net inflows, % GDP	4.4	37	
5.3.5	Research talent, % in business enterprise ⊙	2.4	75	○ ◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**19.5**	**76**	
6.1	**Knowledge creation**	**8.6**	**75**	
6.1.1	Patents by origin/bn PPP$ GDP	0.8	66	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	48	
6.1.3	Utility models by origin/bn PPP$ GDP	0.3	39	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.5	85	
6.1.5	Citable documents H-index	15.8	46	
6.2	**Knowledge impact**	**37.5**	**60**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.5	51	
6.2.2	New businesses/th pop. 15-64	2.3	45	
6.2.3	Computer software spending, % GDP	0.2	73	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	16.1	21	●
6.2.5	High- & medium-high-tech manufactures, %	0.2	53	
6.3	**Knowledge diffusion**	**12.5**	**90**	
6.3.1	Intellectual property receipts, % total trade	0.1	55	
6.3.2	High-tech net exports, % total trade	1.3	64	
6.3.3	ICT services exports, % total trade	0.7	92	
6.3.4	FDI net outflows, % GDP	1.4	44	
	CREATIVE OUTPUTS	**22.3**	**85**	
7.1	**Intangible assets**	**36.8**	**86**	
7.1.1	Trademarks by origin/bn PPP$ GDP	33.4	73	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.4	92	○
7.1.3	ICTs & business model creation†	60.3	65	
7.1.4	ICTs & organizational model creation†	54.5	62	
7.2	**Creative goods & services**	**9.9**	**87**	
7.2.1	Cultural & creative services exports, % total trade	0.3	68	
7.2.2	National feature films/mn pop. 15-69	1.4	73	
7.2.3	Entertainment & Media market/th pop. 15-69	5.5	47	
7.2.4	Printing & other media, % manufacturing	1.3	43	
7.2.5	Creative goods exports, % total trade	0.2	79	
7.3	**Online creativity**	**6.0**	**62**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	2.8	66	
7.3.2	Country-code TLDs/th pop. 15-69	17.4	29	●
7.3.3	Wikipedia edits/mn pop. 15-69	4.7	84	
7.3.4	Mobile app creation/bn PPP$ GDP	0.4	72	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

COSTA RICA

GII 2019 rank

55

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
48	**68**	**Upper middle**	**LCN**	**5.0**	**88.7**	**17,559.1**	**54**

		Score/Value	Rank	
	INSTITUTIONS	**61.9**	**68**	
1.1	**Political environment**	**58.4**	**58**	
1.1.1	Political and operational stability*	70.2	61	
1.1.2	Government effectiveness*	52.5	56	
1.2	**Regulatory environment**	**69.9**	**54**	
1.2.1	Regulatory quality*	54.0	48	
1.2.2	Rule of law*	58.4	43	◆
1.2.3	Cost of redundancy dismissal, salary weeks	18.7	76	
1.3	**Business environment**	**57.2**	**110**	○ ◇
1.3.1	Ease of starting a business*	79.9	108	
1.3.2	Ease of resolving insolvency*	34.5	111	○ ◇
	HUMAN CAPITAL & RESEARCH	**28.5**	**72**	
2.1	**Education**	**57.5**	**36**	
2.1.1	Expenditure on education, % GDP	7.4	7	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	23.9	28	
2.1.3	School life expectancy, years	15.4	41	
2.1.4	PISA scales in reading, maths, & science	415.8	54	
2.1.5	Pupil-teacher ratio, secondary ⏲	12.7	55	
2.2	**Tertiary education**	**19.6**	**95**	
2.2.1	Tertiary enrolment, % gross	55.6	52	
2.2.2	Graduates in science & engineering, %	14.4	90	○ ◇
2.2.3	Tertiary inbound mobility, %	1.3	84	
2.3	**Research & development (R&D)**	**8.3**	**64**	
2.3.1	Researchers, FTE/mn pop. ⏲	529.9	66	
2.3.2	Gross expenditure on R&D, % GDP ⏲	0.5	66	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	17.1	54	
	INFRASTRUCTURE	**47.0**	**63**	
3.1	**Information & communication technologies(ICTs)**	**68.7**	**59**	
3.1.1	ICT access*	65.6	67	
3.1.2	ICT use*	64.8	46	◆
3.1.3	Government's online service*	67.4	74	
3.1.4	E-participation*	77.0	57	
3.2	**General infrastructure**	**23.4**	**108**	
3.2.1	Electricity output, kWh/mn pop.	2,238.9	73	
3.2.2	Logistics performance*	34.1	72	
3.2.3	Gross capital formation, % GDP	17.8	105	○
3.3	**Ecological sustainability**	**49.0**	**34**	◆
3.3.1	GDP/unit of energy use	14.5	15	● ◆
3.3.2	Environmental performance*	67.9	29	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.4	59	
	MARKET SOPHISTICATION	**44.2**	**85**	
4.1	**Credit**	**37.8**	**60**	
4.1.1	Ease of getting credit*	85.0	11	● ◆
4.1.2	Domestic credit to private sector, % GDP	62.0	53	
4.1.3	Microfinance gross loans, % GDP ⏲	0.0	71	○
4.2	**Investment**	**32.2**	**112**	○
4.2.1	Ease of protecting minority investors*	48.3	99	
4.2.2	Market capitalization, % GDP	4.6	74	○ ◇
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**62.4**	**58**	
4.3.1	Applied tariff rate, weighted avg., % ⏲	1.8	22	●
4.3.2	Intensity of local competition†	72.9	39	
4.3.3	Domestic market scale, bn PPP$	88.7	84	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**33.2**	**52**	
5.1	**Knowledge workers**	**37.0**	**65**	
5.1.1	Knowledge-intensive employment, %	24.4	58	
5.1.2	Firms offering formal training, % firms ⏲	54.7	14	●
5.1.3	GERD performed by business, % GDP ⏲	0.2	54	
5.1.4	GERD financed by business, %	2.8	87	○ ◇
5.1.5	Females employed w/advanced degrees, %	10.5	63	
5.2	**Innovation linkages**	**18.8**	**95**	
5.2.1	University/industry research collaboration†	45.1	51	
5.2.2	State of cluster development†	49.6	51	
5.2.3	GERD financed by abroad, %	1.3	88	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	109	○ ◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	70	
5.3	**Knowledge absorption**	**43.8**	**29**	◆
5.3.1	Intellectual property payments, % total trade	2.8	8	● ◆
5.3.2	High-tech imports, % total trade	9.1	43	
5.3.3	ICT services imports, % total trade	1.4	50	
5.3.4	FDI net inflows, % GDP	5.0	30	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**24.3**	**56**	
6.1	**Knowledge creation**	**5.9**	**91**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	94	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	57	
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	49	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.0	81	
6.1.5	Citable documents H-index	10.1	66	
6.2	**Knowledge impact**	**36.9**	**62**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.3	38	
6.2.2	New businesses/th pop. 15–64	2.1	49	
6.2.3	Computer software spending, % GDP	0.3	46	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.6	67	
6.2.5	High- & medium-high-tech manufactures, %	0.3	41	
6.3	**Knowledge diffusion**	**30.2**	**30**	◆
6.3.1	Intellectual property receipts, % total trade	0.0	79	
6.3.2	High-tech net exports, % total trade	5.7	28	
6.3.3	ICT services exports, % total trade	6.1	7	● ◆
6.3.4	FDI net outflows, % GDP	0.7	60	
	CREATIVE OUTPUTS	**34.3**	**39**	◆
7.1	**Intangible assets**	**48.6**	**41**	
7.1.1	Trademarks by origin/bn PPP$ GDP	94.1	19	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.1	113	○
7.1.3	ICTs & business model creation†	68.3	34	◆
7.1.4	ICTs & organizational model creation†	63.0	36	◆
7.2	**Creative goods & services**	**34.8**	**16**	● ◆
7.2.1	Cultural & creative services exports, % total trade	4.2	1	● ◆
7.2.2	National feature films/mn pop. 15–69	3.7	50	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	2.2	15	●
7.2.5	Creative goods exports, % total trade	0.4	65	
7.3	**Online creativity**	**5.1**	**65**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	11.3	37	◆
7.3.2	Country-code TLDs/th pop. 15–69	1.4	70	
7.3.3	Wikipedia edits/mn pop. 15–69 ⏲	11.0	62	
7.3.4	Mobile app creation/bn PPP$ GDP	0.4	73	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⏲ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

CÔTE D'IVOIRE

GII 2019 rank

103

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
91	110	Lower middle	SSF	24.9	106.8	4,177.6	123

		Score/Value	Rank	
	INSTITUTIONS	**57.5**	**84**	
1.1	**Political environment**	**40.1**	**105**	
1.1.1	Political and operational stability*	63.2	86	
1.1.2	Government effectiveness*	28.6	116	◇
1.2	**Regulatory environment**	**61.6**	**77**	
1.2.1	Regulatory quality*	32.2	96	
1.2.2	Rule of law*	29.7	99	
1.2.3	Cost of redundancy dismissal, salary weeks	13.1	48	●
1.3	**Business environment**	**70.9**	**63**	
1.3.1	Ease of starting a business*	93.7	23	● ◆
1.3.2	Ease of resolving insolvency*	48.0	72	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**13.6**	**113**	
2.1	**Education**	**33.7**	**101**	
2.1.1	Expenditure on education, % GDP	4.4	65	
2.1.2	Government funding/pupil, secondary, % GDP/cap	23.5	33	●
2.1.3	School life expectancy, years	9.6	108	◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	26.3	100	
2.2	**Tertiary education**	**7.2**	**116**	◇
2.2.1	Tertiary enrolment, % gross ⊙	9.2	110	◇
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	2.1	73	
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**28.1**	**117**	◇
3.1	**Information & communication technologies(ICTs)**	**27.4**	**122**	○ ◇
3.1.1	ICT access*	37.0	107	
3.1.2	ICT use*	32.9	98	
3.1.3	Government's online service*	22.2	124	○ ◇
3.1.4	E-participation*	17.4	126	○ ◇
3.2	**General infrastructure**	**31.7**	**78**	
3.2.1	Electricity output, kWh/mn pop.	432.6	108	
3.2.2	Logistics performance*	47.6	49	● ◆
3.2.3	Gross capital formation, % GDP	23.7	58	
3.3	**Ecological sustainability**	**25.3**	**115**	
3.3.1	GDP/unit of energy use	6.4	95	
3.3.2	Environmental performance*	45.3	108	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	96	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**36.7**	**113**	◇
4.1	**Credit**	**31.2**	**87**	
4.1.1	Ease of getting credit*	70.0	40	●
4.1.2	Domestic credit to private sector, % GDP	26.5	102	
4.1.3	Microfinance gross loans, % GDP	0.8	27	●
4.2	**Investment**	**28.2**	**123**	○
4.2.1	Ease of protecting minority investors*	40.0	114	○ ◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	43	
4.3	**Trade, competition, & market scale**	**50.8**	**105**	
4.3.1	Applied tariff rate, weighted avg., %	10.3	114	◇
4.3.2	Intensity of local competition†	70.2	57	
4.3.3	Domestic market scale, bn PPP$	106.8	76	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.1**	**[94]**	
5.1	**Knowledge workers**	**28.8**	**[85]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms	35.5	39	●
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	0.8	108	
5.2	**Innovation linkages**	**17.4**	**[113]**	
5.2.1	University/industry research collaboration†	22.1	124	○ ◇
5.2.2	State of cluster development†	32.5	116	◇
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**32.1**	**72**	
5.3.1	Intellectual property payments, % total trade	0.0	114	○ ◇
5.3.2	High-tech imports, % total trade	5.6	96	
5.3.3	ICT services imports, % total trade	1.9	29	● ◆
5.3.4	FDI net inflows, % GDP	1.6	94	
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**19.7**	**74**	
6.1	**Knowledge creation**	**3.3**	**115**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	97	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.9	113	
6.1.5	Citable documents H-index	5.3	94	
6.2	**Knowledge impact**	**45.8**	**[26]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	5.1	7	● ◆
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.0	121	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.1	86	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**10.1**	**102**	
6.3.1	Intellectual property receipts, % total trade ⊙	0.0	91	
6.3.2	High-tech net exports, % total trade	1.1	66	
6.3.3	ICT services exports, % total trade	1.2	76	
6.3.4	FDI net outflows, % GDP	0.1	103	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**17.6**	**105**	
7.1	**Intangible assets**	**34.5**	**97**	
7.1.1	Trademarks by origin/bn PPP$ GDP	9.5	106	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.5	58	
7.1.3	ICTs & business model creation†	63.7	53	● ◆
7.1.4	ICTs & organizational model creation†	50.3	80	
7.2	**Creative goods & services**	**1.1**	**[124]**	
7.2.1	Cultural & creative services exports, % total trade	0.1	93	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.1	103	
7.3	**Online creativity**	**0.3**	**116**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.5	109	
7.3.2	Country-code TLDs/th pop. 15–69	0.2	108	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.5	108	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

CROATIA

GII 2019 rank

44

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
52	46	High	EUR	4.2	107.4	26,221.4	41

		Score/Value	Rank	
	INSTITUTIONS	**69.3**	**45**	
1.1	**Political environment**	**66.7**	**42**	
1.1.1	Political and operational stability*	78.9	42	
1.1.2	Government effectiveness*	60.5	41	
1.2	**Regulatory environment**	**71.7**	**46**	
1.2.1	Regulatory quality*	53.3	49	◇
1.2.2	Rule of law*	55.2	48	◇
1.2.3	Cost of redundancy dismissal, salary weeks	15.1	61	
1.3	**Business environment**	**69.4**	**68**	
1.3.1	Ease of starting a business*	82.6	95	○ ◇
1.3.2	Ease of resolving insolvency*	56.2	54	
	HUMAN CAPITAL & RESEARCH	**35.6**	**50**	
2.1	**Education**	**59.1**	**28**	●
2.1.1	Expenditure on education, % GDP ⊙	4.6	60	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	15.0	54	
2.1.4	PISA scales in reading, maths, & science	475.4	34	
2.1.5	Pupil-teacher ratio, secondary ⊙	6.7	1	● ◆
2.2	**Tertiary education**	**36.4**	**48**	
2.2.1	Tertiary enrolment, % gross ⊙	67.5	32	
2.2.2	Graduates in science & engineering, %	25.3	28	
2.2.3	Tertiary inbound mobility, %	0.4	98	○ ◇
2.3	**Research & development (R&D)**	**11.5**	**52**	◇
2.3.1	Researchers, FTE/mn pop.	1,865.4	42	
2.3.2	Gross expenditure on R&D, % GDP	0.9	41	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	4.7	68	◇
	INFRASTRUCTURE	**51.6**	**46**	
3.1	**Information & communication technologies(ICTs)**	**71.1**	**57**	◇
3.1.1	ICT access*	75.8	40	
3.1.2	ICT use*	63.4	49	◇
3.1.3	Government's online service*	68.1	73	◇
3.1.4	E-participation*	77.0	57	
3.2	**General infrastructure**	**30.7**	**85**	◇
3.2.1	Electricity output, kWh/mn pop.	3,025.2	63	
3.2.2	Logistics performance*	48.7	48	
3.2.3	Gross capital formation, % GDP	20.4	90	○
3.3	**Ecological sustainability**	**52.9**	**19**	●
3.3.1	GDP/unit of energy use	10.1	48	
3.3.2	Environmental performance*	65.5	37	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	9.5	6	● ◆
	MARKET SOPHISTICATION	**46.0**	**71**	
4.1	**Credit**	**40.6**	**53**	
4.1.1	Ease of getting credit*	55.0	77	
4.1.2	Domestic credit to private sector, % GDP	57.4	58	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**38.3**	**84**	
4.2.1	Ease of protecting minority investors*	66.7	35	
4.2.2	Market capitalization, % GDP	39.2	38	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	44	
4.3	**Trade, competition, & market scale**	**59.2**	**71**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	2.0	53	
4.3.2	Intensity of local competition†	57.1	117	○ ◇
4.3.3	Domestic market scale, bn PPP$	107.4	75	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**34.3**	**49**	
5.1	**Knowledge workers**	**52.3**	**33**	
5.1.1	Knowledge-intensive employment, %	36.3	34	
5.1.2	Firms offering formal training, % firms	49.3	22	●
5.1.3	GERD performed by business, % GDP	0.4	40	
5.1.4	GERD financed by business, %	42.9	42	
5.1.5	Females employed w/advanced degrees, %	16.8	37	
5.2	**Innovation linkages**	**18.5**	**99**	○ ◇
5.2.1	University/industry research collaboration†	27.7	111	○ ◇
5.2.2	State of cluster development†	30.4	119	○ ◇
5.2.3	GERD financed by abroad, %	10.8	37	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	46	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	56	
5.3	**Knowledge absorption**	**32.2**	**70**	
5.3.1	Intellectual property payments, % total trade	1.1	31	
5.3.2	High-tech imports, % total trade	6.1	91	○
5.3.3	ICT services imports, % total trade	1.5	43	
5.3.4	FDI net inflows, % GDP	2.5	70	
5.3.5	Research talent, % in business enterprise	21.3	56	◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**25.6**	**49**	
6.1	**Knowledge creation**	**17.9**	**50**	
6.1.1	Patents by origin/bn PPP$ GDP	1.5	53	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.4	40	
6.1.3	Utility models by origin/bn PPP$ GDP	0.5	34	
6.1.4	Scientific & technical articles/bn PPP$ GDP	22.7	19	●
6.1.5	Citable documents H-index	15.9	45	
6.2	**Knowledge impact**	**40.4**	**46**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.4	53	
6.2.2	New businesses/th pop. 15-64	5.0	27	●
6.2.3	Computer software spending, % GDP	0.1	99	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	23.3	12	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.2	51	
6.3	**Knowledge diffusion**	**18.5**	**56**	
6.3.1	Intellectual property receipts, % total trade	0.2	38	
6.3.2	High-tech net exports, % total trade	3.1	42	
6.3.3	ICT services exports, % total trade	2.8	36	
6.3.4	FDI net outflows, % GDP	0.2	88	○
	CREATIVE OUTPUTS	**31.0**	**51**	
7.1	**Intangible assets**	**40.6**	**65**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	46.8	54	
7.1.2	Industrial designs by origin/bn PPP$ GDP	4.9	27	●
7.1.3	ICTs & business model creation†	57.9	76	◇
7.1.4	ICTs & organizational model creation†	51.9	72	◇
7.2	**Creative goods & services**	**30.1**	**31**	●
7.2.1	Cultural & creative services exports, % total trade	1.9	7	● ◆
7.2.2	National feature films/mn pop. 15-69	2.0	64	◇
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	2.7	9	● ◆
7.2.5	Creative goods exports, % total trade	0.8	50	
7.3	**Online creativity**	**12.6**	**46**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	14.2	32	●
7.3.2	Country-code TLDs/th pop. 15-69	9.7	40	
7.3.3	Wikipedia edits/mn pop. 15-69	33.2	37	
7.3.4	Mobile app creation/bn PPP$ GDP	4.3	53	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

CYPRUS

GII 2019 rank

28

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
23	28	High	NAWA	1.2	33.8	39,973.2	29

		Score/Value	Rank	
	INSTITUTIONS	**80.3**	**25**	
1.1	**Political environment**	**72.8**	**34**	
1.1.1	Political and operational stability*	80.7	35	
1.1.2	Government effectiveness*	68.8	33	
1.2	**Regulatory environment**	**84.8**	**21**	
1.2.1	Regulatory quality*	69.6	31	
1.2.2	Rule of law*	69.8	33	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	● ◆
1.3	**Business environment**	**83.3**	**24**	
1.3.1	Ease of starting a business*	91.2	46	
1.3.2	Ease of resolving insolvency*	75.5	24	
	HUMAN CAPITAL & RESEARCH	**35.8**	**49**	
2.1	**Education**	**63.4**	**12**	
2.1.1	Expenditure on education, % GDP	6.4	16	
2.1.2	Government funding/pupil, secondary, % GDP/cap	39.4	3	● ◆
2.1.3	School life expectancy, years ⊙	14.6	62	◇
2.1.4	PISA scales in reading, maths, & science	437.5	46	
2.1.5	Pupil-teacher ratio, secondary ⊙	10.4	33	
2.2	**Tertiary education**	**37.5**	**42**	
2.2.1	Tertiary enrolment, % gross ⊙	60.1	45	
2.2.2	Graduates in science & engineering, %	15.9	82	○ ◇
2.2.3	Tertiary inbound mobility, % ⊙	17.5	8	◆
2.3	**Research & development (R&D)**	**6.5**	**71**	◇
2.3.1	Researchers, FTE/mn pop.	1,174.4	49	◇
2.3.2	Gross expenditure on R&D, % GDP	0.6	55	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**55.9**	**34**	
3.1	**Information & communication technologies(ICTs)**	**79.9**	**32**	
3.1.1	ICT access*	79.7	31	
3.1.2	ICT use*	79.6	18	
3.1.3	Government's online service*	78.5	51	
3.1.4	E-participation*	82.0	46	
3.2	**General infrastructure**	**29.9**	**86**	◇
3.2.1	Electricity output, kWh/mn pop.	5,749.4	36	
3.2.2	Logistics performance*	50.9	44	
3.2.3	Gross capital formation, % GDP	17.0	111	○ ◇
3.3	**Ecological sustainability**	**57.8**	**11**	
3.3.1	GDP/unit of energy use	12.2	28	
3.3.2	Environmental performance*	72.6	23	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	8.5	9	◆
	MARKET SOPHISTICATION	**58.2**	**24**	
4.1	**Credit**	**78.8**	**6**	● ◆
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	199.1	2	● ◆
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**38.0**	**86**	
4.2.1	Ease of protecting minority investors*	66.7	35	
4.2.2	Market capitalization, % GDP	12.9	66	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	25	
4.3	**Trade, competition, & market scale**	**57.7**	**76**	◇
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	76.0	20	
4.3.3	Domestic market scale, bn PPP$	33.8	111	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**47.6**	**24**	
5.1	**Knowledge workers**	**49.9**	**38**	
5.1.1	Knowledge-intensive employment, %	35.3	37	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.2	52	
5.1.4	GERD financed by business, %	34.9	53	
5.1.5	Females employed w/advanced degrees, %	24.6	14	◆
5.2	**Innovation linkages**	**36.4**	**36**	
5.2.1	University/industry research collaboration†	39.2	72	◇
5.2.2	State of cluster development†	46.3	67	
5.2.3	GERD financed by abroad, %	18.6	20	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.1	17	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	1.7	23	
5.3	**Knowledge absorption**	**56.3**	**9**	◆
5.3.1	Intellectual property payments, % total trade	1.0	36	
5.3.2	High-tech imports, % total trade	4.6	111	○ ◇
5.3.3	ICT services imports, % total trade	8.1	1	● ◆
5.3.4	FDI net inflows, % GDP	43.8	2	● ◆
5.3.5	Research talent, % in business enterprise	25.6	47	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**41.2**	**20**	
6.1	**Knowledge creation**	**24.6**	**35**	
6.1.1	Patents by origin/bn PPP$ GDP	1.9	47	
6.1.2	PCT patents by origin/bn PPP$ GDP	1.2	28	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	25.6	12	
6.1.5	Citable documents H-index	10.4	63	
6.2	**Knowledge impact**	**48.2**	**19**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.1	84	○
6.2.2	New businesses/th pop. 15-64	16.6	5	● ◆
6.2.3	Computer software spending, % GDP	0.2	71	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	29.6	4	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.2	60	
6.3	**Knowledge diffusion**	**50.6**	**10**	
6.3.1	Intellectual property receipts, % total trade	0.0	82	○
6.3.2	High-tech net exports, % total trade	0.4	86	◇
6.3.3	ICT services exports, % total trade	14.6	1	● ◆
6.3.4	FDI net outflows, % GDP	48.5	1	● ◆
	CREATIVE OUTPUTS	**41.1**	**28**	
7.1	**Intangible assets**	**44.2**	**52**	
7.1.1	Trademarks by origin/bn PPP$ GDP ⊙	97.0	17	◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.4	37	
7.1.3	ICTs & business model creation†	58.1	73	◇
7.1.4	ICTs & organizational model creation†	47.3	92	◇
7.2	**Creative goods & services**	**22.4**	**50**	
7.2.1	Cultural & creative services exports, % total trade	0.1	88	○ ◇
7.2.2	National feature films/mn pop. 15-69	6.8	32	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	2.4	12	◆
7.2.5	Creative goods exports, % total trade	0.5	59	
7.3	**Online creativity**	**53.6**	**9**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	75.2	7	● ◆
7.3.2	Country-code TLDs/th pop. 15-69	4.7	52	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	51.2	23	
7.3.4	Mobile app creation/bn PPP$ GDP	100.0	1	● ◆

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CZECH REPUBLIC (THE)

GII 2019 rank

26

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
21	**29**	**High**	**EUR**	**10.6**	**396.4**	**37,371.0**	**27**

		Score/Value	Rank	
	INSTITUTIONS	**78.6**	**29**	
1.1	**Political environment**	**75.6**	**31**	
1.1.1	Political and operational stability*	84.2	25	
1.1.2	Government effectiveness*	71.3	30	
1.2	**Regulatory environment**	**78.4**	**33**	
1.2.1	Regulatory quality*	75.0	25	
1.2.2	Rule of law*	75.9	26	
1.2.3	Cost of redundancy dismissal, salary weeks	20.2	83	○
1.3	**Business environment**	**81.8**	**29**	
1.3.1	Ease of starting a business*	83.6	89	○ ◇
1.3.2	Ease of resolving insolvency*	80.1	14	●
	HUMAN CAPITAL & RESEARCH	**43.4**	**34**	
2.1	**Education**	**59.7**	**26**	
2.1.1	Expenditure on education, % GDP	5.8	23	
2.1.2	Government funding/pupil, secondary, % GDP/cap	23.7	31	
2.1.3	School life expectancy, years	16.8	19	
2.1.4	PISA scales in reading, maths, & science	490.8	28	
2.1.5	Pupil-teacher ratio, secondary ◷	11.5	44	
2.2	**Tertiary education**	**43.2**	**26**	
2.2.1	Tertiary enrolment, % gross ◷	63.7	38	
2.2.2	Graduates in science & engineering, %	23.5	39	
2.2.3	Tertiary inbound mobility, %	11.5	15	
2.3	**Research & development (R&D)**	**27.3**	**40**	
2.3.1	Researchers, FTE/mn pop.	3,689.9	25	
2.3.2	Gross expenditure on R&D, % GDP	1.8	20	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	25.4	42	
	INFRASTRUCTURE	**56.4**	**32**	
3.1	**Information & communication technologies(ICTs)**	**67.3**	**64**	◇
3.1.1	ICT access*	71.9	60	◇
3.1.2	ICT use*	70.0	34	
3.1.3	Government's online service*	65.3	82	○ ◇
3.1.4	E-participation*	61.8	88	○ ◇
3.2	**General infrastructure**	**48.6**	**22**	
3.2.1	Electricity output, kWh/mn pop.	8,107.8	21	
3.2.2	Logistics performance*	75.6	22	
3.2.3	Gross capital formation, % GDP	26.5	37	
3.3	**Ecological sustainability**	**53.4**	**16**	●
3.3.1	GDP/unit of energy use	7.8	79	○
3.3.2	Environmental performance*	67.7	32	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	11.7	3	● ◆
	MARKET SOPHISTICATION	**52.4**	**46**	
4.1	**Credit**	**46.6**	**41**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	51.6	65	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**39.2**	**80**	○
4.2.1	Ease of protecting minority investors*	58.3	68	○
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	70	○
4.3	**Trade, competition, & market scale**	**71.5**	**31**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	78.2	16	
4.3.3	Domestic market scale, bn PPP$	396.4	46	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**46.3**	**25**	
5.1	**Knowledge workers**	**55.2**	**30**	
5.1.1	Knowledge-intensive employment, %	38.0	31	
5.1.2	Firms offering formal training, % firms	55.1	13	
5.1.3	GERD performed by business, % GDP	1.1	19	
5.1.4	GERD financed by business, %	39.3	46	
5.1.5	Females employed w/advanced degrees, %	12.2	58	◇
5.2	**Innovation linkages**	**34.5**	**40**	
5.2.1	University/industry research collaboration†	50.9	39	
5.2.2	State of cluster development†	50.5	46	
5.2.3	GERD financed by abroad, %	25.0	13	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	62	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.7	30	
5.3	**Knowledge absorption**	**49.1**	**21**	
5.3.1	Intellectual property payments, % total trade	0.8	47	
5.3.2	High-tech imports, % total trade	17.4	8	● ◆
5.3.3	ICT services imports, % total trade	1.3	55	
5.3.4	FDI net inflows, % GDP	3.6	47	
5.3.5	Research talent, % in business enterprise	51.6	23	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**43.8**	**16**	●
6.1	**Knowledge creation**	**35.1**	**24**	
6.1.1	Patents by origin/bn PPP$ GDP	2.7	34	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.5	37	
6.1.3	Utility models by origin/bn PPP$ GDP	3.2	6	● ◆
6.1.4	Scientific & technical articles/bn PPP$ GDP	23.4	17	
6.1.5	Citable documents H-index	28.8	31	
6.2	**Knowledge impact**	**54.5**	**10**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	1.7	47	
6.2.2	New businesses/th pop. 15–64	4.0	31	
6.2.3	Computer software spending, % GDP	0.3	35	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	29.7	3	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.6	5	● ◆
6.3	**Knowledge diffusion**	**41.7**	**19**	
6.3.1	Intellectual property receipts, % total trade	0.3	30	
6.3.2	High-tech net exports, % total trade	17.1	1	● ◆
6.3.3	ICT services exports, % total trade	2.3	45	
6.3.4	FDI net outflows, % GDP	1.7	35	
	CREATIVE OUTPUTS	**43.1**	**21**	
7.1	**Intangible assets**	**50.0**	**36**	
7.1.1	Trademarks by origin/bn PPP$ GDP	61.9	34	
7.1.2	Industrial designs by origin/bn PPP$ GDP	6.5	21	
7.1.3	ICTs & business model creation†	65.7	49	
7.1.4	ICTs & organizational model creation†	66.3	26	
7.2	**Creative goods & services**	**42.2**	**6**	● ◆
7.2.1	Cultural & creative services exports, % total trade	0.5	47	
7.2.2	National feature films/mn pop. 15–69	7.1	29	
7.2.3	Entertainment & Media market/th pop. 15–69	22.2	26	
7.2.4	Printing & other media, % manufacturing	1.0	66	○
7.2.5	Creative goods exports, % total trade	10.1	1	● ◆
7.3	**Online creativity**	**30.1**	**26**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	17.1	30	
7.3.2	Country-code TLDs/th pop. 15–69	48.5	15	●
7.3.3	Wikipedia edits/mn pop. 15–69	56.1	18	
7.3.4	Mobile app creation/bn PPP$ GDP	17.2	27	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

DENMARK

GII 2019 rank

7

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
12	5	High	EUR	5.8	300.3	52,120.5	8

		Score/Value	Rank
	INSTITUTIONS	**91.7**	**6 ●**
1.1	**Political environment**	**91.1**	**10**
1.1.1	Political and operational stability*	93.0	7
1.1.2	Government effectiveness*	90.1	9
1.2	**Regulatory environment**	**95.3**	**7**
1.2.1	Regulatory quality*	85.5	16
1.2.2	Rule of law*	95.7	6 ●
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1 ●
1.3	**Business environment**	**88.8**	**8**
1.3.1	Ease of starting a business*	92.5	38
1.3.2	Ease of resolving insolvency*	85.1	6 ●
	HUMAN CAPITAL & RESEARCH	**63.1**	**4 ● ◆**
2.1	**Education**	**73.5**	**2 ● ◆**
2.1.1	Expenditure on education, % GDP ⊙	7.6	3 ● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	31.1	11 ◆
2.1.3	School life expectancy, years	19.1	5 ●
2.1.4	PISA scales in reading, maths, & science	504.3	16
2.1.5	Pupil-teacher ratio, secondary ⊙	11.3	41
2.2	**Tertiary education**	**42.6**	**29**
2.2.1	Tertiary enrolment, % gross ⊙	81.1	18
2.2.2	Graduates in science & engineering, %	21.0	58 ○
2.2.3	Tertiary inbound mobility, %	10.8	17
2.3	**Research & development (R&D)**	**73.3**	**8**
2.3.1	Researchers, FTE/mn pop	7,923.2	2 ● ◆
2.3.2	Gross expenditure on R&D, % GDP	3.1	7
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	72.8	16
2.3.4	QS university ranking, average score top 3*	57.1	15
	INFRASTRUCTURE	**65.8**	**6 ●**
3.1	**Information & communication technologies(ICTs)**	**93.1**	**2 ● ◆**
3.1.1	ICT access*	82.5	18
3.1.2	ICT use*	90.0	1 ● ◆
3.1.3	Government's online service*	100.0	1 ● ◆
3.1.4	E-participation*	100.0	1 ●
3.2	**General infrastructure**	**44.1**	**33**
3.2.1	Electricity output, kWh/mn pop	5,273.1	40
3.2.2	Logistics performance*	90.2	8
3.2.3	Gross capital formation, % GDP	21.4	83 ○
3.3	**Ecological sustainability**	**60.1**	**7**
3.3.1	GDP/unit of energy use	15.6	13
3.3.2	Environmental performance*	81.6	3 ●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	3.9	28
	MARKET SOPHISTICATION	**66.9**	**9**
4.1	**Credit**	**75.3**	**7**
4.1.1	Ease of getting credit*	70.0	40
4.1.2	Domestic credit to private sector, % GDP	165.4	6 ●
4.1.3	Microfinance gross loans, % GDP	n/a	n/a
4.2	**Investment**	**57.1**	**26**
4.2.1	Ease of protecting minority investors*	66.7	35
4.2.2	Market capitalization, % GDP	n/a	n/a
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	12
4.3	**Trade, competition, & market scale**	**68.2**	**41**
4.3.1	Applied tariff rate, weighted avg., %	1.8	23
4.3.2	Intensity of local competition†	70.9	50
4.3.3	Domestic market scale, bn PPP$	300.3	56 ○

		Score/Value	Rank
	BUSINESS SOPHISTICATION	**59.1**	**9**
5.1	**Knowledge workers**	**71.6**	**8**
5.1.1	Knowledge-intensive employment, %	46.3	13
5.1.2	Firms offering formal training, % firms	n/a	n/a
5.1.3	GERD performed by business, % GDP	2.0	9
5.1.4	GERD financed by business, %	58.5	13
5.1.5	Females employed w/advanced degrees, %	22.2	18
5.2	**Innovation linkages**	**56.4**	**7**
5.2.1	University/industry research collaboration†	64.0	19
5.2.2	State of cluster development†	63.9	19
5.2.3	GERD financed by abroad, %	8.9	46 ○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.1	14
5.2.5	Patent families 2+ offices/bn PPP$ GDP	5.8	10
5.3	**Knowledge absorption**	**49.3**	**20**
5.3.1	Intellectual property payments, % total trade	1.0	39
5.3.2	High-tech imports, % total trade	5.7	94 ○
5.3.3	ICT services imports, % total trade	3.0	9
5.3.4	FDI net inflows, % GDP	1.3	102 ○
5.3.5	Research talent, % in business enterprise	60.5	13
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**46.4**	**14**
6.1	**Knowledge creation**	**52.0**	**12**
6.1.1	Patents by origin/bn PPP$ GDP	12.5	8
6.1.2	PCT patents by origin/bn PPP$ GDP	4.8	8
6.1.3	Utility models by origin/bn PPP$ GDP	0.3	37 ○
6.1.4	Scientific & technical articles/bn PPP$ GDP	35.6	1 ● ◆
6.1.5	Citable documents H-index	50.2	15
6.2	**Knowledge impact**	**48.9**	**16**
6.2.1	Growth rate of PPP$ GDP/worker, %	0.3	81 ○
6.2.2	New businesses/th pop. 15-64	9.9	13
6.2.3	Computer software spending, % GDP	0.6	12
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	9.2	34
6.2.5	High- & medium-high-tech manufactures, %	0.4	16
6.3	**Knowledge diffusion**	**38.4**	**21**
6.3.1	Intellectual property receipts, % total trade	1.7	13
6.3.2	High-tech net exports, % total trade	5.2	30
6.3.3	ICT services exports, % total trade	2.7	38
6.3.4	FDI net outflows, % GDP	3.5	18
	CREATIVE OUTPUTS	**48.6**	**11**
7.1	**Intangible assets**	**54.3**	**23**
7.1.1	Trademarks by origin/bn PPP$ GDP	44.7	57 ○
7.1.2	Industrial designs by origin/bn PPP$ GDP	6.8	20
7.1.3	ICTs & business model creation†	74.4	20
7.1.4	ICTs & organizational model creation†	78.9	7
7.2	**Creative goods & services**	**30.7**	**28**
7.2.1	Cultural & creative services exports, % total trade	0.6	44
7.2.2	National feature films/mn pop. 15-69	13.5	9
7.2.3	Entertainment & Media market/th pop. 15-69	78.0	4
7.2.4	Printing & other media, % manufacturing	1.0	69 ○
7.2.5	Creative goods exports, % total trade	1.6	33
7.3	**Online creativity**	**55.3**	**8**
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	48.7	16
7.3.2	Country-code TLDs/th pop. 15-69	91.9	4 ● ◆
7.3.3	Wikipedia edits/mn pop. 15-69	48.0	26
7.3.4	Mobile app creation/bn PPP$ GDP	48.5	11

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

DOMINICAN REPUBLIC (THE)

GII 2019 rank

87

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
88	90	Upper middle	LCN	10.9	188.3	18,424.6	87

		Score/Value	Rank	
	INSTITUTIONS	**54.3**	**94**	◇
1.1	**Political environment**	**47.5**	**89**	
1.1.1	Political and operational stability*	66.7	74	
1.1.2	Government effectiveness*	38.0	92	
1.2	**Regulatory environment**	**54.9**	**98**	
1.2.1	Regulatory quality*	39.8	74	
1.2.2	Rule of law*	35.3	91	
1.2.3	Cost of redundancy dismissal, salary weeks	26.2	103	
1.3	**Business environment**	**60.5**	**103**	
1.3.1	Ease of starting a business*	83.4	90	
1.3.2	Ease of resolving insolvency*	37.5	106	◇
	HUMAN CAPITAL & RESEARCH	**18.0**	**101**	◇
2.1	**Education**	**37.3**	**91**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	19.1	54	
2.1.3	School life expectancy, years	14.2	69	
2.1.4	PISA scales in reading, maths, & science	339.0	70	○
2.1.5	Pupil-teacher ratio, secondary	18.6	82	
2.2	**Tertiary education**	**16.9**	**98**	◇
2.2.1	Tertiary enrolment, % gross	59.9	46	●
2.2.2	Graduates in science & engineering, %	11.6	97	○ ◇
2.2.3	Tertiary inbound mobility, %	1.7	79	
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**44.6**	**73**	
3.1	**Information & communication technologies(ICTs)**	**55.8**	**83**	
3.1.1	ICT access*	46.1	96	◇
3.1.2	ICT use*	43.0	82	
3.1.3	Government's online service*	66.0	79	
3.1.4	E-participation*	68.0	77	
3.2	**General infrastructure**	**28.7**	**89**	
3.2.1	Electricity output, kWh/mn pop	1,822.9	80	
3.2.2	Logistics performance*	28.0	84	
3.2.3	Gross capital formation, % GDP	24.3	52	●
3.3	**Ecological sustainability**	**49.4**	**32**	● ◆
3.3.1	GDP/unit of energy use	16.7	8	● ◆
3.3.2	Environmental performance*	64.7	42	● ◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	118	○
	MARKET SOPHISTICATION	**46.1**	**70**	
4.1	**Credit**	**19.2**	**119**	○ ◇
4.1.1	Ease of getting credit*	45.0	94	◇
4.1.2	Domestic credit to private sector, % GDP	28.7	98	
4.1.3	Microfinance gross loans, % GDP	0.1	57	
4.2	**Investment**	**56.7**	**[27]**	
4.2.1	Ease of protecting minority investors*	56.7	79	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**62.3**	**59**	
4.3.1	Applied tariff rate, weighted avg., %	4.2	75	
4.3.2	Intensity of local competition†	70.3	56	●
4.3.3	Domestic market scale, bn PPP$	188.3	65	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.3**	**[90]**	
5.1	**Knowledge workers**	**27.1**	**[89]**	
5.1.1	Knowledge-intensive employment, %	16.0	88	
5.1.2	Firms offering formal training, % firms	23.4	68	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	9.4	70	
5.2	**Innovation linkages**	**25.2**	**[64]**	
5.2.1	University/industry research collaboration†	31.8	101	
5.2.2	State of cluster development†	46.9	59	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	85	
5.3	**Knowledge absorption**	**26.5**	**95**	
5.3.1	Intellectual property payments, % total trade	0.5	62	
5.3.2	High-tech imports, % total trade	6.5	83	
5.3.3	ICT services imports, % total trade	0.5	107	
5.3.4	FDI net inflows, % GDP	3.8	44	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.6**	**95**	
6.1	**Knowledge creation**	**0.9**	**129**	○ ◇
6.1.1	Patents by origin/bn PPP$ GDP	0.1	109	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	89	
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	59	○
6.1.4	Scientific & technical articles/bn PPP$ GDP	0.3	128	○ ◇
6.1.5	Citable documents H-index	2.0	118	○
6.2	**Knowledge impact**	**31.8**	**87**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.5	31	●
6.2.2	New businesses/th pop. 15–64	1.5	61	
6.2.3	Computer software spending, % GDP	0.0	118	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.0	106	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**14.1**	**81**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	2.2	52	●
6.3.3	ICT services exports, % total trade	0.7	87	
6.3.4	FDI net outflows, % GDP	0.1	101	
	CREATIVE OUTPUTS	**22.9**	**81**	
7.1	**Intangible assets**	**36.4**	**88**	
7.1.1	Trademarks by origin/bn PPP$ GDP	46.8	53	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	101	
7.1.3	ICTs & business model creation†	59.3	68	
7.1.4	ICTs & organizational model creation†	48.9	84	
7.2	**Creative goods & services**	**16.9**	**[63]**	
7.2.1	Cultural & creative services exports, % total trade	0.2	74	
7.2.2	National feature films/mn pop. 15–69	3.5	52	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	2.2	25	●
7.3	**Online creativity**	**1.9**	**86**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	2.5	71	
7.3.2	Country-code TLDs/th pop. 15–69	1.1	78	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	5.7	78	
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	92	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ECUADOR

GII 2019 rank

99

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
98	98	Upper middle	LCN	16.9	199.7	11,718.1	97

		Score/Value	Rank	
	INSTITUTIONS	**44.7**	**125**	○ ◇
1.1	**Political environment**	**43.4**	**95**	◇
1.1.1	Political and operational stability*	52.6	118	○ ◇
1.1.2	Government effectiveness*	38.8	90	
1.2	**Regulatory environment**	**42.6**	**119**	◇
1.2.1	Regulatory quality*	15.1	123	○ ◇
1.2.2	Rule of law*	27.8	106	◇
1.2.3	Cost of redundancy dismissal, salary weeks	31.8	119	○ ◇
1.3	**Business environment**	**48.0**	**126**	○ ◇
1.3.1	Ease of starting a business*	70.6	121	○ ◇
1.3.2	Ease of resolving insolvency*	25.4	126	○ ◇

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**21.1**	**91**	
2.1	**Education**	**37.3**	**92**	
2.1.1	Expenditure on education, % GDP	5.0	49	●
2.1.2	Government funding/pupil, secondary, % GDP/cap	5.3	104	○ ◇
2.1.3	School life expectancy, years ◷	15.4	42	●
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ◷	21.9	92	◇
2.2	**Tertiary education**	**19.1**	**97**	
2.2.1	Tertiary enrolment, % gross ◷	45.5	64	
2.2.2	Graduates in science & engineering, %	15.8	83	
2.2.3	Tertiary inbound mobility, % ◷	0.8	92	
2.3	**Research & development (R&D)**	**6.9**	**70**	
2.3.1	Researchers, FTE/mn pop. ◷	400.7	71	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.4	68	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	13.6	59	●

		Score/Value	Rank	
	INFRASTRUCTURE	**43.4**	**78**	
3.1	**Information & communication technologies(ICTs)**	**58.4**	**80**	
3.1.1	ICT access*	51.0	86	◇
3.1.2	ICT use*	42.4	83	
3.1.3	Government's online service*	72.9	63	
3.1.4	E-participation*	67.4	79	
3.2	**General infrastructure**	**32.2**	**73**	
3.2.1	Electricity output, kWh/mn pop.	1,666.5	84	
3.2.2	Logistics performance*	38.3	61	
3.2.3	Gross capital formation, % GDP	25.3	44	●
3.3	**Ecological sustainability**	**39.6**	**57**	●
3.3.1	GDP/unit of energy use	11.6	34	●
3.3.2	Environmental performance*	57.4	76	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.0	64	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**43.3**	**89**	
4.1	**Credit**	**24.7**	**109**	
4.1.1	Ease of getting credit*	45.0	94	◇
4.1.2	Domestic credit to private sector, % GDP	32.3	91	
4.1.3	Microfinance gross loans, % GDP	0.9	19	●
4.2	**Investment**	**46.7**	**[48]**	
4.2.1	Ease of protecting minority investors*	46.7	101	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**58.5**	**73**	
4.3.1	Applied tariff rate, weighted avg., %	7.0	98	◇
4.3.2	Intensity of local competition†	69.8	62	
4.3.3	Domestic market scale, bn PPP$	199.7	60	●

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**24.6**	**102**	
5.1	**Knowledge workers**	**37.4**	**61**	
5.1.1	Knowledge-intensive employment, %	13.4	93	◇
5.1.2	Firms offering formal training, % firms	73.7	2	● ◆
5.1.3	GERD performed by business, % GDP ◷	0.2	53	
5.1.4	GERD financed by business, % ◷	0.1	96	○ ◇
5.1.5	Females employed w/advanced degrees, %	8.8	76	
5.2	**Innovation linkages**	**14.9**	**119**	◇
5.2.1	University/industry research collaboration†	34.5	95	
5.2.2	State of cluster development†	36.5	103	◇
5.2.3	GERD financed by abroad, % ◷	2.5	74	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	97	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	83	
5.3	**Knowledge absorption**	**21.6**	**115**	◇
5.3.1	Intellectual property payments, % total trade	0.2	83	
5.3.2	High-tech imports, % total trade	8.1	55	●
5.3.3	ICT services imports, % total trade	0.0	127	○ ◇
5.3.4	FDI net inflows, % GDP	0.9	105	◇
5.3.5	Research talent, % in business enterprise ◷	15.0	61	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.0**	**100**	
6.1	**Knowledge creation**	**5.8**	**93**	
6.1.1	Patents by origin/bn PPP$ GDP	0.1	114	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	56	
6.1.3	Utility models by origin/bn PPP$ GDP	0.2	45	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.9	70	
6.1.5	Citable documents H-index	8.0	79	
6.2	**Knowledge impact**	**29.7**	**95**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-2.0	108	○ ◇
6.2.2	New businesses/th pop. 15-64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.2	64	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	6.1	51	●
6.2.5	High- & medium-high-tech manufactures, %	0.1	74	
6.3	**Knowledge diffusion**	**9.5**	**104**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.4	84	
6.3.3	ICT services exports, % total trade	0.2	116	
6.3.4	FDI net outflows, % GDP	0.3	83	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**20.4**	**93**	
7.1	**Intangible assets**	**35.9**	**94**	
7.1.1	Trademarks by origin/bn PPP$ GDP	42.8	61	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.0	67	
7.1.3	ICTs & business model creation†	53.3	92	
7.1.4	ICTs & organizational model creation†	52.9	66	
7.2	**Creative goods & services**	**8.1**	**93**	
7.2.1	Cultural & creative services exports, % total trade	0.1	85	
7.2.2	National feature films/mn pop. 15-69 ◷	2.1	62	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.1	60	
7.2.5	Creative goods exports, % total trade	0.1	110	
7.3	**Online creativity**	**1.7**	**88**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	2.1	77	
7.3.2	Country-code TLDs/th pop. 15-69	1.1	79	
7.3.3	Wikipedia edits/mn pop. 15-69 ◷	5.0	82	
7.3.4	Mobile app creation/bn PPP$ GDP	0.4	70	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

EGYPT

GII 2019 rank

92

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
74	106	Lower middle	NAWA	99.4	1,297.0	13,366.5	95

		Score/Value	Rank	
	INSTITUTIONS	**47.9**	**118**	○
1.1	**Political environment**	**39.7**	**106**	
1.1.1	Political and operational stability*	56.1	105	
1.1.2	Government effectiveness*	31.5	104	
1.2	**Regulatory environment**	**40.8**	**120**	○
1.2.1	Regulatory quality*	18.8	120	○ ◇
1.2.2	Rule of law*	32.2	95	
1.2.3	Cost of redundancy dismissal, salary weeks	36.8	121	○
1.3	**Business environment**	**63.2**	**90**	
1.3.1	Ease of starting a business*	84.1	84	
1.3.2	Ease of resolving insolvency*	42.3	89	
	HUMAN CAPITAL & RESEARCH	**19.7**	**96**	
2.1	**Education**	**37.0**	**94**	
2.1.1	Expenditure on education, % GDP ⊙	3.8	89	
2.1.2	Government funding/pupil, secondary, % GDP/cap	14.0	86	
2.1.3	School life expectancy, years	13.1	80	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	15.2	68	
2.2	**Tertiary education**	**11.4**	**108**	
2.2.1	Tertiary enrolment, % gross ⊙	34.4	77	
2.2.2	Graduates in science & engineering, %	11.2	99	○ ◇
2.2.3	Tertiary inbound mobility, %	1.8	77	
2.3	**Research & development (R&D)**	**10.7**	**55**	
2.3.1	Researchers, FTE/mn pop.	669.4	61	
2.3.2	Gross expenditure on R&D, % GDP	0.6	51	◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	21.9	48	● ◆
	INFRASTRUCTURE	**36.8**	**94**	
3.1	**Information & communication technologies(ICTs)**	**49.4**	**96**	
3.1.1	ICT access*	55.6	78	
3.1.2	ICT use*	34.7	95	
3.1.3	Government's online service*	53.5	101	
3.1.4	E-participation*	53.9	100	
3.2	**General infrastructure**	**21.1**	**116**	○
3.2.1	Electricity output, kWh/mn pop.	2,030.8	76	◆
3.2.2	Logistics performance*	35.6	66	
3.2.3	Gross capital formation, % GDP	15.5	118	○ ◇
3.3	**Ecological sustainability**	**39.9**	**55**	◆
3.3.1	GDP/unit of energy use	11.2	39	●
3.3.2	Environmental performance*	61.2	59	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.6	81	
	MARKET SOPHISTICATION	**41.0**	**97**	
4.1	**Credit**	**25.8**	**103**	
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	28.5	99	
4.1.3	Microfinance gross loans, % GDP	0.1	58	
4.2	**Investment**	**30.8**	**119**	○
4.2.1	Ease of protecting minority investors*	58.3	68	
4.2.2	Market capitalization, % GDP	15.5	63	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	63	
4.3	**Trade, competition, & market scale**	**66.4**	**48**	●
4.3.1	Applied tariff rate, weighted avg., %	7.4	101	
4.3.2	Intensity of local competition†	65.7	77	
4.3.3	Domestic market scale, bn PPP$	1,297.0	21	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**21.2**	**116**	○ ◇
5.1	**Knowledge workers**	**21.1**	**106**	
5.1.1	Knowledge-intensive employment, %	30.3	43	● ◆
5.1.2	Firms offering formal training, % firms	10.0	89	○ ◇
5.1.3	GERD performed by business, % GDP	0.0	76	
5.1.4	GERD financed by business, %	5.4	79	
5.1.5	Females employed w/advanced degrees, %	5.5	89	
5.2	**Innovation linkages**	**17.5**	**110**	
5.2.1	University/industry research collaboration†	30.0	106	
5.2.2	State of cluster development†	53.9	38	● ◆
5.2.3	GERD financed by abroad, %	0.0	101	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	98	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	88	
5.3	**Knowledge absorption**	**24.9**	**103**	
5.3.1	Intellectual property payments, % total trade	0.4	71	
5.3.2	High-tech imports, % total trade	6.8	73	
5.3.3	ICT services imports, % total trade	1.1	68	
5.3.4	FDI net inflows, % GDP	2.6	69	
5.3.5	Research talent, % in business enterprise	6.5	69	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**22.1**	**64**	
6.1	**Knowledge creation**	**11.1**	**66**	
6.1.1	Patents by origin/bn PPP$ GDP ⊙	0.8	68	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	81	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	7.1	61	
6.1.5	Citable documents H-index	15.5	48	●
6.2	**Knowledge impact**	**43.7**	**32**	●
6.2.1	Growth rate of PPP$ GDP/worker, %	2.5	32	●
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.4	21	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.8	89	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.2	52	
6.3	**Knowledge diffusion**	**11.6**	**94**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.1	113	
6.3.3	ICT services exports, % total trade	1.2	73	
6.3.4	FDI net outflows, % GDP	0.1	102	
	CREATIVE OUTPUTS	**21.1**	**89**	
7.1	**Intangible assets**	**35.8**	**95**	
7.1.1	Trademarks by origin/bn PPP$ GDP ⊙	11.2	104	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.7	56	
7.1.3	ICTs & business model creation†	61.0	59	
7.1.4	ICTs & organizational model creation†	56.0	57	
7.2	**Creative goods & services**	**12.1**	**77**	
7.2.1	Cultural & creative services exports, % total trade	0.1	80	
7.2.2	National feature films/mn pop. 15–69 ⊙	0.6	93	
7.2.3	Entertainment & Media market/th pop. 15–69	0.5	61	○
7.2.4	Printing & other media, % manufacturing ⊙	1.4	35	●
7.2.5	Creative goods exports, % total trade	1.1	41	●
7.3	**Online creativity**	**0.7**	**103**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.2	91	
7.3.2	Country-code TLDs/th pop. 15–69	0.0	123	○
7.3.3	Wikipedia edits/mn pop. 15–69	2.5	97	
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	82	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

EL SALVADOR

GII 2019 rank

108

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
116	97	Lower middle	LCN	6.4	53.7	8,041.2	104

		Score/Value	Rank	
	INSTITUTIONS	**53.9**	**95**	
1.1	**Political environment**	**45.6**	**92**	
1.1.1	Political and operational stability*	61.4	91	
1.1.2	Government effectiveness*	37.7	93	
1.2	**Regulatory environment**	**54.1**	**101**	
1.2.1	Regulatory quality*	37.9	83	
1.2.2	Rule of law*	23.7	114	
1.2.3	Cost of redundancy dismissal, salary weeks	22.9	95	
1.3	**Business environment**	**62.0**	**94**	
1.3.1	Ease of starting a business*	78.4	111	
1.3.2	Ease of resolving insolvency*	45.6	80	
	HUMAN CAPITAL & RESEARCH	**18.3**	**99**	
2.1	**Education**	**29.7**	**108**	
2.1.1	Expenditure on education, % GDP	3.8	90	
2.1.2	Government funding/pupil, secondary, % GDP/cap	15.1	84	
2.1.3	School life expectancy, years	11.7	92	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	27.8	102	◇
2.2	**Tertiary education**	**24.4**	**82**	
2.2.1	Tertiary enrolment, % gross	28.7	84	
2.2.2	Graduates in science & engineering, %	22.3	48	
2.2.3	Tertiary inbound mobility, %	0.4	99	
2.3	**Research & development (R&D)**	**0.9**	**107**	
2.3.1	Researchers, FTE/mn pop. ⊕	65.9	89	
2.3.2	Gross expenditure on R&D, % GDP ⊕	0.1	96	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**35.7**	**98**	
3.1	**Information & communication technologies(ICTs)**	**52.2**	**92**	
3.1.1	ICT access*	48.3	93	
3.1.2	ICT use*	33.0	97	
3.1.3	Government's online service*	62.5	89	
3.1.4	E-participation*	65.2	80	
3.2	**General infrastructure**	**17.9**	**121**	◇
3.2.1	Electricity output, kWh/mn pop.	942.4	95	
3.2.2	Logistics performance*	23.9	95	
3.2.3	Gross capital formation, % GDP	16.1	116	◇
3.3	**Ecological sustainability**	**36.8**	**70**	
3.3.1	GDP/unit of energy use	11.4	38	●
3.3.2	Environmental performance*	53.9	87	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	94	
	MARKET SOPHISTICATION	**44.8**	**81**	
4.1	**Credit**	**36.7**	**63**	
4.1.1	Ease of getting credit*	80.0	20	●
4.1.2	Domestic credit to private sector, % GDP	51.7	64	
4.1.3	Microfinance gross loans, % GDP	0.4	34	
4.2	**Investment**	**38.3**	**[85]**	
4.2.1	Ease of protecting minority investors*	38.3	122	○ ◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**59.2**	**72**	
4.3.1	Applied tariff rate, weighted avg., %	2.1	55	◆
4.3.2	Intensity of local competition†	72.8	40	● ◆
4.3.3	Domestic market scale, bn PPP$	53.7	95	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**25.5**	**97**	
5.1	**Knowledge workers**	**33.0**	**79**	
5.1.1	Knowledge-intensive employment, %	10.6	99	
5.1.2	Firms offering formal training, % firms	53.8	15	● ◆
5.1.3	GERD performed by business, % GDP ⊕	0.1	69	
5.1.4	GERD financed by business, %	40.2	44	◆
5.1.5	Females employed w/advanced degrees, %	3.5	95	
5.2	**Innovation linkages**	**12.4**	**124**	○ ◇
5.2.1	University/industry research collaboration†	27.6	113	
5.2.2	State of cluster development†	29.7	122	○ ◇
5.2.3	GERD financed by abroad, %	3.0	71	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	107	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**31.1**	**81**	
5.3.1	Intellectual property payments, % total trade	1.3	25	● ◆
5.3.2	High-tech imports, % total trade	8.7	47	●
5.3.3	ICT services imports, % total trade	0.6	100	
5.3.4	FDI net inflows, % GDP	1.8	84	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**7.9**	**121**	◇
6.1	**Knowledge creation**	**0.9**	**128**	○
6.1.1	Patents by origin/bn PPP$ GDP	0.1	116	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	91	
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	56	
6.1.4	Scientific & technical articles/bn PPP$ GDP	0.5	126	○
6.1.5	Citable documents H-index	1.4	123	○ ◇
6.2	**Knowledge impact**	**5.1**	**[121]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15-64	0.5	86	
6.2.3	Computer software spending, % GDP	0.0	105	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	4.0	64	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**17.9**	**60**	
6.3.1	Intellectual property receipts, % total trade	0.5	26	● ◆
6.3.2	High-tech net exports, % total trade	2.7	47	●
6.3.3	ICT services exports, % total trade	2.2	50	●
6.3.4	FDI net outflows, % GDP	-0.3	122	○ ◇
	CREATIVE OUTPUTS	**20.4**	**94**	
7.1	**Intangible assets**	**38.0**	**79**	
7.1.1	Trademarks by origin/bn PPP$ GDP	98.2	15	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	102	
7.1.3	ICTs & business model creation†	49.3	108	
7.1.4	ICTs & organizational model creation†	42.7	102	
7.2	**Creative goods & services**	**4.0**	**[107]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	113	
7.2.2	National feature films/mn pop. 15-69 ⊕	0.3	102	○
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.7	53	
7.3	**Online creativity**	**1.6**	**92**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	2.5	73	◆
7.3.2	Country-code TLDs/th pop. 15-69	0.5	92	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊕	4.8	83	
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	95	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ESTONIA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
19	**27**	**High**	**EUR**	**1.3**	**44.2**	**34,095.8**	**24**

		Score/Value	Rank	
	INSTITUTIONS	**81.7**	**23**	
1.1	**Political environment**	**78.3**	**25**	◇
1.1.1	Political and operational stability*	87.7	18	
1.1.2	Government effectiveness*	73.6	27	◇
1.2	**Regulatory environment**	**87.8**	**18**	
1.2.1	Regulatory quality*	86.0	14	
1.2.2	Rule of law*	80.3	22	
1.2.3	Cost of redundancy dismissal, salary weeks	12.9	39	
1.3	**Business environment**	**78.9**	**36**	◇
1.3.1	Ease of starting a business*	95.3	13	
1.3.2	Ease of resolving insolvency*	62.5	44	◇
	HUMAN CAPITAL & RESEARCH	**42.1**	**36**	◇
2.1	**Education**	**56.9**	**40**	
2.1.1	Expenditure on education, % GDP	5.2	41	
2.1.2	Government funding/pupil, secondary, % GDP/cap	18.1	60	◇
2.1.3	School life expectancy, years	16.1	34	
2.1.4	PISA scales in reading, maths, & science	524.3	4	●
2.1.5	Pupil-teacher ratio, secondary ⊙	8.8	16	◆
2.2	**Tertiary education**	**46.0**	**20**	
2.2.1	Tertiary enrolment, % gross ⊙	71.4	25	
2.2.2	Graduates in science & engineering, %	27.5	21	
2.2.3	Tertiary inbound mobility, %	6.8	33	
2.3	**Research & development (R&D)**	**23.4**	**44**	◇
2.3.1	Researchers, FTE/mn pop.	3,568.9	26	◇
2.3.2	Gross expenditure on R&D, % GDP	1.3	27	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	21.6	49	◇
	INFRASTRUCTURE	**61.5**	**16**	
3.1	**Information & communication technologies(ICTs)**	**85.7**	**20**	
3.1.1	ICT access*	81.6	20	
3.1.2	ICT use*	79.9	16	
3.1.3	Government's online service*	90.3	26	
3.1.4	E-participation*	91.0	27	
3.2	**General infrastructure**	**45.8**	**30**	
3.2.1	Electricity output, kWh/mn pop.	9,962.1	15	
3.2.2	Logistics performance*	58.4	35	◇
3.2.3	Gross capital formation, % GDP	26.4	38	
3.3	**Ecological sustainability**	**53.1**	**18**	
3.3.1	GDP/unit of energy use	6.8	90	○
3.3.2	Environmental performance*	64.3	44	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	13.5	1	● ◆
	MARKET SOPHISTICATION	**52.6**	**45**	◇
4.1	**Credit**	**50.3**	**31**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	66.4	45	◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**47.3**	**44**	
4.2.1	Ease of protecting minority investors*	56.7	79	○ ◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	16	
4.3	**Trade, competition, & market scale**	**60.2**	**67**	◇
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	79.7	10	
4.3.3	Domestic market scale, bn PPP$	44.2	100	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**42.6**	**28**	◇
5.1	**Knowledge workers**	**57.4**	**26**	◇
5.1.1	Knowledge-intensive employment, %	45.5	15	
5.1.2	Firms offering formal training, % firms	35.2	40	
5.1.3	GERD performed by business, % GDP	0.6	34	◇
5.1.4	GERD financed by business, %	48.2	31	
5.1.5	Females employed w/advanced degrees, %	25.9	8	● ◆
5.2	**Innovation linkages**	**30.3**	**46**	◇
5.2.1	University/industry research collaboration†	46.4	48	◇
5.2.2	State of cluster development†	45.6	73	○ ◇
5.2.3	GERD financed by abroad, %	13.6	31	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	24	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.8	29	◇
5.3	**Knowledge absorption**	**40.0**	**40**	◇
5.3.1	Intellectual property payments, % total trade	0.3	81	○ ◇
5.3.2	High-tech imports, % total trade	9.6	36	
5.3.3	ICT services imports, % total trade	2.2	23	
5.3.4	FDI net inflows, % GDP	2.3	75	○
5.3.5	Research talent, % in business enterprise	33.9	39	◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**36.0**	**26**	◇
6.1	**Knowledge creation**	**26.0**	**33**	◇
6.1.1	Patents by origin/bn PPP$ GDP	2.2	40	◇
6.1.2	PCT patents by origin/bn PPP$ GDP	1.1	29	◇
6.1.3	Utility models by origin/bn PPP$ GDP	1.3	21	
6.1.4	Scientific & technical articles/bn PPP$ GDP	28.7	9	●
6.1.5	Citable documents H-index	15.8	47	◇
6.2	**Knowledge impact**	**53.7**	**12**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.6	30	
6.2.2	New businesses/th pop. 15-64	20.8	2	● ◆
6.2.3	Computer software spending, % GDP	0.1	79	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	25.2	10	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.2	55	◇
6.3	**Knowledge diffusion**	**28.3**	**34**	
6.3.1	Intellectual property receipts, % total trade	0.1	64	○ ◇
6.3.2	High-tech net exports, % total trade	8.6	19	
6.3.3	ICT services exports, % total trade	3.6	22	
6.3.4	FDI net outflows, % GDP	0.4	72	○
	CREATIVE OUTPUTS	**51.7**	**8**	●
7.1	**Intangible assets**	**58.7**	**11**	
7.1.1	Trademarks by origin/bn PPP$ GDP	81.1	25	
7.1.2	Industrial designs by origin/bn PPP$ GDP	6.4	22	
7.1.3	ICTs & business model creation†	75.2	17	
7.1.4	ICTs & organizational model creation†	79.3	5	●
7.2	**Creative goods & services**	**38.6**	**10**	●
7.2.1	Cultural & creative services exports, % total trade	1.6	11	
7.2.2	National feature films/mn pop. 15-69	19.8	4	● ◆
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	2.1	16	
7.2.5	Creative goods exports, % total trade	1.4	38	
7.3	**Online creativity**	**50.6**	**12**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	9.8	40	◇
7.3.2	Country-code TLDs/th pop. 15-69	36.6	17	
7.3.3	Wikipedia edits/mn pop. 15-69	133.5	2	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	66.0	7	● ◆

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ETHIOPIA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
80	124	Low	SSF	105.0	195.8	2,160.8	n/a

		Score/Value	Rank	
	INSTITUTIONS	**47.5**	**119**	
1.1	**Political environment**	**37.9**	**114**	
1.1.1	Political and operational stability*	54.4	111	
1.1.2	Government effectiveness*	29.6	113	
1.2	**Regulatory environment**	**53.8**	**103**	
1.2.1	Regulatory quality*	15.0	124	
1.2.2	Rule of law*	34.4	93	
1.2.3	Cost of redundancy dismissal, salary weeks	19.1	79	●
1.3	**Business environment**	**50.7**	**124**	◇
1.3.1	Ease of starting a business*	70.8	120	◇
1.3.2	Ease of resolving insolvency*	30.5	118	◇
	HUMAN CAPITAL & RESEARCH	**10.6**	**124**	
2.1	**Education**	**22.7**	**121**	
2.1.1	Expenditure on education, % GDP	4.7	57	●
2.1.2	Government funding/pupil, secondary, % GDP/cap	16.6	74	
2.1.3	School life expectancy, years ⊙	8.4	115	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	40.4	113	○ ◇
2.2	**Tertiary education**	**5.8**	**[119]**	
2.2.1	Tertiary enrolment, % gross ⊙	8.1	112	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**3.3**	**86**	◆
2.3.1	Researchers, FTE/mn pop. ⊙	45.0	92	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.6	52	● ◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**35.6**	**99**	
3.1	**Information & communication technologies(ICTs)**	**38.5**	**108**	
3.1.1	ICT access*	22.5	124	◇
3.1.2	ICT use*	10.9	122	
3.1.3	Government's online service*	63.2	87	◆
3.1.4	E-participation*	57.3	95	
3.2	**General infrastructure**	**48.9**	**21**	● ◆
3.2.1	Electricity output, kWh/mn pop.	109.6	118	
3.2.2	Logistics performance*	n/a	n/a	
3.2.3	Gross capital formation, % GDP	39.5	7	● ◆
3.3	**Ecological sustainability**	**19.4**	**126**	
3.3.1	GDP/unit of energy use	3.1	116	
3.3.2	Environmental performance*	44.8	109	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.0	127	
	MARKET SOPHISTICATION	**27.3**	**128**	◇
4.1	**Credit**	**7.7**	**127**	◇
4.1.1	Ease of getting credit*	15.0	124	◇
4.1.2	Domestic credit to private sector, % GDP	n/a	n/a	
4.1.3	Microfinance gross loans, % GDP	0.0	62	
4.2	**Investment**	**28.3**	**[122]**	
4.2.1	Ease of protecting minority investors*	28.3	127	○ ◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**45.8**	**116**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	12.1	120	
4.3.2	Intensity of local competition†	45.6	125	○ ◇
4.3.3	Domestic market scale, bn PPP$	220.7	59	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**20.2**	**118**	
5.1	**Knowledge workers**	**8.5**	**124**	
5.1.1	Knowledge-intensive employment, % ⊙	4.5	108	
5.1.2	Firms offering formal training, % firms	20.8	73	
5.1.3	GERD performed by business, % GDP ⊙	0.0	84	
5.1.4	GERD financed by business, % ⊙	0.7	92	
5.1.5	Females employed w/advanced degrees, % ⊙	0.3	115	
5.2	**Innovation linkages**	**17.4**	**112**	●
5.2.1	University/industry research collaboration†	43.9	54	●
5.2.2	State of cluster development†	42.7	83	
5.2.3	GERD financed by abroad, % ⊙	2.1	75	◇
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	99	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**34.7**	**58**	●
5.3.1	Intellectual property payments, % total trade	0.0	109	
5.3.2	High-tech imports, % total trade ⊙	21.8	6	● ◆
5.3.3	ICT services imports, % total trade	0.7	89	
5.3.4	FDI net inflows, % GDP	4.8	32	●
5.3.5	Research talent, % in business enterprise ⊙	0.5	81	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**17.0**	**88**	
6.1	**Knowledge creation**	**9.0**	**[73]**	
6.1.1	Patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.9	82	
6.1.5	Citable documents H-index	7.0	83	◆
6.2	**Knowledge impact**	**39.8**	**49**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	5.5	5	● ◆
6.2.2	New businesses/th pop. 15-64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.0	127	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.3	125	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	70	
6.3	**Knowledge diffusion**	**2.1**	**129**	○ ◇
6.3.1	Intellectual property receipts, % total trade	0.0	105	
6.3.2	High-tech net exports, % total trade ⊙	0.1	114	
6.3.3	ICT services exports, % total trade	0.6	97	
6.3.4	FDI net outflows, % GDP	n/a	n/a	
	CREATIVE OUTPUTS	**23.2**	**[80]**	
7.1	**Intangible assets**	**39.4**	**[70]**	
7.1.1	Trademarks by origin/bn PPP$ GDP	n/a	n/a	
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	40.6	119	
7.1.4	ICTs & organizational model creation†	38.2	116	
7.2	**Creative goods & services**	**14.2**	**[71]**	
7.2.1	Cultural & creative services exports, % total trade ⊙	0.0	100	
7.2.2	National feature films/mn pop. 15-69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	1.8	21	●
7.2.5	Creative goods exports, % total trade ⊙	0.0	115	
7.3	**Online creativity**	**0.0**	**129**	○
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	0.0	129	○ ◇
7.3.2	Country-code TLDs/th pop. 15-69	0.0	129	○ ◇
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	0.0	123	
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	98	○ ◇

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

FINLAND

GII 2019 rank

6

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
7	7	High	EUR	5.5	257.2	46,429.5	7

		Score/Value	Rank	
	INSTITUTIONS	**93.6**	**3**	● ◆
1.1	**Political environment**	**92.2**	**5**	
1.1.1	Political and operational stability*	89.5	15	
1.1.2	Government effectiveness*	93.5	4	●
1.2	**Regulatory environment**	**96.1**	**5**	
1.2.1	Regulatory quality*	90.8	8	
1.2.2	Rule of law*	100.0	1	●
1.2.3	Cost of redundancy dismissal, salary weeks	10.1	31	
1.3	**Business environment**	**92.6**	**1**	● ◆
1.3.1	Ease of starting a business*	92.4	39	
1.3.2	Ease of resolving insolvency*	92.8	2	● ◆

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**63.4**	**2**	● ◆
2.1	**Education**	**69.9**	**4**	● ◆
2.1.1	Expenditure on education, % GDP	7.1	10	◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	25.8	22	
2.1.3	School life expectancy, years	19.3	3	● ◆
2.1.4	PISA scales in reading, maths, & science	522.7	6	
2.1.5	Pupil-teacher ratio, secondary ◷	13.2	58	○
2.2	**Tertiary education**	**53.0**	**10**	
2.2.1	Tertiary enrolment, % gross ◷	87.0	10	
2.2.2	Graduates in science & engineering, %	29.5	15	
2.2.3	Tertiary inbound mobility, %	7.8	29	
2.3	**Research & development (R&D)**	**67.3**	**10**	
2.3.1	Researchers, FTE/mn pop.	6,707.5	6	
2.3.2	Gross expenditure on R&D, % GDP	2.8	10	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	79.7	11	
2.3.4	QS university ranking, average score top 3*	48.0	19	

		Score/Value	Rank	
	INFRASTRUCTURE	**62.1**	**12**	
3.1	**Information & communication technologies(ICTs)**	**87.5**	**16**	
3.1.1	ICT access*	73.9	52	◇
3.1.2	ICT use*	79.7	17	
3.1.3	Government's online service*	96.5	8	
3.1.4	E-participation*	100.0	1	●
3.2	**General infrastructure**	**51.7**	**13**	
3.2.1	Electricity output, kWh/mn pop.	12,236.8	10	
3.2.2	Logistics performance*	89.1	10	
3.2.3	Gross capital formation, % GDP	22.9	66	○
3.3	**Ecological sustainability**	**47.0**	**42**	
3.3.1	GDP/unit of energy use	6.3	96	○
3.3.2	Environmental performance*	78.6	10	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	6.0	18	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**57.3**	**27**	
4.1	**Credit**	**54.9**	**25**	
4.1.1	Ease of getting credit*	65.0	54	○
4.1.2	Domestic credit to private sector, % GDP	94.5	29	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**51.7**	**34**	
4.2.1	Ease of protecting minority investors*	58.3	68	○
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.2	11	
4.3	**Trade, competition, & market scale**	**65.2**	**52**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	61.7	99	○ ◇
4.3.3	Domestic market scale, bn PPP$	257.2	58	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**63.9**	**5**	◆
5.1	**Knowledge workers**	**74.0**	**6**	
5.1.1	Knowledge-intensive employment, %	47.4	10	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	1.8	10	
5.1.4	GERD financed by business, %	57.0	15	
5.1.5	Females employed w/advanced degrees, %	27.2	5	◆
5.2	**Innovation linkages**	**62.6**	**4**	● ◆
5.2.1	University/industry research collaboration†	74.7	5	
5.2.2	State of cluster development†	64.9	17	
5.2.3	GERD financed by abroad, %	12.1	35	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	10	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	6.5	3	● ◆
5.3	**Knowledge absorption**	**54.9**	**12**	
5.3.1	Intellectual property payments, % total trade	1.0	37	
5.3.2	High-tech imports, % total trade	7.7	60	○
5.3.3	ICT services imports, % total trade	3.7	4	● ◆
5.3.4	FDI net inflows, % GDP	4.9	31	
5.3.5	Research talent, % in business enterprise	55.5	20	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**55.1**	**9**	
6.1	**Knowledge creation**	**58.5**	**9**	
6.1.1	Patents by origin/bn PPP$ GDP	13.1	7	
6.1.2	PCT patents by origin/bn PPP$ GDP	7.1	1	● ◆
6.1.3	Utility models by origin/bn PPP$ GDP	2.0	11	
6.1.4	Scientific & technical articles/bn PPP$ GDP	30.9	6	◆
6.1.5	Citable documents H-index	42.9	19	
6.2	**Knowledge impact**	**44.9**	**28**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.3	57	○
6.2.2	New businesses/th pop. 15–64	4.0	32	
6.2.3	Computer software spending, % GDP	0.6	17	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	10.8	29	
6.2.5	High- & medium-high-tech manufactures, %	0.3	34	
6.3	**Knowledge diffusion**	**61.9**	**7**	
6.3.1	Intellectual property receipts, % total trade	3.3	6	◆
6.3.2	High-tech net exports, % total trade	4.4	34	
6.3.3	ICT services exports, % total trade	8.1	5	◆
6.3.4	FDI net outflows, % GDP	4.0	14	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**48.1**	**13**	
7.1	**Intangible assets**	**55.3**	**19**	
7.1.1	Trademarks by origin/bn PPP$ GDP	44.7	58	○
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.9	32	
7.1.3	ICTs & business model creation†	84.4	2	● ◆
7.1.4	ICTs & organizational model creation†	80.4	3	● ◆
7.2	**Creative goods & services**	**24.7**	**44**	
7.2.1	Cultural & creative services exports, % total trade	1.0	29	
7.2.2	National feature films/mn pop. 15–69	10.7	15	
7.2.3	Entertainment & Media market/th pop. 15–69	57.5	13	
7.2.4	Printing & other media, % manufacturing	1.1	58	○
7.2.5	Creative goods exports, % total trade	0.5	56	
7.3	**Online creativity**	**57.3**	**6**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	29.2	21	
7.3.2	Country-code TLDs/th pop. 15–69	34.0	18	
7.3.3	Wikipedia edits/mn pop. 15–69	98.1	8	
7.3.4	Mobile app creation/bn PPP$ GDP	100.0	1	● ◆

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

FRANCE

GII 2019 rank

16

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
14	16	High	EUR	65.2	2,968.5	45,775.1	16

		Score/Value	Rank	
	INSTITUTIONS	**83.2**	**19**	
1.1	**Political environment**	**80.4**	**22**	
1.1.1	Political and operational stability*	82.5	32	◇
1.1.2	Government effectiveness*	79.3	21	
1.2	**Regulatory environment**	**85.5**	**20**	
1.2.1	Regulatory quality*	73.0	26	
1.2.2	Rule of law*	84.4	19	
1.2.3	Cost of redundancy dismissal, salary weeks	13.0	41	
1.3	**Business environment**	**83.7**	**21**	
1.3.1	Ease of starting a business*	93.3	27	
1.3.2	Ease of resolving insolvency*	74.1	26	
	HUMAN CAPITAL & RESEARCH	**55.8**	**11**	
2.1	**Education**	**57.8**	**32**	
2.1.1	Expenditure on education, % GDP	5.5	27	
2.1.2	Government funding/pupil, secondary, % GDP/cap	26.5	19	◆
2.1.3	School life expectancy, years	15.5	38	
2.1.4	PISA scales in reading, maths, & science	495.7	24	
2.1.5	Pupil-teacher ratio, secondary ◷	12.9	57	○
2.2	**Tertiary education**	**44.8**	**25**	
2.2.1	Tertiary enrolment, % gross ◷	64.4	37	
2.2.2	Graduates in science & engineering, %	25.6	26	
2.2.3	Tertiary inbound mobility, %	9.9	20	
2.3	**Research & development (R&D)**	**64.6**	**11**	
2.3.1	Researchers, FTE/mn pop.	4,441.1	18	
2.3.2	Gross expenditure on R&D, % GDP	2.2	12	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	87.8	7	●
2.3.4	QS university ranking, average score top 3*	69.3	10	●
	INFRASTRUCTURE	**62.3**	**11**	
3.1	**Information & communication technologies(ICTs)**	**89.6**	**10**	●
3.1.1	ICT access*	83.4	16	
3.1.2	ICT use*	80.3	14	
3.1.3	Government's online service*	97.9	4	●
3.1.4	E-participation*	96.6	13	
3.2	**General infrastructure**	**47.5**	**29**	
3.2.1	Electricity output, kWh/mn pop.	8,177.3	20	
3.2.2	Logistics performance*	83.3	16	
3.2.3	Gross capital formation, % GDP	23.7	59	○
3.3	**Ecological sustainability**	**49.9**	**31**	
3.3.1	GDP/unit of energy use	10.3	46	
3.3.2	Environmental performance*	84.0	2	● ◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.2	46	
	MARKET SOPHISTICATION	**62.9**	**12**	
4.1	**Credit**	**49.2**	**33**	
4.1.1	Ease of getting credit*	50.0	87	○
4.1.2	Domestic credit to private sector, % GDP	101.6	26	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**57.5**	**25**	
4.2.1	Ease of protecting minority investors*	66.7	35	
4.2.2	Market capitalization, % GDP	93.2	14	
4.2.3	Venture capital deals/bn PPP$ GDP	0.2	5	●
4.3	**Trade, competition, & market scale**	**81.9**	**6**	●
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	80.0	8	●
4.3.3	Domestic market scale, bn PPP$	2,968.5	10	●

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**53.3**	**19**	
5.1	**Knowledge workers**	**66.2**	**15**	
5.1.1	Knowledge-intensive employment, %	45.1	16	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	1.4	13	
5.1.4	GERD financed by business, % ◷	54.0	20	
5.1.5	Females employed w/advanced degrees, %	21.6	21	
5.2	**Innovation linkages**	**41.6**	**26**	◇
5.2.1	University/industry research collaboration†	54.6	30	
5.2.2	State of cluster development†	63.2	20	
5.2.3	GERD financed by abroad, % ◷	7.6	51	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	30	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	3.5	14	
5.3	**Knowledge absorption**	**52.1**	**17**	
5.3.1	Intellectual property payments, % total trade	1.9	14	
5.3.2	High-tech imports, % total trade	10.8	23	
5.3.3	ICT services imports, % total trade	2.2	22	
5.3.4	FDI net inflows, % GDP	1.8	85	○
5.3.5	Research talent, % in business enterprise	60.3	14	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**45.0**	**15**	
6.1	**Knowledge creation**	**42.7**	**16**	
6.1.1	Patents by origin/bn PPP$ GDP	8.8	15	
6.1.2	PCT patents by origin/bn PPP$ GDP	2.7	13	
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	57	○
6.1.4	Scientific & technical articles/bn PPP$ GDP	15.8	33	
6.1.5	Citable documents H-index	79.2	5	● ◆
6.2	**Knowledge impact**	**44.7**	**29**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.7	69	○
6.2.2	New businesses/th pop. 15–64	1.8	52	○
6.2.3	Computer software spending, % GDP	0.6	10	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.6	41	
6.2.5	High- & medium-high-tech manufactures, %	0.5	13	
6.3	**Knowledge diffusion**	**47.7**	**13**	
6.3.1	Intellectual property receipts, % total trade	2.0	12	
6.3.2	High-tech net exports, % total trade	12.8	10	●
6.3.3	ICT services exports, % total trade	2.2	51	○
6.3.4	FDI net outflows, % GDP	2.4	27	
	CREATIVE OUTPUTS	**45.0**	**16**	
7.1	**Intangible assets**	**58.8**	**10**	●
7.1.1	Trademarks by origin/bn PPP$ GDP	97.9	16	
7.1.2	Industrial designs by origin/bn PPP$ GDP	6.3	24	
7.1.3	ICTs & business model creation†	77.2	13	
7.1.4	ICTs & organizational model creation†	70.9	19	
7.2	**Creative goods & services**	**26.6**	**39**	
7.2.1	Cultural & creative services exports, % total trade	1.3	20	
7.2.2	National feature films/mn pop. 15–69	6.8	31	
7.2.3	Entertainment & Media market/th pop. 15–69	52.3	15	
7.2.4	Printing & other media, % manufacturing	1.0	61	○
7.2.5	Creative goods exports, % total trade	1.7	32	
7.3	**Online creativity**	**35.7**	**23**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	40.9	18	
7.3.2	Country-code TLDs/th pop. 15–69	20.7	28	
7.3.3	Wikipedia edits/mn pop. 15–69	64.7	15	
7.3.4	Mobile app creation/bn PPP$ GDP	37.7	14	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

GEORGIA

GII 2019 rank

48

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
60	44	Lower middle	NAWA	3.9	43.0	11,485.4	59

		Score/Value	Rank	
	INSTITUTIONS	**74.3**	**36**	◆
1.1	**Political environment**	**64.2**	**45**	◆
1.1.1	Political and operational stability*	71.9	58	◆
1.1.2	Government effectiveness*	60.4	42	◆
1.2	**Regulatory environment**	**80.8**	**28**	◆
1.2.1	Regulatory quality*	70.2	30	◆
1.2.2	Rule of law*	55.1	49	◆
1.2.3	Cost of redundancy dismissal, salary weeks	8.6	17	● ◆
1.3	**Business environment**	**77.7**	**38**	◆
1.3.1	Ease of starting a business*	99.3	2	● ◆
1.3.2	Ease of resolving insolvency*	56.0	55	◆
	HUMAN CAPITAL & RESEARCH	**30.5**	**63**	
2.1	**Education**	**51.5**	**55**	
2.1.1	Expenditure on education, % GDP	3.8	85	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	15.4	39	◆
2.1.4	PISA scales in reading, maths, & science	405.4	61	○
2.1.5	Pupil-teacher ratio, secondary	7.4	5	● ◆
2.2	**Tertiary education**	**34.3**	**57**	
2.2.1	Tertiary enrolment, % gross	57.5	50	◆
2.2.2	Graduates in science & engineering, %	21.9	52	
2.2.3	Tertiary inbound mobility, %	5.6	38	◆
2.3	**Research & development (R&D)**	**5.6**	**75**	
2.3.1	Researchers, FTE/mn pop. ⊙	1,336.6	45	◆
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.3	79	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**44.7**	**72**	◆
3.1	**Information & communication technologies(ICTs)**	**64.3**	**71**	◆
3.1.1	ICT access*	72.1	59	◆
3.1.2	ICT use*	53.3	67	◆
3.1.3	Government's online service*	69.4	70	
3.1.4	E-participation*	62.4	84	
3.2	**General infrastructure**	**39.2**	**46**	
3.2.1	Electricity output, kWh/mn pop.	3,111.3	61	◆
3.2.2	Logistics performance*	17.7	109	○
3.2.3	Gross capital formation, % GDP	35.2	11	● ◆
3.3	**Ecological sustainability**	**30.5**	**91**	
3.3.1	GDP/unit of energy use	7.0	86	
3.3.2	Environmental performance*	55.7	80	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	98	
	MARKET SOPHISTICATION	**62.1**	**15**	● ◆
4.1	**Credit**	**47.1**	**40**	
4.1.1	Ease of getting credit*	85.0	11	●
4.1.2	Domestic credit to private sector, % GDP	62.5	52	
4.1.3	Microfinance gross loans, % GDP	1.6	15	
4.2	**Investment**	**81.7**	**[1]**	
4.2.1	Ease of protecting minority investors*	81.7	2	● ◆
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**57.4**	**79**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	0.7	5	● ◆
4.3.2	Intensity of local competition†	62.7	94	
4.3.3	Domestic market scale, bn PPP$	43.0	102	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**29.5**	**70**	
5.1	**Knowledge workers**	**32.1**	**[81]**	
5.1.1	Knowledge-intensive employment, %	25.3	54	
5.1.2	Firms offering formal training, % firms	10.5	88	○ ◇
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	17.6	32	◆
5.2	**Innovation linkages**	**25.0**	**65**	
5.2.1	University/industry research collaboration†	32.0	98	
5.2.2	State of cluster development†	34.8	107	○
5.2.3	GERD financed by abroad, % ⊙	14.7	28	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	19	◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	48	◆
5.3	**Knowledge absorption**	**31.4**	**78**	
5.3.1	Intellectual property payments, % total trade	0.2	88	
5.3.2	High-tech imports, % total trade	7.5	63	
5.3.3	ICT services imports, % total trade	0.7	90	
5.3.4	FDI net inflows, % GDP	11.6	11	● ◆
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**22.5**	**62**	
6.1	**Knowledge creation**	**16.1**	**55**	
6.1.1	Patents by origin/bn PPP$ GDP	1.9	48	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	59	
6.1.3	Utility models by origin/bn PPP$ GDP	1.4	19	
6.1.4	Scientific & technical articles/bn PPP$ GDP	14.1	37	◆
6.1.5	Citable documents H-index	9.4	73	
6.2	**Knowledge impact**	**38.3**	**55**	
6.2.1	Growth rate of PPP$ GDP/worker, %	5.0	8	● ◆
6.2.2	New businesses/th pop. 15–64	8.4	17	◆
6.2.3	Computer software spending, % GDP	0.1	89	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.3	74	
6.2.5	High- & medium-high-tech manufactures, %	0.1	91	○
6.3	**Knowledge diffusion**	**12.9**	**86**	
6.3.1	Intellectual property receipts, % total trade	0.0	90	○
6.3.2	High-tech net exports, % total trade	0.3	90	
6.3.3	ICT services exports, % total trade	1.1	80	
6.3.4	FDI net outflows, % GDP	2.2	28	◆
	CREATIVE OUTPUTS	**29.1**	**58**	
7.1	**Intangible assets**	**44.7**	**50**	
7.1.1	Trademarks by origin/bn PPP$ GDP	68.8	29	
7.1.2	Industrial designs by origin/bn PPP$ GDP	11.8	12	● ◆
7.1.3	ICTs & business model creation†	52.1	97	
7.1.4	ICTs & organizational model creation†	43.6	99	○
7.2	**Creative goods & services**	**16.9**	**62**	
7.2.1	Cultural & creative services exports, % total trade	0.5	51	◆
7.2.2	National feature films/mn pop. 15–69	6.6	33	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.6	29	
7.2.5	Creative goods exports, % total trade	0.1	97	
7.3	**Online creativity**	**9.9**	**53**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.8	82	
7.3.2	Country-code TLDs/th pop. 15–69	3.4	57	◆
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	44.5	31	◆
7.3.4	Mobile app creation/bn PPP$ GDP	4.3	52	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

GERMANY

GII 2019 rank

9

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
9	12	High	EUR	82.3	4,379.1	52,558.7	9

		Score/Value	Rank	
	INSTITUTIONS	**86.4**	**16**	
1.1	**Political environment**	**88.1**	**13**	
1.1.1	Political and operational stability*	87.7	18	
1.1.2	Government effectiveness*	88.2	11	
1.2	**Regulatory environment**	**84.4**	**23**	
1.2.1	Regulatory quality*	89.8	11	
1.2.2	Rule of law*	88.9	16	
1.2.3	Cost of redundancy dismissal, salary weeks	21.6	89	○ ◇
1.3	**Business environment**	**86.9**	**15**	
1.3.1	Ease of starting a business*	83.6	88	○ ◇
1.3.2	Ease of resolving insolvency*	90.1	4	● ◆
	HUMAN CAPITAL & RESEARCH	**63.2**	**3**	● ◆
2.1	**Education**	**57.8**	**33**	
2.1.1	Expenditure on education, % GDP	4.8	55	○
2.1.2	Government funding/pupil, secondary, % GDP/cap	23.0	34	
2.1.3	School life expectancy, years	17.1	17	
2.1.4	PISA scales in reading, maths, & science	508.1	11	
2.1.5	Pupil-teacher ratio, secondary ⊙	12.0	48	
2.2	**Tertiary education**	**58.6**	**5**	● ◆
2.2.1	Tertiary enrolment, % gross ⊙	68.3	31	
2.2.2	Graduates in science & engineering, %	36.0	4	● ◆
2.2.3	Tertiary inbound mobility, %	8.0	28	
2.3	**Research & development (R&D)**	**73.4**	**7**	
2.3.1	Researchers, FTE/mn pop	5,036.2	12	
2.3.2	Gross expenditure on R&D, % GDP	3.0	8	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	97.2	2	● ◆
2.3.4	QS university ranking, average score top 3*	69.1	11	
	INFRASTRUCTURE	**62.0**	**13**	
3.1	**Information & communication technologies(ICTs)**	**88.2**	**15**	
3.1.1	ICT access*	90.3	6	●
3.1.2	ICT use*	77.2	22	
3.1.3	Government's online service*	93.1	17	
3.1.4	E-participation*	92.1	23	
3.2	**General infrastructure**	**47.8**	**26**	
3.2.1	Electricity output, kWh/mn pop	7,849.4	22	
3.2.2	Logistics performance*	100.0	1	● ◆
3.2.3	Gross capital formation, % GDP	20.4	91	○
3.3	**Ecological sustainability**	**50.1**	**29**	
3.3.1	GDP/unit of energy use	11.6	34	
3.3.2	Environmental performance*	78.4	13	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.4	41	
	MARKET SOPHISTICATION	**58.6**	**20**	
4.1	**Credit**	**53.2**	**28**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	77.7	39	◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**39.7**	**79**	○ ◇
4.2.1	Ease of protecting minority investors*	58.3	68	○
4.2.2	Market capitalization, % GDP	53.9	31	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	20	
4.3	**Trade, competition, & market scale**	**82.9**	**4**	●
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	76.3	18	
4.3.3	Domestic market scale, bn PPP$	4,379.1	5	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**56.1**	**12**	
5.1	**Knowledge workers**	**67.1**	**13**	
5.1.1	Knowledge-intensive employment, %	44.7	17	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	2.1	7	
5.1.4	GERD financed by business, %	65.2	7	
5.1.5	Females employed w/advanced degrees, %	13.2	51	◇
5.2	**Innovation linkages**	**53.9**	**10**	
5.2.1	University/industry research collaboration†	72.8	6	
5.2.2	State of cluster development†	75.4	2	● ◆
5.2.3	GERD financed by abroad, %	5.9	60	○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	32	◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	5.9	9	
5.3	**Knowledge absorption**	**47.5**	**22**	
5.3.1	Intellectual property payments, % total trade	0.8	51	
5.3.2	High-tech imports, % total trade	9.6	37	
5.3.3	ICT services imports, % total trade	2.1	25	
5.3.4	FDI net inflows, % GDP	1.8	86	○
5.3.5	Research talent, % in business enterprise	59.7	15	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**52.7**	**10**	
6.1	**Knowledge creation**	**66.6**	**6**	●
6.1.1	Patents by origin/bn PPP$ GDP	17.5	1	● ◆
6.1.2	PCT patents by origin/bn PPP$ GDP	4.5	9	
6.1.3	Utility models by origin/bn PPP$ GDP	2.3	9	
6.1.4	Scientific & technical articles/bn PPP$ GDP	15.7	35	
6.1.5	Citable documents H-index	87.9	3	● ◆
6.2	**Knowledge impact**	**48.7**	**17**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.6	73	○
6.2.2	New businesses/th pop. 15-64	1.3	64	○
6.2.3	Computer software spending, % GDP	0.6	18	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	15.4	22	
6.2.5	High- & medium-high-tech manufactures, %	0.6	6	
6.3	**Knowledge diffusion**	**42.7**	**17**	
6.3.1	Intellectual property receipts, % total trade	1.2	17	
6.3.2	High-tech net exports, % total trade	11.5	14	
6.3.3	ICT services exports, % total trade	2.3	46	
6.3.4	FDI net outflows, % GDP	3.3	22	
	CREATIVE OUTPUTS	**49.6**	**10**	
7.1	**Intangible assets**	**63.8**	**5**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	65.2	30	
7.1.2	Industrial designs by origin/bn PPP$ GDP	14.5	6	◆
7.1.3	ICTs & business model creation†	78.4	12	
7.1.4	ICTs & organizational model creation†	78.0	8	
7.2	**Creative goods & services**	**26.3**	**41**	
7.2.1	Cultural & creative services exports, % total trade	0.9	33	
7.2.2	National feature films/mn pop. 15-69	4.1	47	
7.2.3	Entertainment & Media market/th pop. 15-69	58.7	12	
7.2.4	Printing & other media, % manufacturing	1.0	63	○
7.2.5	Creative goods exports, % total trade	2.2	26	
7.3	**Online creativity**	**44.4**	**14**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	52.9	14	
7.3.2	Country-code TLDs/th pop. 15-69	77.6	6	● ◆
7.3.3	Wikipedia edits/mn pop. 15-69	52.1	22	
7.3.4	Mobile app creation/bn PPP$ GDP	11.9	40	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

GHANA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
97	109	Lower middle	SSF	29.5	145.8	6,451.7	107

		Score/Value	Rank	
1	**INSTITUTIONS**	**48.9**	**115**	
1.1	**Political environment**	**52.0**	**74**	
1.1.1	Political and operational stability*	68.4	71	
1.1.2	Government effectiveness*	43.8	78	
1.2	**Regulatory environment**	**40.2**	**121**	
1.2.1	Regulatory quality*	38.3	79	
1.2.2	Rule of law*	49.8	53	◆
1.2.3	Cost of redundancy dismissal, salary weeks	49.8	123	○ ◇
1.3	**Business environment**	**54.6**	**117**	◇
1.3.1	Ease of starting a business*	84.3	83	
1.3.2	Ease of resolving insolvency*	24.9	128	○ ◇
2	**HUMAN CAPITAL & RESEARCH**	**19.2**	**97**	
2.1	**Education**	**43.6**	**75**	
2.1.1	Expenditure on education, % GDP	4.5	62	
2.1.2	Government funding/pupil, secondary, % GDP/cap. ◷	26.2	21	●
2.1.3	School life expectancy, years	11.5	94	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	16.0	72	
2.2	**Tertiary education**	**11.8**	**107**	
2.2.1	Tertiary enrolment, % gross	16.2	99	
2.2.2	Graduates in science & engineering, %	13.4	93	◇
2.2.3	Tertiary inbound mobility, %	2.9	64	
2.3	**Research & development (R&D)**	**2.1**	**93**	
2.3.1	Researchers, FTE/mn pop. ◷	38.4	96	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.4	70	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
3	**INFRASTRUCTURE**	**35.0**	**103**	
3.1	**Information & communication technologies(ICTs)**	**54.5**	**86**	
3.1.1	ICT access*	45.6	97	
3.1.2	ICT use*	40.0	89	
3.1.3	Government's online service*	69.4	70	
3.1.4	E-participation*	62.9	82	
3.2	**General infrastructure**	**14.9**	**125**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	461.6	106	
3.2.2	Logistics performance*	23.5	99	
3.2.3	Gross capital formation, % GDP	13.8	119	○ ◇
3.3	**Ecological sustainability**	**35.7**	**75**	
3.3.1	GDP/unit of energy use	11.8	33	●
3.3.2	Environmental performance*	49.7	99	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	102	
4	**MARKET SOPHISTICATION**	**34.3**	**121**	◇
4.1	**Credit**	**25.8**	**104**	
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	13.9	120	○ ◇
4.1.3	Microfinance gross loans, % GDP	0.8	24	●
4.2	**Investment**	**26.7**	**127**	○ ◇
4.2.1	Ease of protecting minority investors*	51.7	89	
4.2.2	Market capitalization, % GDP ◷	8.8	71	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	64	
4.3	**Trade, competition, & market scale**	**50.3**	**107**	
4.3.1	Applied tariff rate, weighted avg., %	10.6	115	◇
4.3.2	Intensity of local competition†	63.4	87	
4.3.3	Domestic market scale, bn PPP$	145.8	70	

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**26.6**	**86**	
5.1	**Knowledge workers**	**20.7**	**108**	
5.1.1	Knowledge-intensive employment, % ◷	11.6	95	
5.1.2	Firms offering formal training, % firms	40.1	35	
5.1.3	GERD performed by business, % GDP ◷	0.0	91	○
5.1.4	GERD financed by business, % ◷	0.1	97	○ ◇
5.1.5	Females employed w/advanced degrees, % ◷	3.4	97	
5.2	**Innovation linkages**	**36.1**	**38**	● ◆
5.2.1	University/industry research collaboration†	47.3	44	● ◆
5.2.2	State of cluster development†	52.9	42	● ◆
5.2.3	GERD financed by abroad, % ◷	31.2	11	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	42	●
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	82	
5.3	**Knowledge absorption**	**23.0**	**[112]**	
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade	3.7	119	
5.3.3	ICT services imports, % total trade	n/a	n/a	
5.3.4	FDI net inflows, % GDP	6.1	25	●
5.3.5	Research talent, % in business enterprise ◷	1.0	77	
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**16.6**	**89**	
6.1	**Knowledge creation**	**4.4**	**103**	
6.1.1	Patents by origin/bn PPP$ GDP	0.1	110	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	58	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.2	79	
6.1.5	Citable documents H-index	7.3	82	
6.2	**Knowledge impact**	**33.2**	**81**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.6	17	●
6.2.2	New businesses/th pop. 15-64 ◷	0.9	73	
6.2.3	Computer software spending, % GDP	0.0	124	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.5	119	◇
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**12.3**	**[92]**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.2	97	
6.3.3	ICT services exports, % total trade	n/a	n/a	
6.3.4	FDI net outflows, % GDP	0.2	91	
7	**CREATIVE OUTPUTS**	**18.9**	**[100]**	
7.1	**Intangible assets**	**35.0**	**96**	
7.1.1	Trademarks by origin/bn PPP$ GDP	6.9	110	
7.1.2	Industrial designs by origin/bn PPP$ GDP	5.5	25	●
7.1.3	ICTs & business model creation†	56.0	84	
7.1.4	ICTs & organizational model creation†	49.7	83	
7.2	**Creative goods & services**	**5.1**	**[100]**	
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15-69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ◷	0.6	85	
7.2.5	Creative goods exports, % total trade ◷	0.0	117	
7.3	**Online creativity**	**0.3**	**[114]**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	0.6	102	
7.3.2	Country-code TLDs/th pop. 15-69	0.0	122	
7.3.3	Wikipedia edits/mn pop. 15-69	n/a	n/a	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

GREECE

GII 2019 rank

41

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
54	40	High	EUR	11.1	312.5	29,123.0	42

		Score/Value	Rank	
	INSTITUTIONS	**67.2**	**51**	◇
1.1	**Political environment**	**59.5**	**53**	◇
1.1.1	Political and operational stability*	70.2	61	◇
1.1.2	Government effectiveness*	54.1	50	◇
1.2	**Regulatory environment**	**68.2**	**60**	◇
1.2.1	Regulatory quality*	48.3	58	◇
1.2.2	Rule of law*	48.6	57	◇
1.2.3	Cost of redundancy dismissal, salary weeks	15.9	67	
1.3	**Business environment**	**73.9**	**53**	
1.3.1	Ease of starting a business*	92.4	40	
1.3.2	Ease of resolving insolvency*	55.4	57	
	HUMAN CAPITAL & RESEARCH	**49.5**	**20**	●
2.1	**Education**	**61.9**	**16**	●
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	22.6	38	
2.1.3	School life expectancy, years	17.9	12	●
2.1.4	PISA scales in reading, maths, & science	458.5	42	
2.1.5	Pupil-teacher ratio, secondary ⊕	8.4	12	●
2.2	**Tertiary education**	**54.8**	**8**	● ◆
2.2.1	Tertiary enrolment, % gross ⊕	126.4	1	● ◆
2.2.2	Graduates in science & engineering, %	28.2	19	●
2.2.3	Tertiary inbound mobility, %	3.3	60	
2.3	**Research & development (R&D)**	**31.7**	**36**	
2.3.1	Researchers, FTE/mn pop.	3,152.8	28	
2.3.2	Gross expenditure on R&D, % GDP	1.1	32	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	41.8	41	
2.3.4	QS university ranking, average score top 3*	21.9	47	
	INFRASTRUCTURE	**51.7**	**43**	
3.1	**Information & communication technologies(ICTs)**	**78.2**	**35**	
3.1.1	ICT access*	79.8	30	
3.1.2	ICT use*	63.2	50	◇
3.1.3	Government's online service*	81.9	41	
3.1.4	E-participation*	87.6	34	
3.2	**General infrastructure**	**25.5**	**100**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	5,479.7	38	
3.2.2	Logistics performance*	53.4	41	
3.2.3	Gross capital formation, % GDP	12.6	121	○ ◇
3.3	**Ecological sustainability**	**51.5**	**25**	
3.3.1	GDP/unit of energy use	11.2	39	
3.3.2	Environmental performance*	73.6	22	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	5.1	22	●
	MARKET SOPHISTICATION	**50.3**	**54**	
4.1	**Credit**	**48.9**	**34**	
4.1.1	Ease of getting credit*	50.0	87	
4.1.2	Domestic credit to private sector, % GDP	100.4	27	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**34.2**	**103**	○ ◇
4.2.1	Ease of protecting minority investors*	63.3	48	
4.2.2	Market capitalization, % GDP	22.0	59	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	57	
4.3	**Trade, competition, & market scale**	**67.7**	**43**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	67.9	69	
4.3.3	Domestic market scale, bn PPP$	312.5	53	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**32.4**	**59**	◇
5.1	**Knowledge workers**	**46.1**	**43**	
5.1.1	Knowledge-intensive employment, %	29.8	45	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.6	36	
5.1.4	GERD financed by business, %	44.8	36	
5.1.5	Females employed w/advanced degrees, %	17.9	29	
5.2	**Innovation linkages**	**21.5**	**77**	◇
5.2.1	University/industry research collaboration†	25.6	122	○ ◇
5.2.2	State of cluster development†	32.3	117	○ ◇
5.2.3	GERD financed by abroad, %	14.9	27	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	37	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.3	39	
5.3	**Knowledge absorption**	**29.5**	**86**	◇
5.3.1	Intellectual property payments, % total trade	0.5	67	
5.3.2	High-tech imports, % total trade	5.4	100	○
5.3.3	ICT services imports, % total trade	1.1	69	
5.3.4	FDI net inflows, % GDP	1.3	101	○
5.3.5	Research talent, % in business enterprise	30.3	41	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**25.1**	**53**	
6.1	**Knowledge creation**	**19.9**	**46**	
6.1.1	Patents by origin/bn PPP$ GDP	2.0	44	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.4	42	
6.1.3	Utility models by origin/bn PPP$ GDP	0.0	61	○
6.1.4	Scientific & technical articles/bn PPP$ GDP	20.5	23	●
6.1.5	Citable documents H-index	31.9	29	
6.2	**Knowledge impact**	**42.3**	**40**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.2	93	○
6.2.2	New businesses/th pop. 15–64 ⊕	0.8	77	
6.2.3	Computer software spending, % GDP	0.6	14	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	25.7	7	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.1	69	
6.3	**Knowledge diffusion**	**13.2**	**84**	◇
6.3.1	Intellectual property receipts, % total trade	0.1	54	
6.3.2	High-tech net exports, % total trade	2.0	54	
6.3.3	ICT services exports, % total trade	1.6	64	
6.3.4	FDI net outflows, % GDP	0.1	104	○
	CREATIVE OUTPUTS	**30.1**	**53**	
7.1	**Intangible assets**	**42.9**	**57**	
7.1.1	Trademarks by origin/bn PPP$ GDP	n/a	n/a	
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.6	34	
7.1.3	ICTs & business model creation†	52.7	96	○ ◇
7.1.4	ICTs & organizational model creation†	44.6	96	○ ◇
7.2	**Creative goods & services**	**22.5**	**48**	
7.2.1	Cultural & creative services exports, % total trade	0.7	38	
7.2.2	National feature films/mn pop. 15–69	11.2	13	●
7.2.3	Entertainment & Media market/th pop. 15–69	19.7	27	
7.2.4	Printing & other media, % manufacturing	1.4	36	
7.2.5	Creative goods exports, % total trade	1.1	42	
7.3	**Online creativity**	**12.0**	**48**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	12.0	35	
7.3.2	Country-code TLDs/th pop. 15–69	16.3	31	
7.3.3	Wikipedia edits/mn pop. 15–69	24.3	43	
7.3.4	Mobile app creation/bn PPP$ GDP	3.4	57	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

GUATEMALA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
102	**105**	**Upper middle**	**LCN**	**17.2**	**145.2**	**8,436.4**	**102**

		Score/Value	Rank	
	INSTITUTIONS	**48.1**	**117**	◇
1.1	**Political environment**	**38.2**	**113**	◇
1.1.1	Political and operational stability*	52.6	118	◇
1.1.2	Government effectiveness*	31.0	108	◇
1.2	**Regulatory environment**	**48.9**	**112**	◇
1.2.1	Regulatory quality*	35.1	91	
1.2.2	Rule of law*	18.3	123	◇
1.2.3	Cost of redundancy dismissal, salary weeks	27.0	104	
1.3	**Business environment**	**57.2**	**112**	◇
1.3.1	Ease of starting a business*	86.7	71	
1.3.2	Ease of resolving insolvency*	27.6	124	◇
	HUMAN CAPITAL & RESEARCH	**11.1**	**121**	◇
2.1	**Education**	**26.2**	**115**	◇
2.1.1	Expenditure on education, % GDP	2.8	108	◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	5.1	105	○ ◇
2.1.3	School life expectancy, years ⊙	10.8	100	◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	10.5	36	●
2.2	**Tertiary education**	**6.9**	**117**	◇
2.2.1	Tertiary enrolment, % gross ⊙	21.8	90	◇
2.2.2	Graduates in science & engineering, % ⊙	9.8	100	○ ◇
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**0.1**	**117**	◇
2.3.1	Researchers, FTE/mn pop. ⊙	22.2	103	◇
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.0	112	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**30.6**	**112**	◇
3.1	**Information & communication technologies(ICTs)**	**49.0**	**98**	◇
3.1.1	ICT access*	48.7	91	◇
3.1.2	ICT use*	20.8	107	◇
3.1.3	Government's online service*	64.6	83	
3.1.4	E-participation*	61.8	88	
3.2	**General infrastructure**	**11.6**	**127**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	750.9	99	◇
3.2.2	Logistics performance*	16.4	112	◇
3.2.3	Gross capital formation, % GDP	12.1	122	◇
3.3	**Ecological sustainability**	**31.2**	**89**	◇
3.3.1	GDP/unit of energy use	8.5	69	
3.3.2	Environmental performance*	52.3	90	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	121	
	MARKET SOPHISTICATION	**43.2**	**93**	
4.1	**Credit**	**32.3**	**82**	
4.1.1	Ease of getting credit*	80.0	20	●
4.1.2	Domestic credit to private sector, % GDP	33.3	90	
4.1.3	Microfinance gross loans, % GDP	0.2	45	
4.2	**Investment**	**31.7**	**[113]**	
4.2.1	Ease of protecting minority investors*	31.7	126	○ ◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**65.5**	**50**	●
4.3.1	Applied tariff rate, weighted avg., % ⊙	1.4	14	●
4.3.2	Intensity of local competition†	72.8	41	●
4.3.3	Domestic market scale, bn PPP$	145.2	71	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**33.7**	**50**	●
5.1	**Knowledge workers**	**27.2**	**88**	
5.1.1	Knowledge-intensive employment, %	9.1	101	◇
5.1.2	Firms offering formal training, % firms ⊙	51.9	17	●
5.1.3	GERD performed by business, % GDP ⊙	0.0	93	○ ◇
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	2.2	99	◇
5.2	**Innovation linkages**	**39.4**	**29**	● ◆
5.2.1	University/industry research collaboration†	41.6	62	
5.2.2	State of cluster development†	42.9	82	
5.2.3	GERD financed by abroad, % ⊙	49.0	4	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	101	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**34.4**	**59**	
5.3.1	Intellectual property payments, % total trade	1.2	27	●
5.3.2	High-tech imports, % total trade	9.9	31	●
5.3.3	ICT services imports, % total trade	0.9	75	
5.3.4	FDI net inflows, % GDP	1.6	91	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**12.5**	**111**	
6.1	**Knowledge creation**	**1.3**	**126**	
6.1.1	Patents by origin/bn PPP$ GDP	0.0	125	○
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	96	
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	60	
6.1.4	Scientific & technical articles/bn PPP$ GDP	0.5	127	○ ◇
6.1.5	Citable documents H-index	3.6	108	
6.2	**Knowledge impact**	**24.7**	**106**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.5	99	
6.2.2	New businesses/th pop. 15–64 ⊙	0.5	83	
6.2.3	Computer software spending, % GDP	0.0	122	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.5	96	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**11.6**	**95**	
6.3.1	Intellectual property receipts, % total trade	0.0	70	
6.3.2	High-tech net exports, % total trade	1.4	62	
6.3.3	ICT services exports, % total trade	1.5	70	
6.3.4	FDI net outflows, % GDP	0.1	100	
	CREATIVE OUTPUTS	**21.1**	**90**	
7.1	**Intangible assets**	**39.8**	**69**	
7.1.1	Trademarks by origin/bn PPP$ GDP	45.0	56	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.1	112	
7.1.3	ICTs & business model creation†	64.4	52	●
7.1.4	ICTs & organizational model creation†	57.0	56	●
7.2	**Creative goods & services**	**2.9**	**[110]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	94	
7.2.2	National feature films/mn pop. 15–69 ⊙	1.2	77	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.3	74	
7.3	**Online creativity**	**1.8**	**87**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	4.1	59	
7.3.2	Country-code TLDs/th pop. 15–69	0.5	93	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	3.9	88	
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	97	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

GUINEA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
124	127	Low	SSF	13.1	30.3	2,309.6	n/a

		Score/Value	Rank	
	INSTITUTIONS	**50.6**	**108**	
1.1	**Political environment**	**33.4**	**122**	
1.1.1	Political and operational stability*	57.9	101	
1.1.2	Government effectiveness*	21.2	123	
1.2	**Regulatory environment**	**56.8**	**93**	
1.2.1	Regulatory quality*	19.5	119	
1.2.2	Rule of law*	13.9	125	
1.2.3	Cost of redundancy dismissal, salary weeks	10.1	30	●
1.3	**Business environment**	**61.5**	**96**	
1.3.1	Ease of starting a business*	83.9	86	●
1.3.2	Ease of resolving insolvency*	39.1	102	
	HUMAN CAPITAL & RESEARCH	**6.5**	**128**	○ ◇
2.1	**Education**	**13.8**	**128**	○ ◇
2.1.1	Expenditure on education, % GDP	2.2	116	◇
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	8.7	100	◇
2.1.3	School life expectancy, years ⊙	9.1	109	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	33.1	108	
2.2	**Tertiary education**	**5.8**	**120**	
2.2.1	Tertiary enrolment, % gross ⊙	11.3	105	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, % ⊙	0.9	88	
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**27.0**	**121**	
3.1	**Information & communication technologies(ICTs)**	**27.1**	**123**	
3.1.1	ICT access*	29.8	118	
3.1.2	ICT use*	12.0	121	
3.1.3	Government's online service*	31.3	118	
3.1.4	E-participation*	35.4	115	
3.2	**General infrastructure**	**22.4**	**111**	
3.2.1	Electricity output, kWh/mn pop.	n/a	n/a	
3.2.2	Logistics performance*	6.4	119	
3.2.3	Gross capital formation, % GDP	19.8	94	
3.3	**Ecological sustainability**	**31.4**	**88**	
3.3.1	GDP/unit of energy use	n/a	n/a	
3.3.2	Environmental performance*	46.6	106	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	119	
	MARKET SOPHISTICATION	**31.4**	**125**	
4.1	**Credit**	**11.8**	**123**	
4.1.1	Ease of getting credit*	30.0	115	
4.1.2	Domestic credit to private sector, % GDP ⊙	9.6	125	○
4.1.3	Microfinance gross loans, % GDP ⊙	0.2	43	●
4.2	**Investment**	**40.0**	**[72]**	
4.2.1	Ease of protecting minority investors*	40.0	114	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**42.3**	**125**	
4.3.1	Applied tariff rate, weighted avg., %	12.3	121	
4.3.2	Intensity of local competition†	75.9	21	● ◆
4.3.3	Domestic market scale, bn PPP$	30.3	115	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**23.3**	**[110]**	
5.1	**Knowledge workers**	**16.6**	**[114]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms	16.0	83	◇
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**33.5**	**[42]**	● ◆
5.2.1	University/industry research collaboration†	67.2	14	● ◆
5.2.2	State of cluster development†	50.3	47	● ◆
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**19.8**	**124**	◇
5.3.1	Intellectual property payments, % total trade ⊙	0.0	115	
5.3.2	High-tech imports, % total trade ⊙	2.0	126	○ ◇
5.3.3	ICT services imports, % total trade	0.2	119	◇
5.3.4	FDI net inflows, % GDP	8.2	18	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**2.9**	**129**	○ ◇
6.1	**Knowledge creation**	**1.1**	**127**	○ ◇
6.1.1	Patents by origin/bn PPP$ GDP	0.0	122	◇
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.1	121	◇
6.1.5	Citable documents H-index	1.4	123	◇
6.2	**Knowledge impact**	**1.6**	**[128]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15-64 ⊙	0.1	98	
6.2.3	Computer software spending, % GDP	0.0	106	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.4	123	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**5.9**	**128**	○
6.3.1	Intellectual property receipts, % total trade ⊙	-0.1	109	○ ◇
6.3.2	High-tech net exports, % total trade ⊙	0.1	108	
6.3.3	ICT services exports, % total trade	0.0	127	○
6.3.4	FDI net outflows, % GDP	0.1	99	
	CREATIVE OUTPUTS	**19.6**	**98**	
7.1	**Intangible assets**	**38.6**	**77**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	8.4	108	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.7	55	●
7.1.3	ICTs & business model creation†	68.2	35	● ◆
7.1.4	ICTs & organizational model creation†	60.0	45	● ◆
7.2	**Creative goods & services**	**1.2**	**[123]**	
7.2.1	Cultural & creative services exports, % total trade	0.1	90	
7.2.2	National feature films/mn pop. 15-69 ⊙	0.8	85	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade ⊙	0.0	120	
7.3	**Online creativity**	**0.0**	**128**	○
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	0.0	126	
7.3.2	Country-code TLDs/th pop. 15-69	0.0	128	○
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	0.0	126	○
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

HONDURAS

GII 2019 rank

104

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
104	101	Lower middle	LCN	9.4	49.0	5,212.0	105

		Score/Value	Rank	
	INSTITUTIONS	**46.9**	**121**	○
1.1	**Political environment**	**40.9**	**101**	
1.1.1	Political and operational stability*	54.4	111	
1.1.2	Government effectiveness*	34.1	98	
1.2	**Regulatory environment**	**45.2**	**117**	
1.2.1	Regulatory quality*	30.2	99	
1.2.2	Rule of law*	18.7	121	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	30.3	116	
1.3	**Business environment**	**54.6**	**118**	◇
1.3.1	Ease of starting a business*	77.1	115	
1.3.2	Ease of resolving insolvency*	32.1	114	◇
	HUMAN CAPITAL & RESEARCH	**18.3**	**100**	
2.1	**Education**	**42.1**	**78**	
2.1.1	Expenditure on education, % GDP	6.0	21	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap. ⊙	20.0	50	
2.1.3	School life expectancy, years ⊙	10.2	105	◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	16.7	74	
2.2	**Tertiary education**	**12.6**	**106**	
2.2.1	Tertiary enrolment, % gross ⊙	20.8	91	
2.2.2	Graduates in science & engineering, % ⊙	14.7	89	
2.2.3	Tertiary inbound mobility, % ⊙	0.8	93	
2.3	**Research & development (R&D)**	**0.0**	**119**	
2.3.1	Researchers, FTE/mn pop. ⊙	22.8	102	○
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.0	113	○ ◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**32.5**	**109**	
3.1	**Information & communication technologies(ICTs)**	**41.7**	**101**	
3.1.1	ICT access*	40.7	103	
3.1.2	ICT use*	20.3	108	◇
3.1.3	Government's online service*	51.4	104	
3.1.4	E-participation*	54.5	98	
3.2	**General infrastructure**	**27.0**	**91**	
3.2.1	Electricity output, kWh/mn pop.	964.1	93	
3.2.2	Logistics performance*	25.3	88	
3.2.3	Gross capital formation, % GDP	24.1	53	●
3.3	**Ecological sustainability**	**28.8**	**105**	
3.3.1	GDP/unit of energy use	6.7	91	
3.3.2	Environmental performance*	51.5	93	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.6	79	
	MARKET SOPHISTICATION	**45.7**	**75**	
4.1	**Credit**	**38.7**	**58**	●
4.1.1	Ease of getting credit*	85.0	11	●
4.1.2	Domestic credit to private sector, % GDP	57.4	57	●
4.1.3	Microfinance gross loans, % GDP	0.3	40	
4.2	**Investment**	**41.7**	**[65]**	
4.2.1	Ease of protecting minority investors*	41.7	108	◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**56.9**	**81**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	2.8	62	
4.3.2	Intensity of local competition†	69.5	63	
4.3.3	Domestic market scale, bn PPP$	49.0	96	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**28.9**	**76**	
5.1	**Knowledge workers**	**33.5**	**[77]**	
5.1.1	Knowledge-intensive employment, %	12.2	94	
5.1.2	Firms offering formal training, % firms	47.7	24	●
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	3.5	96	
5.2	**Innovation linkages**	**21.8**	**74**	
5.2.1	University/industry research collaboration†	37.9	81	
5.2.2	State of cluster development†	46.0	68	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	106	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**31.5**	**76**	
5.3.1	Intellectual property payments, % total trade	0.7	56	●
5.3.2	High-tech imports, % total trade	7.5	64	
5.3.3	ICT services imports, % total trade	0.8	82	
5.3.4	FDI net inflows, % GDP	5.7	27	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**12.9**	**110**	
6.1	**Knowledge creation**	**1.8**	**124**	○
6.1.1	Patents by origin/bn PPP$ GDP	0.1	112	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	0.2	46	
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.5	120	○
6.1.5	Citable documents H-index	1.6	121	○ ◇
6.2	**Knowledge impact**	**15.1**	**[114]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.3	60	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.7	66	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**21.6**	**45**	●
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.5	78	
6.3.3	ICT services exports, % total trade	3.0	29	●
6.3.4	FDI net outflows, % GDP	1.3	47	● ◆
	CREATIVE OUTPUTS	**20.2**	**96**	
7.1	**Intangible assets**	**38.7**	**75**	
7.1.1	Trademarks by origin/bn PPP$ GDP	49.5	49	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.1	111	○
7.1.3	ICTs & business model creation†	60.3	64	
7.1.4	ICTs & organizational model creation†	55.3	59	
7.2	**Creative goods & services**	**2.4**	**[114]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	107	
7.2.2	National feature films/mn pop. 15–69	2.2	61	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.1	108	
7.3	**Online creativity**	**0.7**	**104**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.6	106	
7.3.2	Country-code TLDs/th pop. 15–69	0.4	98	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	2.9	95	
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	86	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

HONG KONG, CHINA

GII 2019 rank

13

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
16	8	High	SEAO	7.4	484.0	64,215.7	14

		Score/Value	Rank	
1	**INSTITUTIONS**	**91.1**	**7**	
1.1	**Political environment**	**93.4**	**4**	
1.1.1	Political and operational stability*	94.7	4	
1.1.2	Government effectiveness*	92.7	5	
1.2	**Regulatory environment**	**98.0**	**3**	●
1.2.1	Regulatory quality*	100.0	1	● ◆
1.2.2	Rule of law*	91.8	12	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**81.9**	**28**	
1.3.1	Ease of starting a business*	98.2	5	◆
1.3.2	Ease of resolving insolvency*	65.7	41	◇
2	**HUMAN CAPITAL & RESEARCH**	**46.1**	**28**	◇
2.1	**Education**	**53.6**	**48**	
2.1.1	Expenditure on education, % GDP	3.3	96	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	22.2	40	
2.1.3	School life expectancy, years	16.5	21	
2.1.4	PISA scales in reading, maths, & science	532.6	2	● ◆
2.1.5	Pupil-teacher ratio, secondary	11.5	43	
2.2	**Tertiary education**	**50.0**	**15**	
2.2.1	Tertiary enrolment, % gross	73.8	23	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	11.4	16	
2.3	**Research & development (R&D)**	**34.7**	**33**	◇
2.3.1	Researchers, FTE/mn pop	3,411.7	27	◇
2.3.2	Gross expenditure on R&D, % GDP	0.8	43	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	80.1	7	
3	**INFRASTRUCTURE**	**67.9**	**4**	◆
3.1	**Information & communication technologies(ICTs)**	**87.3**	**[18]**	
3.1.1	ICT access*	91.4	4	◆
3.1.2	ICT use*	83.2	8	
3.1.3	Government's online service*	n/a	n/a	
3.1.4	E-participation*	n/a	n/a	
3.2	**General infrastructure**	**44.1**	**34**	
3.2.1	Electricity output, kWh/mn pop	5,205.2	41	
3.2.2	Logistics performance*	86.8	12	
3.2.3	Gross capital formation, % GDP	22.2	74	○
3.3	**Ecological sustainability**	**72.2**	**2**	● ◆
3.3.1	GDP/unit of energy use	27.0	1	● ◆
3.3.2	Environmental performance*	n/a	n/a	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.2	44	
4	**MARKET SOPHISTICATION**	**77.3**	**3**	● ◆
4.1	**Credit**	**87.5**	**2**	● ◆
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP ⊙	203.8	1	● ◆
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**67.7**	**11**	◆
4.2.1	Ease of protecting minority investors*	78.3	10	◆
4.2.2	Market capitalization, % GDP	1,099.6	1	● ◆
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	26	
4.3	**Trade, competition, & market scale**	**76.8**	**16**	
4.3.1	Applied tariff rate, weighted avg., %	0.0	1	● ◆
4.3.2	Intensity of local competition†	85.6	2	● ◆
4.3.3	Domestic market scale, bn PPP$	484.0	41	

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**51.1**	**20**	
5.1	**Knowledge workers**	**51.9**	**35**	◇
5.1.1	Knowledge-intensive employment, % ⊙	39.0	29	◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.4	43	◇
5.1.4	GERD financed by business, %	50.0	26	
5.1.5	Females employed w/advanced degrees, % ⊙	15.9	41	◇
5.2	**Innovation linkages**	**44.7**	**21**	
5.2.1	University/industry research collaboration†	66.4	15	
5.2.2	State of cluster development†	72.6	6	◆
5.2.3	GERD financed by abroad, %	4.4	65	○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.2	4	◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	1.1	25	◇
5.3	**Knowledge absorption**	**56.6**	**8**	
5.3.1	Intellectual property payments, % total trade	0.3	76	○ ◇
5.3.2	High-tech imports, % total trade	49.8	1	● ◆
5.3.3	ICT services imports, % total trade	0.3	112	○ ◇
5.3.4	FDI net inflows, % GDP	45.3	1	● ◆
5.3.5	Research talent, % in business enterprise	37.3	34	◇
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**32.9**	**33**	◇
6.1	**Knowledge creation**	**21.5**	**[39]**	
6.1.1	Patents by origin/bn PPP$ GDP	0.7	70	◇
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	1.1	22	
6.1.4	Scientific & technical articles/bn PPP$ GDP	n/a	n/a	
6.1.5	Citable documents H-index	35.5	25	
6.2	**Knowledge impact**	**50.1**	**14**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.1	41	
6.2.2	New businesses/th pop. 15-64	27.3	1	● ◆
6.2.3	Computer software spending, % GDP	0.4	27	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	5.7	55	
6.2.5	High- & medium-high-tech manufactures, %	0.1	82	○ ◇
6.3	**Knowledge diffusion**	**27.0**	**36**	
6.3.1	Intellectual property receipts, % total trade	0.1	52	◇
6.3.2	High-tech net exports, % total trade ⊙	0.1	104	○ ◇
6.3.3	ICT services exports, % total trade	0.4	103	○ ◇
6.3.4	FDI net outflows, % GDP	26.2	1	● ◆
7	**CREATIVE OUTPUTS**	**55.9**	**3**	● ◆
7.1	**Intangible assets**	**50.2**	**35**	
7.1.1	Trademarks by origin/bn PPP$ GDP	64.8	31	
7.1.2	Industrial designs by origin/bn PPP$ GDP	2.7	44	
7.1.3	ICTs & business model creation†	74.6	19	
7.1.4	ICTs & organizational model creation†	67.6	23	◇
7.2	**Creative goods & services**	**70.5**	**1**	● ◆
7.2.1	Cultural & creative services exports, % total trade	0.1	76	○ ◇
7.2.2	National feature films/mn pop. 15-69 ⊙	10.4	17	
7.2.3	Entertainment & Media market/th pop. 15-69	50.9	16	
7.2.4	Printing & other media, % manufacturing	4.8	1	● ◆
7.2.5	Creative goods exports, % total trade	9.9	1	● ◆
7.3	**Online creativity**	**52.8**	**10**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	71.9	8	
7.3.2	Country-code TLDs/th pop. 15-69	12.3	36	◇
7.3.3	Wikipedia edits/mn pop. 15-69	84.1	11	
7.3.4	Mobile app creation/bn PPP$ GDP	70.2	5	◆

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

HUNGARY

GII 2019 rank

33

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
26	39	High	EUR	9.7	308.2	31,902.7	33

		Score/Value	Rank	
	INSTITUTIONS	**71.6**	**41**	
1.1	**Political environment**	**67.4**	**41**	
1.1.1	Political and operational stability*	84.2	25	
1.1.2	Government effectiveness*	59.0	43	◇
1.2	**Regulatory environment**	**75.8**	**36**	
1.2.1	Regulatory quality*	59.4	42	
1.2.2	Rule of law*	60.4	40	
1.2.3	Cost of redundancy dismissal, salary weeks	13.4	50	
1.3	**Business environment**	**71.5**	**59**	
1.3.1	Ease of starting a business*	87.9	66	
1.3.2	Ease of resolving insolvency*	55.0	60	
	HUMAN CAPITAL & RESEARCH	**41.0**	**41**	
2.1	**Education**	**51.8**	**52**	
2.1.1	Expenditure on education, % GDP	4.6	59	
2.1.2	Government funding/pupil, secondary, % GDP/cap	21.2	45	
2.1.3	School life expectancy, years	15.1	49	
2.1.4	PISA scales in reading, maths, & science	474.4	36	
2.1.5	Pupil-teacher ratio, secondary ⊙	10.0	30	
2.2	**Tertiary education**	**36.8**	**47**	
2.2.1	Tertiary enrolment, % gross ⊙	48.0	59	
2.2.2	Graduates in science & engineering, %	22.8	45	
2.2.3	Tertiary inbound mobility, %	8.9	22	
2.3	**Research & development (R&D)**	**34.4**	**34**	
2.3.1	Researchers, FTE/mn pop.	2,924.0	31	
2.3.2	Gross expenditure on R&D, % GDP	1.4	25	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	52.5	27	
2.3.4	QS university ranking, average score top 3*	20.5	50	
	INFRASTRUCTURE	**52.7**	**40**	
3.1	**Information & communication technologies(ICTs)**	**71.5**	**54**	◇
3.1.1	ICT access*	77.9	34	
3.1.2	ICT use*	63.6	48	◇
3.1.3	Government's online service*	73.6	57	◇
3.1.4	E-participation*	70.8	67	○ ◇
3.2	**General infrastructure**	**37.8**	**52**	
3.2.1	Electricity output, kWh/mn pop.	3,354.0	58	
3.2.2	Logistics performance*	63.4	30	
3.2.3	Gross capital formation, % GDP	23.3	62	
3.3	**Ecological sustainability**	**48.9**	**35**	
3.3.1	GDP/unit of energy use	9.4	61	
3.3.2	Environmental performance*	65.0	39	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	7.6	11	● ◆
	MARKET SOPHISTICATION	**45.7**	**76**	○
4.1	**Credit**	**44.5**	**46**	
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP	33.4	89	○ ◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**27.1**	**124**	○ ◇
4.2.1	Ease of protecting minority investors*	50.0	93	○ ◇
4.2.2	Market capitalization, % GDP	18.3	62	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	56	○
4.3	**Trade, competition, & market scale**	**65.5**	**51**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	59.3	110	○ ◇
4.3.3	Domestic market scale, bn PPP$	308.2	54	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**40.8**	**33**	
5.1	**Knowledge workers**	**42.1**	**51**	
5.1.1	Knowledge-intensive employment, %	34.3	38	
5.1.2	Firms offering formal training, % firms	15.8	84	○ ◇
5.1.3	GERD performed by business, % GDP	1.0	22	
5.1.4	GERD financed by business, %	56.4	17	
5.1.5	Females employed w/advanced degrees, %	14.4	43	
5.2	**Innovation linkages**	**27.3**	**57**	
5.2.1	University/industry research collaboration†	44.4	53	
5.2.2	State of cluster development†	46.8	62	
5.2.3	GERD financed by abroad, %	16.6	21	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	73	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.4	35	
5.3	**Knowledge absorption**	**53.0**	**16**	●
5.3.1	Intellectual property payments, % total trade	1.5	22	
5.3.2	High-tech imports, % total trade	13.2	17	●
5.3.3	ICT services imports, % total trade	1.3	58	
5.3.4	FDI net inflows, % GDP	13.6	9	●
5.3.5	Research talent, % in business enterprise	61.7	11	●
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**42.8**	**17**	●
6.1	**Knowledge creation**	**20.3**	**43**	
6.1.1	Patents by origin/bn PPP$ GDP	2.0	42	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.5	36	
6.1.3	Utility models by origin/bn PPP$ GDP	0.7	31	
6.1.4	Scientific & technical articles/bn PPP$ GDP	15.8	34	
6.1.5	Citable documents H-index	28.3	33	
6.2	**Knowledge impact**	**49.6**	**15**	●
6.2.1	Growth rate of PPP$ GDP/worker, %	1.4	54	
6.2.2	New businesses/th pop. 15-64	3.4	37	
6.2.3	Computer software spending, % GDP	0.3	36	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	20.5	16	●
6.2.5	High- & medium-high-tech manufactures, %	0.6	8	● ◆
6.3	**Knowledge diffusion**	**58.4**	**8**	● ◆
6.3.1	Intellectual property receipts, % total trade	1.6	16	●
6.3.2	High-tech net exports, % total trade	12.5	11	● ◆
6.3.3	ICT services exports, % total trade	1.9	58	
6.3.4	FDI net outflows, % GDP	11.6	1	● ◆
	CREATIVE OUTPUTS	**34.6**	**38**	
7.1	**Intangible assets**	**43.0**	**56**	
7.1.1	Trademarks by origin/bn PPP$ GDP	40.5	64	○
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.2	40	
7.1.3	ICTs & business model creation†	65.5	50	
7.1.4	ICTs & organizational model creation†	60.3	42	
7.2	**Creative goods & services**	**31.6**	**24**	
7.2.1	Cultural & creative services exports, % total trade	0.8	36	
7.2.2	National feature films/mn pop. 15-69	5.2	42	
7.2.3	Entertainment & Media market/th pop. 15-69	14.1	29	◇
7.2.4	Printing & other media, % manufacturing	0.8	75	○
7.2.5	Creative goods exports, % total trade	6.1	9	● ◆
7.3	**Online creativity**	**20.6**	**32**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	10.4	39	
7.3.2	Country-code TLDs/th pop. 15-69	29.1	20	
7.3.3	Wikipedia edits/mn pop. 15-69	53.7	21	
7.3.4	Mobile app creation/bn PPP$ GDP	6.7	46	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ICELAND

GII 2019 rank

20

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
18	22	High	EUR	0.3	19.3	55,917.3	23

		Score/Value	Rank	
	INSTITUTIONS	**86.8**	**15**	
1.1	**Political environment**	**85.5**	**15**	
1.1.1	Political and operational stability*	93.0	7	
1.1.2	Government effectiveness*	81.7	17	
1.2	**Regulatory environment**	**88.5**	**16**	
1.2.1	Regulatory quality*	80.4	19	
1.2.2	Rule of law*	88.9	17	
1.2.3	Cost of redundancy dismissal, salary weeks	13.0	42	
1.3	**Business environment**	**86.3**	**16**	
1.3.1	Ease of starting a business*	90.7	50	
1.3.2	Ease of resolving insolvency*	81.9	11	
	HUMAN CAPITAL & RESEARCH	**45.4**	**30**	◇
2.1	**Education**	**64.4**	**9**	
2.1.1	Expenditure on education, % GDP	7.7	2	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	20.8	46	
2.1.3	School life expectancy, years	19.2	4	●
2.1.4	PISA scales in reading, maths, & science	480.9	33	◇
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**30.0**	**68**	◇
2.2.1	Tertiary enrolment, % gross ⏲	73.6	24	
2.2.2	Graduates in science & engineering, % ⏲	15.7	84	○ ◇
2.2.3	Tertiary inbound mobility, %	6.8	34	
2.3	**Research & development (R&D)**	**41.7**	**24**	◇
2.3.1	Researchers, FTE/mn pop.	6,118.9	8	
2.3.2	Gross expenditure on R&D, % GDP	2.2	14	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	45.8	36	
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**59.2**	**24**	
3.1	**Information & communication technologies(ICTs)**	**80.7**	**30**	◇
3.1.1	ICT access*	92.9	2	● ◆
3.1.2	ICT use*	88.2	3	● ◆
3.1.3	Government's online service*	72.9	63	◇
3.1.4	E-participation*	68.5	73	◇
3.2	**General infrastructure**	**57.3**	**6**	
3.2.1	Electricity output, kWh/mn pop.	56,585.3	1	● ◆
3.2.2	Logistics performance*	54.3	39	◇
3.2.3	Gross capital formation, % GDP	23.1	64	
3.3	**Ecological sustainability**	**39.5**	**58**	◇
3.3.1	GDP/unit of energy use	2.7	118	○ ◇
3.3.2	Environmental performance*	78.6	11	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	5.0	23	
	MARKET SOPHISTICATION	**56.0**	**35**	
4.1	**Credit**	**51.2**	**29**	
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	89.8	30	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**64.2**	**16**	
4.2.1	Ease of protecting minority investors*	70.0	27	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.2	6	
4.3	**Trade, competition, & market scale**	**52.6**	**98**	○ ◇
4.3.1	Applied tariff rate, weighted avg., %	1.6	17	
4.3.2	Intensity of local competition†	70.0	61	◇
4.3.3	Domestic market scale, bn PPP$	19.3	126	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**48.0**	**23**	◇
5.1	**Knowledge workers**	**66.8**	**14**	
5.1.1	Knowledge-intensive employment, %	50.0	6	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	1.4	14	
5.1.4	GERD financed by business, %	36.4	51	◇
5.1.5	Females employed w/advanced degrees, %	24.4	15	
5.2	**Innovation linkages**	**47.7**	**16**	
5.2.1	University/industry research collaboration†	59.7	24	
5.2.2	State of cluster development†	52.6	43	◇
5.2.3	GERD financed by abroad, %	24.5	14	◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	41	◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	3.9	13	
5.3	**Knowledge absorption**	**29.5**	**84**	○ ◇
5.3.1	Intellectual property payments, % total trade	1.1	33	
5.3.2	High-tech imports, % total trade	5.1	105	○ ◇
5.3.3	ICT services imports, % total trade	2.3	19	
5.3.4	FDI net inflows, % GDP	-9.3	129	○ ◇
5.3.5	Research talent, % in business enterprise	42.7	30	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**37.6**	**23**	
6.1	**Knowledge creation**	**40.0**	**19**	
6.1.1	Patents by origin/bn PPP$ GDP	5.1	24	
6.1.2	PCT patents by origin/bn PPP$ GDP	2.5	14	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	32.6	5	● ◆
6.1.5	Citable documents H-index	18.6	40	◇
6.2	**Knowledge impact**	**39.6**	**51**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	1.3	56	
6.2.2	New businesses/th pop. 15–64	12.1	10	
6.2.3	Computer software spending, % GDP	0.3	44	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.3	43	
6.2.5	High- & medium-high-tech manufactures, %	0.1	73	○ ◇
6.3	**Knowledge diffusion**	**33.2**	**26**	
6.3.1	Intellectual property receipts, % total trade	2.4	10	
6.3.2	High-tech net exports, % total trade	1.5	60	◇
6.3.3	ICT services exports, % total trade	2.7	37	
6.3.4	FDI net outflows, % GDP	n/a	n/a	
	CREATIVE OUTPUTS	**50.4**	**9**	
7.1	**Intangible assets**	**54.0**	**24**	
7.1.1	Trademarks by origin/bn PPP$ GDP	93.8	20	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.8	74	○
7.1.3	ICTs & business model creation†	72.8	26	
7.1.4	ICTs & organizational model creation†	75.5	13	
7.2	**Creative goods & services**	**30.9**	**25**	
7.2.1	Cultural & creative services exports, % total trade	0.6	40	
7.2.2	National feature films/mn pop. 15–69 ⏲	98.5	1	● ◆
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.7	24	
7.2.5	Creative goods exports, % total trade	0.1	105	○ ◇
7.3	**Online creativity**	**62.5**	**4**	● ◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	100.0	1	● ◆
7.3.2	Country-code TLDs/th pop. 15–69	78.2	5	● ◆
7.3.3	Wikipedia edits/mn pop. 15–69 ⏲	104.8	4	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	1.2	64	○ ◇

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⏲ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

INDIA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
51	61	Lower middle	CSA	1,354.1	10,401.4	7,873.7	57

		Score/Value	Rank	
	INSTITUTIONS	**59.5**	**77**	
1.1	**Political environment**	**53.0**	**71**	
1.1.1	Political and operational stability*	61.4	91	
1.1.2	Government effectiveness*	48.8	65	◆
1.2	**Regulatory environment**	**64.5**	**69**	
1.2.1	Regulatory quality*	35.1	90	
1.2.2	Rule of law*	46.5	64	◆
1.2.3	Cost of redundancy dismissal, salary weeks	15.8	63	
1.3	**Business environment**	**60.9**	**101**	
1.3.1	Ease of starting a business*	81.0	104	
1.3.2	Ease of resolving insolvency*	40.8	95	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**33.5**	**53**	◆
2.1	**Education**	**28.0**	**110**	○
2.1.1	Expenditure on education, % GDP ⊙	3.8	84	
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	16.8	72	
2.1.3	School life expectancy, years	12.3	87	
2.1.4	PISA scales in reading, maths, & science ⊙	336.0	71	○ ◇
2.1.5	Pupil-teacher ratio, secondary ⊙	28.5	104	○ ◇
2.2	**Tertiary education**	**38.4**	**40**	◆
2.2.1	Tertiary enrolment, % gross	27.5	86	
2.2.2	Graduates in science & engineering, %	32.6	7	● ◆
2.2.3	Tertiary inbound mobility, %	0.1	107	○
2.3	**Research & development (R&D)**	**34.2**	**35**	◆
2.3.1	Researchers, FTE/mn pop. ⊙	216.2	77	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.6	50	◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	73.9	15	● ◆
2.3.4	QS university ranking, average score top 3*	47.3	21	● ◆

		Score/Value	Rank	
	INFRASTRUCTURE	**43.0**	**79**	
3.1	**Information & communication technologies(ICTs)**	**62.5**	**75**	
3.1.1	ICT access*	38.5	105	○
3.1.2	ICT use*	20.8	106	○
3.1.3	Government's online service*	95.1	9	● ◆
3.1.4	E-participation*	95.5	15	● ◆
3.2	**General infrastructure**	**41.9**	**42**	◆
3.2.1	Electricity output, kWh/mn pop.	1,115.8	92	
3.2.2	Logistics performance*	52.1	43	◆
3.2.3	Gross capital formation, % GDP	31.5	17	●
3.3	**Ecological sustainability**	**24.7**	**117**	○
3.3.1	GDP/unit of energy use	9.2	62	
3.3.2	Environmental performance*	30.6	125	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.8	70	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**56.3**	**33**	◆
4.1	**Credit**	**38.7**	**57**	
4.1.1	Ease of getting credit*	80.0	20	
4.1.2	Domestic credit to private sector, % GDP	49.7	69	
4.1.3	Microfinance gross loans, % GDP	0.8	23	
4.2	**Investment**	**50.8**	**37**	
4.2.1	Ease of protecting minority investors*	80.0	6	● ◆
4.2.2	Market capitalization, % GDP	76.9	20	◆
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	30	◆
4.3	**Trade, competition, & market scale**	**79.4**	**9**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	5.8	93	
4.3.2	Intensity of local competition†	67.6	70	
4.3.3	Domestic market scale, bn PPP$	10,401.4	3	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**31.0**	**65**	
5.1	**Knowledge workers**	**24.1**	**99**	
5.1.1	Knowledge-intensive employment, % ⊙	14.2	91	
5.1.2	Firms offering formal training, % firms	35.9	38	
5.1.3	GERD performed by business, % GDP ⊙	0.3	49	◆
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	1.6	103	○
5.2	**Innovation linkages**	**33.6**	**41**	◆
5.2.1	University/industry research collaboration†	60.1	23	◆
5.2.2	State of cluster development†	60.4	25	◆
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	48	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	46	◆
5.3	**Knowledge absorption**	**35.4**	**56**	
5.3.1	Intellectual property payments, % total trade	1.2	29	◆
5.3.2	High-tech imports, % total trade	10.3	27	
5.3.3	ICT services imports, % total trade	1.2	62	
5.3.4	FDI net inflows, % GDP	1.9	83	
5.3.5	Research talent, % in business enterprise ⊙	26.4	46	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**33.5**	**32**	◆
6.1	**Knowledge creation**	**20.9**	**42**	
6.1.1	Patents by origin/bn PPP$ GDP	1.6	52	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	51	◆
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.3	77	
6.1.5	Citable documents H-index	38.9	21	● ◆
6.2	**Knowledge impact**	**43.4**	**35**	
6.2.1	Growth rate of PPP$ GDP/worker, %	5.9	4	● ◆
6.2.2	New businesses/th pop. 15–64	0.1	100	○
6.2.3	Computer software spending, % GDP	0.2	65	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.8	65	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.3	33	◆
6.3	**Knowledge diffusion**	**36.1**	**23**	◆
6.3.1	Intellectual property receipts, % total trade	0.1	50	
6.3.2	High-tech net exports, % total trade	2.8	46	
6.3.3	ICT services exports, % total trade	10.4	1	● ◆
6.3.4	FDI net outflows, % GDP	0.3	76	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**23.5**	**78**	
7.1	**Intangible assets**	**37.8**	**81**	
7.1.1	Trademarks by origin/bn PPP$ GDP	25.6	79	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.8	77	
7.1.3	ICTs & business model creation†	61.1	58	
7.1.4	ICTs & organizational model creation†	59.6	47	◆
7.2	**Creative goods & services**	**15.2**	**66**	
7.2.1	Cultural & creative services exports, % total trade	0.7	39	◆
7.2.2	National feature films/mn pop. 15–69 ⊙	2.2	60	
7.2.3	Entertainment & Media market/th pop. 15–69	0.5	60	○
7.2.4	Printing & other media, % manufacturing ⊙	0.6	88	○
7.2.5	Creative goods exports, % total trade	2.7	22	
7.3	**Online creativity**	**3.2**	**76**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.9	98	
7.3.2	Country-code TLDs/th pop. 15–69	0.6	91	
7.3.3	Wikipedia edits/mn pop. 15–69	1.0	105	
7.3.4	Mobile app creation/bn PPP$ GDP	10.7	42	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

INDONESIA

GII 2019 rank

85

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
78	87	Lower middle	SEAO	266.8	3,495.9	13,229.5	85

		Score/Value	Rank	
	INSTITUTIONS	**53.2**	**99**	
1.1	**Political environment**	**53.9**	**68**	◆
1.1.1	Political and operational stability*	66.7	74	
1.1.2	Government effectiveness*	47.5	68	◆
1.2	**Regulatory environment**	**31.1**	**128**	○ ◇
1.2.1	Regulatory quality*	39.1	75	
1.2.2	Rule of law*	37.2	82	
1.2.3	Cost of redundancy dismissal, salary weeks	57.8	125	○ ◇
1.3	**Business environment**	**74.6**	**49**	◆
1.3.1	Ease of starting a business*	81.2	102	
1.3.2	Ease of resolving insolvency*	67.9	33	● ◆
	HUMAN CAPITAL & RESEARCH	**21.3**	**90**	
2.1	**Education**	**33.9**	**99**	
2.1.1	Expenditure on education, % GDP	3.6	92	
2.1.2	Government funding/pupil, secondary, % GDP/cap	10.5	94	○
2.1.3	School life expectancy, years	13.4	78	
2.1.4	PISA scales in reading, maths, & science	395.5	63	
2.1.5	Pupil-teacher ratio, secondary	15.3	69	
2.2	**Tertiary education**	**21.5**	**89**	
2.2.1	Tertiary enrolment, % gross	36.3	74	
2.2.2	Graduates in science & engineering, %	19.4	68	
2.2.3	Tertiary inbound mobility, %	0.1	110	○
2.3	**Research & development (R&D)**	**8.4**	**63**	
2.3.1	Researchers, FTE/mn pop. ◷	89.2	86	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.1	109	○ ◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	31.3	36	● ◆
	INFRASTRUCTURE	**44.2**	**75**	◆
3.1	**Information & communication technologies(ICTs)**	**53.7**	**88**	
3.1.1	ICT access*	51.4	85	
3.1.2	ICT use*	44.8	77	◆
3.1.3	Government's online service*	56.9	92	
3.1.4	E-participation*	61.8	88	
3.2	**General infrastructure**	**43.5**	**35**	● ◆
3.2.1	Electricity output, kWh/mn pop.	952.1	94	
3.2.2	Logistics performance*	50.8	45	◆
3.2.3	Gross capital formation, % GDP	33.4	15	●
3.3	**Ecological sustainability**	**35.4**	**76**	
3.3.1	GDP/unit of energy use	11.9	30	●
3.3.2	Environmental performance*	46.9	105	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.7	75	
	MARKET SOPHISTICATION	**48.8**	**64**	
4.1	**Credit**	**29.0**	**96**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	38.7	85	
4.1.3	Microfinance gross loans, % GDP	0.0	61	
4.2	**Investment**	**36.8**	**90**	
4.2.1	Ease of protecting minority investors*	63.3	48	
4.2.2	Market capitalization, % GDP	46.0	32	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	60	
4.3	**Trade, competition, & market scale**	**80.6**	**7**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	2.1	54	◆
4.3.2	Intensity of local competition†	73.2	37	◆
4.3.3	Domestic market scale, bn PPP$	3,495.9	7	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**25.7**	**95**	
5.1	**Knowledge workers**	**10.9**	**122**	○ ◇
5.1.1	Knowledge-intensive employment, %	10.9	97	
5.1.2	Firms offering formal training, % firms	7.7	90	○ ◇
5.1.3	GERD performed by business, % GDP ◷	0.0	78	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	6.0	85	
5.2	**Innovation linkages**	**29.4**	**50**	
5.2.1	University/industry research collaboration†	53.8	34	● ◆
5.2.2	State of cluster development†	60.0	27	● ◆
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	92	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	91	
5.3	**Knowledge absorption**	**36.7**	**48**	
5.3.1	Intellectual property payments, % total trade	1.0	35	◆
5.3.2	High-tech imports, % total trade	8.5	49	
5.3.3	ICT services imports, % total trade	1.3	54	
5.3.4	FDI net inflows, % GDP	1.6	90	
5.3.5	Research talent, % in business enterprise ◷	35.5	37	◆
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**17.6**	**82**	
6.1	**Knowledge creation**	**4.6**	**101**	
6.1.1	Patents by origin/bn PPP$ GDP	0.7	72	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	97	○
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	54	
6.1.4	Scientific & technical articles/bn PPP$ GDP	0.6	125	○
6.1.5	Citable documents H-index	12.7	55	
6.2	**Knowledge impact**	**36.7**	**64**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.3	37	
6.2.2	New businesses/th pop. 15-64	0.3	91	
6.2.3	Computer software spending, % GDP	0.3	33	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.2	85	
6.2.5	High- & medium-high-tech manufactures, % ◷	0.3	37	◆
6.3	**Knowledge diffusion**	**11.5**	**96**	
6.3.1	Intellectual property receipts, % total trade	0.0	76	
6.3.2	High-tech net exports, % total trade	3.1	43	
6.3.3	ICT services exports, % total trade	0.5	101	
6.3.4	FDI net outflows, % GDP	0.0	112	○
	CREATIVE OUTPUTS	**24.0**	**76**	
7.1	**Intangible assets**	**40.0**	**68**	
7.1.1	Trademarks by origin/bn PPP$ GDP	16.0	93	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.7	80	
7.1.3	ICTs & business model creation†	67.1	40	◆
7.1.4	ICTs & organizational model creation†	65.4	27	● ◆
7.2	**Creative goods & services**	**13.9**	**73**	
7.2.1	Cultural & creative services exports, % total trade	0.0	99	
7.2.2	National feature films/mn pop. 15-69 ◷	0.5	96	○
7.2.3	Entertainment & Media market/th pop. 15-69	2.2	52	◆
7.2.4	Printing & other media, % manufacturing ◷	0.8	77	
7.2.5	Creative goods exports, % total trade	2.9	19	● ◆
7.3	**Online creativity**	**2.0**	**83**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.5	88	
7.3.2	Country-code TLDs/th pop. 15-69	0.4	97	
7.3.3	Wikipedia edits/mn pop. 15-69	2.0	99	
7.3.4	Mobile app creation/bn PPP$ GDP	4.8	49	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

IRAN (ISLAMIC REPUBLIC OF)

GII 2019 rank

61

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
47	86	Upper middle	CSA	82.0	1,652.9	19,556.6	65

		Score/Value	Rank	
	INSTITUTIONS	**48.8**	**116**	○ ◇
1.1	**Political environment**	**46.7**	**90**	
1.1.1	Political and operational stability*	56.1	105	◇
1.1.2	Government effectiveness*	41.9	85	
1.2	**Regulatory environment**	**48.0**	**115**	○ ◇
1.2.1	Regulatory quality*	9.8	127	○ ◇
1.2.2	Rule of law*	28.3	105	
1.2.3	Cost of redundancy dismissal, salary weeks	23.1	96	
1.3	**Business environment**	**51.7**	**123**	○ ◇
1.3.1	Ease of starting a business*	67.8	123	○ ◇
1.3.2	Ease of resolving insolvency*	35.6	109	◇
	HUMAN CAPITAL & RESEARCH	**37.6**	**43**	
2.1	**Education**	**41.0**	**80**	
2.1.1	Expenditure on education, % GDP	3.8	87	
2.1.2	Government funding/pupil, secondary, % GDP/cap	17.7	63	
2.1.3	School life expectancy, years	14.9	55	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	19.0	84	
2.2	**Tertiary education**	**62.6**	**2**	● ◆
2.2.1	Tertiary enrolment, % gross ⊙	68.8	30	●
2.2.2	Graduates in science & engineering, %	43.9	3	● ◆
2.2.3	Tertiary inbound mobility, %	0.4	97	○
2.3	**Research & development (R&D)**	**9.1**	**59**	
2.3.1	Researchers, FTE/mn pop. ⊙	671.0	60	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.3	83	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	23.4	45	
	INFRASTRUCTURE	**46.0**	**68**	
3.1	**Information & communication technologies(ICTs)**	**59.6**	**79**	
3.1.1	ICT access*	72.7	58	
3.1.2	ICT use*	49.8	71	
3.1.3	Government's online service*	63.2	87	
3.1.4	E-participation*	52.8	102	
3.2	**General infrastructure**	**48.6**	**23**	● ◆
3.2.1	Electricity output, kWh/mn pop.	3,601.1	56	
3.2.2	Logistics performance*	36.9	63	
3.2.3	Gross capital formation, % GDP	39.1	8	● ◆
3.3	**Ecological sustainability**	**29.8**	**97**	◇
3.3.1	GDP/unit of energy use	5.9	101	◇
3.3.2	Environmental performance*	58.2	70	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	88	
	MARKET SOPHISTICATION	**40.0**	**100**	◇
4.1	**Credit**	**40.2**	**54**	
4.1.1	Ease of getting credit*	50.0	87	
4.1.2	Domestic credit to private sector, % GDP ⊙	66.1	47	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**25.2**	**128**	○ ◇
4.2.1	Ease of protecting minority investors*	33.3	125	○ ◇
4.2.2	Market capitalization, % GDP	24.6	53	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**54.7**	**90**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	15.2	127	○ ◇
4.3.2	Intensity of local competition†	58.0	113	○ ◇
4.3.3	Domestic market scale, bn PPP$	1,652.9	18	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**22.6**	**113**	○ ◇
5.1	**Knowledge workers**	**26.3**	**[93]**	
5.1.1	Knowledge-intensive employment, %	18.7	76	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ⊙	0.1	65	
5.1.4	GERD financed by business, % ⊙	30.9	57	
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**20.3**	**84**	
5.2.1	University/industry research collaboration†	33.6	97	
5.2.2	State of cluster development†	43.9	78	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	110	○ ◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	78	
5.3	**Knowledge absorption**	**21.1**	**120**	○ ◇
5.3.1	Intellectual property payments, % total trade ⊙	0.2	92	
5.3.2	High-tech imports, % total trade	4.9	107	
5.3.3	ICT services imports, % total trade ⊙	0.5	104	
5.3.4	FDI net inflows, % GDP	0.8	108	◇
5.3.5	Research talent, % in business enterprise ⊙	15.0	60	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**27.2**	**46**	
6.1	**Knowledge creation**	**27.9**	**32**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP	9.3	14	● ◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	64	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	17.6	27	● ◆
6.1.5	Citable documents H-index	17.6	41	
6.2	**Knowledge impact**	**46.3**	**23**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	3.4	18	●
6.2.2	New businesses/th pop. 15-64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.3	59	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.5	100	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.4	30	●
6.3	**Knowledge diffusion**	**7.5**	**116**	○ ◇
6.3.1	Intellectual property receipts, % total trade ⊙	0.0	86	
6.3.2	High-tech net exports, % total trade	0.3	91	
6.3.3	ICT services exports, % total trade ⊙	0.6	95	
6.3.4	FDI net outflows, % GDP ⊙	0.0	108	
	CREATIVE OUTPUTS	**32.5**	**45**	
7.1	**Intangible assets**	**62.6**	**6**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	200.7	4	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	10.9	13	● ◆
7.1.3	ICTs & business model creation†	57.6	78	
7.1.4	ICTs & organizational model creation†	47.4	91	
7.2	**Creative goods & services**	**1.4**	**120**	○ ◇
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15-69	1.7	71	
7.2.3	Entertainment & Media market/th pop. 15-69	1.7	54	◇
7.2.4	Printing & other media, % manufacturing ⊙	0.2	102	○ ◇
7.2.5	Creative goods exports, % total trade	0.1	111	
7.3	**Online creativity**	**3.2**	**77**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.8	79	
7.3.2	Country-code TLDs/th pop. 15-69	4.7	50	
7.3.3	Wikipedia edits/mn pop. 15-69	9.4	64	
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	96	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

IRELAND

GII 2019 rank

12

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
10	**20**	**High**	**EUR**	**4.8**	**378.5**	**78,784.8**	**10**

		Score/Value	Rank	
1	**INSTITUTIONS**	**85.5**	**18**	
1.1	**Political environment**	**81.7**	**18**	
1.1.1	Political and operational stability*	89.5	15	
1.1.2	Government effectiveness*	77.8	23	
1.2	**Regulatory environment**	**87.3**	**19**	
1.2.1	Regulatory quality*	84.5	17	
1.2.2	Rule of law*	84.2	20	
1.2.3	Cost of redundancy dismissal, salary weeks	14.3	56	○
1.3	**Business environment**	**87.5**	**12**	
1.3.1	Ease of starting a business*	95.9	10	
1.3.2	Ease of resolving insolvency*	79.1	17	
2	**HUMAN CAPITAL & RESEARCH**	**48.4**	**22**	
2.1	**Education**	**49.7**	**61**	○ ◇
2.1.1	Expenditure on education, % GDP	3.8	88	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	16.5	75	○ ◇
2.1.3	School life expectancy, years	18.8	9	●
2.1.4	PISA scales in reading, maths, & science	509.0	10	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**45.4**	**23**	
2.2.1	Tertiary enrolment, % gross ◷	77.6	21	
2.2.2	Graduates in science & engineering, %	25.2	29	
2.2.3	Tertiary inbound mobility, %	8.2	26	
2.3	**Research & development (R&D)**	**50.0**	**20**	
2.3.1	Researchers, FTE/mn pop	4,288.6	21	
2.3.2	Gross expenditure on R&D, % GDP	1.0	34	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	78.4	12	
2.3.4	QS university ranking, average score top 3*	47.0	22	
3	**INFRASTRUCTURE**	**66.3**	**5**	● ◆
3.1	**Information & communication technologies(ICTs)**	**83.8**	**23**	
3.1.1	ICT access*	81.3	22	
3.1.2	ICT use*	77.9	20	
3.1.3	Government's online service*	82.6	39	◇
3.1.4	E-participation*	93.3	22	
3.2	**General infrastructure**	**45.7**	**32**	
3.2.1	Electricity output, kWh/mn pop	6,394.0	32	
3.2.2	Logistics performance*	67.7	28	◇
3.2.3	Gross capital formation, % GDP	27.1	34	
3.3	**Ecological sustainability**	**69.6**	**4**	● ◆
3.3.1	GDP/unit of energy use	23.3	3	● ◆
3.3.2	Environmental performance*	78.8	9	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.8	34	
4	**MARKET SOPHISTICATION**	**54.6**	**39**	
4.1	**Credit**	**44.8**	**44**	◇
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	44.4	76	○ ◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**50.1**	**38**	
4.2.1	Ease of protecting minority investors*	75.0	14	
4.2.2	Market capitalization, % GDP	42.4	34	○ ◇
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	14	
4.3	**Trade, competition, & market scale**	**69.0**	**37**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	69.4	64	○ ◇
4.3.3	Domestic market scale, bn PPP$	378.5	48	

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**55.8**	**13**	
5.1	**Knowledge workers**	**62.1**	**22**	
5.1.1	Knowledge-intensive employment, %	42.5	21	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.7	27	◇
5.1.4	GERD financed by business, %	49.0	30	
5.1.5	Females employed w/advanced degrees, %	25.6	9	● ◆
5.2	**Innovation linkages**	**46.2**	**17**	
5.2.1	University/industry research collaboration†	69.9	11	
5.2.2	State of cluster development†	60.8	23	
5.2.3	GERD financed by abroad, %	23.6	16	◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	18	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	1.8	22	
5.3	**Knowledge absorption**	**59.1**	**5**	●
5.3.1	Intellectual property payments, % total trade	22.2	1	● ◆
5.3.2	High-tech imports, % total trade	8.1	56	○
5.3.3	ICT services imports, % total trade	1.5	46	
5.3.4	FDI net inflows, % GDP	35.3	4	● ◆
5.3.5	Research talent, % in business enterprise	53.3	22	
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**56.9**	**6**	●
6.1	**Knowledge creation**	**28.7**	**31**	◇
6.1.1	Patents by origin/bn PPP$ GDP	2.2	39	◇
6.1.2	PCT patents by origin/bn PPP$ GDP	1.6	22	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	13.2	39	◇
6.1.5	Citable documents H-index	33.2	28	
6.2	**Knowledge impact**	**58.6**	**3**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	2.8	28	◆
6.2.2	New businesses/th pop. 15-64	6.7	21	
6.2.3	Computer software spending, % GDP	0.8	2	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.3	44	
6.2.5	High- & medium-high-tech manufactures, % ◷	0.7	2	● ◆
6.3	**Knowledge diffusion**	**83.4**	**1**	● ◆
6.3.1	Intellectual property receipts, % total trade	2.8	7	●
6.3.2	High-tech net exports, % total trade	9.9	16	
6.3.3	ICT services exports, % total trade	22.7	1	● ◆
6.3.4	FDI net outflows, % GDP	28.7	1	● ◆
7	**CREATIVE OUTPUTS**	**43.3**	**19**	
7.1	**Intangible assets**	**60.5**	**8**	●
7.1.1	Trademarks by origin/bn PPP$ GDP	n/a	n/a	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.4	59	○
7.1.3	ICTs & business model creation†	76.5	14	
7.1.4	ICTs & organizational model creation†	70.8	20	
7.2	**Creative goods & services**	**18.4**	**59**	○ ◇
7.2.1	Cultural & creative services exports, % total trade	0.2	72	○ ◇
7.2.2	National feature films/mn pop. 15-69 ◷	8.9	21	
7.2.3	Entertainment & Media market/th pop. 15-69	49.6	18	
7.2.4	Printing & other media, % manufacturing	0.5	94	○ ◇
7.2.5	Creative goods exports, % total trade	1.3	40	
7.3	**Online creativity**	**33.7**	**24**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	61.0	11	
7.3.2	Country-code TLDs/th pop. 15-69	22.1	26	
7.3.3	Wikipedia edits/mn pop. 15-69	49.5	24	
7.3.4	Mobile app creation/bn PPP$ GDP	18.3	25	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ISRAEL

GII 2019 rank

10

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
8	17	High	NAWA	8.5	336.1	37,972.0	11

		Score/Value	Rank	
	INSTITUTIONS	**77.9**	**31**	◇
1.1	**Political environment**	**78.6**	**24**	
1.1.1	Political and operational stability*	75.4	46	◇
1.1.2	Government effectiveness*	80.1	20	
1.2	**Regulatory environment**	**72.6**	**44**	◇
1.2.1	Regulatory quality*	76.1	23	
1.2.2	Rule of law*	73.4	28	◇
1.2.3	Cost of redundancy dismissal, salary weeks	27.4	111	○ ◇
1.3	**Business environment**	**82.5**	**26**	
1.3.1	Ease of starting a business*	92.4	41	
1.3.2	Ease of resolving insolvency*	72.7	27	
	HUMAN CAPITAL & RESEARCH	**54.5**	**14**	
2.1	**Education**	**55.6**	**42**	
2.1.1	Expenditure on education, % GDP	5.9	22	
2.1.2	Government funding/pupil, secondary, % GDP/cap	18.7	56	○
2.1.3	School life expectancy, years	16.0	35	
2.1.4	PISA scales in reading, maths, & science	471.7	38	○ ◇
2.1.5	Pupil-teacher ratio, secondary ⊕	9.8	26	
2.2	**Tertiary education**	**29.7**	**72**	○ ◇
2.2.1	Tertiary enrolment, % gross	62.7	42	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, % ⊕	2.8	67	○ ◇
2.3	**Research & development (R&D)**	**78.2**	**2**	● ◆
2.3.1	Researchers, FTE/mn pop. ⊕	8,250.5	1	● ◆
2.3.2	Gross expenditure on R&D, % GDP	4.6	1	● ◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	70.0	17	
2.3.4	QS university ranking, average score top 3*	42.6	27	
	INFRASTRUCTURE	**56.1**	**33**	◇
3.1	**Information & communication technologies(ICTs)**	**80.6**	**31**	◇
3.1.1	ICT access*	80.3	27	
3.1.2	ICT use*	76.2	24	
3.1.3	Government's online service*	82.6	39	◇
3.1.4	E-participation*	83.2	43	◇
3.2	**General infrastructure**	**37.9**	**51**	◇
3.2.1	Electricity output, kWh/mn pop.	7,791.4	24	
3.2.2	Logistics performance*	58.2	36	◇
3.2.3	Gross capital formation, % GDP	20.9	89	○
3.3	**Ecological sustainability**	**50.0**	**30**	
3.3.1	GDP/unit of energy use	12.0	29	
3.3.2	Environmental performance*	75.0	19	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.8	35	
	MARKET SOPHISTICATION	**61.4**	**16**	
4.1	**Credit**	**47.7**	**37**	
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	66.0	48	◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**66.5**	**14**	
4.2.1	Ease of protecting minority investors*	73.3	21	
4.2.2	Market capitalization, % GDP	71.6	21	
4.2.3	Venture capital deals/bn PPP$ GDP	0.4	3	● ◆
4.3	**Trade, competition, & market scale**	**69.8**	**34**	
4.3.1	Applied tariff rate, weighted avg., %	1.9	50	
4.3.2	Intensity of local competition†	75.4	24	
4.3.3	Domestic market scale, bn PPP$	336.1	50	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**66.5**	**3**	● ◆
5.1	**Knowledge workers**	**63.4**	**19**	
5.1.1	Knowledge-intensive employment, %	48.4	8	
5.1.2	Firms offering formal training, % firms	18.6	76	○ ◇
5.1.3	GERD performed by business, % GDP	3.9	1	● ◆
5.1.4	GERD financed by business, %	34.7	54	○ ◇
5.1.5	Females employed w/advanced degrees, % ⊕	28.4	3	● ◆
5.2	**Innovation linkages**	**82.5**	**1**	● ◆
5.2.1	University/industry research collaboration†	79.4	2	● ◆
5.2.2	State of cluster development†	58.5	30	
5.2.3	GERD financed by abroad, %	49.8	3	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	8	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	6.9	2	● ◆
5.3	**Knowledge absorption**	**53.7**	**15**	
5.3.1	Intellectual property payments, % total trade	0.5	65	○ ◇
5.3.2	High-tech imports, % total trade	9.0	45	
5.3.3	ICT services imports, % total trade	2.1	24	
5.3.4	FDI net inflows, % GDP	4.2	40	
5.3.5	Research talent, % in business enterprise ⊕	83.7	1	● ◆
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**56.9**	**7**	
6.1	**Knowledge creation**	**56.7**	**10**	
6.1.1	Patents by origin/bn PPP$ GDP	4.5	25	
6.1.2	PCT patents by origin/bn PPP$ GDP	5.7	7	◆
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	24.2	14	
6.1.5	Citable documents H-index	47.1	16	
6.2	**Knowledge impact**	**48.0**	**21**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.2	59	
6.2.2	New businesses/th pop. 15–64	3.4	36	
6.2.3	Computer software spending, % GDP	0.3	57	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	27.1	5	◆
6.2.5	High- & medium-high-tech manufactures, % ⊕	0.4	19	
6.3	**Knowledge diffusion**	**65.9**	**4**	◆
6.3.1	Intellectual property receipts, % total trade	1.7	14	
6.3.2	High-tech net exports, % total trade	11.9	13	
6.3.3	ICT services exports, % total trade	12.2	1	● ◆
6.3.4	FDI net outflows, % GDP	3.3	21	
	CREATIVE OUTPUTS	**46.3**	**14**	
7.1	**Intangible assets**	**49.1**	**39**	
7.1.1	Trademarks by origin/bn PPP$ GDP	11.8	101	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.4	38	
7.1.3	ICTs & business model creation†	81.5	5	
7.1.4	ICTs & organizational model creation†	77.0	12	
7.2	**Creative goods & services**	**28.4**	**34**	
7.2.1	Cultural & creative services exports, % total trade	2.5	4	◆
7.2.2	National feature films/mn pop. 15–69 ⊕	5.7	38	
7.2.3	Entertainment & Media market/th pop. 15–69	35.8	21	◇
7.2.4	Printing & other media, % manufacturing ⊕	1.1	57	○
7.2.5	Creative goods exports, % total trade	1.7	31	
7.3	**Online creativity**	**58.8**	**5**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	22.4	26	
7.3.2	Country-code TLDs/th pop. 15–69	12.7	35	◇
7.3.3	Wikipedia edits/mn pop. 15–69	148.4	1	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	100.0	1	● ◆

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ITALY

GII 2019 rank

30

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
29	30	High	EUR	59.3	2,398.2	39,637.0	31

		Score/Value	Rank	
	INSTITUTIONS	**75.3**	**34**	
1.1	**Political environment**	**63.7**	**46**	◇
1.1.1	Political and operational stability*	73.7	50	◇
1.1.2	Government effectiveness*	58.7	44	◇
1.2	**Regulatory environment**	**79.0**	**31**	
1.2.1	Regulatory quality*	60.8	39	
1.2.2	Rule of law*	55.0	50	◇
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	● ◆
1.3	**Business environment**	**83.4**	**23**	
1.3.1	Ease of starting a business*	89.5	57	
1.3.2	Ease of resolving insolvency*	77.3	21	
	HUMAN CAPITAL & RESEARCH	**45.4**	**31**	
2.1	**Education**	**53.6**	**49**	
2.1.1	Expenditure on education, % GDP	4.1	75	○
2.1.2	Government funding/pupil, secondary, % GDP/cap	22.9	37	
2.1.3	School life expectancy, years	16.2	30	
2.1.4	PISA scales in reading, maths, & science	485.0	31	
2.1.5	Pupil-teacher ratio, secondary ⊙	10.0	31	
2.2	**Tertiary education**	**37.0**	**46**	
2.2.1	Tertiary enrolment, % gross ⊙	63.0	40	
2.2.2	Graduates in science & engineering, %	23.3	42	
2.2.3	Tertiary inbound mobility, %	5.1	39	
2.3	**Research & development (R&D)**	**45.5**	**22**	
2.3.1	Researchers, FTE/mn pop.	2,294.5	37	
2.3.2	Gross expenditure on R&D, % GDP	1.4	24	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	77.2	13	●
2.3.4	QS university ranking, average score top 3*	47.6	20	
	INFRASTRUCTURE	**59.4**	**22**	
3.1	**Information & communication technologies(ICTs)**	**82.6**	**24**	
3.1.1	ICT access*	74.3	48	◇
3.1.2	ICT use*	65.3	44	
3.1.3	Government's online service*	95.1	9	●
3.1.4	E-participation*	95.5	15	●
3.2	**General infrastructure**	**37.2**	**55**	
3.2.1	Electricity output, kWh/mn pop.	4,845.3	46	
3.2.2	Logistics performance*	78.4	19	
3.2.3	Gross capital formation, % GDP	18.1	103	○ ◇
3.3	**Ecological sustainability**	**58.3**	**9**	●
3.3.1	GDP/unit of energy use	13.5	18	
3.3.2	Environmental performance*	77.0	16	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	6.3	17	
	MARKET SOPHISTICATION	**51.4**	**50**	
4.1	**Credit**	**41.7**	**50**	
4.1.1	Ease of getting credit*	45.0	94	○
4.1.2	Domestic credit to private sector, % GDP	81.7	35	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**34.0**	**104**	○ ◇
4.2.1	Ease of protecting minority investors*	58.3	68	○
4.2.2	Market capitalization, % GDP ⊙	26.5	51	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	33	
4.3	**Trade, competition, & market scale**	**78.7**	**12**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	71.4	47	
4.3.3	Domestic market scale, bn PPP$	2,398.2	12	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**42.2**	**29**	
5.1	**Knowledge workers**	**50.7**	**36**	
5.1.1	Knowledge-intensive employment, %	36.1	36	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.8	23	
5.1.4	GERD financed by business, %	52.1	23	
5.1.5	Females employed w/advanced degrees, %	12.6	54	
5.2	**Innovation linkages**	**37.6**	**34**	
5.2.1	University/industry research collaboration†	49.5	41	
5.2.2	State of cluster development†	74.5	4	● ◆
5.2.3	GERD financed by abroad, %	9.8	44	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	61	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	2.0	21	
5.3	**Knowledge absorption**	**38.2**	**43**	
5.3.1	Intellectual property payments, % total trade	0.9	45	
5.3.2	High-tech imports, % total trade	6.7	77	○
5.3.3	ICT services imports, % total trade	1.7	32	
5.3.4	FDI net inflows, % GDP	0.8	114	○
5.3.5	Research talent, % in business enterprise	42.6	31	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**38.9**	**22**	
6.1	**Knowledge creation**	**38.0**	**23**	
6.1.1	Patents by origin/bn PPP$ GDP	5.6	21	
6.1.2	PCT patents by origin/bn PPP$ GDP	1.4	25	
6.1.3	Utility models by origin/bn PPP$ GDP	0.8	30	
6.1.4	Scientific & technical articles/bn PPP$ GDP	16.9	30	
6.1.5	Citable documents H-index	69.2	7	● ◆
6.2	**Knowledge impact**	**55.7**	**6**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	0.1	85	○
6.2.2	New businesses/th pop. 15-64	2.7	41	
6.2.3	Computer software spending, % GDP	0.6	13	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	42.2	1	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.4	26	
6.3	**Knowledge diffusion**	**23.1**	**42**	
6.3.1	Intellectual property receipts, % total trade	0.7	22	
6.3.2	High-tech net exports, % total trade	5.3	29	
6.3.3	ICT services exports, % total trade	1.6	67	
6.3.4	FDI net outflows, % GDP	0.8	56	
	CREATIVE OUTPUTS	**36.8**	**37**	
7.1	**Intangible assets**	**53.0**	**28**	
7.1.1	Trademarks by origin/bn PPP$ GDP	47.3	52	
7.1.2	Industrial designs by origin/bn PPP$ GDP	16.6	5	● ◆
7.1.3	ICTs & business model creation†	66.0	47	
7.1.4	ICTs & organizational model creation†	54.6	61	◇
7.2	**Creative goods & services**	**21.7**	**51**	
7.2.1	Cultural & creative services exports, % total trade	0.4	60	
7.2.2	National feature films/mn pop. 15-69	4.2	46	
7.2.3	Entertainment & Media market/th pop. 15-69	29.4	23	
7.2.4	Printing & other media, % manufacturing	1.3	44	
7.2.5	Creative goods exports, % total trade	2.2	24	
7.3	**Online creativity**	**19.4**	**36**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	23.2	24	
7.3.2	Country-code TLDs/th pop. 15-69	21.5	27	
7.3.3	Wikipedia edits/mn pop. 15-69	44.1	32	
7.3.4	Mobile app creation/bn PPP$ GDP	3.4	58	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

JAMAICA

GII 2019 rank

81

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
69	84	Upper middle	LCN	2.9	27.0	9,446.6	81

		Score/Value	Rank	
	INSTITUTIONS	**71.3**	**42**	◆
1.1	**Political environment**	**62.9**	**48**	◆
1.1.1	Political and operational stability*	71.9	58	
1.1.2	Government effectiveness*	58.4	45	◆
1.2	**Regulatory environment**	**67.4**	**63**	
1.2.1	Regulatory quality*	45.8	64	
1.2.2	Rule of law*	42.2	70	
1.2.3	Cost of redundancy dismissal, salary weeks	14.0	54	
1.3	**Business environment**	**83.6**	**22**	● ◆
1.3.1	Ease of starting a business*	97.4	6	● ◆
1.3.2	Ease of resolving insolvency*	69.8	31	◆

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**24.4**	**86**	
2.1	**Education**	**52.4**	**[50]**	
2.1.1	Expenditure on education, % GDP	5.3	34	
2.1.2	Government funding/pupil, secondary, % GDP/cap	26.7	18	● ◆
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	15.5	71	
2.2	**Tertiary education**	**20.8**	**[93]**	
2.2.1	Tertiary enrolment, % gross ◷	26.9	88	◇
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**33.7**	**105**	◇
3.1	**Information & communication technologies(ICTs)**	**38.5**	**107**	◇
3.1.1	ICT access*	53.6	81	
3.1.2	ICT use*	37.1	93	◇
3.1.3	Government's online service*	31.9	117	○ ◇
3.1.4	E-participation*	31.5	118	○ ◇
3.2	**General infrastructure**	**23.1**	**110**	○
3.2.1	Electricity output, kWh/mn pop.	1,468.8	89	
3.2.2	Logistics performance*	21.3	104	○ ◇
3.2.3	Gross capital formation, % GDP	21.0	88	
3.3	**Ecological sustainability**	**39.4**	**59**	
3.3.1	GDP/unit of energy use	7.9	76	
3.3.2	Environmental performance*	58.6	68	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	4.6	25	●

		Score/Value	Rank	
	MARKET SOPHISTICATION	**36.4**	**114**	○ ◇
4.1	**Credit**	**33.8**	**74**	
4.1.1	Ease of getting credit*	85.0	11	● ◆
4.1.2	Domestic credit to private sector, % GDP ◷	32.0	92	
4.1.3	Microfinance gross loans, % GDP	0.2	44	
4.2	**Investment**	**32.9**	**109**	
4.2.1	Ease of protecting minority investors*	55.0	84	
4.2.2	Market capitalization, % GDP ◷	32.1	46	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	34	
4.3	**Trade, competition, & market scale**	**42.5**	**124**	○ ◇
4.3.1	Applied tariff rate, weighted avg., % ◷	10.8	117	○ ◇
4.3.2	Intensity of local competition†	72.1	45	
4.3.3	Domestic market scale, bn PPP$	27.0	120	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**31.5**	**64**	
5.1	**Knowledge workers**	**33.6**	**[75]**	
5.1.1	Knowledge-intensive employment, %	21.7	70	
5.1.2	Firms offering formal training, % firms ◷	25.9	61	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**28.8**	**52**	◆
5.2.1	University/industry research collaboration†	47.1	45	
5.2.2	State of cluster development†	48.2	55	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	25	● ◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	69	
5.3	**Knowledge absorption**	**32.2**	**71**	
5.3.1	Intellectual property payments, % total trade	0.9	43	
5.3.2	High-tech imports, % total trade	4.4	113	○
5.3.3	ICT services imports, % total trade	1.3	57	
5.3.4	FDI net inflows, % GDP	6.4	21	● ◆
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.7**	**94**	
6.1	**Knowledge creation**	**5.7**	**[94]**	
6.1.1	Patents by origin/bn PPP$ GDP	0.4	79	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.6	84	
6.1.5	Citable documents H-index	4.2	100	
6.2	**Knowledge impact**	**28.5**	**97**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-1.9	107	○ ◇
6.2.2	New businesses/th pop. 15–64	1.3	63	
6.2.3	Computer software spending, % GDP	0.4	25	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.5	98	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**12.7**	**87**	
6.3.1	Intellectual property receipts, % total trade	0.1	58	
6.3.2	High-tech net exports, % total trade	0.0	124	○
6.3.3	ICT services exports, % total trade	2.1	53	
6.3.4	FDI net outflows, % GDP	0.8	57	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**28.6**	**60**	
7.1	**Intangible assets**	**50.3**	**33**	
7.1.1	Trademarks by origin/bn PPP$ GDP	105.9	10	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	4.9	26	●
7.1.3	ICTs & business model creation†	63.6	54	
7.1.4	ICTs & organizational model creation†	55.2	60	
7.2	**Creative goods & services**	**12.4**	**[76]**	
7.2.1	Cultural & creative services exports, % total trade	1.3	21	●
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.2	84	
7.3	**Online creativity**	**1.4**	**98**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.8	81	
7.3.2	Country-code TLDs/th pop. 15–69	1.0	81	
7.3.3	Wikipedia edits/mn pop. 15–69 ◷	2.3	98	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

JAPAN

GII 2019 rank

15

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
17	**14**	**High**	**SEAO**	**127.2**	**5,632.5**	**44,227.2**	**13**

		Score/Value	Rank	
	INSTITUTIONS	**89.9**	**10**	
1.1	**Political environment**	**88.2**	**12**	
1.1.1	Political and operational stability*	93.0	7	
1.1.2	Government effectiveness*	85.7	13	
1.2	**Regulatory environment**	**91.7**	**15**	
1.2.1	Regulatory quality*	78.8	20	
1.2.2	Rule of law*	87.8	18	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**89.8**	**5**	●
1.3.1	Ease of starting a business*	86.1	74	○ ◇
1.3.2	Ease of resolving insolvency*	93.5	1	● ◆
	HUMAN CAPITAL & RESEARCH	**49.1**	**21**	
2.1	**Education**	**57.3**	**37**	
2.1.1	Expenditure on education, % GDP	3.5	95	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	15.2	47	◇
2.1.4	PISA scales in reading, maths, & science	528.9	3	● ◆
2.1.5	Pupil-teacher ratio, secondary ◷	11.2	40	
2.2	**Tertiary education**	**13.6**	**[103]**	
2.2.1	Tertiary enrolment, % gross	n/a	n/a	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	3.7	57	◇
2.3	**Research & development (R&D)**	**76.3**	**5**	●
2.3.1	Researchers, FTE/mn pop	5,304.9	10	
2.3.2	Gross expenditure on R&D, % GDP	3.2	5	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	92.0	5	●
2.3.4	QS university ranking, average score top 3*	79.2	8	
	INFRASTRUCTURE	**64.0**	**9**	
3.1	**Information & communication technologies(ICTs)**	**90.3**	**7**	
3.1.1	ICT access*	86.3	11	
3.1.2	ICT use*	81.3	12	
3.1.3	Government's online service*	95.1	9	
3.1.4	E-participation*	98.3	5	
3.2	**General infrastructure**	**50.7**	**15**	
3.2.1	Electricity output, kWh/mn pop	8,500.2	19	
3.2.2	Logistics performance*	91.8	5	
3.2.3	Gross capital formation, % GDP	24.5	48	
3.3	**Ecological sustainability**	**50.9**	**27**	
3.3.1	GDP/unit of energy use	11.2	39	
3.3.2	Environmental performance*	74.7	20	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	4.4	26	
	MARKET SOPHISTICATION	**65.8**	**10**	
4.1	**Credit**	**68.5**	**12**	
4.1.1	Ease of getting credit*	55.0	77	○
4.1.2	Domestic credit to private sector, % GDP	168.2	5	● ◆
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**42.9**	**63**	◇
4.2.1	Ease of protecting minority investors*	60.0	61	○
4.2.2	Market capitalization, % GDP	113.1	8	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	51	○ ◇
4.3	**Trade, competition, & market scale**	**85.9**	**3**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	2.5	59	
4.3.2	Intensity of local competition†	87.2	1	● ◆
4.3.3	Domestic market scale, bn PPP$	5,632.5	4	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**56.5**	**11**	
5.1	**Knowledge workers**	**63.1**	**21**	
5.1.1	Knowledge-intensive employment, %	25.2	56	◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	2.5	3	● ◆
5.1.4	GERD financed by business, %	78.3	1	● ◆
5.1.5	Females employed w/advanced degrees, % ◷	21.0	22	
5.2	**Innovation linkages**	**50.2**	**12**	
5.2.1	University/industry research collaboration†	64.5	18	
5.2.2	State of cluster development†	72.3	7	
5.2.3	GERD financed by abroad, %	0.6	94	○ ◇
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	36	◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	13.2	4	◆
5.3	**Knowledge absorption**	**56.2**	**10**	
5.3.1	Intellectual property payments, % total trade	2.4	9	
5.3.2	High-tech imports, % total trade	13.8	14	
5.3.3	ICT services imports, % total trade	1.7	34	
5.3.4	FDI net inflows, % GDP	0.4	121	○
5.3.5	Research talent, % in business enterprise	73.7	3	● ◆
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**50.8**	**12**	
6.1	**Knowledge creation**	**56.1**	**11**	
6.1.1	Patents by origin/bn PPP$ GDP	47.8	1	● ◆
6.1.2	PCT patents by origin/bn PPP$ GDP	8.8	1	● ◆
6.1.3	Utility models by origin/bn PPP$ GDP	0.8	28	
6.1.4	Scientific & technical articles/bn PPP$ GDP	9.2	53	◇
6.1.5	Citable documents H-index	71.0	6	
6.2	**Knowledge impact**	**39.7**	**50**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	0.0	89	○
6.2.2	New businesses/th pop. 15-64 ◷	0.2	95	○ ◇
6.2.3	Computer software spending, % GDP	0.3	47	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	8.9	35	
6.2.5	High- & medium-high-tech manufactures, % ◷	0.5	9	
6.3	**Knowledge diffusion**	**56.4**	**9**	
6.3.1	Intellectual property receipts, % total trade	4.8	1	● ◆
6.3.2	High-tech net exports, % total trade	12.1	12	
6.3.3	ICT services exports, % total trade	0.6	98	○
6.3.4	FDI net outflows, % GDP	3.4	20	
	CREATIVE OUTPUTS	**37.9**	**35**	◇
7.1	**Intangible assets**	**54.5**	**22**	
7.1.1	Trademarks by origin/bn PPP$ GDP	91.1	21	
7.1.2	Industrial designs by origin/bn PPP$ GDP	4.5	29	
7.1.3	ICTs & business model creation†	73.2	25	
7.1.4	ICTs & organizational model creation†	67.8	22	◇
7.2	**Creative goods & services**	**30.9**	**26**	
7.2.1	Cultural & creative services exports, % total trade	0.4	55	
7.2.2	National feature films/mn pop. 15-69	7.0	30	
7.2.3	Entertainment & Media market/th pop. 15-69	67.1	6	
7.2.4	Printing & other media, % manufacturing ◷	1.7	26	
7.2.5	Creative goods exports, % total trade	2.0	27	
7.3	**Online creativity**	**11.6**	**49**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	15.4	31	◇
7.3.2	Country-code TLDs/th pop. 15-69	5.1	48	◇
7.3.3	Wikipedia edits/mn pop. 15-69	18.6	50	◇
7.3.4	Mobile app creation/bn PPP$ GDP	13.2	35	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

JORDAN

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
71	91	Upper middle	NAWA	9.9	93.2	9,433.5	79

		Score/Value	Rank	
	INSTITUTIONS	**62.1**	**67**	
1.1	**Political environment**	**54.5**	**67**	
1.1.1	Political and operational stability*	64.9	79	
1.1.2	Government effectiveness*	49.4	64	
1.2	**Regulatory environment**	**74.5**	**38**	● ◆
1.2.1	Regulatory quality*	44.5	66	
1.2.2	Rule of law*	53.3	51	◆
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**57.4**	**109**	○ ◇
1.3.1	Ease of starting a business*	84.4	81	
1.3.2	Ease of resolving insolvency*	30.3	120	○ ◇

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**29.4**	**68**	
2.1	**Education**	**37.3**	**93**	
2.1.1	Expenditure on education, % GDP	3.6	91	
2.1.2	Government funding/pupil, secondary, % GDP/cap	17.0	71	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	399.0	62	○
2.1.5	Pupil-teacher ratio, secondary	11.4	42	
2.2	**Tertiary education**	**43.2**	**27**	●
2.2.1	Tertiary enrolment, % gross	31.7	82	
2.2.2	Graduates in science & engineering, % ⊙	26.4	24	●
2.2.3	Tertiary inbound mobility, %	13.9	11	● ◆
2.3	**Research & development (R&D)**	**7.8**	**66**	
2.3.1	Researchers, FTE/mn pop	601.1	64	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.3	75	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	17.1	55	

		Score/Value	Rank	
	INFRASTRUCTURE	**38.2**	**91**	
3.1	**Information & communication technologies(ICTs)**	**54.2**	**87**	
3.1.1	ICT access*	61.5	73	
3.1.2	ICT use*	57.5	60	
3.1.3	Government's online service*	49.3	105	
3.1.4	E-participation*	48.3	105	
3.2	**General infrastructure**	**23.9**	**104**	
3.2.1	Electricity output, kWh/mn pop	2,085.7	75	
3.2.2	Logistics performance*	29.2	82	
3.2.3	Gross capital formation, % GDP	19.4	96	
3.3	**Ecological sustainability**	**36.6**	**73**	
3.3.1	GDP/unit of energy use	8.7	66	
3.3.2	Environmental performance*	62.2	55	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.9	69	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**38.9**	**106**	◇
4.1	**Credit**	**25.5**	**107**	
4.1.1	Ease of getting credit*	35.0	110	○ ◇
4.1.2	Domestic credit to private sector, % GDP ⊙	75.1	41	●
4.1.3	Microfinance gross loans, % GDP	0.4	36	
4.2	**Investment**	**31.3**	**116**	○ ◇
4.2.1	Ease of protecting minority investors*	46.7	101	
4.2.2	Market capitalization, % GDP	63.7	25	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	42	
4.3	**Trade, competition, & market scale**	**59.8**	**69**	
4.3.1	Applied tariff rate, weighted avg., %	4.4	79	
4.3.2	Intensity of local competition†	76.0	19	● ◆
4.3.3	Domestic market scale, bn PPP$	93.2	81	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**16.9**	**128**	○ ◇
5.1	**Knowledge workers**	**0.0**	**[129]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms	3.4	91	○ ◇
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**26.7**	**59**	
5.2.1	University/industry research collaboration†	40.6	66	
5.2.2	State of cluster development†	57.7	31	● ◆
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	90	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	71	
5.3	**Knowledge absorption**	**23.9**	**106**	
5.3.1	Intellectual property payments, % total trade	0.1	98	
5.3.2	High-tech imports, % total trade	6.6	79	
5.3.3	ICT services imports, % total trade	0.2	118	○ ◇
5.3.4	FDI net inflows, % GDP	4.4	36	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**17.4**	**84**	
6.1	**Knowledge creation**	**14.4**	**[57]**	
6.1.1	Patents by origin/bn PPP$ GDP	0.3	88	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	14.1	36	●
6.1.5	Citable documents H-index	8.4	77	
6.2	**Knowledge impact**	**30.5**	**91**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.2	94	○
6.2.2	New businesses/th pop. 15–64	0.6	80	
6.2.3	Computer software spending, % GDP	0.3	49	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	4.2	63	
6.2.5	High- & medium-high-tech manufactures, %	0.2	50	
6.3	**Knowledge diffusion**	**7.3**	**117**	○ ◇
6.3.1	Intellectual property receipts, % total trade	0.1	48	
6.3.2	High-tech net exports, % total trade	0.4	82	
6.3.3	ICT services exports, % total trade	0.1	123	○
6.3.4	FDI net outflows, % GDP	0.0	111	○

		Score/Value	Rank	
	CREATIVE OUTPUTS	**26.8**	**67**	
7.1	**Intangible assets**	**37.7**	**82**	
7.1.1	Trademarks by origin/bn PPP$ GDP	34.7	70	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.8	76	
7.1.3	ICTs & business model creation†	63.5	55	
7.1.4	ICTs & organizational model creation†	52.6	68	
7.2	**Creative goods & services**	**23.1**	**46**	
7.2.1	Cultural & creative services exports, % total trade	0.3	64	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	1.9	53	○ ◇
7.2.4	Printing & other media, % manufacturing	2.4	13	● ◆
7.2.5	Creative goods exports, % total trade ⊙	1.5	36	●
7.3	**Online creativity**	**8.9**	**54**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	5.2	54	
7.3.2	Country-code TLDs/th pop. 15–69	0.2	107	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	21.7	48	
7.3.4	Mobile app creation/bn PPP$ GDP	15.6	32	●

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

KAZAKHSTAN

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
92	64	Upper middle	CSA	18.4	507.6	27,549.8	74

		Score/Value	Rank	
	INSTITUTIONS	**68.3**	**49**	
1.1	**Political environment**	**54.6**	**66**	
1.1.1	Political and operational stability*	70.2	61	
1.1.2	Government effectiveness*	46.8	69	
1.2	**Regulatory environment**	**70.0**	**53**	
1.2.1	Regulatory quality*	46.5	62	
1.2.2	Rule of law*	35.5	87	
1.2.3	Cost of redundancy dismissal, salary weeks	8.7	19	●
1.3	**Business environment**	**80.4**	**31**	● ◆
1.3.1	Ease of starting a business*	93.0	33	●
1.3.2	Ease of resolving insolvency*	67.8	34	● ◆
	HUMAN CAPITAL & RESEARCH	**29.8**	**67**	
2.1	**Education**	**44.3**	**72**	
2.1.1	Expenditure on education, % GDP	2.9	105	◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	20.2	49	
2.1.3	School life expectancy, years	15.3	45	
2.1.4	PISA scales in reading, maths, & science ⊕	416.4	53	
2.1.5	Pupil-teacher ratio, secondary	7.0	2	● ◆
2.2	**Tertiary education**	**34.5**	**54**	
2.2.1	Tertiary enrolment, % gross	53.3	53	
2.2.2	Graduates in science & engineering, %	24.8	31	
2.2.3	Tertiary inbound mobility, %	2.2	72	
2.3	**Research & development (R&D)**	**10.7**	**56**	
2.3.1	Researchers, FTE/mn pop. ⊕	687.6	59	
2.3.2	Gross expenditure on R&D, % GDP ⊕	0.1	97	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	31.7	35	●
	INFRASTRUCTURE	**46.1**	**67**	
3.1	**Information & communication technologies(ICTs)**	**76.2**	**40**	◆
3.1.1	ICT access*	75.4	41	◆
3.1.2	ICT use*	58.9	58	
3.1.3	Government's online service*	86.8	32	● ◆
3.1.4	E-participation*	83.7	42	
3.2	**General infrastructure**	**35.4**	**63**	
3.2.1	Electricity output, kWh/mn pop.	5,990.3	34	◆
3.2.2	Logistics performance*	34.9	70	
3.2.3	Gross capital formation, % GDP	25.5	42	
3.3	**Ecological sustainability**	**26.7**	**109**	◇
3.3.1	GDP/unit of energy use	5.0	109	○ ◇
3.3.2	Environmental performance*	54.6	85	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	99	
	MARKET SOPHISTICATION	**46.3**	**69**	
4.1	**Credit**	**26.8**	**102**	
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	29.9	95	
4.1.3	Microfinance gross loans, % GDP	0.2	46	
4.2	**Investment**	**44.9**	**57**	
4.2.1	Ease of protecting minority investors*	85.0	1	● ◆
4.2.2	Market capitalization, % GDP	25.4	52	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	75	○
4.3	**Trade, competition, & market scale**	**67.3**	**45**	
4.3.1	Applied tariff rate, weighted avg., %	2.4	58	
4.3.2	Intensity of local competition†	60.0	107	◇
4.3.3	Domestic market scale, bn PPP$	507.6	40	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**28.1**	**78**	
5.1	**Knowledge workers**	**41.2**	**54**	
5.1.1	Knowledge-intensive employment, % ⊕	33.3	39	◆
5.1.2	Firms offering formal training, % firms	28.3	54	
5.1.3	GERD performed by business, % GDP ⊕	0.1	68	
5.1.4	GERD financed by business, %	39.6	45	
5.1.5	Females employed w/advanced degrees, % ⊕	17.5	33	
5.2	**Innovation linkages**	**15.6**	**118**	○ ◇
5.2.1	University/industry research collaboration†	40.5	67	
5.2.2	State of cluster development†	34.4	110	◇
5.2.3	GERD financed by abroad, %	1.5	85	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	74	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	54	
5.3	**Knowledge absorption**	**27.6**	**92**	
5.3.1	Intellectual property payments, % total trade	0.3	80	
5.3.2	High-tech imports, % total trade	6.5	84	
5.3.3	ICT services imports, % total trade	0.6	99	
5.3.4	FDI net inflows, % GDP	6.2	22	● ◆
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**18.2**	**81**	
6.1	**Knowledge creation**	**10.6**	**68**	
6.1.1	Patents by origin/bn PPP$ GDP	2.4	36	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	80	
6.1.3	Utility models by origin/bn PPP$ GDP	1.6	16	●
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.8	116	○
6.1.5	Citable documents H-index	3.5	110	
6.2	**Knowledge impact**	**29.5**	**96**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.1	23	●
6.2.2	New businesses/th pop. 15–64	2.2	47	
6.2.3	Computer software spending, % GDP	0.0	120	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.8	113	
6.2.5	High- & medium-high-tech manufactures, %	0.1	84	
6.3	**Knowledge diffusion**	**14.7**	**78**	
6.3.1	Intellectual property receipts, % total trade	0.0	99	○ ◇
6.3.2	High-tech net exports, % total trade	3.6	41	
6.3.3	ICT services exports, % total trade	0.2	115	○
6.3.4	FDI net outflows, % GDP	1.6	38	
	CREATIVE OUTPUTS	**18.4**	**102**	◇
7.1	**Intangible assets**	**31.5**	**103**	
7.1.1	Trademarks by origin/bn PPP$ GDP ⊕	18.8	90	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	98	
7.1.3	ICTs & business model creation†	54.7	87	
7.1.4	ICTs & organizational model creation†	48.2	87	
7.2	**Creative goods & services**	**6.8**	**96**	
7.2.1	Cultural & creative services exports, % total trade	0.1	91	
7.2.2	National feature films/mn pop. 15–69	6.0	37	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	0.5	92	○
7.2.5	Creative goods exports, % total trade	0.1	93	
7.3	**Online creativity**	**3.8**	**71**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.3	114	○
7.3.2	Country-code TLDs/th pop. 15–69	3.2	60	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊕	17.3	52	
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	90	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

KENYA

GII 2019 rank

77

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
64	89	Lower middle	SSF	51.0	177.4	3,690.9	78

		Score/Value	Rank
	INSTITUTIONS	**59.2**	**78**
1.1	**Political environment**	**45.9**	**91**
1.1.1	Political and operational stability*	59.6	98
1.1.2	Government effectiveness*	39.0	88
1.2	**Regulatory environment**	**61.9**	**76**
1.2.1	Regulatory quality*	35.7	88
1.2.2	Rule of law*	35.5	88
1.2.3	Cost of redundancy dismissal, salary weeks	15.8	63
1.3	**Business environment**	**69.9**	**67**
1.3.1	Ease of starting a business*	82.4	97
1.3.2	Ease of resolving insolvency*	57.4	52 ◆
	HUMAN CAPITAL & RESEARCH	**17.5**	**104**
2.1	**Education**	**33.8**	**[100]**
2.1.1	Expenditure on education, % GDP	5.2	39
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a
2.1.3	School life expectancy, years	10.5	102 ○
2.1.4	PISA scales in reading, maths, & science	n/a	n/a
2.1.5	Pupil-teacher ratio, secondary	33.4	109 ○ ◇
2.2	**Tertiary education**	**13.4**	**104**
2.2.1	Tertiary enrolment, % gross	11.7	104
2.2.2	Graduates in science & engineering, %	16.5	79
2.2.3	Tertiary inbound mobility, %	0.9	89
2.3	**Research & development (R&D)**	**5.5**	**76**
2.3.1	Researchers, FTE/mn pop.	225.0	76
2.3.2	Gross expenditure on R&D, % GDP	0.8	45 ◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43 ○ ◇
2.3.4	QS university ranking, average score top 3*	2.5	77
	INFRASTRUCTURE	**29.6**	**116** ○ ◇
3.1	**Information & communication technologies(ICTs)**	**43.3**	**100**
3.1.1	ICT access*	39.6	104
3.1.2	ICT use*	17.6	112 ○ ◇
3.1.3	Government's online service*	62.5	89
3.1.4	E-participation*	53.4	101
3.2	**General infrastructure**	**20.9**	**117** ○
3.2.1	Electricity output, kWh/mn pop.	201.2	113 ○ ◇
3.2.2	Logistics performance*	35.1	67
3.2.3	Gross capital formation, % GDP	16.8	112 ○ ◇
3.3	**Ecological sustainability**	**24.5**	**118** ○
3.3.1	GDP/unit of energy use	5.3	104
3.3.2	Environmental performance*	47.3	103
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	91
	MARKET SOPHISTICATION	**51.8**	**48**
4.1	**Credit**	**58.1**	**21** ● ◆
4.1.1	Ease of getting credit*	90.0	7 ● ◆
4.1.2	Domestic credit to private sector, % GDP	29.3	97
4.1.3	Microfinance gross loans, % GDP	4.2	6 ● ◆
4.2	**Investment**	**46.3**	**52**
4.2.1	Ease of protecting minority investors*	78.3	10 ● ◆
4.2.2	Market capitalization, % GDP	30.0	49
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	23 ◆
4.3	**Trade, competition, & market scale**	**51.2**	**103**
4.3.1	Applied tariff rate, weighted avg., %	12.3	121 ○ ◇
4.3.2	Intensity of local competition†	72.0	46 ◆
4.3.3	Domestic market scale, bn PPP$	177.4	67

		Score/Value	Rank
	BUSINESS SOPHISTICATION	**32.2**	**61** ◆
5.1	**Knowledge workers**	**26.3**	**[92]**
5.1.1	Knowledge-intensive employment, %	n/a	n/a
5.1.2	Firms offering formal training, % firms	40.6	34
5.1.3	GERD performed by business, % GDP	0.1	66
5.1.4	GERD financed by business, %	4.3	83
5.1.5	Females employed w/advanced degrees, %	n/a	n/a
5.2	**Innovation linkages**	**45.0**	**20** ● ◆
5.2.1	University/industry research collaboration†	55.1	29 ● ◆
5.2.2	State of cluster development†	55.4	34 ◆
5.2.3	GERD financed by abroad, %	47.1	5 ● ◆
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	50
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	77
5.3	**Knowledge absorption**	**25.2**	**100**
5.3.1	Intellectual property payments, % total trade	1.2	26 ● ◆
5.3.2	High-tech imports, % total trade	9.1	42
5.3.3	ICT services imports, % total trade	0.3	116 ○ ◇
5.3.4	FDI net inflows, % GDP	0.8	111 ○
5.3.5	Research talent, % in business enterprise	11.4	63
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**20.1**	**72**
6.1	**Knowledge creation**	**11.3**	**65**
6.1.1	Patents by origin/bn PPP$ GDP	0.8	67
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	76
6.1.3	Utility models by origin/bn PPP$ GDP	0.9	24
6.1.4	Scientific & technical articles/bn PPP$ GDP	6.0	68
6.1.5	Citable documents H-index	14.3	52
6.2	**Knowledge impact**	**30.4**	**92**
6.2.1	Growth rate of PPP$ GDP/worker, %	2.1	43
6.2.2	New businesses/th pop. 15-64	0.8	75
6.2.3	Computer software spending, % GDP	0.2	77
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.6	69
6.2.5	High- & medium-high-tech manufactures, %	0.1	77
6.3	**Knowledge diffusion**	**18.5**	**57**
6.3.1	Intellectual property receipts, % total trade	0.6	25 ● ◆
6.3.2	High-tech net exports, % total trade	0.3	88
6.3.3	ICT services exports, % total trade	3.3	26 ●
6.3.4	FDI net outflows, % GDP	0.3	80
	CREATIVE OUTPUTS	**28.3**	**61**
7.1	**Intangible assets**	**41.1**	**64**
7.1.1	Trademarks by origin/bn PPP$ GDP	32.5	74
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.9	70
7.1.3	ICTs & business model creation†	68.9	33 ● ◆
7.1.4	ICTs & organizational model creation†	60.0	44 ◆
7.2	**Creative goods & services**	**30.6**	**30** ● ◆
7.2.1	Cultural & creative services exports, % total trade	0.0	98
7.2.2	National feature films/mn pop. 15-69	n/a	n/a
7.2.3	Entertainment & Media market/th pop. 15-69	2.4	51 ◆
7.2.4	Printing & other media, % manufacturing	4.2	3 ● ◆
7.2.5	Creative goods exports, % total trade	0.3	75
7.3	**Online creativity**	**0.6**	**106**
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.0	97
7.3.2	Country-code TLDs/th pop. 15-69	0.8	84
7.3.3	Wikipedia edits/mn pop. 15-69	1.0	103
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	89 ○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

KUWAIT

GII 2019 rank

60

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
56	75	High	NAWA	4.2	303.3	67,000.2	60

		Score/Value	Rank	
	INSTITUTIONS	**55.6**	**90**	◇
1.1	**Political environment**	**49.4**	**85**	◇
1.1.1	Political and operational stability*	63.2	86	◇
1.1.2	Government effectiveness*	42.5	83	◇
1.2	**Regulatory environment**	**57.0**	**92**	◇
1.2.1	Regulatory quality*	40.3	73	◇
1.2.2	Rule of law*	49.1	55	◇
1.2.3	Cost of redundancy dismissal, salary weeks	28.1	113	○ ◇
1.3	**Business environment**	**60.3**	**105**	◇
1.3.1	Ease of starting a business*	81.4	101	◇
1.3.2	Ease of resolving insolvency*	39.3	101	◇

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**25.5**	**[81]**	
2.1	**Education**	**48.2**	**[67]**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	17.6	64	
2.1.3	School life expectancy, years ⊙	13.6	73	◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	7.6	6	● ◆
2.2	**Tertiary education**	**25.3**	**[79]**	
2.2.1	Tertiary enrolment, % gross ⊙	32.6	80	◇
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**2.9**	**87**	◇
2.3.1	Researchers, FTE/mn pop	491.8	68	◇
2.3.2	Gross expenditure on R&D, % GDP	0.1	110	○ ◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	4.5	71	◇

		Score/Value	Rank	
	INFRASTRUCTURE	**50.2**	**53**	◇
3.1	**Information & communication technologies(ICTs)**	**73.7**	**48**	●
3.1.1	ICT access*	78.3	33	●
3.1.2	ICT use*	68.2	38	●
3.1.3	Government's online service*	79.2	48	●
3.1.4	E-participation*	69.1	70	◇
3.2	**General infrastructure**	**42.5**	**39**	●
3.2.1	Electricity output, kWh/mn pop	17,307.2	5	● ◆
3.2.2	Logistics performance*	37.3	62	◇
3.2.3	Gross capital formation, % GDP	22.2	75	
3.3	**Ecological sustainability**	**34.4**	**80**	◇
3.3.1	GDP/unit of energy use	7.6	82	
3.3.2	Environmental performance*	62.3	54	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.5	83	◇

		Score/Value	Rank	
	MARKET SOPHISTICATION	**53.5**	**41**	●
4.1	**Credit**	**41.1**	**52**	
4.1.1	Ease of getting credit*	35.0	110	○ ◇
4.1.2	Domestic credit to private sector, % GDP	99.2	28	●
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**58.3**	**[22]**	
4.2.1	Ease of protecting minority investors*	58.3	68	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**61.0**	**64**	
4.3.1	Applied tariff rate, weighted avg., %	4.3	77	
4.3.2	Intensity of local competition†	56.0	119	○ ◇
4.3.3	Domestic market scale, bn PPP$	303.3	55	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**24.7**	**[100]**	
5.1	**Knowledge workers**	**26.6**	**[91]**	
5.1.1	Knowledge-intensive employment, % ⊙	22.7	66	◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, % ⊙	1.0	90	○ ◇
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**19.6**	**89**	◇
5.2.1	University/industry research collaboration†	40.2	68	
5.2.2	State of cluster development†	49.9	49	
5.2.3	GERD financed by abroad, % ⊙	1.2	90	◇
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	56	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	81	
5.3	**Knowledge absorption**	**28.1**	**[91]**	
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade	6.8	76	
5.3.3	ICT services imports, % total trade	0.7	92	◇
5.3.4	FDI net inflows, % GDP	0.2	122	○
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**25.2**	**52**	
6.1	**Knowledge creation**	**6.8**	**[85]**	
6.1.1	Patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	2.1	112	◇
6.1.5	Citable documents H-index	7.6	81	◇
6.2	**Knowledge impact**	**33.4**	**79**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-1.5	103	○ ◇
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.4	26	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.5	101	◇
6.2.5	High- & medium-high-tech manufactures, %	0.2	54	
6.3	**Knowledge diffusion**	**35.4**	**24**	●
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.3	87	◇
6.3.3	ICT services exports, % total trade	3.9	20	●
6.3.4	FDI net outflows, % GDP	5.5	11	●

		Score/Value	Rank	
	CREATIVE OUTPUTS	**29.2**	**56**	
7.1	**Intangible assets**	**53.7**	**[25]**	
7.1.1	Trademarks by origin/bn PPP$ GDP	n/a	n/a	
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	56.6	82	◇
7.1.4	ICTs & organizational model creation†	50.9	78	◇
7.2	**Creative goods & services**	**4.6**	**103**	◇
7.2.1	Cultural & creative services exports, % total trade	0.0	110	○ ◇
7.2.2	National feature films/mn pop. 15–69	1.9	67	◇
7.2.3	Entertainment & Media market/th pop. 15–69	11.3	34	◇
7.2.4	Printing & other media, % manufacturing	0.4	97	○ ◇
7.2.5	Creative goods exports, % total trade	0.2	78	
7.3	**Online creativity**	**4.9**	**67**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	7.6	44	●
7.3.2	Country-code TLDs/th pop. 15–69	0.3	100	◇
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	16.3	54	
7.3.4	Mobile app creation/bn PPP$ GDP	0.7	67	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

KYRGYZSTAN

GII 2019 rank

90

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
111	78	Lower middle	CSA	6.1	24.4	3,843.6	94

		Score/Value	Rank	
	INSTITUTIONS	**54.6**	**92**	
1.1	**Political environment**	**37.0**	**117**	◇
1.1.1	Political and operational stability*	52.6	118	
1.1.2	Government effectiveness*	29.2	114	
1.2	**Regulatory environment**	**56.5**	**96**	
1.2.1	Regulatory quality*	32.6	95	
1.2.2	Rule of law*	21.9	118	◇
1.2.3	Cost of redundancy dismissal, salary weeks	17.3	71	
1.3	**Business environment**	**70.3**	**64**	
1.3.1	Ease of starting a business*	93.0	32	●
1.3.2	Ease of resolving insolvency*	47.6	74	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**31.7**	**60**	◆
2.1	**Education**	**64.1**	**[11]**	
2.1.1	Expenditure on education, % GDP	7.2	9	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	13.4	77	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	10.4	35	● ◆
2.2	**Tertiary education**	**30.4**	**65**	
2.2.1	Tertiary enrolment, % gross	43.7	67	
2.2.2	Graduates in science & engineering, %	20.5	63	
2.2.3	Tertiary inbound mobility, %	6.4	36	◆
2.3	**Research & development (R&D)**	**0.7**	**111**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	0.1	104	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**38.8**	**89**	
3.1	**Information & communication technologies(ICTs)**	**55.0**	**85**	
3.1.1	ICT access*	47.1	95	
3.1.2	ICT use*	39.7	91	
3.1.3	Government's online service*	64.6	83	
3.1.4	E-participation*	68.5	73	
3.2	**General infrastructure**	**34.6**	**66**	
3.2.1	Electricity output, kWh/mn pop.	2,181.3	74	◆
3.2.2	Logistics performance*	22.6	100	
3.2.3	Gross capital formation, % GDP	30.7	19	●
3.3	**Ecological sustainability**	**26.7**	**110**	
3.3.1	GDP/unit of energy use	5.1	108	◇
3.3.2	Environmental performance*	54.9	83	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	124	○ ◇

		Score/Value	Rank	
	MARKET SOPHISTICATION	**55.6**	**36**	● ◆
4.1	**Credit**	**51.2**	**30**	●
4.1.1	Ease of getting credit*	75.0	29	●
4.1.2	Domestic credit to private sector, % GDP	21.8	110	
4.1.3	Microfinance gross loans, % GDP	4.1	7	● ◆
4.2	**Investment**	**66.7**	**[12]**	
4.2.1	Ease of protecting minority investors*	66.7	35	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**49.0**	**110**	
4.3.1	Applied tariff rate, weighted avg., %	2.9	63	
4.3.2	Intensity of local competition†	56.5	118	◇
4.3.3	Domestic market scale, bn PPP$	24.4	122	◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.7**	**84**	
5.1	**Knowledge workers**	**37.3**	**62**	
5.1.1	Knowledge-intensive employment, %	18.5	78	
5.1.2	Firms offering formal training, % firms	62.7	6	● ◆
5.1.3	GERD performed by business, % GDP	0.0	77	
5.1.4	GERD financed by business, %	6.4	78	
5.1.5	Females employed w/advanced degrees, % ⊙	10.8	61	
5.2	**Innovation linkages**	**13.9**	**121**	
5.2.1	University/industry research collaboration†	27.6	112	
5.2.2	State of cluster development†	29.1	123	○ ◇
5.2.3	GERD financed by abroad, %	3.1	70	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**28.9**	**88**	
5.3.1	Intellectual property payments, % total trade	0.2	91	
5.3.2	High-tech imports, % total trade	7.1	70	
5.3.3	ICT services imports, % total trade	0.6	95	
5.3.4	FDI net inflows, % GDP	8.3	17	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**17.3**	**85**	
6.1	**Knowledge creation**	**10.3**	**70**	
6.1.1	Patents by origin/bn PPP$ GDP	6.0	18	● ◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	0.9	26	
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.2	99	
6.1.5	Citable documents H-index	1.4	125	○ ◇
6.2	**Knowledge impact**	**28.3**	**98**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.9	25	●
6.2.2	New businesses/th pop. 15–64	1.3	65	
6.2.3	Computer software spending, % GDP	0.1	90	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.3	124	○ ◇
6.2.5	High- & medium-high-tech manufactures, %	0.0	100	○ ◇
6.3	**Knowledge diffusion**	**13.2**	**83**	
6.3.1	Intellectual property receipts, % total trade	0.0	66	
6.3.2	High-tech net exports, % total trade	2.3	51	
6.3.3	ICT services exports, % total trade	1.0	82	
6.3.4	FDI net outflows, % GDP	0.7	58	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**13.3**	**122**	◇
7.1	**Intangible assets**	**23.1**	**125**	○ ◇
7.1.1	Trademarks by origin/bn PPP$ GDP	22.4	84	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.5	85	
7.1.3	ICTs & business model creation†	36.5	124	○ ◇
7.1.4	ICTs & organizational model creation†	34.8	120	◇
7.2	**Creative goods & services**	**5.5**	**99**	
7.2.1	Cultural & creative services exports, % total trade	0.4	59	
7.2.2	National feature films/mn pop. 15–69	0.3	103	○
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	0.7	81	
7.2.5	Creative goods exports, % total trade	0.1	99	
7.3	**Online creativity**	**1.5**	**95**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.2	116	◇
7.3.2	Country-code TLDs/th pop. 15–69	0.8	86	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	7.3	69	
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	85	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

LATVIA

GII 2019 rank

34

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
34	**36**	**High**	**EUR**	**1.9**	**57.3**	**29,901.3**	**34**

		Score/Value	Rank	
1	**INSTITUTIONS**	**77.2**	**32**	
1.1	**Political environment**	**72.5**	**36**	
1.1.1	Political and operational stability*	80.7	35	
1.1.2	Government effectiveness*	68.5	34	
1.2	**Regulatory environment**	**82.2**	**26**	
1.2.1	Regulatory quality*	72.9	28	
1.2.2	Rule of law*	71.0	32	
1.2.3	Cost of redundancy dismissal, salary weeks	13.0	42	
1.3	**Business environment**	**76.9**	**39**	
1.3.1	Ease of starting a business*	94.1	21	
1.3.2	Ease of resolving insolvency*	59.6	49	
2	**HUMAN CAPITAL & RESEARCH**	**36.9**	**44**	
2.1	**Education**	**59.0**	**29**	
2.1.1	Expenditure on education, % GDP	5.3	31	
2.1.2	Government funding/pupil, secondary, % GDP/cap	24.8	25	
2.1.3	School life expectancy, years	16.2	32	
2.1.4	PISA scales in reading, maths, & science	486.8	30	
2.1.5	Pupil-teacher ratio, secondary ⊙	8.1	10	● ◆
2.2	**Tertiary education**	**40.4**	**38**	
2.2.1	Tertiary enrolment, % gross	88.1	9	●
2.2.2	Graduates in science & engineering, %	20.5	60	
2.2.3	Tertiary inbound mobility, %	7.7	30	
2.3	**Research & development (R&D)**	**11.4**	**53**	◇
2.3.1	Researchers, FTE/mn pop.	1,785.9	43	
2.3.2	Gross expenditure on R&D, % GDP	0.5	62	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	13.1	60	
3	**INFRASTRUCTURE**	**50.5**	**51**	◇
3.1	**Information & communication technologies(ICTs)**	**71.3**	**56**	◇
3.1.1	ICT access*	74.5	46	
3.1.2	ICT use*	75.4	28	
3.1.3	Government's online service*	66.7	75	◇
3.1.4	E-participation*	68.5	73	◇
3.2	**General infrastructure**	**31.1**	**82**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	3,882.0	52	
3.2.2	Logistics performance*	34.9	69	◇
3.2.3	Gross capital formation, % GDP	23.3	63	
3.3	**Ecological sustainability**	**49.1**	**33**	
3.3.1	GDP/unit of energy use	9.9	54	
3.3.2	Environmental performance*	66.1	35	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	6.9	15	●
4	**MARKET SOPHISTICATION**	**54.4**	**40**	
4.1	**Credit**	**56.3**	**23**	
4.1.1	Ease of getting credit*	85.0	11	◆
4.1.2	Domestic credit to private sector, % GDP	60.2	54	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**46.6**	**49**	
4.2.1	Ease of protecting minority investors*	63.3	48	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	27	
4.3	**Trade, competition, & market scale**	**60.4**	**66**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	74.3	33	
4.3.3	Domestic market scale, bn PPP$	57.3	94	○ ◇
5	**BUSINESS SOPHISTICATION**	**37.4**	**41**	
5.1	**Knowledge workers**	**44.8**	**46**	
5.1.1	Knowledge-intensive employment, %	42.1	23	
5.1.2	Firms offering formal training, % firms	25.2	64	○
5.1.3	GERD performed by business, % GDP	0.1	56	
5.1.4	GERD financed by business, %	21.6	65	○ ◇
5.1.5	Females employed w/advanced degrees, %	24.8	13	● ◆
5.2	**Innovation linkages**	**32.0**	**44**	
5.2.1	University/industry research collaboration†	38.3	78	○ ◇
5.2.2	State of cluster development†	46.0	70	
5.2.3	GERD financed by abroad, %	27.8	12	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	65	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.4	36	
5.3	**Knowledge absorption**	**35.5**	**54**	
5.3.1	Intellectual property payments, % total trade	0.2	84	○ ◇
5.3.2	High-tech imports, % total trade	11.9	19	
5.3.3	ICT services imports, % total trade	1.7	33	
5.3.4	FDI net inflows, % GDP	2.6	68	
5.3.5	Research talent, % in business enterprise	18.6	58	○ ◇
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**27.5**	**45**	
6.1	**Knowledge creation**	**13.0**	**61**	
6.1.1	Patents by origin/bn PPP$ GDP	1.9	45	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.5	34	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	10.2	47	
6.1.5	Citable documents H-index	8.4	77	◇
6.2	**Knowledge impact**	**41.9**	**42**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.4	20	◆
6.2.2	New businesses/th pop. 15–64	8.0	20	
6.2.3	Computer software spending, % GDP	0.1	86	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	17.8	19	
6.2.5	High- & medium-high-tech manufactures, %	0.1	80	○ ◇
6.3	**Knowledge diffusion**	**27.8**	**35**	
6.3.1	Intellectual property receipts, % total trade	0.0	69	○
6.3.2	High-tech net exports, % total trade	7.4	22	
6.3.3	ICT services exports, % total trade	3.8	21	
6.3.4	FDI net outflows, % GDP	1.0	52	
7	**CREATIVE OUTPUTS**	**42.8**	**22**	
7.1	**Intangible assets**	**48.0**	**44**	
7.1.1	Trademarks by origin/bn PPP$ GDP	72.3	27	
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.5	35	
7.1.3	ICTs & business model creation†	66.1	46	
7.1.4	ICTs & organizational model creation†	62.7	37	
7.2	**Creative goods & services**	**46.9**	**3**	● ◆
7.2.1	Cultural & creative services exports, % total trade	1.5	13	●
7.2.2	National feature films/mn pop. 15–69	15.4	7	● ◆
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	2.8	8	● ◆
7.2.5	Creative goods exports, % total trade	3.1	18	●
7.3	**Online creativity**	**28.3**	**27**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	9.5	41	
7.3.2	Country-code TLDs/th pop. 15–69	25.6	24	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	99.7	7	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	10.9	41	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

LEBANON

GII 2019 rank

88

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
82	92	Upper middle	NAWA	6.1	91.2	14,684.1	90

		Score/Value	Rank	
	INSTITUTIONS	**51.8**	**102**	◇
1.1	**Political environment**	**37.3**	**115**	○ ◇
1.1.1	Political and operational stability*	43.9	127	○ ◇
1.1.2	Government effectiveness*	34.1	99	◇
1.2	**Regulatory environment**	**64.1**	**71**	
1.2.1	Regulatory quality*	33.7	93	
1.2.2	Rule of law*	24.6	113	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	8.7	21	●
1.3	**Business environment**	**54.1**	**120**	○ ◇
1.3.1	Ease of starting a business*	78.6	110	
1.3.2	Ease of resolving insolvency*	29.6	121	○ ◇
	HUMAN CAPITAL & RESEARCH	**25.3**	**82**	
2.1	**Education**	**26.5**	**113**	○ ◇
2.1.1	Expenditure on education, % GDP ⊙	2.5	114	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	5.8	103	○ ◇
2.1.3	School life expectancy, years	11.3	96	◇
2.1.4	PISA scales in reading, maths, & science	376.4	66	○
2.1.5	Pupil-teacher ratio, secondary	7.9	8	● ◆
2.2	**Tertiary education**	**35.7**	**51**	
2.2.1	Tertiary enrolment, % gross	38.1	73	
2.2.2	Graduates in science & engineering, % ⊙	23.4	40	
2.2.3	Tertiary inbound mobility, %	8.9	21	● ◆
2.3	**Research & development (R&D)**	**13.8**	**[48]**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	27.6	40	
	INFRASTRUCTURE	**37.1**	**93**	◇
3.1	**Information & communication technologies(ICTs)**	**53.0**	**91**	
3.1.1	ICT access*	65.3	68	
3.1.2	ICT use*	55.0	64	
3.1.3	Government's online service*	47.2	108	◇
3.1.4	E-participation*	44.4	107	◇
3.2	**General infrastructure**	**20.8**	**119**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	3,109.8	62	
3.2.2	Logistics performance*	30.6	78	
3.2.3	Gross capital formation, % GDP	n/a	n/a	
3.3	**Ecological sustainability**	**37.6**	**68**	
3.3.1	GDP/unit of energy use	10.0	52	
3.3.2	Environmental performance*	61.1	60	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	87	
	MARKET SOPHISTICATION	**41.8**	**95**	
4.1	**Credit**	**30.9**	**90**	
4.1.1	Ease of getting credit*	40.0	104	◇
4.1.2	Domestic credit to private sector, % GDP	105.5	23	● ◆
4.1.3	Microfinance gross loans, % GDP	0.1	50	
4.2	**Investment**	**33.3**	**106**	
4.2.1	Ease of protecting minority investors*	41.7	108	○ ◇
4.2.2	Market capitalization, % GDP	22.6	57	
4.2.3	Venture capital deals/bn PPP$ GDP	0.2	9	● ◆
4.3	**Trade, competition, & market scale**	**61.3**	**62**	
4.3.1	Applied tariff rate, weighted avg., %	3.8	72	
4.3.2	Intensity of local competition†	79.0	12	● ◆
4.3.3	Domestic market scale, bn PPP$	91.2	82	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**29.3**	**75**	
5.1	**Knowledge workers**	**30.6**	**[82]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms	26.6	58	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**25.6**	**63**	
5.2.1	University/industry research collaboration†	41.1	65	
5.2.2	State of cluster development†	47.4	56	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	44	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	61	
5.3	**Knowledge absorption**	**31.6**	**75**	
5.3.1	Intellectual property payments, % total trade	0.1	96	
5.3.2	High-tech imports, % total trade ⊙	3.8	118	○
5.3.3	ICT services imports, % total trade	1.8	31	● ◆
5.3.4	FDI net inflows, % GDP	4.7	33	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**13.5**	**[109]**	
6.1	**Knowledge creation**	**14.3**	**[58]**	
6.1.1	Patents by origin/bn PPP$ GDP ⊙	1.3	55	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	10.3	46	
6.1.5	Citable documents H-index	10.6	61	
6.2	**Knowledge impact**	**9.2**	**[116]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.1	102	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	6.1	50	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**17.2**	**68**	
6.3.1	Intellectual property receipts, % total trade	0.1	63	
6.3.2	High-tech net exports, % total trade	1.0	68	
6.3.3	ICT services exports, % total trade	2.5	40	
6.3.4	FDI net outflows, % GDP	1.8	34	
	CREATIVE OUTPUTS	**26.5**	**68**	
7.1	**Intangible assets**	**30.3**	**106**	
7.1.1	Trademarks by origin/bn PPP$ GDP ⊙	15.1	96	
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	43.2	117	○ ◇
7.1.4	ICTs & organizational model creation†	42.4	105	◇
7.2	**Creative goods & services**	**34.6**	**17**	● ◆
7.2.1	Cultural & creative services exports, % total trade	1.7	9	● ◆
7.2.2	National feature films/mn pop. 15–69 ⊙	3.6	51	
7.2.3	Entertainment & Media market/th pop. 15–69	3.3	49	
7.2.4	Printing & other media, % manufacturing ⊙	4.1	4	● ◆
7.2.5	Creative goods exports, % total trade	0.5	57	
7.3	**Online creativity**	**10.7**	**51**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	6.5	49	
7.3.2	Country-code TLDs/th pop. 15–69	0.3	105	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	7.5	68	
7.3.4	Mobile app creation/bn PPP$ GDP	31.1	16	● ◆

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

LITHUANIA

GII 2019 rank

38

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
40	38	High	EUR	2.9	96.9	34,825.8	40

		Score/Value	Rank	
1	**INSTITUTIONS**	**76.0**	**33**	
1.1	**Political environment**	**75.5**	**32**	
1.1.1	Political and operational stability*	86.0	21	●
1.1.2	Government effectiveness*	70.3	32	
1.2	**Regulatory environment**	**82.6**	**25**	
1.2.1	Regulatory quality*	73.0	27	
1.2.2	Rule of law*	72.6	31	
1.2.3	Cost of redundancy dismissal, salary weeks	13.0	42	
1.3	**Business environment**	**70.0**	**66**	
1.3.1	Ease of starting a business*	93.2	28	
1.3.2	Ease of resolving insolvency*	46.9	77	◇
2	**HUMAN CAPITAL & RESEARCH**	**36.3**	**47**	
2.1	**Education**	**51.7**	**53**	
2.1.1	Expenditure on education, % GDP	4.2	72	
2.1.2	Government funding/pupil, secondary, % GDP/cap	17.1	70	○
2.1.3	School life expectancy, years	16.5	22	●
2.1.4	PISA scales in reading, maths, & science	475.4	35	
2.1.5	Pupil-teacher ratio, secondary ⊙	7.7	7	● ◆
2.2	**Tertiary education**	**38.4**	**41**	
2.2.1	Tertiary enrolment, % gross ⊙	71.1	27	
2.2.2	Graduates in science & engineering, %	23.8	35	
2.2.3	Tertiary inbound mobility, %	4.1	53	
2.3	**Research & development (R&D)**	**18.9**	**46**	
2.3.1	Researchers, FTE/mn pop	3,013.2	29	
2.3.2	Gross expenditure on R&D, % GDP	0.9	39	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	19.8	52	
3	**INFRASTRUCTURE**	**51.7**	**44**	
3.1	**Information & communication technologies(ICTs)**	**75.4**	**43**	
3.1.1	ICT access*	73.7	54	◇
3.1.2	ICT use*	67.8	39	
3.1.3	Government's online service*	79.9	45	
3.1.4	E-participation*	80.3	51	
3.2	**General infrastructure**	**25.8**	**97**	○ ◇
3.2.1	Electricity output, kWh/mn pop	1,280.8	90	○ ◇
3.2.2	Logistics performance*	44.6	53	◇
3.2.3	Gross capital formation, % GDP	18.3	101	○ ◇
3.3	**Ecological sustainability**	**53.7**	**14**	●
3.3.1	GDP/unit of energy use	10.5	45	
3.3.2	Environmental performance*	69.3	28	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	8.5	10	● ◆
4	**MARKET SOPHISTICATION**	**50.9**	**51**	
4.1	**Credit**	**44.0**	**47**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	41.4	80	◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**45.3**	**55**	
4.2.1	Ease of protecting minority investors*	66.7	35	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	55	○
4.3	**Trade, competition, & market scale**	**63.4**	**57**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	75.1	26	
4.3.3	Domestic market scale, bn PPP$	96.9	77	

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**38.0**	**39**	
5.1	**Knowledge workers**	**56.2**	**29**	
5.1.1	Knowledge-intensive employment, %	41.8	24	
5.1.2	Firms offering formal training, % firms	42.0	31	
5.1.3	GERD performed by business, % GDP	0.3	47	
5.1.4	GERD financed by business, %	39.0	47	
5.1.5	Females employed w/advanced degrees, %	27.9	4	● ◆
5.2	**Innovation linkages**	**29.2**	**51**	
5.2.1	University/industry research collaboration†	51.4	37	
5.2.2	State of cluster development†	41.3	90	○ ◇
5.2.3	GERD financed by abroad, %	19.2	19	●
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	39	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.3	37	
5.3	**Knowledge absorption**	**28.6**	**89**	○ ◇
5.3.1	Intellectual property payments, % total trade	0.2	90	○ ◇
5.3.2	High-tech imports, % total trade	6.5	85	○
5.3.3	ICT services imports, % total trade	0.8	84	○
5.3.4	FDI net inflows, % GDP	2.4	73	
5.3.5	Research talent, % in business enterprise	29.0	43	
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**24.4**	**55**	
6.1	**Knowledge creation**	**16.7**	**53**	
6.1.1	Patents by origin/bn PPP$ GDP	1.1	59	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.4	39	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	17.2	29	
6.1.5	Citable documents H-index	11.3	58	
6.2	**Knowledge impact**	**36.9**	**61**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.5	34	◆
6.2.2	New businesses/th pop. 15-64	3.3	38	
6.2.3	Computer software spending, % GDP	0.1	97	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	14.1	25	
6.2.5	High- & medium-high-tech manufactures, %	0.2	59	
6.3	**Knowledge diffusion**	**19.6**	**50**	
6.3.1	Intellectual property receipts, % total trade	0.1	60	
6.3.2	High-tech net exports, % total trade	5.9	26	
6.3.3	ICT services exports, % total trade ⊙	1.0	81	
6.3.4	FDI net outflows, % GDP	1.2	50	
7	**CREATIVE OUTPUTS**	**40.3**	**30**	
7.1	**Intangible assets**	**48.4**	**42**	
7.1.1	Trademarks by origin/bn PPP$ GDP	53.7	44	
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.5	36	
7.1.3	ICTs & business model creation†	69.8	31	
7.1.4	ICTs & organizational model creation†	68.4	21	●
7.2	**Creative goods & services**	**20.8**	**56**	
7.2.1	Cultural & creative services exports, % total trade	0.6	43	
7.2.2	National feature films/mn pop. 15-69	5.5	40	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.2	49	
7.2.5	Creative goods exports, % total trade	2.0	29	
7.3	**Online creativity**	**43.5**	**15**	●
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	13.1	34	
7.3.2	Country-code TLDs/th pop. 15-69	26.3	22	●
7.3.3	Wikipedia edits/mn pop. 15-69	54.3	19	●
7.3.4	Mobile app creation/bn PPP$ GDP	98.0	4	● ◆

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

LUXEMBOURG

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
11	23	High	EUR	0.6	66.1	106,704.9	15

		Score/Value	Rank	
	INSTITUTIONS	**80.7**	**24**	
1.1	**Political environment**	**90.4**	**11**	
1.1.1	Political and operational stability*	96.5	2	● ◆
1.1.2	Government effectiveness*	87.3	12	
1.2	**Regulatory environment**	**84.5**	**22**	
1.2.1	Regulatory quality*	87.3	13	
1.2.2	Rule of law*	92.3	11	
1.2.3	Cost of redundancy dismissal, salary weeks	21.7	91	◇
1.3	**Business environment**	**67.1**	**74**	◇
1.3.1	Ease of starting a business*	88.7	59	◇
1.3.2	Ease of resolving insolvency*	45.5	81	◇
	HUMAN CAPITAL & RESEARCH	**41.7**	**38**	◇
2.1	**Education**	**48.3**	**66**	◇
2.1.1	Expenditure on education, % GDP	3.9	82	◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	19.2	52	
2.1.3	School life expectancy, years	14.2	68	◇
2.1.4	PISA scales in reading, maths, & science	483.3	32	◇
2.1.5	Pupil-teacher ratio, secondary ◷	8.8	17	◆
2.2	**Tertiary education**	**41.1**	**34**	
2.2.1	Tertiary enrolment, % gross ◷	19.6	94	○ ◇
2.2.2	Graduates in science & engineering, %	17.9	74	○
2.2.3	Tertiary inbound mobility, %	47.0	1	● ◆
2.3	**Research & development (R&D)**	**35.6**	**31**	◇
2.3.1	Researchers, FTE/mn pop.	4,682.5	15	
2.3.2	Gross expenditure on R&D, % GDP	1.3	29	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	58.7	23	
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**58.7**	**25**	◇
3.1	**Information & communication technologies (ICTs)**	**90.7**	**5**	●
3.1.1	ICT access*	94.2	1	● ◆
3.1.2	ICT use*	82.4	10	
3.1.3	Government's online service*	92.4	22	
3.1.4	E-participation*	93.8	19	
3.2	**General infrastructure**	**32.2**	**74**	◇
3.2.1	Electricity output, kWh/mn pop.	1,480.0	88	○ ◇
3.2.2	Logistics performance*	73.3	24	
3.2.3	Gross capital formation, % GDP	17.4	106	○ ◇
3.3	**Ecological sustainability**	**53.3**	**17**	
3.3.1	GDP/unit of energy use	13.9	17	
3.3.2	Environmental performance*	79.1	7	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.9	49	
	MARKET SOPHISTICATION	**46.9**	**68**	◇
4.1	**Credit**	**32.8**	**77**	◇
4.1.1	Ease of getting credit*	15.0	124	○ ◇
4.1.2	Domestic credit to private sector, % GDP	105.9	21	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**47.2**	**45**	
4.2.1	Ease of protecting minority investors*	48.3	99	○ ◇
4.2.2	Market capitalization, % GDP	98.5	12	
4.2.3	Venture capital deals/bn PPP$ GDP	0.2	8	
4.3	**Trade, competition, & market scale**	**60.7**	**65**	◇
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	72.4	43	
4.3.3	Domestic market scale, bn PPP$	66.1	92	◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**60.7**	**8**	
5.1	**Knowledge workers**	**66.1**	**16**	
5.1.1	Knowledge-intensive employment, %	55.9	2	● ◆
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.7	28	◇
5.1.4	GERD financed by business, % ◷	47.1	32	
5.1.5	Females employed w/advanced degrees, %	17.7	30	
5.2	**Innovation linkages**	**56.8**	**6**	●
5.2.1	University/industry research collaboration†	68.2	13	
5.2.2	State of cluster development†	67.0	13	
5.2.3	GERD financed by abroad, % ◷	3.4	69	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	11	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	8.2	4	◆
5.3	**Knowledge absorption**	**59.1**	**4**	●
5.3.1	Intellectual property payments, % total trade	4.3	1	● ◆
5.3.2	High-tech imports, % total trade	1.9	127	○ ◇
5.3.3	ICT services imports, % total trade	3.1	8	◆
5.3.4	FDI net inflows, % GDP	35.7	3	● ◆
5.3.5	Research talent, % in business enterprise	41.9	32	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**42.2**	**18**	
6.1	**Knowledge creation**	**43.5**	**15**	
6.1.1	Patents by origin/bn PPP$ GDP	11.5	9	
6.1.2	PCT patents by origin/bn PPP$ GDP	5.9	1	● ◆
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	12.1	41	◇
6.1.5	Citable documents H-index	9.1	74	◇
6.2	**Knowledge impact**	**34.9**	**74**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.9	101	○ ◇
6.2.2	New businesses/th pop. 15–64	15.4	8	◆
6.2.3	Computer software spending, % GDP	0.2	69	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.4	72	◇
6.2.5	High- & medium-high-tech manufactures, %	0.1	68	◇
6.3	**Knowledge diffusion**	**48.0**	**11**	
6.3.1	Intellectual property receipts, % total trade	2.0	11	
6.3.2	High-tech net exports, % total trade	0.6	76	◇
6.3.3	ICT services exports, % total trade	3.5	24	
6.3.4	FDI net outflows, % GDP	63.5	1	● ◆
	CREATIVE OUTPUTS	**56.2**	**2**	● ◆
7.1	**Intangible assets**	**59.4**	**9**	
7.1.1	Trademarks by origin/bn PPP$ GDP	102.9	11	
7.1.2	Industrial designs by origin/bn PPP$ GDP	4.6	28	
7.1.3	ICTs & business model creation†	80.3	9	
7.1.4	ICTs & organizational model creation†	72.2	15	
7.2	**Creative goods & services**	**38.6**	**9**	
7.2.1	Cultural & creative services exports, % total trade	4.0	1	● ◆
7.2.2	National feature films/mn pop. 15–69 ◷	42.4	1	● ◆
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	0.9	73	
7.2.5	Creative goods exports, % total trade	0.1	100	○ ◇
7.3	**Online creativity**	**67.6**	**1**	● ◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	90.8	4	● ◆
7.3.2	Country-code TLDs/th pop. 15–69	63.3	9	
7.3.3	Wikipedia edits/mn pop. 15–69 ◷	87.7	9	
7.3.4	Mobile app creation/bn PPP$ GDP	57.2	9	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MADAGASCAR

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
109	122	Low	SSF	26.3	42.8	1,630.2	n/a

		Score/Value	Rank	
	INSTITUTIONS	**49.9**	**109**	
1.1	**Political environment**	**31.9**	**123**	
1.1.1	Political and operational stability*	57.9	101	
1.1.2	Government effectiveness*	19.0	126	○
1.2	**Regulatory environment**	**56.7**	**94**	
1.2.1	Regulatory quality*	23.3	110	
1.2.2	Rule of law*	23.7	115	
1.2.3	Cost of redundancy dismissal, salary weeks	14.7	58	
1.3	**Business environment**	**61.2**	**100**	
1.3.1	Ease of starting a business*	88.1	65	
1.3.2	Ease of resolving insolvency*	34.2	112	
	HUMAN CAPITAL & RESEARCH	**15.3**	**109**	
2.1	**Education**	**23.5**	**118**	
2.1.1	Expenditure on education, % GDP ⊙	2.8	109	◇
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	8.4	101	◇
2.1.3	School life expectancy, years	10.4	103	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	20.0	88	
2.2	**Tertiary education**	**22.2**	**86**	◆
2.2.1	Tertiary enrolment, % gross ⊙	4.8	118	
2.2.2	Graduates in science & engineering, %	23.3	41	●
2.2.3	Tertiary inbound mobility, %	1.7	80	
2.3	**Research & development (R&D)**	**0.1**	**118**	
2.3.1	Researchers, FTE/mn pop	30.6	99	
2.3.2	Gross expenditure on R&D, % GDP	0.0	114	○ ◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**22.6**	**126**	○
3.1	**Information & communication technologies(ICTs)**	**23.3**	**125**	○
3.1.1	ICT access*	22.3	125	○ ◇
3.1.2	ICT use*	7.6	125	○ ◇
3.1.3	Government's online service*	30.6	119	
3.1.4	E-participation*	32.6	116	
3.2	**General infrastructure**	**21.4**	**113**	
3.2.1	Electricity output, kWh/mn pop	n/a	n/a	
3.2.2	Logistics performance*	15.2	113	
3.2.3	Gross capital formation, % GDP	17.1	110	
3.3	**Ecological sustainability**	**23.0**	**121**	
3.3.1	GDP/unit of energy use	n/a	n/a	
3.3.2	Environmental performance*	33.7	123	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	109	
	MARKET SOPHISTICATION	**40.3**	**98**	
4.1	**Credit**	**23.2**	**112**	
4.1.1	Ease of getting credit*	40.0	104	
4.1.2	Domestic credit to private sector, % GDP	13.6	122	○
4.1.3	Microfinance gross loans, % GDP	1.5	16	●
4.2	**Investment**	**51.7**	**[35]**	
4.2.1	Ease of protecting minority investors*	51.7	89	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**46.1**	**115**	
4.3.1	Applied tariff rate, weighted avg., %	5.7	92	
4.3.2	Intensity of local competition†	n/a	n/a	
4.3.3	Domestic market scale, bn PPP$	42.8	103	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**18.4**	**[125]**	
5.1	**Knowledge workers**	**7.6**	**[126]**	
5.1.1	Knowledge-intensive employment, % ⊙	3.4	113	
5.1.2	Firms offering formal training, % firms	12.7	86	◇
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	1.9	101	
5.2	**Innovation linkages**	**10.1**	**[128]**	
5.2.1	University/industry research collaboration†	n/a	n/a	
5.2.2	State of cluster development†	n/a	n/a	
5.2.3	GERD financed by abroad, % ⊙	10.6	40	●
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**37.6**	**45**	● ◆
5.3.1	Intellectual property payments, % total trade	0.4	72	
5.3.2	High-tech imports, % total trade	4.1	116	
5.3.3	ICT services imports, % total trade	2.5	14	● ◆
5.3.4	FDI net inflows, % GDP	4.3	39	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.4**	**96**	
6.1	**Knowledge creation**	**3.7**	**113**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	95	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	88	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.6	95	
6.1.5	Citable documents H-index	3.8	105	
6.2	**Knowledge impact**	**28.2**	**99**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.1	60	
6.2.2	New businesses/th pop. 15–64	0.1	103	○
6.2.3	Computer software spending, % GDP	0.0	116	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.9	87	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**14.4**	**79**	
6.3.1	Intellectual property receipts, % total trade	0.2	37	● ◆
6.3.2	High-tech net exports, % total trade	0.1	112	
6.3.3	ICT services exports, % total trade	2.3	48	●
6.3.4	FDI net outflows, % GDP	0.9	55	
	CREATIVE OUTPUTS	**15.5**	**113**	
7.1	**Intangible assets**	**23.8**	**[124]**	
7.1.1	Trademarks by origin/bn PPP$ GDP	60.4	35	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	4.1	31	● ◆
7.1.3	ICTs & business model creation†	n/a	n/a	
7.1.4	ICTs & organizational model creation†	n/a	n/a	
7.2	**Creative goods & services**	**14.3**	**70**	◆
7.2.1	Cultural & creative services exports, % total trade	0.1	82	
7.2.2	National feature films/mn pop. 15–69	0.8	88	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	2.0	20	● ◆
7.2.5	Creative goods exports, % total trade	0.1	95	
7.3	**Online creativity**	**0.2**	**120**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.1	122	
7.3.2	Country-code TLDs/th pop. 15–69	0.1	118	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.4	109	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MALAWI

GII 2019 rank

118

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
112	119	Low	SSF	19.2	23.7	1,199.4	114

		Score/Value	Rank	
	INSTITUTIONS	**51.3**	**105**	
1.1	**Political environment**	**40.7**	**102**	
1.1.1	Political and operational stability*	61.4	91	
1.1.2	Government effectiveness*	30.3	111	
1.2	**Regulatory environment**	**58.0**	**89**	
1.2.1	Regulatory quality*	21.9	114	
1.2.2	Rule of law*	36.6	84	
1.2.3	Cost of redundancy dismissal, salary weeks	16.7	68	
1.3	**Business environment**	**55.2**	**116**	
1.3.1	Ease of starting a business*	77.2	114	
1.3.2	Ease of resolving insolvency*	33.3	113	
	HUMAN CAPITAL & RESEARCH	**10.8**	**122**	
2.1	**Education**	**30.1**	**107**	
2.1.1	Expenditure on education, % GDP	4.0	78	
2.1.2	Government funding/pupil, secondary, % GDP/cap	25.2	24	●
2.1.3	School life expectancy, years ⊕	10.4	104	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊕	37.9	112	○ ◇
2.2	**Tertiary education**	**2.0**	**125**	○ ◇
2.2.1	Tertiary enrolment, % gross ⊕	0.8	123	○ ◇
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, % ⊕	1.1	85	
2.3	**Research & development (R&D)**	**0.1**	**116**	
2.3.1	Researchers, FTE/mn pop. ⊕	48.3	90	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**23.5**	**125**	
3.1	**Information & communication technologies(ICTs)**	**20.4**	**127**	○ ◇
3.1.1	ICT access*	22.6	123	○ ◇
3.1.2	ICT use*	13.1	120	
3.1.3	Government's online service*	25.7	122	
3.1.4	E-participation*	20.2	123	◇
3.2	**General infrastructure**	**16.7**	**122**	
3.2.1	Electricity output, kWh/mn pop.	n/a	n/a	
3.2.2	Logistics performance*	24.4	92	
3.2.3	Gross capital formation, % GDP	11.8	123	○ ◇
3.3	**Ecological sustainability**	**33.2**	**83**	
3.3.1	GDP/unit of energy use	n/a	n/a	
3.3.2	Environmental performance*	49.2	101	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	115	
	MARKET SOPHISTICATION	**38.8**	**107**	
4.1	**Credit**	**32.0**	**83**	
4.1.1	Ease of getting credit*	90.0	7	● ◆
4.1.2	Domestic credit to private sector, % GDP ⊕	10.5	124	○
4.1.3	Microfinance gross loans, % GDP	0.2	41	
4.2	**Investment**	**36.8**	**89**	
4.2.1	Ease of protecting minority investors*	50.0	93	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	31	●
4.3	**Trade, competition, & market scale**	**47.4**	**113**	
4.3.1	Applied tariff rate, weighted avg., % ⊕	4.8	82	◆
4.3.2	Intensity of local competition†	61.1	105	
4.3.3	Domestic market scale, bn PPP$	23.7	123	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**29.5**	**[72]**	
5.1	**Knowledge workers**	**17.8**	**[112]**	
5.1.1	Knowledge-intensive employment, % ⊕	3.8	110	
5.1.2	Firms offering formal training, % firms	32.9	45	●
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	0.6	111	
5.2	**Innovation linkages**	**33.0**	**[43]**	
5.2.1	University/industry research collaboration†	28.7	110	
5.2.2	State of cluster development†	35.2	105	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	n/a	n/a	
5.3	**Knowledge absorption**	**37.7**	**44**	● ◆
5.3.1	Intellectual property payments, % total trade	0.2	87	
5.3.2	High-tech imports, % total trade	10.5	25	●
5.3.3	ICT services imports, % total trade	1.5	47	●
5.3.4	FDI net inflows, % GDP	6.2	24	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.0**	**99**	
6.1	**Knowledge creation**	**8.3**	**78**	
6.1.1	Patents by origin/bn PPP$ GDP ⊕	0.1	105	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	9.7	51	● ◆
6.1.5	Citable documents H-index	7.0	83	◆
6.2	**Knowledge impact**	**22.1**	**110**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.4	98	
6.2.2	New businesses/th pop. 15–64 ⊕	0.1	102	
6.2.3	Computer software spending, % GDP	0.0	109	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.8	112	
6.2.5	High- & medium-high-tech manufactures, % ⊕	0.1	83	
6.3	**Knowledge diffusion**	**14.8**	**77**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.5	81	◆
6.3.3	ICT services exports, % total trade	2.1	52	●
6.3.4	FDI net outflows, % GDP	-0.1	117	
	CREATIVE OUTPUTS	**15.5**	**114**	
7.1	**Intangible assets**	**25.9**	**119**	
7.1.1	Trademarks by origin/bn PPP$ GDP ⊕	23.6	82	
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	40.0	121	
7.1.4	ICTs & organizational model creation†	28.7	124	○ ◇
7.2	**Creative goods & services**	**10.0**	**[85]**	
7.2.1	Cultural & creative services exports, % total trade	0.1	81	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊕	1.2	46	●
7.2.5	Creative goods exports, % total trade	0.1	104	
7.3	**Online creativity**	**0.1**	**121**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.2	118	
7.3.2	Country-code TLDs/th pop. 15–69	0.3	104	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊕	0.0	124	○
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MALAYSIA

GII 2019 rank

35

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
39	34	Upper middle	SEAO	32.0	999.8	30,859.9	35

		Score/Value	Rank	
	INSTITUTIONS	**71.6**	**40**	◆
1.1	**Political environment**	**72.6**	**35**	◆
1.1.1	Political and operational stability*	84.2	25	◆
1.1.2	Government effectiveness*	66.9	37	◆
1.2	**Regulatory environment**	**67.3**	**64**	
1.2.1	Regulatory quality*	60.3	40	◆
1.2.2	Rule of law*	57.3	46	◆
1.2.3	Cost of redundancy dismissal, salary weeks	23.9	100	○
1.3	**Business environment**	**75.0**	**46**	
1.3.1	Ease of starting a business*	82.8	94	○
1.3.2	Ease of resolving insolvency*	67.2	38	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**44.2**	**33**	◆
2.1	**Education**	**46.1**	**70**	
2.1.1	Expenditure on education, % GDP	4.7	56	
2.1.2	Government funding/pupil, secondary, % GDP/cap	23.0	35	
2.1.3	School life expectancy, years	13.5	76	○
2.1.4	PISA scales in reading, maths, & science ⊙	412.7	58	○
2.1.5	Pupil-teacher ratio, secondary	12.3	51	
2.2	**Tertiary education**	**47.8**	**18**	◆
2.2.1	Tertiary enrolment, % gross	41.9	68	
2.2.2	Graduates in science & engineering, %	32.1	8	● ◆
2.2.3	Tertiary inbound mobility, %	8.1	27	◆
2.3	**Research & development (R&D)**	**38.6**	**27**	◆
2.3.1	Researchers, FTE/mn pop. ⊙	2,357.9	36	◆
2.3.2	Gross expenditure on R&D, % GDP ⊙	1.4	23	◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	44.3	37	◆
2.3.4	QS university ranking, average score top 3*	50.6	17	● ◆

		Score/Value	Rank	
	INFRASTRUCTURE	**51.8**	**42**	◆
3.1	**Information & communication technologies(ICTs)**	**79.4**	**33**	◆
3.1.1	ICT access*	75.0	43	◆
3.1.2	ICT use*	64.8	47	◆
3.1.3	Government's online service*	88.9	27	◆
3.1.4	E-participation*	88.8	32	
3.2	**General infrastructure**	**38.1**	**50**	
3.2.1	Electricity output, kWh/mn pop.	5,022.8	45	
3.2.2	Logistics performance*	54.1	40	◆
3.2.3	Gross capital formation, % GDP	24.3	51	
3.3	**Ecological sustainability**	**37.9**	**66**	
3.3.1	GDP/unit of energy use	8.8	65	
3.3.2	Environmental performance*	59.2	66	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.4	42	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**57.8**	**25**	◆
4.1	**Credit**	**44.8**	**45**	◆
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP	118.8	18	◆
4.1.3	Microfinance gross loans, % GDP ⊙	0.1	52	
4.2	**Investment**	**55.9**	**29**	
4.2.1	Ease of protecting minority investors*	81.7	2	● ◆
4.2.2	Market capitalization, % GDP	131.7	6	● ◆
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	48	
4.3	**Trade, competition, & market scale**	**72.6**	**27**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	4.0	74	
4.3.2	Intensity of local competition†	76.7	17	● ◆
4.3.3	Domestic market scale, bn PPP$	999.8	25	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**39.3**	**36**	◆
5.1	**Knowledge workers**	**38.1**	**58**	
5.1.1	Knowledge-intensive employment, % ⊙	27.3	50	
5.1.2	Firms offering formal training, % firms	18.5	77	○ ◇
5.1.3	GERD performed by business, % GDP ⊙	0.8	25	◆
5.1.4	GERD financed by business, %	56.9	16	◆
5.1.5	Females employed w/advanced degrees, % ⊙	12.5	56	
5.2	**Innovation linkages**	**30.2**	**47**	◆
5.2.1	University/industry research collaboration†	72.0	8	● ◆
5.2.2	State of cluster development†	71.1	8	● ◆
5.2.3	GERD financed by abroad, %	0.9	91	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	34	◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	50	
5.3	**Knowledge absorption**	**49.5**	**19**	◆
5.3.1	Intellectual property payments, % total trade	0.7	53	
5.3.2	High-tech imports, % total trade	26.4	3	● ◆
5.3.3	ICT services imports, % total trade	1.4	48	
5.3.4	FDI net inflows, % GDP	3.6	46	
5.3.5	Research talent, % in business enterprise ⊙	21.9	53	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**32.1**	**34**	◆
6.1	**Knowledge creation**	**9.9**	**71**	
6.1.1	Patents by origin/bn PPP$ GDP	1.2	57	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	58	
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	48	○
6.1.4	Scientific & technical articles/bn PPP$ GDP	8.0	59	
6.1.5	Citable documents H-index	17.0	43	
6.2	**Knowledge impact**	**46.3**	**24**	◆
6.2.1	Growth rate of PPP$ GDP/worker, %	3.3	21	
6.2.2	New businesses/th pop. 15–64	2.3	46	
6.2.3	Computer software spending, % GDP	0.4	29	◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	11.1	27	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.4	17	◆
6.3	**Knowledge diffusion**	**40.0**	**20**	◆
6.3.1	Intellectual property receipts, % total trade	0.1	62	
6.3.2	High-tech net exports, % total trade	34.1	1	● ◆
6.3.3	ICT services exports, % total trade	1.3	72	
6.3.4	FDI net outflows, % GDP	2.9	23	◆

		Score/Value	Rank	
	CREATIVE OUTPUTS	**32.8**	**44**	
7.1	**Intangible assets**	**44.4**	**51**	
7.1.1	Trademarks by origin/bn PPP$ GDP	20.9	87	○
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.6	83	○
7.1.3	ICTs & business model creation†	74.4	21	◆
7.1.4	ICTs & organizational model creation†	71.9	17	● ◆
7.2	**Creative goods & services**	**37.1**	**11**	● ◆
7.2.1	Cultural & creative services exports, % total trade	0.3	67	
7.2.2	National feature films/mn pop. 15–69	3.8	48	
7.2.3	Entertainment & Media market/th pop. 15–69	9.7	36	◆
7.2.4	Printing & other media, % manufacturing ⊙	0.9	72	○
7.2.5	Creative goods exports, % total trade	9.8	1	● ◆
7.3	**Online creativity**	**5.2**	**64**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	6.2	51	
7.3.2	Country-code TLDs/th pop. 15–69	4.0	56	
7.3.3	Wikipedia edits/mn pop. 15–69	9.4	65	
7.3.4	Mobile app creation/bn PPP$ GDP	4.2	54	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MALI

GII 2019 rank

112

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
100	120	Low	SSF	19.1	44.3	2,384.0	112

		Score/Value	Rank	
	INSTITUTIONS	**51.4**	**103**	
1.1	**Political environment**	**31.7**	**124**	○
1.1.1	Political and operational stability*	47.4	123	○
1.1.2	Government effectiveness*	23.8	121	
1.2	**Regulatory environment**	**58.8**	**85**	
1.2.1	Regulatory quality*	26.6	105	
1.2.2	Rule of law*	25.8	110	
1.2.3	Cost of redundancy dismissal, salary weeks	13.7	52	●
1.3	**Business environment**	**63.8**	**85**	
1.3.1	Ease of starting a business*	84.1	85	
1.3.2	Ease of resolving insolvency*	43.5	86	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**10.7**	**123**	○
2.1	**Education**	**27.1**	**111**	
2.1.1	Expenditure on education, % GDP	3.1	101	
2.1.2	Government funding/pupil, secondary, % GDP/cap	20.3	48	●
2.1.3	School life expectancy, years ⊙	7.3	117	○ ◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	17.4	77	
2.2	**Tertiary education**	**3.4**	**122**	○ ◇
2.2.1	Tertiary enrolment, % gross ⊙	5.5	117	○
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, % ⊙	0.9	90	
2.3	**Research & development (R&D)**	**1.6**	**96**	
2.3.1	Researchers, FTE/mn pop.	32.8	98	
2.3.2	Gross expenditure on R&D, % GDP	0.3	80	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**27.5**	**119**	
3.1	**Information & communication technologies(ICTs)**	**25.2**	**124**	○
3.1.1	ICT access*	35.7	110	
3.1.2	ICT use*	14.6	117	
3.1.3	Government's online service*	26.4	121	
3.1.4	E-participation*	24.2	121	◇
3.2	**General infrastructure**	**27.8**	**90**	
3.2.1	Electricity output, kWh/mn pop.	n/a	n/a	
3.2.2	Logistics performance*	24.6	91	
3.2.3	Gross capital formation, % GDP	19.4	98	
3.3	**Ecological sustainability**	**29.6**	**98**	
3.3.1	GDP/unit of energy use	n/a	n/a	
3.3.2	Environmental performance*	43.7	112	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	116	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**33.9**	**123**	○
4.1	**Credit**	**18.3**	**120**	
4.1.1	Ease of getting credit*	30.0	115	
4.1.2	Domestic credit to private sector, % GDP	27.1	101	
4.1.3	Microfinance gross loans, % GDP	0.8	22	●
4.2	**Investment**	**40.0**	**[72]**	
4.2.1	Ease of protecting minority investors*	40.0	114	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**43.3**	**123**	○
4.3.1	Applied tariff rate, weighted avg., %	10.0	112	
4.3.2	Intensity of local competition†	58.3	112	
4.3.3	Domestic market scale, bn PPP$	44.3	98	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**30.1**	**68**	◆
5.1	**Knowledge workers**	**8.1**	**125**	○
5.1.1	Knowledge-intensive employment, % ⊙	3.7	111	
5.1.2	Firms offering formal training, % firms	17.7	80	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	0.8	91	
5.1.5	Females employed w/advanced degrees, % ⊙	0.3	114	○
5.2	**Innovation linkages**	**41.3**	**27**	● ◆
5.2.1	University/industry research collaboration†	39.8	70	
5.2.2	State of cluster development†	46.5	66	◆
5.2.3	GERD financed by abroad, %	50.2	2	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	77	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**41.1**	**39**	● ◆
5.3.1	Intellectual property payments, % total trade ⊙	0.1	107	
5.3.2	High-tech imports, % total trade	6.6	81	
5.3.3	ICT services imports, % total trade	3.1	7	● ◆
5.3.4	FDI net inflows, % GDP	2.1	80	
5.3.5	Research talent, % in business enterprise	31.4	40	● ◆

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**20.5**	**[71]**	
6.1	**Knowledge creation**	**3.8**	**[111]**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	96	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	2.3	108	◇
6.1.5	Citable documents H-index	4.0	102	
6.2	**Knowledge impact**	**38.9**	**[53]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.8	29	●
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.0	113	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.2	127	○
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**18.8**	**53**	● ◆
6.3.1	Intellectual property receipts, % total trade	0.0	95	
6.3.2	High-tech net exports, % total trade	0.1	116	
6.3.3	ICT services exports, % total trade	5.0	9	● ◆
6.3.4	FDI net outflows, % GDP	0.6	64	●

		Score/Value	Rank	
	CREATIVE OUTPUTS	**14.2**	**119**	
7.1	**Intangible assets**	**27.2**	**116**	
7.1.1	Trademarks by origin/bn PPP$ GDP	5.3	115	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	99	
7.1.3	ICTs & business model creation†	48.6	111	
7.1.4	ICTs & organizational model creation†	45.0	95	
7.2	**Creative goods & services**	**0.2**	**[127]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	103	
7.2.2	National feature films/mn pop. 15–69	0.1	107	○ ◇
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade ⊙	0.0	118	
7.3	**Online creativity**	**2.3**	**81**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.1	121	
7.3.2	Country-code TLDs/th pop. 15–69	6.7	45	● ◆
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.1	121	○
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MALTA

GII 2019 rank

27

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
20	**32**	**High**	**EUR**	**0.4**	**20.8**	**45,605.9**	**26**

		Score/Value	Rank	
	INSTITUTIONS	**75.2**	**35**	
1.1	**Political environment**	**75.9**	**30**	
1.1.1	Political and operational stability*	86.0	21	
1.1.2	Government effectiveness*	70.9	31	
1.2	**Regulatory environment**	**88.2**	**17**	
1.2.1	Regulatory quality*	76.4	22	
1.2.2	Rule of law*	76.6	24	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	● ◆
1.3	**Business environment**	**61.5**	**97**	○ ◇
1.3.1	Ease of starting a business*	84.9	79	◇
1.3.2	Ease of resolving insolvency*	38.1	105	○ ◇
	HUMAN CAPITAL & RESEARCH	**36.6**	**45**	
2.1	**Education**	**60.0**	**24**	
2.1.1	Expenditure on education, % GDP	5.3	35	
2.1.2	Government funding/pupil, secondary, % GDP/cap	29.9	13	◆
2.1.3	School life expectancy, years	15.9	36	
2.1.4	PISA scales in reading, maths, & science	463.4	40	
2.1.5	Pupil-teacher ratio, secondary ⊙	7.2	4	● ◆
2.2	**Tertiary education**	**29.9**	**69**	◇
2.2.1	Tertiary enrolment, % gross ⊙	48.8	58	
2.2.2	Graduates in science & engineering, %	18.0	72	○
2.2.3	Tertiary inbound mobility, %	8.4	23	
2.3	**Research & development (R&D)**	**19.8**	**45**	
2.3.1	Researchers, FTE/mn pop.	2,075.0	40	
2.3.2	Gross expenditure on R&D, % GDP	0.5	56	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	42.5	39	
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**61.1**	**18**	
3.1	**Information & communication technologies(ICTs)**	**84.6**	**22**	
3.1.1	ICT access*	91.3	5	● ◆
3.1.2	ICT use*	78.1	19	
3.1.3	Government's online service*	84.0	36	
3.1.4	E-participation*	84.8	39	
3.2	**General infrastructure**	**25.8**	**98**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	1,945.5	78	◇
3.2.2	Logistics performance*	35.1	68	◇
3.2.3	Gross capital formation, % GDP	19.9	93	○
3.3	**Ecological sustainability**	**72.8**	**1**	● ◆
3.3.1	GDP/unit of energy use	25.6	2	● ◆
3.3.2	Environmental performance*	80.9	4	● ◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.8	52	
	MARKET SOPHISTICATION	**45.2**	**80**	◇
4.1	**Credit**	**36.2**	**65**	
4.1.1	Ease of getting credit*	35.0	110	○ ◇
4.1.2	Domestic credit to private sector, % GDP	79.6	37	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**44.0**	**59**	
4.2.1	Ease of protecting minority investors*	61.7	54	
4.2.2	Market capitalization, % GDP	40.8	36	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	13	
4.3	**Trade, competition, & market scale**	**55.5**	**87**	◇
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	80.4	7	◆
4.3.3	Domestic market scale, bn PPP$	20.8	125	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**54.9**	**15**	
5.1	**Knowledge workers**	**53.8**	**31**	
5.1.1	Knowledge-intensive employment, %	42.5	22	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.3	44	
5.1.4	GERD financed by business, %	54.5	18	
5.1.5	Females employed w/advanced degrees, %	13.3	50	
5.2	**Innovation linkages**	**55.8**	**8**	◆
5.2.1	University/industry research collaboration†	48.8	42	
5.2.2	State of cluster development†	53.8	41	
5.2.3	GERD financed by abroad, %	10.7	38	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.3	1	● ◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	5.3	11	◆
5.3	**Knowledge absorption**	**55.1**	**11**	
5.3.1	Intellectual property payments, % total trade	3.6	4	● ◆
5.3.2	High-tech imports, % total trade ⊙	8.4	51	
5.3.3	ICT services imports, % total trade	1.2	61	
5.3.4	FDI net inflows, % GDP	25.9	6	◆
5.3.5	Research talent, % in business enterprise	57.0	16	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**31.9**	**35**	
6.1	**Knowledge creation**	**21.0**	**41**	
6.1.1	Patents by origin/bn PPP$ GDP ⊙	5.2	23	
6.1.2	PCT patents by origin/bn PPP$ GDP	2.2	16	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	10.0	48	
6.1.5	Citable documents H-index	5.4	93	○ ◇
6.2	**Knowledge impact**	**43.2**	**37**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.4	78	○
6.2.2	New businesses/th pop. 15-64	17.9	4	● ◆
6.2.3	Computer software spending, % GDP	0.4	30	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	9.9	31	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	76	○ ◇
6.3	**Knowledge diffusion**	**31.5**	**28**	
6.3.1	Intellectual property receipts, % total trade	2.5	9	◆
6.3.2	High-tech net exports, % total trade ⊙	3.8	37	
6.3.3	ICT services exports, % total trade	0.5	100	○
6.3.4	FDI net outflows, % GDP	n/a	n/a	
	CREATIVE OUTPUTS	**55.0**	**4**	● ◆
7.1	**Intangible assets**	**64.2**	**4**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	119.8	8	◆
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊙	12.4	10	◆
7.1.3	ICTs & business model creation†	76.1	15	
7.1.4	ICTs & organizational model creation†	64.4	31	
7.2	**Creative goods & services**	**54.2**	**2**	● ◆
7.2.1	Cultural & creative services exports, % total trade	5.9	1	● ◆
7.2.2	National feature films/mn pop. 15-69	16.4	6	◆
7.2.3	Entertainment & Media market/th pop. 15-69	12.1	32	◇
7.2.4	Printing & other media, % manufacturing ⊙	22.4	1	● ◆
7.2.5	Creative goods exports, % total trade ⊙	0.2	81	
7.3	**Online creativity**	**37.3**	**20**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	93.7	3	● ◆
7.3.2	Country-code TLDs/th pop. 15-69	15.6	33	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	41.9	33	
7.3.4	Mobile app creation/bn PPP$ GDP	11.9	39	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MAURITIUS

GII 2019 rank
82

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
96	67	Upper middle	SSF	1.3	30.1	23,699.5	75

		Score/Value	Rank	
	INSTITUTIONS	**63.6**	**62**	
1.1	**Political environment**	**76.0**	**29**	◆
1.1.1	Political and operational stability*	91.2	12	● ◆
1.1.2	Government effectiveness*	68.3	35	◆
1.2	**Regulatory environment**	**33.3**	**126**	○ ◇
1.2.1	Regulatory quality*	68.7	33	◆
1.2.2	Rule of law*	64.4	36	◆
1.2.3	Cost of redundancy dismissal, salary weeks	73.6	127	○ ◇
1.3	**Business environment**	**81.7**	**30**	◆
1.3.1	Ease of starting a business*	94.3	18	● ◆
1.3.2	Ease of resolving insolvency*	69.1	32	◆
	HUMAN CAPITAL & RESEARCH	**27.1**	**77**	
2.1	**Education**	**56.5**	**41**	
2.1.1	Expenditure on education, % GDP	5.0	47	
2.1.2	Government funding/pupil, secondary, % GDP/cap	32.0	10	● ◆
2.1.3	School life expectancy, years	15.0	53	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	12.7	53	
2.2	**Tertiary education**	**23.5**	**84**	
2.2.1	Tertiary enrolment, % gross	38.8	71	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	4.5	45	
2.3	**Research & development (R&D)**	**1.4**	**100**	
2.3.1	Researchers, FTE/mn pop. ⊙	181.8	79	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.2	91	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**44.2**	**76**	
3.1	**Information & communication technologies(ICTs)**	**66.3**	**66**	
3.1.1	ICT access*	74.3	49	◆
3.1.2	ICT use*	49.0	73	
3.1.3	Government's online service*	72.9	63	
3.1.4	E-participation*	69.1	70	
3.2	**General infrastructure**	**20.8**	**118**	○ ◇
3.2.1	Electricity output, kWh/mn pop	2,414.3	72	
3.2.2	Logistics performance*	31.3	77	
3.2.3	Gross capital formation, % GDP	15.8	117	○ ◇
3.3	**Ecological sustainability**	**45.4**	**44**	
3.3.1	GDP/unit of energy use	15.6	10	● ◆
3.3.2	Environmental performance*	56.6	78	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.8	72	
	MARKET SOPHISTICATION	**53.4**	**43**	
4.1	**Credit**	**56.9**	**22**	● ◆
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	102.3	25	● ◆
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**46.4**	**50**	
4.2.1	Ease of protecting minority investors*	75.0	14	● ◆
4.2.2	Market capitalization, % GDP	65.7	24	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	36	
4.3	**Trade, competition, & market scale**	**56.8**	**82**	
4.3.1	Applied tariff rate, weighted avg., %	0.9	8	●
4.3.2	Intensity of local competition†	70.5	54	
4.3.3	Domestic market scale, bn PPP$	30.1	116	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**27.9**	**79**	
5.1	**Knowledge workers**	**27.9**	**87**	
5.1.1	Knowledge-intensive employment, %	24.0	60	
5.1.2	Firms offering formal training, % firms ⊙	25.6	62	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, % ⊙	0.3	95	○ ◇
5.1.5	Females employed w/advanced degrees, %	8.4	78	
5.2	**Innovation linkages**	**24.2**	**69**	
5.2.1	University/industry research collaboration†	35.7	90	
5.2.2	State of cluster development†	51.2	45	
5.2.3	GERD financed by abroad, % ⊙	6.4	56	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	29	◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	45	
5.3	**Knowledge absorption**	**31.6**	**74**	
5.3.1	Intellectual property payments, % total trade	0.3	78	
5.3.2	High-tech imports, % total trade	5.5	97	
5.3.3	ICT services imports, % total trade	1.6	36	
5.3.4	FDI net inflows, % GDP	2.3	76	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**11.0**	**116**	○ ◇
6.1	**Knowledge creation**	**4.0**	**[106]**	
6.1.1	Patents by origin/bn PPP$ GDP	0.0	123	○
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.1	92	
6.1.5	Citable documents H-index	2.4	116	○
6.2	**Knowledge impact**	**17.8**	**113**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15-64	9.8	14	● ◆
6.2.3	Computer software spending, % GDP	0.2	72	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.2	45	
6.2.5	High- & medium-high-tech manufactures, %	0.0	98	○ ◇
6.3	**Knowledge diffusion**	**11.2**	**97**	
6.3.1	Intellectual property receipts, % total trade	0.0	78	
6.3.2	High-tech net exports, % total trade ⊙	0.0	127	○
6.3.3	ICT services exports, % total trade	2.0	54	
6.3.4	FDI net outflows, % GDP	0.3	78	
	CREATIVE OUTPUTS	**24.9**	**73**	
7.1	**Intangible assets**	**36.0**	**92**	
7.1.1	Trademarks by origin/bn PPP$ GDP	36.6	69	
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊙	0.4	89	
7.1.3	ICTs & business model creation†	57.4	79	
7.1.4	ICTs & organizational model creation†	53.2	65	
7.2	**Creative goods & services**	**21.3**	**53**	
7.2.1	Cultural & creative services exports, % total trade	0.1	78	
7.2.2	National feature films/mn pop. 15-69	9.3	20	● ◆
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.8	22	●
7.2.5	Creative goods exports, % total trade	0.9	47	
7.3	**Online creativity**	**6.5**	**60**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	13.2	33	◆
7.3.2	Country-code TLDs/th pop. 15-69	2.2	66	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	5.9	75	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MEXICO

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
55	**59**	**Upper middle**	**LCN**	**130.8**	**2,575.2**	**20,601.7**	**56**

		Score/Value	Rank	
	INSTITUTIONS	**62.8**	**66**	
1.1	**Political environment**	**51.1**	**78**	
1.1.1	Political and operational stability*	61.4	91	
1.1.2	Government effectiveness*	45.9	72	
1.2	**Regulatory environment**	**59.0**	**84**	
1.2.1	Regulatory quality*	47.2	61	
1.2.2	Rule of law*	31.4	97	
1.2.3	Cost of redundancy dismissal, salary weeks	22.0	94	
1.3	**Business environment**	**78.4**	**37**	
1.3.1	Ease of starting a business*	85.9	75	
1.3.2	Ease of resolving insolvency*	70.8	30	◆
	HUMAN CAPITAL & RESEARCH	**33.4**	**54**	
2.1	**Education**	**43.5**	**76**	
2.1.1	Expenditure on education, % GDP	5.2	38	
2.1.2	Government funding/pupil, secondary, % GDP/cap	15.6	79	
2.1.3	School life expectancy, years	14.3	66	
2.1.4	PISA scales in reading, maths, & science	415.7	55	
2.1.5	Pupil-teacher ratio, secondary	16.9	75	
2.2	**Tertiary education**	**30.7**	**64**	
2.2.1	Tertiary enrolment, % gross	38.2	72	
2.2.2	Graduates in science & engineering, %	25.5	27	
2.2.3	Tertiary inbound mobility, %	0.3	102	○ ◇
2.3	**Research & development (R&D)**	**25.8**	**42**	
2.3.1	Researchers, FTE/mn pop. 🕓	244.2	74	
2.3.2	Gross expenditure on R&D, % GDP 🕓	0.5	65	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	49.0	29	◆
2.3.4	QS university ranking, average score top 3*	41.2	30	◆
	INFRASTRUCTURE	**48.3**	**59**	
3.1	**Information & communication technologies(ICTs)**	**72.8**	**51**	
3.1.1	ICT access*	54.9	79	
3.1.2	ICT use*	49.6	72	
3.1.3	Government's online service*	92.4	22	● ◆
3.1.4	E-participation*	94.4	17	● ◆
3.2	**General infrastructure**	**31.9**	**76**	
3.2.1	Electricity output, kWh/mn pop.	2,586.2	69	
3.2.2	Logistics performance*	46.2	50	
3.2.3	Gross capital formation, % GDP	22.5	70	
3.3	**Ecological sustainability**	**40.1**	**54**	
3.3.1	GDP/unit of energy use	11.6	34	
3.3.2	Environmental performance*	59.7	64	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.7	74	
	MARKET SOPHISTICATION	**49.9**	**57**	
4.1	**Credit**	**37.3**	**62**	
4.1.1	Ease of getting credit*	90.0	7	● ◆
4.1.2	Domestic credit to private sector, % GDP	35.5	87	
4.1.3	Microfinance gross loans, % GDP 🕓	0.4	35	
4.2	**Investment**	**32.8**	**110**	○
4.2.1	Ease of protecting minority investors*	58.3	68	
4.2.2	Market capitalization, % GDP	34.4	44	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	69	○
4.3	**Trade, competition, & market scale**	**79.5**	**8**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	1.2	12	●
4.3.2	Intensity of local competition†	70.1	59	
4.3.3	Domestic market scale, bn PPP$	2,575.2	11	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**29.4**	**73**	
5.1	**Knowledge workers**	**35.7**	**68**	
5.1.1	Knowledge-intensive employment, %	19.9	74	
5.1.2	Firms offering formal training, % firms 🕓	50.8	20	●
5.1.3	GERD performed by business, % GDP 🕓	0.1	55	
5.1.4	GERD financed by business, %	20.7	66	
5.1.5	Females employed w/advanced degrees, %	8.8	74	
5.2	**Innovation linkages**	**20.0**	**87**	
5.2.1	University/industry research collaboration†	43.7	56	
5.2.2	State of cluster development†	53.8	39	◆
5.2.3	GERD financed by abroad, %	0.6	95	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	81	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	63	
5.3	**Knowledge absorption**	**32.6**	**67**	
5.3.1	Intellectual property payments, % total trade	0.1	104	○
5.3.2	High-tech imports, % total trade	17.0	10	● ◆
5.3.3	ICT services imports, % total trade	0.0	125	○ ◇
5.3.4	FDI net inflows, % GDP	3.1	54	
5.3.5	Research talent, % in business enterprise 🕓	24.5	50	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**25.5**	**50**	
6.1	**Knowledge creation**	**11.0**	**67**	
6.1.1	Patents by origin/bn PPP$ GDP	0.5	76	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	65	
6.1.3	Utility models by origin/bn PPP$ GDP	0.2	42	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.3	88	
6.1.5	Citable documents H-index	27.4	34	◆
6.2	**Knowledge impact**	**36.7**	**65**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.3	82	
6.2.2	New businesses/th pop. 15–64	0.5	83	○
6.2.3	Computer software spending, % GDP	0.2	66	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.9	77	
6.2.5	High- & medium-high-tech manufactures, %	0.5	11	● ◆
6.3	**Knowledge diffusion**	**28.7**	**33**	◆
6.3.1	Intellectual property receipts, % total trade	0.0	102	○ ◇
6.3.2	High-tech net exports, % total trade	15.0	9	● ◆
6.3.3	ICT services exports, % total trade	0.0	126	○
6.3.4	FDI net outflows, % GDP	0.7	61	
	CREATIVE OUTPUTS	**29.2**	**55**	
7.1	**Intangible assets**	**41.4**	**62**	
7.1.1	Trademarks by origin/bn PPP$ GDP	44.1	59	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.7	82	
7.1.3	ICTs & business model creation†	67.6	37	◆
7.1.4	ICTs & organizational model creation†	57.9	53	
7.2	**Creative goods & services**	**32.1**	**22**	● ◆
7.2.1	Cultural & creative services exports, % total trade	0.0	118	○
7.2.2	National feature films/mn pop. 15–69	2.0	66	
7.2.3	Entertainment & Media market/th pop. 15–69	7.5	40	
7.2.4	Printing & other media, % manufacturing	0.4	96	○ ◇
7.2.5	Creative goods exports, % total trade	9.6	1	● ◆
7.3	**Online creativity**	**2.2**	**82**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	2.5	72	
7.3.2	Country-code TLDs/th pop. 15–69	3.3	58	
7.3.3	Wikipedia edits/mn pop. 15–69	3.4	93	
7.3.4	Mobile app creation/bn PPP$ GDP	0.7	66	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. 🕓 indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MONGOLIA

GII 2019 rank

53

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
44	73	Lower middle	SEAO	3.1	43.2	13,446.5	53

		Score/Value	Rank	
	INSTITUTIONS	**59.8**	**76**	
1.1	**Political environment**	**52.5**	**73**	
1.1.1	Political and operational stability*	77.2	44	◆
1.1.2	Government effectiveness*	40.2	86	
1.2	**Regulatory environment**	**68.8**	**58**	◆
1.2.1	Regulatory quality*	38.8	77	
1.2.2	Rule of law*	38.4	80	
1.2.3	Cost of redundancy dismissal, salary weeks	8.7	19	● ◆
1.3	**Business environment**	**58.1**	**108**	
1.3.1	Ease of starting a business*	86.9	70	
1.3.2	Ease of resolving insolvency*	29.4	122	○ ◇
	HUMAN CAPITAL & RESEARCH	**24.6**	**84**	
2.1	**Education**	**41.9**	**79**	
2.1.1	Expenditure on education, % GDP	4.1	76	
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	15.4	81	
2.1.3	School life expectancy, years ⊙	14.6	61	◆
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	14.5	65	
2.2	**Tertiary education**	**31.1**	**63**	
2.2.1	Tertiary enrolment, % gross	64.8	36	◆
2.2.2	Graduates in science & engineering, %	21.6	53	
2.2.3	Tertiary inbound mobility, %	1.0	87	
2.3	**Research & development (R&D)**	**0.9**	**108**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	0.1	99	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**41.0**	**84**	
3.1	**Information & communication technologies(ICTs)**	**55.6**	**84**	
3.1.1	ICT access*	49.1	89	
3.1.2	ICT use*	40.0	88	
3.1.3	Government's online service*	59.7	91	
3.1.4	E-participation*	73.6	63	
3.2	**General infrastructure**	**36.8**	**57**	
3.2.1	Electricity output, kWh/mn pop.	1,870.3	79	
3.2.2	Logistics performance*	14.5	114	○ ◇
3.2.3	Gross capital formation, % GDP	34.8	12	● ◆
3.3	**Ecological sustainability**	**30.6**	**90**	
3.3.1	GDP/unit of energy use	6.8	89	
3.3.2	Environmental performance*	57.5	72	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	122	○
	MARKET SOPHISTICATION	**62.2**	**13**	● ◆
4.1	**Credit**	**68.0**	**14**	● ◆
4.1.1	Ease of getting credit*	80.0	20	
4.1.2	Domestic credit to private sector, % GDP	53.0	61	
4.1.3	Microfinance gross loans, % GDP	18.5	1	● ◆
4.2	**Investment**	**68.3**	**[9]**	
4.2.1	Ease of protecting minority investors*	68.3	30	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**50.4**	**106**	
4.3.1	Applied tariff rate, weighted avg., %	5.5	91	
4.3.2	Intensity of local competition†	61.9	98	
4.3.3	Domestic market scale, bn PPP$	43.2	101	◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**23.5**	**108**	
5.1	**Knowledge workers**	**42.4**	**49**	◆
5.1.1	Knowledge-intensive employment, %	23.7	61	
5.1.2	Firms offering formal training, % firms	60.9	7	● ◆
5.1.3	GERD performed by business, % GDP	0.0	86	○
5.1.4	GERD financed by business, %	4.6	82	
5.1.5	Females employed w/advanced degrees, %	18.5	27	◆
5.2	**Innovation linkages**	**13.8**	**123**	○
5.2.1	University/industry research collaboration†	26.6	119	○
5.2.2	State of cluster development†	30.2	120	○ ◇
5.2.3	GERD financed by abroad, %	2.1	76	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	65	
5.3	**Knowledge absorption**	**14.4**	**129**	○ ◇
5.3.1	Intellectual property payments, % total trade	0.3	75	
5.3.2	High-tech imports, % total trade	4.3	114	
5.3.3	ICT services imports, % total trade	1.1	66	
5.3.4	FDI net inflows, % GDP	-7.8	128	○ ◇
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**17.2**	**86**	
6.1	**Knowledge creation**	**34.0**	**26**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP	3.1	31	◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	75	
6.1.3	Utility models by origin/bn PPP$ GDP	6.4	1	● ◆
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.4	87	
6.1.5	Citable documents H-index	3.7	106	
6.2	**Knowledge impact**	**10.6**	**115**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64 ⊙	6.3	23	● ◆
6.2.3	Computer software spending, % GDP	0.1	81	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.8	114	
6.2.5	High- & medium-high-tech manufactures, %	0.1	92	
6.3	**Knowledge diffusion**	**7.2**	**120**	○
6.3.1	Intellectual property receipts, % total trade	0.0	73	
6.3.2	High-tech net exports, % total trade	0.1	118	
6.3.3	ICT services exports, % total trade	0.4	106	
6.3.4	FDI net outflows, % GDP	0.2	86	
	CREATIVE OUTPUTS	**43.5**	**18**	● ◆
7.1	**Intangible assets**	**68.5**	**2**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	229.1	2	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	17.9	4	● ◆
7.1.3	ICTs & business model creation†	51.3	101	
7.1.4	ICTs & organizational model creation†	42.8	101	
7.2	**Creative goods & services**	**33.4**	**19**	● ◆
7.2.1	Cultural & creative services exports, % total trade	0.2	73	
7.2.2	National feature films/mn pop. 15–69	26.3	1	● ◆
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	2.4	11	● ◆
7.2.5	Creative goods exports, % total trade	0.0	125	○
7.3	**Online creativity**	**3.4**	**75**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.6	101	
7.3.2	Country-code TLDs/th pop. 15–69	2.2	65	◆
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	15.7	58	
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	83	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MONTENEGRO

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
46	55	Upper middle	EUR	0.6	11.8	19,043.3	52

		Score/Value	Rank	
	INSTITUTIONS	**68.9**	**46**	◆
1.1	**Political environment**	**58.7**	**56**	
1.1.1	Political and operational stability*	75.4	46	
1.1.2	Government effectiveness*	50.3	62	
1.2	**Regulatory environment**	**71.7**	**47**	
1.2.1	Regulatory quality*	50.0	56	
1.2.2	Rule of law*	46.7	63	
1.2.3	Cost of redundancy dismissal, salary weeks	11.2	35	
1.3	**Business environment**	**76.3**	**42**	
1.3.1	Ease of starting a business*	86.7	72	
1.3.2	Ease of resolving insolvency*	66.0	40	
	HUMAN CAPITAL & RESEARCH	**33.0**	**[56]**	
2.1	**Education**	**49.3**	**[62]**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	15.0	51	
2.1.4	PISA scales in reading, maths, & science	418.7	52	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**45.7**	**[22]**	
2.2.1	Tertiary enrolment, % gross	58.2	48	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**3.8**	**83**	
2.3.1	Researchers, FTE/mn pop. ◷	714.3	57	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.3	76	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**48.8**	**56**	
3.1	**Information & communication technologies(ICTs)**	**68.3**	**61**	
3.1.1	ICT access*	74.4	47	◆
3.1.2	ICT use*	58.1	59	
3.1.3	Government's online service*	66.7	75	
3.1.4	E-participation*	74.2	62	
3.2	**General infrastructure**	**39.0**	**47**	
3.2.1	Electricity output, kWh/mn pop.	5,066.1	42	
3.2.2	Logistics performance*	31.9	76	
3.2.3	Gross capital formation, % GDP	30.2	22	●
3.3	**Ecological sustainability**	**39.0**	**63**	
3.3.1	GDP/unit of energy use	9.8	56	
3.3.2	Environmental performance*	61.3	58	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.5	56	
	MARKET SOPHISTICATION	**44.4**	**83**	
4.1	**Credit**	**36.5**	**64**	
4.1.1	Ease of getting credit*	85.0	11	● ◆
4.1.2	Domestic credit to private sector, % GDP ◷	48.9	71	
4.1.3	Microfinance gross loans, % GDP	0.1	48	
4.2	**Investment**	**52.8**	**33**	
4.2.1	Ease of protecting minority investors*	61.7	54	
4.2.2	Market capitalization, % GDP ◷	82.6	19	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**43.9**	**121**	○ ◇
4.3.1	Applied tariff rate, weighted avg., %	3.1	64	
4.3.2	Intensity of local competition†	62.9	92	
4.3.3	Domestic market scale, bn PPP$	11.8	128	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**32.2**	**62**	
5.1	**Knowledge workers**	**39.9**	**57**	
5.1.1	Knowledge-intensive employment, %	37.6	32	◆
5.1.2	Firms offering formal training, % firms	23.7	67	
5.1.3	GERD performed by business, % GDP ◷	0.1	71	○
5.1.4	GERD financed by business, % ◷	29.8	61	
5.1.5	Females employed w/advanced degrees, %	17.5	34	
5.2	**Innovation linkages**	**21.1**	**80**	
5.2.1	University/industry research collaboration†	41.6	61	
5.2.2	State of cluster development†	41.8	86	
5.2.3	GERD financed by abroad, % ◷	5.9	60	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**35.5**	**53**	
5.3.1	Intellectual property payments, % total trade	0.2	85	
5.3.2	High-tech imports, % total trade	5.5	98	○
5.3.3	ICT services imports, % total trade	2.6	13	● ◆
5.3.4	FDI net inflows, % GDP	11.3	12	● ◆
5.3.5	Research talent, % in business enterprise ◷	12.2	62	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**18.5**	**79**	
6.1	**Knowledge creation**	**12.9**	**62**	
6.1.1	Patents by origin/bn PPP$ GDP ◷	1.0	62	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.7	33	◆
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	16.8	31	◆
6.1.5	Citable documents H-index	0.6	127	○ ◇
6.2	**Knowledge impact**	**33.3**	**80**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.0	86	○
6.2.2	New businesses/th pop. 15-64	6.7	22	●
6.2.3	Computer software spending, % GDP	0.4	23	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	4.6	59	
6.2.5	High- & medium-high-tech manufactures, % ◷	0.1	88	○ ◇
6.3	**Knowledge diffusion**	**9.3**	**107**	○
6.3.1	Intellectual property receipts, % total trade	0.0	77	
6.3.2	High-tech net exports, % total trade	0.2	96	
6.3.3	ICT services exports, % total trade	2.4	43	
6.3.4	FDI net outflows, % GDP	-1.2	123	○ ◇
	CREATIVE OUTPUTS	**41.4**	**26**	● ◆
7.1	**Intangible assets**	**45.3**	**49**	
7.1.1	Trademarks by origin/bn PPP$ GDP	n/a	n/a	
7.1.2	Industrial designs by origin/bn PPP$ GDP ◷	0.8	79	
7.1.3	ICTs & business model creation†	58.6	71	
7.1.4	ICTs & organizational model creation†	52.6	70	
7.2	**Creative goods & services**	**35.8**	**14**	● ◆
7.2.1	Cultural & creative services exports, % total trade ◷	1.5	14	● ◆
7.2.2	National feature films/mn pop. 15-69 ◷	13.2	10	● ◆
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ◷	3.0	6	● ◆
7.2.5	Creative goods exports, % total trade	0.1	94	
7.3	**Online creativity**	**39.3**	**18**	● ◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.5	89	
7.3.2	Country-code TLDs/th pop. 15-69	100.0	1	● ◆
7.3.3	Wikipedia edits/mn pop. 15-69 ◷	24.3	44	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MOROCCO

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
66	83	Lower middle	NAWA	36.2	315.4	8,932.6	76

		Score/Value	Rank	
	INSTITUTIONS	**61.1**	**72**	◆
1.1	**Political environment**	**50.7**	**79**	
1.1.1	Political and operational stability*	66.7	74	
1.1.2	Government effectiveness*	42.7	81	
1.2	**Regulatory environment**	**59.7**	**82**	
1.2.1	Regulatory quality*	35.8	86	
1.2.2	Rule of law*	41.7	71	
1.2.3	Cost of redundancy dismissal, salary weeks	20.7	86	
1.3	**Business environment**	**72.9**	**55**	◆
1.3.1	Ease of starting a business*	93.0	31	●
1.3.2	Ease of resolving insolvency*	52.8	65	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**27.8**	**75**	
2.1	**Education**	**54.0**	**47**	●
2.1.1	Expenditure on education, % GDP ⏱	5.3	36	●
2.1.2	Government funding/pupil, secondary, % GDP/cap ⏱	36.5	5	● ◆
2.1.3	School life expectancy, years	13.5	75	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	20.3	90	○
2.2	**Tertiary education**	**21.5**	**90**	
2.2.1	Tertiary enrolment, % gross	33.8	78	
2.2.2	Graduates in science & engineering, %	18.4	71	
2.2.3	Tertiary inbound mobility, %	2.0	75	
2.3	**Research & development (R&D)**	**7.9**	**65**	
2.3.1	Researchers, FTE/mn pop. ⏱	1,069.0	51	◆
2.3.2	Gross expenditure on R&D, % GDP ⏱	0.7	49	◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	3.5	73	

		Score/Value	Rank	
	INFRASTRUCTURE	**48.0**	**61**	◆
3.1	**Information & communication technologies(ICTs)**	**62.5**	**74**	
3.1.1	ICT access*	63.6	70	◆
3.1.2	ICT use*	42.2	84	
3.1.3	Government's online service*	66.7	75	
3.1.4	E-participation*	77.5	56	
3.2	**General infrastructure**	**37.5**	**53**	
3.2.1	Electricity output, kWh/mn pop.	899.5	96	
3.2.2	Logistics performance*	22.3	101	○
3.2.3	Gross capital formation, % GDP	34.4	13	● ◆
3.3	**Ecological sustainability**	**43.9**	**47**	● ◆
3.3.1	GDP/unit of energy use	13.2	23	● ◆
3.3.2	Environmental performance*	63.5	49	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.6	82	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**42.9**	**94**	
4.1	**Credit**	**26.8**	**101**	
4.1.1	Ease of getting credit*	45.0	94	○
4.1.2	Domestic credit to private sector, % GDP	63.0	51	
4.1.3	Microfinance gross loans, % GDP	0.4	37	
4.2	**Investment**	**36.3**	**96**	
4.2.1	Ease of protecting minority investors*	60.0	61	
4.2.2	Market capitalization, % GDP	54.1	30	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	52	
4.3	**Trade, competition, & market scale**	**65.6**	**49**	
4.3.1	Applied tariff rate, weighted avg., %	3.2	66	
4.3.2	Intensity of local competition†	67.2	73	
4.3.3	Domestic market scale, bn PPP$	315.4	52	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**19.8**	**122**	○ ◇
5.1	**Knowledge workers**	**20.9**	**107**	○
5.1.1	Knowledge-intensive employment, % ⏱	6.9	105	○ ◇
5.1.2	Firms offering formal training, % firms	26.3	60	
5.1.3	GERD performed by business, % GDP ⏱	0.2	51	◆
5.1.4	GERD financed by business, % ⏱	29.9	60	
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**16.9**	**114**	○
5.2.1	University/industry research collaboration†	31.2	103	○
5.2.2	State of cluster development†	45.9	71	
5.2.3	GERD financed by abroad, % ⏱	1.7	81	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	80	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	80	
5.3	**Knowledge absorption**	**21.5**	**116**	○
5.3.1	Intellectual property payments, % total trade	0.3	82	
5.3.2	High-tech imports, % total trade	6.5	86	
5.3.3	ICT services imports, % total trade	0.5	103	○
5.3.4	FDI net inflows, % GDP	2.6	62	
5.3.5	Research talent, % in business enterprise ⏱	7.0	67	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**20.7**	**69**	
6.1	**Knowledge creation**	**8.4**	**77**	
6.1.1	Patents by origin/bn PPP$ GDP	0.7	74	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	55	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.8	72	
6.1.5	Citable documents H-index	10.0	67	
6.2	**Knowledge impact**	**36.2**	**67**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.3	39	●
6.2.2	New businesses/th pop. 15–64	1.7	59	
6.2.3	Computer software spending, % GDP	0.3	58	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.9	78	
6.2.5	High- & medium-high-tech manufactures, % ⏱	0.3	38	●
6.3	**Knowledge diffusion**	**17.6**	**64**	
6.3.1	Intellectual property receipts, % total trade	0.0	88	○
6.3.2	High-tech net exports, % total trade	1.5	61	
6.3.3	ICT services exports, % total trade	3.4	25	●
6.3.4	FDI net outflows, % GDP	0.7	59	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**26.0**	**69**	
7.1	**Intangible assets**	**48.3**	**43**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	56.9	39	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	12.4	9	● ◆
7.1.3	ICTs & business model creation†	60.4	63	
7.1.4	ICTs & organizational model creation†	51.3	76	
7.2	**Creative goods & services**	**5.6**	**98**	
7.2.1	Cultural & creative services exports, % total trade	0.4	53	
7.2.2	National feature films/mn pop. 15–69	1.5	72	
7.2.3	Entertainment & Media market/th pop. 15–69	0.8	58	○
7.2.4	Printing & other media, % manufacturing ⏱	0.7	84	○
7.2.5	Creative goods exports, % total trade	0.1	101	
7.3	**Online creativity**	**1.6**	**91**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.6	86	
7.3.2	Country-code TLDs/th pop. 15–69	0.8	85	
7.3.3	Wikipedia edits/mn pop. 15–69 ⏱	5.2	81	
7.3.4	Mobile app creation/bn PPP$ GDP	0.4	71	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⏱ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

MOZAMBIQUE

GII 2019 rank

119

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
114	118	Low	SSF	30.5	39.3	1,291.4	n/a

		Score/Value	Rank	
	INSTITUTIONS	**43.7**	**126**	
1.1	**Political environment**	**35.9**	**119**	
1.1.1	Political and operational stability*	57.9	101	
1.1.2	Government effectiveness*	24.9	120	
1.2	**Regulatory environment**	**38.0**	**123**	◇
1.2.1	Regulatory quality*	22.4	112	
1.2.2	Rule of law*	19.8	119	
1.2.3	Cost of redundancy dismissal, salary weeks	37.5	122	◇
1.3	**Business environment**	**57.2**	**110**	
1.3.1	Ease of starting a business*	67.6	124	◇
1.3.2	Ease of resolving insolvency*	46.9	76	● ◆
	HUMAN CAPITAL & RESEARCH	**17.4**	**105**	
2.1	**Education**	**48.9**	**64**	● ◆
2.1.1	Expenditure on education, % GDP ◷	6.5	15	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap ◷	44.0	2	● ◆
2.1.3	School life expectancy, years	9.7	107	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	36.5	111	○ ◇
2.2	**Tertiary education**	**1.5**	**126**	○ ◇
2.2.1	Tertiary enrolment, % gross	6.9	114	
2.2.2	Graduates in science & engineering, %	9.0	101	○ ◇
2.2.3	Tertiary inbound mobility, %	0.3	103	
2.3	**Research & development (R&D)**	**1.9**	**94**	
2.3.1	Researchers, FTE/mn pop. ◷	41.5	93	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.3	74	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**33.6**	**107**	
3.1	**Information & communication technologies(ICTs)**	**30.8**	**119**	
3.1.1	ICT access*	20.8	126	○ ◇
3.1.2	ICT use*	15.6	115	
3.1.3	Government's online service*	42.4	113	
3.1.4	E-participation*	44.4	107	
3.2	**General infrastructure**	**50.4**	**17**	● ◆
3.2.1	Electricity output, kWh/mn pop.	649.7	103	
3.2.2	Logistics performance*	n/a	n/a	
3.2.3	Gross capital formation, % GDP	40.0	6	● ◆
3.3	**Ecological sustainability**	**19.6**	**124**	
3.3.1	GDP/unit of energy use	2.4	120	○
3.3.2	Environmental performance*	46.4	107	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.5	86	
	MARKET SOPHISTICATION	**34.8**	**120**	
4.1	**Credit**	**11.8**	**124**	
4.1.1	Ease of getting credit*	25.0	122	
4.1.2	Domestic credit to private sector, % GDP	25.6	106	
4.1.3	Microfinance gross loans, % GDP	0.0	68	
4.2	**Investment**	**41.7**	**[65]**	
4.2.1	Ease of protecting minority investors*	41.7	108	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**50.9**	**104**	
4.3.1	Applied tariff rate, weighted avg., % ◷	3.6	70	● ◆
4.3.2	Intensity of local competition†	54.9	122	
4.3.3	Domestic market scale, bn PPP$	39.3	105	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**25.1**	**98**	
5.1	**Knowledge workers**	**2.5**	**128**	○ ◇
5.1.1	Knowledge-intensive employment, % ◷	3.9	109	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ◷	0.0	88	◇
5.1.4	GERD financed by business, % ◷	0.5	93	
5.1.5	Females employed w/advanced degrees, % ◷	0.7	110	
5.2	**Innovation linkages**	**44.4**	**22**	● ◆
5.2.1	University/industry research collaboration†	37.2	87	
5.2.2	State of cluster development†	36.5	102	
5.2.3	GERD financed by abroad, % ◷	39.9	8	●
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	87	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	n/a	n/a	
5.3	**Knowledge absorption**	**28.5**	**90**	
5.3.1	Intellectual property payments, % total trade	0.3	77	
5.3.2	High-tech imports, % total trade	3.7	120	
5.3.3	ICT services imports, % total trade	1.5	44	●
5.3.4	FDI net inflows, % GDP	24.3	7	● ◆
5.3.5	Research talent, % in business enterprise ◷	0.3	85	○
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**14.7**	**104**	
6.1	**Knowledge creation**	**3.9**	**108**	
6.1.1	Patents by origin/bn PPP$ GDP ◷	0.4	77	◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP ◷	0.2	44	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.2	91	
6.1.5	Citable documents H-index	4.1	101	
6.2	**Knowledge impact**	**33.0**	**[82]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.4	79	
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.0	117	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.6	94	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**7.3**	**118**	
6.3.1	Intellectual property receipts, % total trade ◷	0.0	97	
6.3.2	High-tech net exports, % total trade	0.5	79	◆
6.3.3	ICT services exports, % total trade	0.3	111	
6.3.4	FDI net outflows, % GDP	0.2	90	
	CREATIVE OUTPUTS	**14.9**	**116**	
7.1	**Intangible assets**	**28.8**	**109**	
7.1.1	Trademarks by origin/bn PPP$ GDP ◷	36.8	68	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP ◷	0.8	73	
7.1.3	ICTs & business model creation†	48.4	113	
7.1.4	ICTs & organizational model creation†	35.8	119	
7.2	**Creative goods & services**	**1.9**	**[117]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	104	
7.2.2	National feature films/mn pop. 15–69	2.0	65	● ◆
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.0	127	○
7.3	**Online creativity**	**0.1**	**124**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.0	128	○
7.3.2	Country-code TLDs/th pop. 15–69	0.1	110	
7.3.3	Wikipedia edits/mn pop. 15–69 ◷	0.2	116	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NAMIBIA

GII 2019 rank

101

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
103	99	Upper middle	SSF	2.6	27.5	11,228.8	93

		Score/Value	Rank	
	INSTITUTIONS	**61.2**	**71**	
1.1	**Political environment**	**59.4**	**54**	
1.1.1	Political and operational stability*	75.4	46	●
1.1.2	Government effectiveness*	51.4	58	
1.2	**Regulatory environment**	**71.1**	**48**	●
1.2.1	Regulatory quality*	36.9	84	
1.2.2	Rule of law*	52.7	52	◆
1.2.3	Cost of redundancy dismissal, salary weeks	9.7	28	●
1.3	**Business environment**	**53.0**	**122**	○ ◇
1.3.1	Ease of starting a business*	69.1	122	○ ◇
1.3.2	Ease of resolving insolvency*	37.0	107	◇
	HUMAN CAPITAL & RESEARCH	**13.9**	**112**	○ ◇
2.1	**Education**	**23.5**	**[119]**	
2.1.1	Expenditure on education, % GDP ◷	3.1	100	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**15.9**	**99**	◇
2.2.1	Tertiary enrolment, % gross ◷	20.6	92	◇
2.2.2	Graduates in science & engineering, %	13.0	96	○ ◇
2.2.3	Tertiary inbound mobility, %	7.1	32	● ◆
2.3	**Research & development (R&D)**	**2.2**	**91**	
2.3.1	Researchers, FTE/mn pop. ◷	143.3	83	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.3	73	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**34.9**	**104**	◇
3.1	**Information & communication technologies(ICTs)**	**40.5**	**104**	◇
3.1.1	ICT access*	45.4	98	◇
3.1.2	ICT use*	32.3	99	◇
3.1.3	Government's online service*	45.1	111	○ ◇
3.1.4	E-participation*	39.3	111	○ ◇
3.2	**General infrastructure**	**24.5**	**101**	
3.2.1	Electricity output, kWh/mn pop.	573.0	105	○ ◇
3.2.2	Logistics performance*	n/a	n/a	
3.2.3	Gross capital formation, % GDP	22.3	73	
3.3	**Ecological sustainability**	**39.6**	**56**	
3.3.1	GDP/unit of energy use	11.9	30	●
3.3.2	Environmental performance*	58.5	69	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	89	
	MARKET SOPHISTICATION	**40.2**	**99**	◇
4.1	**Credit**	**29.9**	**93**	
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	63.8	50	
4.1.3	Microfinance gross loans, % GDP ◷	0.0	59	
4.2	**Investment**	**36.7**	**93**	
4.2.1	Ease of protecting minority investors*	51.7	89	
4.2.2	Market capitalization, % GDP	19.7	61	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**54.1**	**92**	
4.3.1	Applied tariff rate, weighted avg., %	0.9	10	●
4.3.2	Intensity of local competition†	62.0	96	◇
4.3.3	Domestic market scale, bn PPP$	27.5	118	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**24.7**	**101**	
5.1	**Knowledge workers**	**22.9**	**101**	
5.1.1	Knowledge-intensive employment, % ◷	18.7	75	
5.1.2	Firms offering formal training, % firms	25.4	63	
5.1.3	GERD performed by business, % GDP ◷	0.0	73	
5.1.4	GERD financed by business, % ◷	11.1	73	
5.1.5	Females employed w/advanced degrees, % ◷	7.7	80	
5.2	**Innovation linkages**	**26.1**	**62**	
5.2.1	University/industry research collaboration†	37.5	84	
5.2.2	State of cluster development†	42.2	84	
5.2.3	GERD financed by abroad, % ◷	15.8	25	●
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	28	● ◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**25.1**	**102**	
5.3.1	Intellectual property payments, % total trade	0.1	101	
5.3.2	High-tech imports, % total trade	7.4	65	
5.3.3	ICT services imports, % total trade	0.9	76	
5.3.4	FDI net inflows, % GDP	5.9	26	●
5.3.5	Research talent, % in business enterprise ◷	6.9	68	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**6.0**	**124**	○ ◇
6.1	**Knowledge creation**	**5.4**	**95**	
6.1.1	Patents by origin/bn PPP$ GDP	0.4	81	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	63	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.9	69	
6.1.5	Citable documents H-index	3.7	106	
6.2	**Knowledge impact**	**5.3**	**120**	○ ◇
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15-64 ◷	0.9	74	
6.2.3	Computer software spending, % GDP	0.1	82	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.5	97	
6.2.5	High- & medium-high-tech manufactures, % ◷	0.0	95	○ ◇
6.3	**Knowledge diffusion**	**7.1**	**121**	○ ◇
6.3.1	Intellectual property receipts, % total trade	0.0	94	
6.3.2	High-tech net exports, % total trade	0.0	121	○
6.3.3	ICT services exports, % total trade	0.7	88	
6.3.4	FDI net outflows, % GDP	-0.1	118	○
	CREATIVE OUTPUTS	**27.5**	**64**	
7.1	**Intangible assets**	**51.7**	**29**	●
7.1.1	Trademarks by origin/bn PPP$ GDP	128.7	5	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	55.0	86	
7.1.4	ICTs & organizational model creation†	46.7	94	
7.2	**Creative goods & services**	**2.8**	**[111]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	95	
7.2.2	National feature films/mn pop. 15-69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.3	69	
7.3	**Online creativity**	**3.9**	**70**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	8.5	42	●
7.3.2	Country-code TLDs/th pop. 15-69	0.7	87	
7.3.3	Wikipedia edits/mn pop. 15-69 ◷	3.6	91	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NEPAL

GII 2019 rank

109

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
119	93	Low	CSA	29.6	86.1	2,904.9	108

		Score/Value	Rank	
	INSTITUTIONS	**49.8**	**110**	
1.1	**Political environment**	**35.5**	**120**	
1.1.1	Political and operational stability*	56.1	105	
1.1.2	Government effectiveness*	25.2	119	
1.2	**Regulatory environment**	**48.2**	**114**	
1.2.1	Regulatory quality*	22.7	111	
1.2.2	Rule of law*	28.5	104	
1.2.3	Cost of redundancy dismissal, salary weeks	27.2	105	◇
1.3	**Business environment**	**65.8**	**79**	
1.3.1	Ease of starting a business*	84.4	82	
1.3.2	Ease of resolving insolvency*	47.2	75	◆
	HUMAN CAPITAL & RESEARCH	**12.9**	**115**	
2.1	**Education**	**32.3**	**104**	
2.1.1	Expenditure on education, % GDP	5.1	45	●
2.1.2	Government funding/pupil, secondary, % GDP/cap	11.0	91	
2.1.3	School life expectancy, years	12.2	90	◆
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	28.8	105	
2.2	**Tertiary education**	**4.4**	**121**	○
2.2.1	Tertiary enrolment, % gross	11.8	103	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, % ⏲	0.0	111	○ ◇
2.3	**Research & development (R&D)**	**2.1**	**92**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP ⏲	0.3	77	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**42.2**	**80**	◆
3.1	**Information & communication technologies(ICTs)**	**53.6**	**89**	◆
3.1.1	ICT access*	42.0	101	◆
3.1.2	ICT use*	25.5	100	◆
3.1.3	Government's online service*	68.8	72	◆
3.1.4	E-participation*	78.1	55	● ◆
3.2	**General infrastructure**	**55.4**	**9**	● ◆
3.2.1	Electricity output, kWh/mn pop.	146.4	116	○
3.2.2	Logistics performance*	21.0	105	
3.2.3	Gross capital formation, % GDP	51.8	1	● ◆
3.3	**Ecological sustainability**	**17.6**	**129**	○ ◇
3.3.1	GDP/unit of energy use	5.1	107	
3.3.2	Environmental performance*	31.4	124	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	107	
	MARKET SOPHISTICATION	**45.9**	**72**	◆
4.1	**Credit**	**34.3**	**70**	
4.1.1	Ease of getting credit*	50.0	87	
4.1.2	Domestic credit to private sector, % GDP	79.8	36	● ◆
4.1.3	Microfinance gross loans, % GDP	0.9	20	●
4.2	**Investment**	**58.3**	**[22]**	
4.2.1	Ease of protecting minority investors*	58.3	68	◆
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**45.0**	**118**	
4.3.1	Applied tariff rate, weighted avg., % ⏲	12.4	124	○
4.3.2	Intensity of local competition†	63.1	91	
4.3.3	Domestic market scale, bn PPP$	86.1	85	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**32.8**	**54**	● ◆
5.1	**Knowledge workers**	**37.6**	**[60]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms	31.9	49	●
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**29.6**	**[49]**	
5.2.1	University/industry research collaboration†	30.1	105	
5.2.2	State of cluster development†	38.0	96	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	54	●
5.2.5	Patent families 2+ offices/bn PPP$ GDP	n/a	n/a	
5.3	**Knowledge absorption**	**31.1**	**[80]**	
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade	11.5	21	●
5.3.3	ICT services imports, % total trade	0.2	121	○ ◇
5.3.4	FDI net inflows, % GDP	0.5	119	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**10.4**	**[118]**	
6.1	**Knowledge creation**	**7.3**	**[81]**	
6.1.1	Patents by origin/bn PPP$ GDP	0.3	89	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.7	73	
6.1.5	Citable documents H-index	6.3	87	
6.2	**Knowledge impact**	**3.7**	**125**	○ ◇
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64	1.0	72	
6.2.3	Computer software spending, % GDP	0.0	119	○
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.9	109	
6.2.5	High- & medium-high-tech manufactures, % ⏲	0.1	90	
6.3	**Knowledge diffusion**	**20.3**	**[49]**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.1	111	
6.3.3	ICT services exports, % total trade	4.2	17	● ◆
6.3.4	FDI net outflows, % GDP	n/a	n/a	
	CREATIVE OUTPUTS	**15.5**	**112**	
7.1	**Intangible assets**	**28.3**	**110**	
7.1.1	Trademarks by origin/bn PPP$ GDP	50.6	47	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	104	
7.1.3	ICTs & business model creation†	40.4	120	○
7.1.4	ICTs & organizational model creation†	37.9	117	○
7.2	**Creative goods & services**	**4.0**	**[106]**	
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⏲	0.4	95	◇
7.2.5	Creative goods exports, % total trade	0.2	80	◆
7.3	**Online creativity**	**1.7**	**89**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.5	110	
7.3.2	Country-code TLDs/th pop. 15–69 ⏲	0.9	82	
7.3.3	Wikipedia edits/mn pop. 15–69 ⏲	6.1	73	◆
7.3.4	Mobile app creation/bn PPP$ GDP	1.2	65	◆

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⏲ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NETHERLANDS (THE)

GII 2019 rank

4

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
2	11	High	EUR	17.1	972.5	56,383.2	2

		Score/Value	Rank	
	INSTITUTIONS	**90.9**	**8**	
1.1	**Political environment**	**91.4**	**8**	
1.1.1	Political and operational stability*	91.2	12	
1.1.2	Government effectiveness*	91.4	7	
1.2	**Regulatory environment**	**91.9**	**14**	
1.2.1	Regulatory quality*	96.9	4	●
1.2.2	Rule of law*	94.8	7	
1.2.3	Cost of redundancy dismissal, salary weeks	15.8	65	○
1.3	**Business environment**	**89.3**	**7**	
1.3.1	Ease of starting a business*	94.3	19	
1.3.2	Ease of resolving insolvency*	84.3	7	
	HUMAN CAPITAL & RESEARCH	**52.4**	**17**	
2.1	**Education**	**60.1**	**23**	
2.1.1	Expenditure on education, % GDP	5.4	29	
2.1.2	Government funding/pupil, secondary, % GDP/cap	22.9	36	
2.1.3	School life expectancy, years	18.0	11	
2.1.4	PISA scales in reading, maths, & science	507.9	12	
2.1.5	Pupil-teacher ratio, secondary ⊙	14.4	64	○
2.2	**Tertiary education**	**32.8**	**59**	○
2.2.1	Tertiary enrolment, % gross ⊙	80.4	19	
2.2.2	Graduates in science & engineering, % ⊙	14.1	91	○ ◇
2.2.3	Tertiary inbound mobility, %	10.7	18	
2.3	**Research & development (R&D)**	**64.4**	**12**	
2.3.1	Researchers, FTE/mn pop.	5,007.1	13	
2.3.2	Gross expenditure on R&D, % GDP	2.0	17	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	85.4	9	
2.3.4	QS university ranking, average score top 3*	68.1	13	
	INFRASTRUCTURE	**61.8**	**14**	
3.1	**Information & communication technologies(ICTs)**	**91.1**	**4**	●
3.1.1	ICT access*	87.5	8	
3.1.2	ICT use*	84.8	7	
3.1.3	Government's online service*	93.1	17	
3.1.4	E-participation*	98.9	4	●
3.2	**General infrastructure**	**45.7**	**31**	
3.2.1	Electricity output, kWh/mn pop.	6,805.9	31	
3.2.2	Logistics performance*	91.5	6	
3.2.3	Gross capital formation, % GDP	21.3	85	○
3.3	**Ecological sustainability**	**48.5**	**36**	
3.3.1	GDP/unit of energy use	10.9	42	
3.3.2	Environmental performance*	75.5	18	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	3.0	33	
	MARKET SOPHISTICATION	**58.2**	**23**	
4.1	**Credit**	**49.3**	**32**	
4.1.1	Ease of getting credit*	45.0	94	○ ◇
4.1.2	Domestic credit to private sector, % GDP	111.9	20	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**48.8**	**42**	
4.2.1	Ease of protecting minority investors*	58.3	68	○
4.2.2	Market capitalization, % GDP	111.0	9	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	15	
4.3	**Trade, competition, & market scale**	**76.5**	**18**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	○
4.3.2	Intensity of local competition†	80.5	5	●
4.3.3	Domestic market scale, bn PPP$	972.5	26	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**63.7**	**6**	◆
5.1	**Knowledge workers**	**64.6**	**18**	
5.1.1	Knowledge-intensive employment, %	46.8	12	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	1.2	17	
5.1.4	GERD financed by business, %	52.0	24	
5.1.5	Females employed w/advanced degrees, %	19.7	24	
5.2	**Innovation linkages**	**59.0**	**5**	●
5.2.1	University/industry research collaboration†	75.5	4	● ◆
5.2.2	State of cluster development†	72.8	5	● ◆
5.2.3	GERD financed by abroad, %	13.9	30	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	23	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	6.0	8	
5.3	**Knowledge absorption**	**67.6**	**2**	● ◆
5.3.1	Intellectual property payments, % total trade	8.1	1	● ◆
5.3.2	High-tech imports, % total trade	11.5	22	
5.3.3	ICT services imports, % total trade	2.3	17	
5.3.4	FDI net inflows, % GDP	27.7	5	● ◆
5.3.5	Research talent, % in business enterprise	62.7	7	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**61.8**	**3**	● ◆
6.1	**Knowledge creation**	**65.0**	**7**	
6.1.1	Patents by origin/bn PPP$ GDP	10.0	12	
6.1.2	PCT patents by origin/bn PPP$ GDP	4.3	10	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	20.8	21	
6.1.5	Citable documents H-index	68.8	8	
6.2	**Knowledge impact**	**45.4**	**27**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.6	70	○
6.2.2	New businesses/th pop. 15–64	6.1	24	
6.2.3	Computer software spending, % GDP	0.6	8	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	10.9	28	
6.2.5	High- & medium-high-tech manufactures, %	0.3	36	
6.3	**Knowledge diffusion**	**75.0**	**2**	● ◆
6.3.1	Intellectual property receipts, % total trade	7.0	1	● ◆
6.3.2	High-tech net exports, % total trade	11.2	15	
6.3.3	ICT services exports, % total trade	3.6	23	
6.3.4	FDI net outflows, % GDP	36.3	1	● ◆
	CREATIVE OUTPUTS	**53.2**	**5**	● ◆
7.1	**Intangible assets**	**56.1**	**16**	
7.1.1	Trademarks by origin/bn PPP$ GDP	53.9	43	○
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.8	33	
7.1.3	ICTs & business model creation†	84.0	3	● ◆
7.1.4	ICTs & organizational model creation†	80.2	4	● ◆
7.2	**Creative goods & services**	**37.1**	**12**	
7.2.1	Cultural & creative services exports, % total trade	1.7	10	
7.2.2	National feature films/mn pop. 15–69	7.6	23	
7.2.3	Entertainment & Media market/th pop. 15–69	50.4	17	
7.2.4	Printing & other media, % manufacturing	1.2	51	○
7.2.5	Creative goods exports, % total trade	4.1	14	
7.3	**Online creativity**	**63.3**	**2**	● ◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	78.9	5	● ◆
7.3.2	Country-code TLDs/th pop. 15–69	100.0	1	● ◆
7.3.3	Wikipedia edits/mn pop. 15–69	86.3	10	
7.3.4	Mobile app creation/bn PPP$ GDP	16.3	28	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NEW ZEALAND

GII 2019 rank

25

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
32	18	High	SEAO	4.7	199.3	40,135.4	22

		Score/Value	Rank	
1	**INSTITUTIONS**	**92.1**	**5**	●
1.1	**Political environment**	**91.7**	**7**	●
1.1.1	Political and operational stability*	96.5	2	● ◆
1.1.2	Government effectiveness*	89.4	10	●
1.2	**Regulatory environment**	**98.8**	**1**	●
1.2.1	Regulatory quality*	98.0	3	● ◆
1.2.2	Rule of law*	97.2	5	●
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**85.9**	**18**	
1.3.1	Ease of starting a business*	100.0	1	● ◆
1.3.2	Ease of resolving insolvency*	71.8	29	
2	**HUMAN CAPITAL & RESEARCH**	**52.6**	**16**	
2.1	**Education**	**63.0**	**15**	
2.1.1	Expenditure on education, % GDP	6.3	17	
2.1.2	Government funding/pupil, secondary, % GDP/cap	20.8	47	
2.1.3	School life expectancy, years	18.8	7	●
2.1.4	PISA scales in reading, maths, & science	505.9	14	
2.1.5	Pupil-teacher ratio, secondary	13.6	61	○
2.2	**Tertiary education**	**51.3**	**12**	
2.2.1	Tertiary enrolment, % gross	82.0	15	
2.2.2	Graduates in science & engineering, %	21.2	56	○
2.2.3	Tertiary inbound mobility, %	19.8	5	● ◆
2.3	**Research & development (R&D)**	**43.4**	**23**	◇
2.3.1	Researchers, FTE/mn pop. ⊙	4,052.4	24	
2.3.2	Gross expenditure on R&D, % GDP ⊙	1.2	30	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	47.8	32	
2.3.4	QS university ranking, average score top 3*	50.1	18	
3	**INFRASTRUCTURE**	**60.9**	**20**	
3.1	**Information & communication technologies(ICTs)**	**90.5**	**6**	●
3.1.1	ICT access*	86.2	12	
3.1.2	ICT use*	82.3	11	
3.1.3	Government's online service*	95.1	9	
3.1.4	E-participation*	98.3	5	●
3.2	**General infrastructure**	**50.4**	**18**	
3.2.1	Electricity output, kWh/mn pop.	8,935.3	18	
3.2.2	Logistics performance*	84.8	15	
3.2.3	Gross capital formation, % GDP	25.4	43	
3.3	**Ecological sustainability**	**41.8**	**49**	
3.3.1	GDP/unit of energy use	7.9	77	○
3.3.2	Environmental performance*	76.0	17	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.5	57	
4	**MARKET SOPHISTICATION**	**68.5**	**6**	●
4.1	**Credit**	**87.2**	**3**	● ◆
4.1.1	Ease of getting credit*	100.0	1	● ◆
4.1.2	Domestic credit to private sector, % GDP	152.9	8	●
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**51.5**	**36**	
4.2.1	Ease of protecting minority investors*	81.7	2	● ◆
4.2.2	Market capitalization, % GDP	43.4	33	◇
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	18	
4.3	**Trade, competition, & market scale**	**66.7**	**46**	
4.3.1	Applied tariff rate, weighted avg., %	1.4	13	
4.3.2	Intensity of local competition†	70.8	52	
4.3.3	Domestic market scale, bn PPP$	199.3	61	

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**41.4**	**31**	◇
5.1	**Knowledge workers**	**43.8**	**[48]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ⊙	0.6	33	◇
5.1.4	GERD financed by business, % ⊙	43.8	38	
5.1.5	Females employed w/advanced degrees, % ⊙	19.5	25	
5.2	**Innovation linkages**	**40.2**	**28**	
5.2.1	University/industry research collaboration†	62.7	21	
5.2.2	State of cluster development†	55.2	35	◇
5.2.3	GERD financed by abroad, % ⊙	7.8	50	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	15	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	2.2	19	
5.3	**Knowledge absorption**	**40.0**	**41**	◇
5.3.1	Intellectual property payments, % total trade	1.7	17	
5.3.2	High-tech imports, % total trade	10.0	29	
5.3.3	ICT services imports, % total trade	1.4	49	
5.3.4	FDI net inflows, % GDP	0.7	115	○
5.3.5	Research talent, % in business enterprise ⊙	36.9	36	◇
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**29.8**	**42**	◇
6.1	**Knowledge creation**	**39.1**	**20**	
6.1.1	Patents by origin/bn PPP$ GDP	5.4	22	
6.1.2	PCT patents by origin/bn PPP$ GDP	1.4	24	◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	26.4	11	
6.1.5	Citable documents H-index	33.9	27	
6.2	**Knowledge impact**	**36.8**	**63**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.6	100	○ ◇
6.2.2	New businesses/th pop. 15–64	14.5	9	
6.2.3	Computer software spending, % GDP	0.3	56	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	5.5	57	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	66	○ ◇
6.3	**Knowledge diffusion**	**13.6**	**82**	○ ◇
6.3.1	Intellectual property receipts, % total trade	0.7	23	
6.3.2	High-tech net exports, % total trade	1.0	69	○ ◇
6.3.3	ICT services exports, % total trade	1.1	77	○
6.3.4	FDI net outflows, % GDP	-0.3	121	○ ◇
7	**CREATIVE OUTPUTS**	**42.2**	**23**	
7.1	**Intangible assets**	**53.4**	**27**	
7.1.1	Trademarks by origin/bn PPP$ GDP	90.5	22	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.8	54	
7.1.3	ICTs & business model creation†	73.5	23	
7.1.4	ICTs & organizational model creation†	71.3	18	
7.2	**Creative goods & services**	**24.8**	**43**	
7.2.1	Cultural & creative services exports, % total trade	0.5	52	
7.2.2	National feature films/mn pop. 15–69	6.2	36	
7.2.3	Entertainment & Media market/th pop. 15–69	59.0	11	
7.2.4	Printing & other media, % manufacturing ⊙	1.8	23	
7.2.5	Creative goods exports, % total trade	0.5	61	
7.3	**Online creativity**	**37.1**	**21**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	32.5	20	
7.3.2	Country-code TLDs/th pop. 15–69	59.7	10	●
7.3.3	Wikipedia edits/mn pop. 15–69	59.7	16	
7.3.4	Mobile app creation/bn PPP$ GDP	15.9	31	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NICARAGUA

GII 2019 rank

120

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
122	108	Lower middle	LCN	6.3	35.8	5,682.7	n/a

		Score/Value	Rank	
	INSTITUTIONS	**52.5**	**101**	
1.1	**Political environment**	**38.8**	**109**	
1.1.1	Political and operational stability*	54.4	111	
1.1.2	Government effectiveness*	31.1	107	
1.2	**Regulatory environment**	**58.0**	**88**	
1.2.1	Regulatory quality*	23.9	108	
1.2.2	Rule of law*	29.3	100	
1.2.3	Cost of redundancy dismissal, salary weeks	14.9	60	●
1.3	**Business environment**	**60.5**	**104**	
1.3.1	Ease of starting a business*	79.8	109	
1.3.2	Ease of resolving insolvency*	41.1	93	
	HUMAN CAPITAL & RESEARCH	**11.7**	**[118]**	
2.1	**Education**	**22.8**	**[120]**	
2.1.1	Expenditure on education, % GDP	4.3	67	
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	7.3	102	○ ◇
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	30.8	107	○ ◇
2.2	**Tertiary education**	**n/a**	**[n/a]**	
2.2.1	Tertiary enrolment, % gross	n/a	n/a	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**0.7**	**112**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.1	106	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**33.6**	**106**	
3.1	**Information & communication technologies(ICTs)**	**36.0**	**113**	◇
3.1.1	ICT access*	43.6	99	
3.1.2	ICT use*	21.3	105	
3.1.3	Government's online service*	40.3	114	◇
3.1.4	E-participation*	38.8	112	◇
3.2	**General infrastructure**	**33.1**	**70**	
3.2.1	Electricity output, kWh/mn pop.	746.3	100	
3.2.2	Logistics performance*	n/a	n/a	
3.2.3	Gross capital formation, % GDP	28.1	29	●
3.3	**Ecological sustainability**	**31.7**	**87**	
3.3.1	GDP/unit of energy use	7.9	78	
3.3.2	Environmental performance*	55.0	82	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	90	
	MARKET SOPHISTICATION	**39.1**	**105**	
4.1	**Credit**	**29.0**	**97**	
4.1.1	Ease of getting credit*	50.0	87	
4.1.2	Domestic credit to private sector, % GDP	42.6	78	
4.1.3	Microfinance gross loans, % GDP	1.1	18	●
4.2	**Investment**	**35.0**	**[99]**	
4.2.1	Ease of protecting minority investors*	35.0	123	○ ◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**53.3**	**95**	
4.3.1	Applied tariff rate, weighted avg., %	2.3	57	● ◆
4.3.2	Intensity of local competition†	60.3	106	◇
4.3.3	Domestic market scale, bn PPP$	35.8	109	◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**27.9**	**80**	
5.1	**Knowledge workers**	**41.3**	**[52]**	
5.1.1	Knowledge-intensive employment, % ⊙	13.8	92	
5.1.2	Firms offering formal training, % firms	57.3	11	● ◆
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	6.1	84	
5.2	**Innovation linkages**	**15.9**	**116**	
5.2.1	University/industry research collaboration†	27.1	115	
5.2.2	State of cluster development†	33.7	113	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	102	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**26.5**	**96**	
5.3.1	Intellectual property payments, % total trade	0.0	111	◇
5.3.2	High-tech imports, % total trade	8.1	57	●
5.3.3	ICT services imports, % total trade	0.3	117	◇
5.3.4	FDI net inflows, % GDP	6.9	19	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**7.9**	**122**	○ ◇
6.1	**Knowledge creation**	**1.7**	**125**	○
6.1.1	Patents by origin/bn PPP$ GDP ⊙	0.0	124	○
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	84	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.1	122	○
6.1.5	Citable documents H-index	2.9	113	
6.2	**Knowledge impact**	**4.6**	**[122]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.1	98	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.7	90	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**17.5**	**65**	●
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.2	99	
6.3.3	ICT services exports, % total trade	2.6	39	●
6.3.4	FDI net outflows, % GDP	0.5	67	●
	CREATIVE OUTPUTS	**16.3**	**[110]**	
7.1	**Intangible assets**	**30.8**	**104**	
7.1.1	Trademarks by origin/bn PPP$ GDP ⊙	40.2	65	
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊙	0.0	116	○
7.1.3	ICTs & business model creation†	48.9	110	
7.1.4	ICTs & organizational model creation†	43.0	100	
7.2	**Creative goods & services**	**2.1**	**[115]**	
7.2.1	Cultural & creative services exports, % total trade ⊙	0.0	97	
7.2.2	National feature films/mn pop. 15–69 ⊙	0.3	100	○
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.3	71	
7.3	**Online creativity**	**1.6**	**[90]**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	2.8	68	● ◆
7.3.2	Country-code TLDs/th pop. 15–69	0.5	94	
7.3.3	Wikipedia edits/mn pop. 15–69	n/a	n/a	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NIGERIA

GII 2019 rank

114

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
105	116	Lower middle	SSF	195.9	1,169.1	6,027.2	118

		Score/Value	Rank	
	INSTITUTIONS	**49.3**	**114**	
1.1	**Political environment**	**30.7**	**126**	○ ◇
1.1.1	Political and operational stability*	45.6	125	○ ◇
1.1.2	Government effectiveness*	23.3	122	◇
1.2	**Regulatory environment**	**60.4**	**81**	
1.2.1	Regulatory quality*	18.2	121	◇
1.2.2	Rule of law*	23.5	117	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	● ◆
1.3	**Business environment**	**56.7**	**113**	
1.3.1	Ease of starting a business*	83.0	92	
1.3.2	Ease of resolving insolvency*	30.4	119	◇
	HUMAN CAPITAL & RESEARCH	**11.3**	**119**	◇
2.1	**Education**	**26.4**	**[114]**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years ⊙	8.7	113	○ ◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	23.2	94	
2.2	**Tertiary education**	**7.5**	**[114]**	
2.2.1	Tertiary enrolment, % gross ⊙	10.2	107	◇
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**26.6**	**122**	◇
3.1	**Information & communication technologies(ICTs)**	**36.7**	**111**	◇
3.1.1	ICT access*	29.9	117	◇
3.1.2	ICT use*	15.9	114	◇
3.1.3	Government's online service*	52.8	103	
3.1.4	E-participation*	48.3	105	
3.2	**General infrastructure**	**14.1**	**126**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	166.1	115	◇
3.2.2	Logistics performance*	21.9	102	
3.2.3	Gross capital formation, % GDP	13.6	120	○ ◇
3.3	**Ecological sustainability**	**29.1**	**103**	
3.3.1	GDP/unit of energy use	6.6	93	
3.3.2	Environmental performance*	54.8	84	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.1	125	○ ◇
	MARKET SOPHISTICATION	**43.4**	**88**	
4.1	**Credit**	**34.2**	**72**	
4.1.1	Ease of getting credit*	85.0	11	●
4.1.2	Domestic credit to private sector, % GDP	14.2	119	◇
4.1.3	Microfinance gross loans, % GDP	0.8	26	●
4.2	**Investment**	**34.8**	**101**	
4.2.1	Ease of protecting minority investors*	66.7	35	●
4.2.2	Market capitalization, % GDP	9.1	70	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	47	
4.3	**Trade, competition, & market scale**	**61.2**	**63**	●
4.3.1	Applied tariff rate, weighted avg., % ⊙	11.3	118	◇
4.3.2	Intensity of local competition†	68.7	66	●
4.3.3	Domestic market scale, bn PPP$	1,169.1	23	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.7**	**85**	
5.1	**Knowledge workers**	**37.2**	**[64]**	
5.1.1	Knowledge-intensive employment, % ⊙	28.4	49	● ◆
5.1.2	Firms offering formal training, % firms	30.7	50	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	5.0	90	
5.2	**Innovation linkages**	**18.4**	**100**	
5.2.1	University/industry research collaboration†	23.7	123	○ ◇
5.2.2	State of cluster development†	41.5	88	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	89	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	92	
5.3	**Knowledge absorption**	**24.6**	**105**	
5.3.1	Intellectual property payments, % total trade	0.5	64	●
5.3.2	High-tech imports, % total trade	4.0	117	
5.3.3	ICT services imports, % total trade	0.9	81	
5.3.4	FDI net inflows, % GDP	0.9	106	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**14.0**	**106**	
6.1	**Knowledge creation**	**5.0**	**99**	
6.1.1	Patents by origin/bn PPP$ GDP ⊙	0.1	119	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	98	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.8	115	
6.1.5	Citable documents H-index	10.3	65	●
6.2	**Knowledge impact**	**26.9**	**102**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.1	91	◇
6.2.2	New businesses/th pop. 15-64	0.8	78	
6.2.3	Computer software spending, % GDP	0.1	83	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.2	126	○ ◇
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**10.1**	**101**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.0	122	○
6.3.3	ICT services exports, % total trade	0.6	99	
6.3.4	FDI net outflows, % GDP	0.3	79	
	CREATIVE OUTPUTS	**18.8**	**101**	
7.1	**Intangible assets**	**32.0**	**102**	
7.1.1	Trademarks by origin/bn PPP$ GDP ⊙	19.8	89	
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊙	0.8	72	
7.1.3	ICTs & business model creation†	55.1	85	
7.1.4	ICTs & organizational model creation†	47.5	88	
7.2	**Creative goods & services**	**10.8**	**[81]**	
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15-69 ⊙	11.2	12	● ◆
7.2.3	Entertainment & Media market/th pop. 15-69	0.6	59	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade ⊙	0.0	126	○
7.3	**Online creativity**	**0.3**	**117**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	0.5	107	
7.3.2	Country-code TLDs/th pop. 15-69	0.3	102	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	0.3	112	
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	81	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NIGER (THE)

GII 2019 rank

127

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
127	125	Low	SSF	22.3	23.5	1,216.8	n/a

		Score/Value	Rank	
	INSTITUTIONS	**54.4**	**93**	
1.1	**Political environment**	**38.3**	**112**	
1.1.1	Political and operational stability*	54.4	111	
1.1.2	Government effectiveness*	30.2	112	
1.2	**Regulatory environment**	**58.5**	**86**	
1.2.1	Regulatory quality*	23.7	109	
1.2.2	Rule of law*	28.5	103	
1.2.3	Cost of redundancy dismissal, salary weeks	14.0	55	●
1.3	**Business environment**	**66.6**	**76**	
1.3.1	Ease of starting a business*	93.7	24	● ◆
1.3.2	Ease of resolving insolvency*	39.4	100	
	HUMAN CAPITAL & RESEARCH	**9.9**	**126**	◇
2.1	**Education**	**19.2**	**124**	◇
2.1.1	Expenditure on education, % GDP	3.5	93	
2.1.2	Government funding/pupil, secondary, % GDP/cap	16.0	77	
2.1.3	School life expectancy, years	6.5	118	○ ◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	29.7	106	
2.2	**Tertiary education**	**10.4**	**110**	
2.2.1	Tertiary enrolment, % gross	4.0	120	
2.2.2	Graduates in science & engineering, %	13.2	94	
2.2.3	Tertiary inbound mobility, %	4.3	47	●
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**25.5**	**124**	
3.1	**Information & communication technologies(ICTs)**	**18.7**	**[128]**	
3.1.1	ICT access*	n/a	n/a	
3.1.2	ICT use*	n/a	n/a	
3.1.3	Government's online service*	16.0	127	○ ◇
3.1.4	E-participation*	21.4	122	◇
3.2	**General infrastructure**	**35.6**	**62**	●
3.2.1	Electricity output, kWh/mn pop.	25.4	121	○ ◇
3.2.2	Logistics performance*	0.3	121	◇
3.2.3	Gross capital formation, % GDP	38.5	9	● ◆
3.3	**Ecological sustainability**	**22.3**	**122**	
3.3.1	GDP/unit of energy use	6.3	96	
3.3.2	Environmental performance*	35.7	122	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.0	65	● ◆
	MARKET SOPHISTICATION	**27.3**	**127**	◇
4.1	**Credit**	**12.5**	**122**	
4.1.1	Ease of getting credit*	30.0	115	
4.1.2	Domestic credit to private sector, % GDP	15.7	114	
4.1.3	Microfinance gross loans, % GDP ⊙	0.1	49	
4.2	**Investment**	**40.0**	**[72]**	
4.2.1	Ease of protecting minority investors*	40.0	114	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**29.4**	**127**	◇
4.3.1	Applied tariff rate, weighted avg., %	11.9	119	
4.3.2	Intensity of local competition†	n/a	n/a	
4.3.3	Domestic market scale, bn PPP$	23.5	124	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**22.8**	**[112]**	
5.1	**Knowledge workers**	**21.2**	**[105]**	
5.1.1	Knowledge-intensive employment, %	n/a	n/a	
5.1.2	Firms offering formal training, % firms	27.5	57	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	0.2	117	○ ◇
5.2	**Innovation linkages**	**0.0**	**[129]**	
5.2.1	University/industry research collaboration†	n/a	n/a	
5.2.2	State of cluster development†	n/a	n/a	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**47.1**	**24**	● ◆
5.3.1	Intellectual property payments, % total trade ⊙	0.0	110	
5.3.2	High-tech imports, % total trade ⊙	7.2	69	●
5.3.3	ICT services imports, % total trade	3.5	5	● ◆
5.3.4	FDI net inflows, % GDP	5.2	29	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**16.1**	**90**	
6.1	**Knowledge creation**	**3.2**	**116**	
6.1.1	Patents by origin/bn PPP$ GDP ⊙	0.3	84	◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	77	◆
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.3	97	
6.1.5	Citable documents H-index	2.6	114	
6.2	**Knowledge impact**	**28.1**	**100**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.1	61	●
6.2.2	New businesses/th pop. 15–64 ⊙	0.0	106	○ ◇
6.2.3	Computer software spending, % GDP	0.0	111	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.6	92	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**16.9**	**70**	●
6.3.1	Intellectual property receipts, % total trade ⊙	0.0	106	
6.3.2	High-tech net exports, % total trade ⊙	0.1	103	
6.3.3	ICT services exports, % total trade	4.3	14	● ◆
6.3.4	FDI net outflows, % GDP	0.5	68	●
	CREATIVE OUTPUTS	**0.4**	**[129]**	
7.1	**Intangible assets**	**0.0**	**[129]**	
7.1.1	Trademarks by origin/bn PPP$ GDP	2.8	121	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊙	0.0	114	
7.1.3	ICTs & business model creation†	n/a	n/a	
7.1.4	ICTs & organizational model creation†	n/a	n/a	
7.2	**Creative goods & services**	**1.3**	**[121]**	
7.2.1	Cultural & creative services exports, % total trade	0.1	87	
7.2.2	National feature films/mn pop. 15–69 ⊙	0.7	91	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade ⊙	0.0	113	
7.3	**Online creativity**	**0.3**	**115**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.0	96	◆
7.3.2	Country-code TLDs/th pop. 15–69	0.0	127	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.0	127	○ ◇
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NORTH MACEDONIA

GII 2019 rank

59

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
63	52	Upper middle	EUR	2.1	32.3	15,709.5	84

		Score/Value	Rank	
	INSTITUTIONS	**69.7**	**43**	◆
1.1	**Political environment**	**56.7**	**64**	
1.1.1	Political and operational stability*	70.2	61	
1.1.2	Government effectiveness*	49.9	63	
1.2	**Regulatory environment**	**70.1**	**52**	
1.2.1	Regulatory quality*	55.5	45	
1.2.2	Rule of law*	40.0	74	
1.2.3	Cost of redundancy dismissal, salary weeks	13.0	42	
1.3	**Business environment**	**82.4**	**27**	● ◆
1.3.1	Ease of starting a business*	92.1	42	
1.3.2	Ease of resolving insolvency*	72.7	28	● ◆

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**26.4**	**80**	
2.1	**Education**	**48.7**	**[65]**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years ⊙	13.3	79	
2.1.4	PISA scales in reading, maths, & science	368.9	68	○
2.1.5	Pupil-teacher ratio, secondary ⊙	9.4	22	●
2.2	**Tertiary education**	**26.5**	**77**	
2.2.1	Tertiary enrolment, % gross ⊙	41.1	69	
2.2.2	Graduates in science & engineering, % ⊙	20.0	66	
2.2.3	Tertiary inbound mobility, % ⊙	3.5	58	
2.3	**Research & development (R&D)**	**4.0**	**80**	
2.3.1	Researchers, FTE/mn pop.	729.2	55	
2.3.2	Gross expenditure on R&D, % GDP	0.4	72	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**44.9**	**71**	
3.1	**Information & communication technologies(ICTs)**	**66.6**	**65**	
3.1.1	ICT access*	68.3	63	
3.1.2	ICT use*	56.3	62	
3.1.3	Government's online service*	71.5	69	
3.1.4	E-participation*	70.2	69	
3.2	**General infrastructure**	**19.8**	**120**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	2,706.3	66	
3.2.2	Logistics performance*	30.0	80	
3.2.3	Gross capital formation, % GDP	n/a	n/a	
3.3	**Ecological sustainability**	**48.2**	**37**	◆
3.3.1	GDP/unit of energy use	10.1	49	
3.3.2	Environmental performance*	61.1	61	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	7.5	12	● ◆

		Score/Value	Rank	
	MARKET SOPHISTICATION	**57.1**	**28**	● ◆
4.1	**Credit**	**37.6**	**61**	
4.1.1	Ease of getting credit*	85.0	11	● ◆
4.1.2	Domestic credit to private sector, % GDP	50.0	68	
4.1.3	Microfinance gross loans, % GDP	0.3	39	
4.2	**Investment**	**80.0**	**[3]**	
4.2.1	Ease of protecting minority investors*	80.0	6	● ◆
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**53.8**	**93**	
4.3.1	Applied tariff rate, weighted avg., %	1.9	52	
4.3.2	Intensity of local competition†	62.5	95	
4.3.3	Domestic market scale, bn PPP$	32.3	112	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**30.5**	**66**	
5.1	**Knowledge workers**	**42.2**	**50**	
5.1.1	Knowledge-intensive employment, %	29.0	47	
5.1.2	Firms offering formal training, % firms	46.9	25	●
5.1.3	GERD performed by business, % GDP	0.1	62	
5.1.4	GERD financed by business, %	27.4	63	
5.1.5	Females employed w/advanced degrees, %	13.8	47	
5.2	**Innovation linkages**	**18.0**	**107**	○
5.2.1	University/industry research collaboration†	29.2	108	○ ◇
5.2.2	State of cluster development†	37.0	99	
5.2.3	GERD financed by abroad, %	5.9	59	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**31.2**	**79**	
5.3.1	Intellectual property payments, % total trade	0.9	41	
5.3.2	High-tech imports, % total trade	5.4	102	○
5.3.3	ICT services imports, % total trade	1.4	52	
5.3.4	FDI net inflows, % GDP	3.8	43	
5.3.5	Research talent, % in business enterprise	21.5	55	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**21.6**	**66**	
6.1	**Knowledge creation**	**8.8**	**74**	
6.1.1	Patents by origin/bn PPP$ GDP ⊙	1.6	51	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	52	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	8.1	57	
6.1.5	Citable documents H-index	4.7	96	
6.2	**Knowledge impact**	**39.3**	**52**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.0	90	○
6.2.2	New businesses/th pop. 15–64	3.9	33	
6.2.3	Computer software spending, % GDP	0.1	80	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	14.3	24	●
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.4	20	● ◆
6.3	**Knowledge diffusion**	**16.8**	**71**	
6.3.1	Intellectual property receipts, % total trade	0.1	46	
6.3.2	High-tech net exports, % total trade	1.1	67	
6.3.3	ICT services exports, % total trade	2.5	42	
6.3.4	FDI net outflows, % GDP	1.4	45	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**28.1**	**62**	
7.1	**Intangible assets**	**39.3**	**72**	
7.1.1	Trademarks by origin/bn PPP$ GDP	n/a	n/a	
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.2	39	
7.1.3	ICTs & business model creation†	48.4	112	○ ◇
7.1.4	ICTs & organizational model creation†	41.1	111	○ ◇
7.2	**Creative goods & services**	**21.0**	**55**	
7.2.1	Cultural & creative services exports, % total trade	0.8	35	
7.2.2	National feature films/mn pop. 15–69	5.1	43	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	2.1	18	●
7.2.5	Creative goods exports, % total trade	0.2	85	
7.3	**Online creativity**	**12.7**	**45**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	6.7	47	
7.3.2	Country-code TLDs/th pop. 15–69	4.9	49	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	47.1	29	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	7.5	44	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

NORWAY

GII 2019 rank

19

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
27	13	High	EUR	5.4	398.3	74,356.1	19

		Score/Value	Rank	
	INSTITUTIONS	**93.9**	**2**	● ◆
1.1	**Political environment**	**94.7**	**3**	● ◆
1.1.1	Political and operational stability*	94.7	4	●
1.1.2	Government effectiveness*	94.6	3	● ◆
1.2	**Regulatory environment**	**97.1**	**4**	●
1.2.1	Regulatory quality*	90.6	9	
1.2.2	Rule of law*	99.8	2	●
1.2.3	Cost of redundancy dismissal, salary weeks	8.7	21	
1.3	**Business environment**	**89.9**	**3**	●
1.3.1	Ease of starting a business*	94.3	19	
1.3.2	Ease of resolving insolvency*	85.4	5	●

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**53.9**	**15**	
2.1	**Education**	**70.1**	**3**	● ◆
2.1.1	Expenditure on education, % GDP	7.6	4	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	26.4	20	◆
2.1.3	School life expectancy, years	18.1	10	
2.1.4	PISA scales in reading, maths, & science	504.5	15	
2.1.5	Pupil-teacher ratio, secondary ◷	8.7	14	◆
2.2	**Tertiary education**	**35.8**	**50**	
2.2.1	Tertiary enrolment, % gross	82.0	16	
2.2.2	Graduates in science & engineering, %	20.5	61	○
2.2.3	Tertiary inbound mobility, %	3.9	55	
2.3	**Research & development (R&D)**	**55.8**	**19**	
2.3.1	Researchers, FTE/mn pop.	6,407.5	7	
2.3.2	Gross expenditure on R&D, % GDP	2.1	16	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	57.2	24	
2.3.4	QS university ranking, average score top 3*	42.9	26	

		Score/Value	Rank	
	INFRASTRUCTURE	**69.9**	**1**	● ◆
3.1	**Information & communication technologies(ICTs)**	**89.6**	**9**	
3.1.1	ICT access*	77.6	35	
3.1.2	ICT use*	88.1	5	● ◆
3.1.3	Government's online service*	95.1	9	
3.1.4	E-participation*	97.8	11	
3.2	**General infrastructure**	**68.5**	**1**	● ◆
3.2.1	Electricity output, kWh/mn pop.	28,078.2	1	● ◆
3.2.2	Logistics performance*	76.4	21	
3.2.3	Gross capital formation, % GDP	28.2	27	
3.3	**Ecological sustainability**	**51.5**	**24**	
3.3.1	GDP/unit of energy use	11.8	32	
3.3.2	Environmental performance*	77.5	14	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	3.5	29	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**58.6**	**22**	
4.1	**Credit**	**63.0**	**18**	
4.1.1	Ease of getting credit*	55.0	77	○
4.1.2	Domestic credit to private sector, % GDP	146.3	10	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**45.3**	**54**	
4.2.1	Ease of protecting minority investors*	75.0	14	
4.2.2	Market capitalization, % GDP	61.5	27	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	40	○ ◇
4.3	**Trade, competition, & market scale**	**67.4**	**44**	
4.3.1	Applied tariff rate, weighted avg., %	3.1	65	◇
4.3.2	Intensity of local competition†	69.3	65	○ ◇
4.3.3	Domestic market scale, bn PPP$	398.3	45	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**50.2**	**21**	
5.1	**Knowledge workers**	**69.4**	**10**	
5.1.1	Knowledge-intensive employment, %	52.5	4	●
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	1.1	20	
5.1.4	GERD financed by business, %	43.2	40	◇
5.1.5	Females employed w/advanced degrees, %	25.2	10	
5.2	**Innovation linkages**	**38.3**	**31**	
5.2.1	University/industry research collaboration†	61.7	22	
5.2.2	State of cluster development†	64.6	18	
5.2.3	GERD financed by abroad, %	9.5	45	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.1	22	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	1.7	24	◇
5.3	**Knowledge absorption**	**42.7**	**33**	
5.3.1	Intellectual property payments, % total trade	0.4	69	○ ◇
5.3.2	High-tech imports, % total trade	6.6	80	○
5.3.3	ICT services imports, % total trade	2.8	10	
5.3.4	FDI net inflows, % GDP	-0.9	125	○
5.3.5	Research talent, % in business enterprise	48.1	26	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**33.7**	**30**	◇
6.1	**Knowledge creation**	**38.0**	**22**	
6.1.1	Patents by origin/bn PPP$ GDP	4.4	26	
6.1.2	PCT patents by origin/bn PPP$ GDP	1.9	18	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	19.3	26	
6.1.5	Citable documents H-index	39.3	20	
6.2	**Knowledge impact**	**41.0**	**45**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.6	71	○
6.2.2	New businesses/th pop. 15-64	8.2	18	
6.2.3	Computer software spending, % GDP	0.6	16	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	6.5	48	
6.2.5	High- & medium-high-tech manufactures, %	0.2	58	○ ◇
6.3	**Knowledge diffusion**	**22.1**	**43**	◇
6.3.1	Intellectual property receipts, % total trade	0.4	28	◇
6.3.2	High-tech net exports, % total trade	3.0	45	
6.3.3	ICT services exports, % total trade	1.7	63	
6.3.4	FDI net outflows, % GDP	2.8	26	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**43.2**	**20**	
7.1	**Intangible assets**	**48.0**	**45**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	33.9	72	○
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.5	57	
7.1.3	ICTs & business model creation†	73.2	24	
7.1.4	ICTs & organizational model creation†	77.4	10	
7.2	**Creative goods & services**	**28.5**	**33**	
7.2.1	Cultural & creative services exports, % total trade ◷	0.6	45	
7.2.2	National feature films/mn pop. 15-69	10.1	18	
7.2.3	Entertainment & Media market/th pop. 15-69	92.3	3	● ◆
7.2.4	Printing & other media, % manufacturing	1.2	52	
7.2.5	Creative goods exports, % total trade	0.5	60	
7.3	**Online creativity**	**48.4**	**13**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	50.7	15	
7.3.2	Country-code TLDs/th pop. 15-69	56.5	12	
7.3.3	Wikipedia edits/mn pop. 15-69	104.3	5	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	16.0	30	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

OMAN

GII 2019 rank

80

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
101	57	High	NAWA	4.8	198.2	46,584.0	69

		Score/Value	Rank	
	INSTITUTIONS	**61.5**	**69**	◇
1.1	**Political environment**	**61.3**	**49**	◇
1.1.1	Political and operational stability*	80.7	35	
1.1.2	Government effectiveness*	51.6	57	◇
1.2	**Regulatory environment**	**55.5**	**97**	◇
1.2.1	Regulatory quality*	53.2	50	◇
1.2.2	Rule of law*	57.8	45	◇
1.2.3	Cost of redundancy dismissal, salary weeks	n/a	n/a	
1.3	**Business environment**	**67.6**	**72**	◇
1.3.1	Ease of starting a business*	92.9	34	●
1.3.2	Ease of resolving insolvency*	42.3	88	◇

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**43.3**	**35**	
2.1	**Education**	**64.4**	**10**	●
2.1.1	Expenditure on education, % GDP	6.7	12	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	34.9	9	● ◆
2.1.3	School life expectancy, years	14.7	58	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	10.0	29	●
2.2	**Tertiary education**	**61.4**	**4**	● ◆
2.2.1	Tertiary enrolment, % gross ⊙	44.6	66	◇
2.2.2	Graduates in science & engineering, %	44.8	1	● ◆
2.2.3	Tertiary inbound mobility, %	2.9	63	
2.3	**Research & development (R&D)**	**4.0**	**82**	◇
2.3.1	Researchers, FTE/mn pop.	244.0	75	◇
2.3.2	Gross expenditure on R&D, % GDP	0.2	88	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	8.6	65	◇

		Score/Value	Rank	
	INFRASTRUCTURE	**51.3**	**48**	
3.1	**Information & communication technologies(ICTs)**	**75.8**	**42**	
3.1.1	ICT access*	76.6	38	
3.1.2	ICT use*	62.2	52	◇
3.1.3	Government's online service*	81.3	43	
3.1.4	E-participation*	83.2	43	
3.2	**General infrastructure**	**48.0**	**24**	●
3.2.1	Electricity output, kWh/mn pop.	7,722.3	25	●
3.2.2	Logistics performance*	53.0	42	
3.2.3	Gross capital formation, % GDP	31.5	16	● ◆
3.3	**Ecological sustainability**	**30.0**	**95**	◇
3.3.1	GDP/unit of energy use	7.0	84	
3.3.2	Environmental performance*	51.3	94	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.2	62	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**45.5**	**78**	◇
4.1	**Credit**	**35.0**	**67**	◇
4.1.1	Ease of getting credit*	35.0	110	○ ◇
4.1.2	Domestic credit to private sector, % GDP ⊙	75.0	42	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**36.6**	**94**	
4.2.1	Ease of protecting minority investors*	46.7	101	◇
4.2.2	Market capitalization, % GDP	41.3	35	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**65.0**	**53**	
4.3.1	Applied tariff rate, weighted avg., %	1.7	21	●
4.3.2	Intensity of local competition†	66.2	76	
4.3.3	Domestic market scale, bn PPP$	198.2	62	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**23.8**	**107**	◇
5.1	**Knowledge workers**	**28.7**	**[86]**	
5.1.1	Knowledge-intensive employment, % ⊙	18.5	77	◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.1	64	◇
5.1.4	GERD financed by business, %	38.5	49	
5.1.5	Females employed w/advanced degrees, %	n/a	n/a	
5.2	**Innovation linkages**	**24.9**	**67**	
5.2.1	University/industry research collaboration†	51.0	38	
5.2.2	State of cluster development†	60.5	24	●
5.2.3	GERD financed by abroad, %	0.1	99	○ ◇
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	27	●
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	86	
5.3	**Knowledge absorption**	**18.0**	**126**	○ ◇
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade	4.9	108	
5.3.3	ICT services imports, % total trade	0.3	114	○ ◇
5.3.4	FDI net inflows, % GDP	1.4	98	
5.3.5	Research talent, % in business enterprise	0.8	79	○ ◇

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**12.3**	**112**	○ ◇
6.1	**Knowledge creation**	**4.2**	**104**	◇
6.1.1	Patents by origin/bn PPP$ GDP	0.0	120	○
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	70	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	2.9	105	◇
6.1.5	Citable documents H-index	6.1	88	◇
6.2	**Knowledge impact**	**20.1**	**112**	○ ◇
6.2.1	Growth rate of PPP$ GDP/worker, %	-3.8	110	○ ◇
6.2.2	New businesses/th pop. 15-64	2.1	48	
6.2.3	Computer software spending, % GDP	0.1	101	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.5	71	
6.2.5	High- & medium-high-tech manufactures, %	0.2	61	
6.3	**Knowledge diffusion**	**12.6**	**89**	◇
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.1	109	○ ◇
6.3.3	ICT services exports, % total trade	0.3	108	
6.3.4	FDI net outflows, % GDP	1.5	41	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**21.5**	**88**	◇
7.1	**Intangible assets**	**38.8**	**74**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	59.5	36	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.1	109	○ ◇
7.1.3	ICTs & business model creation†	59.2	70	◇
7.1.4	ICTs & organizational model creation†	52.5	71	◇
7.2	**Creative goods & services**	**6.2**	**97**	◇
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15-69	1.1	79	◇
7.2.3	Entertainment & Media market/th pop. 15-69	5.4	48	◇
7.2.4	Printing & other media, % manufacturing	0.6	89	○
7.2.5	Creative goods exports, % total trade	0.5	58	
7.3	**Online creativity**	**1.9**	**85**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.7	84	◇
7.3.2	Country-code TLDs/th pop. 15-69	0.2	106	◇
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	5.7	77	◇
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

PAKISTAN

GII 2019 rank

105

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
89	**113**	**Lower middle**	**CSA**	**200.8**	**1,148.3**	**5,679.8**	**109**

		Score/Value	Rank	
	INSTITUTIONS	**53.1**	**100**	
1.1	**Political environment**	**39.7**	**107**	
1.1.1	Political and operational stability*	54.4	111	
1.1.2	Government effectiveness*	32.4	101	
1.2	**Regulatory environment**	**48.7**	**113**	
1.2.1	Regulatory quality*	26.0	107	
1.2.2	Rule of law*	27.2	109	
1.2.3	Cost of redundancy dismissal, salary weeks	27.2	105	
1.3	**Business environment**	**70.9**	**62**	
1.3.1	Ease of starting a business*	81.9	100	
1.3.2	Ease of resolving insolvency*	59.9	48	● ◆
	HUMAN CAPITAL & RESEARCH	**12.5**	**116**	
2.1	**Education**	**21.6**	**122**	○ ◇
2.1.1	Expenditure on education, % GDP	2.8	110	○
2.1.2	Government funding/pupil, secondary, % GDP/cap	10.9	92	
2.1.3	School life expectancy, years	8.5	114	○ ◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	19.4	86	
2.2	**Tertiary education**	**7.4**	**[115]**	◇
2.2.1	Tertiary enrolment, % gross	10.1	108	◇
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**8.6**	**62**	
2.3.1	Researchers, FTE/mn pop.	293.6	73	
2.3.2	Gross expenditure on R&D, % GDP	0.2	84	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	25.7	41	● ◆
	INFRASTRUCTURE	**27.3**	**120**	○ ◇
3.1	**Information & communication technologies(ICTs)**	**38.5**	**109**	
3.1.1	ICT access*	35.1	111	◇
3.1.2	ICT use*	13.9	118	○ ◇
3.1.3	Government's online service*	54.9	100	
3.1.4	E-participation*	50.0	104	
3.2	**General infrastructure**	**16.2**	**123**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	590.1	104	
3.2.2	Logistics performance*	16.6	110	◇
3.2.3	Gross capital formation, % GDP	16.4	113	◇
3.3	**Ecological sustainability**	**27.4**	**108**	
3.3.1	GDP/unit of energy use	9.6	60	
3.3.2	Environmental performance*	37.5	121	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	97	
	MARKET SOPHISTICATION	**39.6**	**102**	
4.1	**Credit**	**20.1**	**118**	◇
4.1.1	Ease of getting credit*	45.0	94	
4.1.2	Domestic credit to private sector, % GDP	17.0	112	◇
4.1.3	Microfinance gross loans, % GDP	0.6	28	●
4.2	**Investment**	**38.8**	**83**	
4.2.1	Ease of protecting minority investors*	71.7	24	● ◆
4.2.2	Market capitalization, % GDP	29.2	50	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	72	○
4.3	**Trade, competition, & market scale**	**60.0**	**68**	
4.3.1	Applied tariff rate, weighted avg., %	10.1	113	◇
4.3.2	Intensity of local competition†	57.7	115	◇
4.3.3	Domestic market scale, bn PPP$	1,148.3	24	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**25.5**	**96**	
5.1	**Knowledge workers**	**23.6**	**[100]**	
5.1.1	Knowledge-intensive employment, %	11.6	96	
5.1.2	Firms offering formal training, % firms	32.0	47	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	1.6	104	
5.2	**Innovation linkages**	**20.4**	**83**	
5.2.1	University/industry research collaboration†	44.5	52	
5.2.2	State of cluster development†	49.2	52	
5.2.3	GERD financed by abroad, %	2.7	72	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	59	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	90	
5.3	**Knowledge absorption**	**32.5**	**68**	
5.3.1	Intellectual property payments, % total trade	0.5	63	
5.3.2	High-tech imports, % total trade	10.6	24	●
5.3.3	ICT services imports, % total trade	0.9	73	
5.3.4	FDI net inflows, % GDP	0.8	110	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**20.6**	**70**	
6.1	**Knowledge creation**	**13.3**	**[59]**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	101	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	8.5	56	
6.1.5	Citable documents H-index	14.4	50	●
6.2	**Knowledge impact**	**36.1**	**68**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.9	27	●
6.2.2	New businesses/th pop. 15–64	0.1	104	○
6.2.3	Computer software spending, % GDP	0.3	52	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.7	91	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**12.3**	**91**	
6.3.1	Intellectual property receipts, % total trade	0.0	75	
6.3.2	High-tech net exports, % total trade	0.8	73	
6.3.3	ICT services exports, % total trade	2.2	49	●
6.3.4	FDI net outflows, % GDP	0.0	109	
	CREATIVE OUTPUTS	**17.6**	**104**	
7.1	**Intangible assets**	**33.5**	**98**	
7.1.1	Trademarks by origin/bn PPP$ GDP	28.9	77	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.4	91	
7.1.3	ICTs & business model creation†	53.8	89	
7.1.4	ICTs & organizational model creation†	51.6	75	
7.2	**Creative goods & services**	**2.0**	**116**	
7.2.1	Cultural & creative services exports, % total trade	0.1	77	
7.2.2	National feature films/mn pop. 15–69	0.1	106	○
7.2.3	Entertainment & Media market/th pop. 15–69	0.4	62	○ ◇
7.2.4	Printing & other media, % manufacturing	0.3	100	○
7.2.5	Creative goods exports, % total trade	0.3	72	
7.3	**Online creativity**	**1.5**	**96**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.6	105	
7.3.2	Country-code TLDs/th pop. 15–69	0.2	109	
7.3.3	Wikipedia edits/mn pop. 15–69	1.6	101	
7.3.4	Mobile app creation/bn PPP$ GDP	4.2	55	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

PANAMA

GII 2019 rank

75

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
72	**79**	**High**	**LCN**	**4.2**	**111.4**	**25,674.5**	**70**

		Score/Value	Rank	
	INSTITUTIONS	**62.9**	**65**	◇
1.1	**Political environment**	**55.7**	**65**	◇
1.1.1	Political and operational stability*	73.7	50	◇
1.1.2	Government effectiveness*	46.7	70	◇
1.2	**Regulatory environment**	**67.2**	**65**	◇
1.2.1	Regulatory quality*	52.3	54	◇
1.2.2	Rule of law*	47.4	62	◇
1.2.3	Cost of redundancy dismissal, salary weeks	18.1	75	
1.3	**Business environment**	**65.8**	**78**	◇
1.3.1	Ease of starting a business*	92.1	43	
1.3.2	Ease of resolving insolvency*	39.6	99	◇
	HUMAN CAPITAL & RESEARCH	**20.2**	**95**	◇
2.1	**Education**	**31.7**	**106**	◇
2.1.1	Expenditure on education, % GDP ⊙	3.2	98	◇
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	9.2	99	○ ◇
2.1.3	School life expectancy, years ⊙	12.7	84	◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	14.5	66	◇
2.2	**Tertiary education**	**27.6**	**73**	◇
2.2.1	Tertiary enrolment, % gross ⊙	47.3	63	◇
2.2.2	Graduates in science & engineering, % ⊙	17.2	77	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**1.2**	**104**	◇
2.3.1	Researchers, FTE/mn pop. ⊙	39.1	95	◇
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.1	111	○ ◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	3.4	74	◇
	INFRASTRUCTURE	**57.2**	**30**	●
3.1	**Information & communication technologies(ICTs)**	**61.7**	**76**	◇
3.1.1	ICT access*	63.5	71	◇
3.1.2	ICT use*	45.6	76	◇
3.1.3	Government's online service*	66.0	79	◇
3.1.4	E-participation*	71.9	64	◇
3.2	**General infrastructure**	**57.6**	**5**	● ◆
3.2.1	Electricity output, kWh/mn pop.	2,701.2	68	◇
3.2.2	Logistics performance*	56.7	37	●
3.2.3	Gross capital formation, % GDP	43.5	5	● ◆
3.3	**Ecological sustainability**	**52.3**	**20**	●
3.3.1	GDP/unit of energy use	18.9	7	● ◆
3.3.2	Environmental performance*	62.7	50	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	104	◇
	MARKET SOPHISTICATION	**45.9**	**73**	
4.1	**Credit**	**42.3**	**49**	
4.1.1	Ease of getting credit*	80.0	20	● ◆
4.1.2	Domestic credit to private sector, % GDP	87.1	31	●
4.1.3	Microfinance gross loans, % GDP	0.3	38	
4.2	**Investment**	**37.3**	**88**	
4.2.1	Ease of protecting minority investors*	51.7	89	◇
4.2.2	Market capitalization, % GDP	24.0	54	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**58.0**	**75**	◇
4.3.1	Applied tariff rate, weighted avg., % ⊙	5.4	90	◇
4.3.2	Intensity of local competition†	70.7	53	
4.3.3	Domestic market scale, bn PPP$	111.4	74	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**19.1**	**123**	○ ◇
5.1	**Knowledge workers**	**21.7**	**104**	◇
5.1.1	Knowledge-intensive employment, %	24.7	57	◇
5.1.2	Firms offering formal training, % firms ⊙	11.0	87	○ ◇
5.1.3	GERD performed by business, % GDP ⊙	0.0	90	○ ◇
5.1.4	GERD financed by business, % ⊙	10.8	74	◇
5.1.5	Females employed w/advanced degrees, %	10.5	62	◇
5.2	**Innovation linkages**	**18.3**	**103**	◇
5.2.1	University/industry research collaboration†	35.5	91	◇
5.2.2	State of cluster development†	46.6	65	
5.2.3	GERD financed by abroad, % ⊙	0.3	97	○ ◇
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	47	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	66	
5.3	**Knowledge absorption**	**17.4**	**128**	○ ◇
5.3.1	Intellectual property payments, % total trade	0.2	89	◇
5.3.2	High-tech imports, % total trade ⊙	2.9	123	○ ◇
5.3.3	ICT services imports, % total trade	0.3	113	◇
5.3.4	FDI net inflows, % GDP	8.9	14	●
5.3.5	Research talent, % in business enterprise ⊙	0.9	78	◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**10.6**	**117**	◇
6.1	**Knowledge creation**	**8.5**	**76**	◇
6.1.1	Patents by origin/bn PPP$ GDP	0.3	85	
6.1.2	PCT patents by origin/bn PPP$ GDP	1.7	21	●
6.1.3	Utility models by origin/bn PPP$ GDP	0.0	64	○ ◇
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.1	100	◇
6.1.5	Citable documents H-index	10.9	59	
6.2	**Knowledge impact**	**7.0**	**118**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15-64	0.8	75	
6.2.3	Computer software spending, % GDP	0.2	70	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.9	88	◇
6.2.5	High- & medium-high-tech manufactures, %	0.0	93	◇
6.3	**Knowledge diffusion**	**16.3**	**72**	
6.3.1	Intellectual property receipts, % total trade	0.0	81	
6.3.2	High-tech net exports, % total trade ⊙	3.6	40	
6.3.3	ICT services exports, % total trade	1.1	79	
6.3.4	FDI net outflows, % GDP	1.3	46	
	CREATIVE OUTPUTS	**33.3**	**43**	
7.1	**Intangible assets**	**40.3**	**67**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	41.4	63	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.0	118	○ ◇
7.1.3	ICTs & business model creation†	67.5	38	
7.1.4	ICTs & organizational model creation†	57.4	55	
7.2	**Creative goods & services**	**32.2**	**21**	●
7.2.1	Cultural & creative services exports, % total trade	0.5	48	
7.2.2	National feature films/mn pop. 15-69 ⊙	0.4	98	○ ◇
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	3.0	7	● ◆
7.2.5	Creative goods exports, % total trade ⊙	2.5	23	●
7.3	**Online creativity**	**20.2**	**33**	●
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	66.4	9	● ◆
7.3.2	Country-code TLDs/th pop. 15-69	1.1	80	◇
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	14.6	59	◇
7.3.4	Mobile app creation/bn PPP$ GDP	3.5	56	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

PARAGUAY

GII 2019 rank

95

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
94	95	Upper middle	LCN	6.9	95.0	13,395.3	89

		Score/Value	Rank	
	INSTITUTIONS	**49.4**	**113**	◇
1.1	**Political environment**	**39.0**	**108**	◇
1.1.1	Political and operational stability*	63.2	86	
1.1.2	Government effectiveness*	26.8	117	◇
1.2	**Regulatory environment**	**49.9**	**111**	◇
1.2.1	Regulatory quality*	35.7	87	
1.2.2	Rule of law*	29.2	101	
1.2.3	Cost of redundancy dismissal, salary weeks	29.4	114	
1.3	**Business environment**	**59.4**	**107**	
1.3.1	Ease of starting a business*	77.5	113	
1.3.2	Ease of resolving insolvency*	41.3	91	
	HUMAN CAPITAL & RESEARCH	**22.0**	**89**	
2.1	**Education**	**37.7**	**89**	
2.1.1	Expenditure on education, % GDP	4.5	61	●
2.1.2	Government funding/pupil, secondary, % GDP/cap	15.5	80	
2.1.3	School life expectancy, years ⊕	12.3	88	◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊕	18.4	80	
2.2	**Tertiary education**	**27.3**	**[75]**	
2.2.1	Tertiary enrolment, % gross ⊕	35.1	76	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**1.1**	**105**	
2.3.1	Researchers, FTE/mn pop. ⊕	122.1	84	
2.3.2	Gross expenditure on R&D, % GDP ⊕	0.2	95	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**38.4**	**90**	
3.1	**Information & communication technologies(ICTs)**	**49.2**	**97**	◇
3.1.1	ICT access*	43.5	100	◇
3.1.2	ICT use*	40.3	87	◇
3.1.3	Government's online service*	55.6	98	
3.1.4	E-participation*	57.3	95	
3.2	**General infrastructure**	**31.6**	**80**	
3.2.1	Electricity output, kWh/mn pop.	9,475.6	16	● ◆
3.2.2	Logistics performance*	33.6	73	
3.2.3	Gross capital formation, % GDP	19.4	97	
3.3	**Ecological sustainability**	**34.4**	**81**	
3.3.1	GDP/unit of energy use	9.9	54	●
3.3.2	Environmental performance*	53.9	86	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	100	
	MARKET SOPHISTICATION	**43.2**	**91**	
4.1	**Credit**	**31.3**	**85**	
4.1.1	Ease of getting credit*	40.0	104	◇
4.1.2	Domestic credit to private sector, % GDP	40.0	82	
4.1.3	Microfinance gross loans, % GDP	2.1	12	● ◆
4.2	**Investment**	**41.7**	**[65]**	
4.2.1	Ease of protecting minority investors*	41.7	108	◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**56.7**	**83**	
4.3.1	Applied tariff rate, weighted avg., %	4.8	83	
4.3.2	Intensity of local competition†	65.6	78	
4.3.3	Domestic market scale, bn PPP$	95.0	80	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.6**	**87**	
5.1	**Knowledge workers**	**29.0**	**84**	
5.1.1	Knowledge-intensive employment, %	17.7	83	
5.1.2	Firms offering formal training, % firms	46.4	26	●
5.1.3	GERD performed by business, % GDP ⊕	0.0	92	○
5.1.4	GERD financed by business, %	0.4	94	○ ◇
5.1.5	Females employed w/advanced degrees, %	9.6	68	
5.2	**Innovation linkages**	**18.5**	**98**	
5.2.1	University/industry research collaboration†	26.4	121	○ ◇
5.2.2	State of cluster development†	34.3	111	◇
5.2.3	GERD financed by abroad, %	13.0	33	●
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	91	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**32.3**	**69**	
5.3.1	Intellectual property payments, % total trade	0.2	93	
5.3.2	High-tech imports, % total trade	16.7	11	● ◆
5.3.3	ICT services imports, % total trade	0.0	128	○ ◇
5.3.4	FDI net inflows, % GDP	1.3	100	◇
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**6.4**	**123**	◇
6.1	**Knowledge creation**	**2.2**	**[120]**	
6.1.1	Patents by origin/bn PPP$ GDP ⊕	0.3	86	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	0.6	124	○ ◇
6.1.5	Citable documents H-index	3.1	112	
6.2	**Knowledge impact**	**7.5**	**117**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64	0.1	97	
6.2.3	Computer software spending, % GDP	0.0	104	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.6	68	
6.2.5	High- & medium-high-tech manufactures, % ⊕	0.1	67	
6.3	**Knowledge diffusion**	**9.4**	**105**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.5	80	
6.3.3	ICT services exports, % total trade	0.1	124	○
6.3.4	FDI net outflows, % GDP	0.3	84	
	CREATIVE OUTPUTS	**30.1**	**52**	●
7.1	**Intangible assets**	**55.0**	**21**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP ⊕	220.4	3	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊕	2.0	50	●
7.1.3	ICTs & business model creation†	52.8	94	
7.1.4	ICTs & organizational model creation†	41.8	109	◇
7.2	**Creative goods & services**	**9.1**	**89**	
7.2.1	Cultural & creative services exports, % total trade	0.0	116	○
7.2.2	National feature films/mn pop. 15–69 ⊕	1.3	75	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊕	1.3	37	●
7.2.5	Creative goods exports, % total trade	0.0	114	
7.3	**Online creativity**	**1.5**	**97**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.7	85	
7.3.2	Country-code TLDs/th pop. 15–69	1.3	74	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊕	4.2	86	
7.3.4	Mobile app creation/bn PPP$ GDP	0.0	91	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

PERU

GII 2019 rank

69

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
86	**48**	**Upper middle**	**LCN**	**32.6**	**458.4**	**14,224.3**	**71**

		Score/Value	Rank	
	INSTITUTIONS	**61.2**	**70**	
1.1	**Political environment**	**50.6**	**80**	
1.1.1	Political and operational stability*	64.9	79	
1.1.2	Government effectiveness*	43.4	79	
1.2	**Regulatory environment**	**69.0**	**57**	
1.2.1	Regulatory quality*	53.2	52	
1.2.2	Rule of law*	33.1	94	
1.2.3	Cost of redundancy dismissal, salary weeks	11.4	36	●
1.3	**Business environment**	**64.1**	**84**	
1.3.1	Ease of starting a business*	82.4	96	
1.3.2	Ease of resolving insolvency*	45.7	79	
	HUMAN CAPITAL & RESEARCH	**30.4**	**66**	
2.1	**Education**	**39.7**	**86**	
2.1.1	Expenditure on education, % GDP	3.9	81	
2.1.2	Government funding/pupil, secondary, % GDP/cap	15.3	82	
2.1.3	School life expectancy, years	14.6	60	
2.1.4	PISA scales in reading, maths, & science	393.6	65	○
2.1.5	Pupil-teacher ratio, secondary	14.2	63	
2.2	**Tertiary education**	**45.8**	**21**	● ◆
2.2.1	Tertiary enrolment, % gross ⊕	69.6	28	● ◆
2.2.2	Graduates in science & engineering, %	23.8	36	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**5.7**	**73**	
2.3.1	Researchers, FTE/mn pop	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	0.1	101	○
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	14.8	56	
	INFRASTRUCTURE	**46.7**	**65**	
3.1	**Information & communication technologies(ICTs)**	**65.2**	**70**	
3.1.1	ICT access*	50.8	87	◇
3.1.2	ICT use*	41.6	86	
3.1.3	Government's online service*	81.9	41	
3.1.4	E-participation*	86.5	36	●
3.2	**General infrastructure**	**26.7**	**92**	
3.2.1	Electricity output, kWh/mn pop	1,634.3	86	
3.2.2	Logistics performance*	29.5	81	
3.2.3	Gross capital formation, % GDP	22.3	72	
3.3	**Ecological sustainability**	**48.1**	**39**	● ◆
3.3.1	GDP/unit of energy use	15.6	10	● ◆
3.3.2	Environmental performance*	61.9	57	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.2	63	
	MARKET SOPHISTICATION	**57.6**	**26**	● ◆
4.1	**Credit**	**64.5**	**17**	● ◆
4.1.1	Ease of getting credit*	75.0	29	●
4.1.2	Domestic credit to private sector, % GDP	42.3	79	
4.1.3	Microfinance gross loans, % GDP	5.8	1	● ◆
4.2	**Investment**	**36.2**	**97**	
4.2.1	Ease of protecting minority investors*	63.3	48	
4.2.2	Market capitalization, % GDP	39.7	37	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	54	
4.3	**Trade, competition, & market scale**	**72.1**	**30**	●
4.3.1	Applied tariff rate, weighted avg., %	0.8	6	●
4.3.2	Intensity of local competition†	72.5	42	
4.3.3	Domestic market scale, bn PPP$	458.4	44	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**36.6**	**43**	
5.1	**Knowledge workers**	**56.8**	**[27]**	
5.1.1	Knowledge-intensive employment, %	24.4	59	
5.1.2	Firms offering formal training, % firms ⊕	60.1	8	● ◆
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	16.3	38	●
5.2	**Innovation linkages**	**18.8**	**94**	
5.2.1	University/industry research collaboration†	31.9	100	○
5.2.2	State of cluster development†	39.5	94	
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	104	○ ◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	72	
5.3	**Knowledge absorption**	**34.2**	**62**	
5.3.1	Intellectual property payments, % total trade	0.7	57	
5.3.2	High-tech imports, % total trade	8.4	52	
5.3.3	ICT services imports, % total trade	1.2	59	
5.3.4	FDI net inflows, % GDP	3.7	45	
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**15.3**	**97**	
6.1	**Knowledge creation**	**7.1**	**82**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	93	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	68	
6.1.3	Utility models by origin/bn PPP$ GDP	0.6	33	
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.6	117	○
6.1.5	Citable documents H-index	12.6	56	
6.2	**Knowledge impact**	**31.6**	**88**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.3	55	
6.2.2	New businesses/th pop. 15-64	3.6	35	
6.2.3	Computer software spending, % GDP	0.2	67	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.2	75	
6.2.5	High- & medium-high-tech manufactures, %	0.1	75	
6.3	**Knowledge diffusion**	**7.3**	**119**	○ ◇
6.3.1	Intellectual property receipts, % total trade	0.0	74	
6.3.2	High-tech net exports, % total trade	0.4	83	
6.3.3	ICT services exports, % total trade	0.3	112	○
6.3.4	FDI net outflows, % GDP	0.1	98	○
	CREATIVE OUTPUTS	**23.4**	**79**	
7.1	**Intangible assets**	**36.7**	**87**	
7.1.1	Trademarks by origin/bn PPP$ GDP	50.0	48	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.2	100	○
7.1.3	ICTs & business model creation†	59.3	69	
7.1.4	ICTs & organizational model creation†	48.6	85	
7.2	**Creative goods & services**	**17.5**	**61**	
7.2.1	Cultural & creative services exports, % total trade	0.1	84	
7.2.2	National feature films/mn pop. 15-69	1.1	80	
7.2.3	Entertainment & Media market/th pop. 15-69	7.4	41	
7.2.4	Printing & other media, % manufacturing	2.5	10	● ◆
7.2.5	Creative goods exports, % total trade	0.3	70	
7.3	**Online creativity**	**2.6**	**80**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	5.2	53	
7.3.2	Country-code TLDs/th pop. 15-69	1.3	73	
7.3.3	Wikipedia edits/mn pop. 15-69	5.8	76	
7.3.4	Mobile app creation/bn PPP$ GDP	0.1	84	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

PHILIPPINES

GII 2019 rank

54

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
42	76	Lower middle	SEAO	106.5	956.0	8,935.9	73

		Score/Value	Rank	
	INSTITUTIONS	**56.0**	**89**	
1.1	**Political environment**	**49.9**	**84**	
1.1.1	Political and operational stability*	59.6	98	
1.1.2	Government effectiveness*	45.0	73	
1.2	**Regulatory environment**	**54.6**	**99**	
1.2.1	Regulatory quality*	42.5	69	
1.2.2	Rule of law*	35.4	90	
1.2.3	Cost of redundancy dismissal, salary weeks	27.4	111	○
1.3	**Business environment**	**63.6**	**89**	
1.3.1	Ease of starting a business*	72.0	119	○ ◇
1.3.2	Ease of resolving insolvency*	55.2	58	◆
	HUMAN CAPITAL & RESEARCH	**24.6**	**83**	
2.1	**Education**	**33.3**	**[102]**	
2.1.1	Expenditure on education, % GDP ⊙	2.7	112	○
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years ⊙	12.7	83	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	23.5	96	
2.2	**Tertiary education**	**34.5**	**55**	
2.2.1	Tertiary enrolment, % gross	35.3	75	
2.2.2	Graduates in science & engineering, %	28.7	18	●
2.2.3	Tertiary inbound mobility, % ⊙	0.1	108	○
2.3	**Research & development (R&D)**	**6.2**	**72**	
2.3.1	Researchers, FTE/mn pop. ⊙	187.7	78	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.1	98	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	19.9	51	◆
	INFRASTRUCTURE	**48.5**	**58**	◆
3.1	**Information & communication technologies(ICTs)**	**68.5**	**60**	◆
3.1.1	ICT access*	47.5	94	
3.1.2	ICT use*	44.7	78	◆
3.1.3	Government's online service*	88.2	30	◆
3.1.4	E-participation*	93.8	19	● ◆
3.2	**General infrastructure**	**34.2**	**67**	
3.2.1	Electricity output, kWh/mn pop.	878.8	97	
3.2.2	Logistics performance*	39.3	59	
3.2.3	Gross capital formation, % GDP	27.5	31	
3.3	**Ecological sustainability**	**42.8**	**48**	◆
3.3.1	GDP/unit of energy use	13.3	19	◆
3.3.2	Environmental performance*	57.7	71	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.2	61	◆
	MARKET SOPHISTICATION	**38.3**	**110**	
4.1	**Credit**	**8.8**	**126**	○ ◇
4.1.1	Ease of getting credit*	5.0	128	○ ◇
4.1.2	Domestic credit to private sector, % GDP	47.8	72	
4.1.3	Microfinance gross loans, % GDP	0.0	76	○
4.2	**Investment**	**30.9**	**118**	○
4.2.1	Ease of protecting minority investors*	43.3	105	◇
4.2.2	Market capitalization, % GDP	84.3	18	◆
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	68	○
4.3	**Trade, competition, & market scale**	**75.2**	**20**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	1.7	18	● ◆
4.3.2	Intensity of local competition†	75.0	27	◆
4.3.3	Domestic market scale, bn PPP$	956.0	27	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**40.9**	**32**	◆
5.1	**Knowledge workers**	**46.1**	**44**	◆
5.1.1	Knowledge-intensive employment, %	25.2	55	
5.1.2	Firms offering formal training, % firms	59.8	9	● ◆
5.1.3	GERD performed by business, % GDP ⊙	0.0	72	
5.1.4	GERD financed by business, % ⊙	36.9	50	
5.1.5	Females employed w/advanced degrees, % ⊙	12.4	57	
5.2	**Innovation linkages**	**22.6**	**71**	
5.2.1	University/industry research collaboration†	57.5	25	◆
5.2.2	State of cluster development†	50.0	48	
5.2.3	GERD financed by abroad, % ⊙	1.8	80	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	43	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	76	
5.3	**Knowledge absorption**	**54.1**	**14**	● ◆
5.3.1	Intellectual property payments, % total trade	0.7	55	
5.3.2	High-tech imports, % total trade	23.2	5	● ◆
5.3.3	ICT services imports, % total trade	0.8	83	
5.3.4	FDI net inflows, % GDP	2.6	65	
5.3.5	Research talent, % in business enterprise ⊙	63.2	6	● ◆
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**33.7**	**31**	◆
6.1	**Knowledge creation**	**11.5**	**64**	
6.1.1	Patents by origin/bn PPP$ GDP	0.4	82	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	90	
6.1.3	Utility models by origin/bn PPP$ GDP	1.6	15	
6.1.4	Scientific & technical articles/bn PPP$ GDP	0.9	123	○
6.1.5	Citable documents H-index	13.4	54	
6.2	**Knowledge impact**	**43.2**	**38**	
6.2.1	Growth rate of PPP$ GDP/worker, %	4.9	10	● ◆
6.2.2	New businesses/th pop. 15-64	0.3	91	○
6.2.3	Computer software spending, % GDP	0.3	55	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	4.4	61	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.4	25	◆
6.3	**Knowledge diffusion**	**46.5**	**14**	● ◆
6.3.1	Intellectual property receipts, % total trade	0.0	87	
6.3.2	High-tech net exports, % total trade	32.7	1	● ◆
6.3.3	ICT services exports, % total trade	5.5	8	● ◆
6.3.4	FDI net outflows, % GDP	1.3	48	◆
	CREATIVE OUTPUTS	**27.7**	**63**	
7.1	**Intangible assets**	**41.3**	**63**	
7.1.1	Trademarks by origin/bn PPP$ GDP	30.7	75	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.9	71	
7.1.3	ICTs & business model creation†	68.9	32	◆
7.1.4	ICTs & organizational model creation†	61.7	39	◆
7.2	**Creative goods & services**	**26.6**	**40**	◆
7.2.1	Cultural & creative services exports, % total trade	0.1	92	
7.2.2	National feature films/mn pop. 15-69 ⊙	0.8	86	
7.2.3	Entertainment & Media market/th pop. 15-69	2.6	50	◆
7.2.4	Printing & other media, % manufacturing ⊙	0.6	87	
7.2.5	Creative goods exports, % total trade	7.0	8	● ◆
7.3	**Online creativity**	**1.4**	**99**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.1	92	
7.3.2	Country-code TLDs/th pop. 15-69	0.3	101	
7.3.3	Wikipedia edits/mn pop. 15-69	3.8	89	
7.3.4	Mobile app creation/bn PPP$ GDP	1.4	63	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

POLAND

GII 2019 rank

39

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
41	37	High	EUR	38.1	1,201.9	31,938.7	39

		Score/Value	Rank	
	INSTITUTIONS	**73.6**	**37**	
1.1	**Political environment**	**68.2**	**39**	
1.1.1	Political and operational stability*	80.7	35	
1.1.2	Government effectiveness*	61.9	40	
1.2	**Regulatory environment**	**72.9**	**42**	
1.2.1	Regulatory quality*	65.6	36	
1.2.2	Rule of law*	58.9	42	
1.2.3	Cost of redundancy dismissal, salary weeks	18.8	77	○
1.3	**Business environment**	**79.7**	**34**	
1.3.1	Ease of starting a business*	82.9	93	○ ◇
1.3.2	Ease of resolving insolvency*	76.5	23	●
	HUMAN CAPITAL & RESEARCH	**41.2**	**40**	
2.1	**Education**	**57.0**	**39**	
2.1.1	Expenditure on education, % GDP	4.8	54	
2.1.2	Government funding/pupil, secondary, % GDP/cap	22.1	41	
2.1.3	School life expectancy, years	16.4	23	●
2.1.4	PISA scales in reading, maths, & science	503.9	17	
2.1.5	Pupil-teacher ratio, secondary	9.2	19	●
2.2	**Tertiary education**	**35.5**	**52**	
2.2.1	Tertiary enrolment, % gross	66.6	34	
2.2.2	Graduates in science & engineering, %	22.9	44	
2.2.3	Tertiary inbound mobility, %	3.4	59	
2.3	**Research & development (R&D)**	**31.0**	**37**	
2.3.1	Researchers, FTE/mn pop.	3,001.9	30	
2.3.2	Gross expenditure on R&D, % GDP	1.0	35	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	39.9	42	
2.3.4	QS university ranking, average score top 3*	25.4	42	
	INFRASTRUCTURE	**53.8**	**38**	
3.1	**Information & communication technologies(ICTs)**	**81.5**	**28**	
3.1.1	ICT access*	74.0	50	◇
3.1.2	ICT use*	69.8	35	
3.1.3	Government's online service*	93.1	17	●
3.1.4	E-participation*	89.3	31	
3.2	**General infrastructure**	**38.2**	**49**	
3.2.1	Electricity output, kWh/mn pop.	4,421.3	50	
3.2.2	Logistics performance*	69.0	27	
3.2.3	Gross capital formation, % GDP	21.5	81	○
3.3	**Ecological sustainability**	**41.5**	**50**	
3.3.1	GDP/unit of energy use	9.7	57	
3.3.2	Environmental performance*	64.1	46	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.6	39	
	MARKET SOPHISTICATION	**47.9**	**65**	
4.1	**Credit**	**33.5**	**75**	○ ◇
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP	52.5	63	
4.1.3	Microfinance gross loans, % GDP	0.1	54	○
4.2	**Investment**	**35.3**	**98**	○
4.2.1	Ease of protecting minority investors*	61.7	54	
4.2.2	Market capitalization, % GDP	32.2	45	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	41	
4.3	**Trade, competition, & market scale**	**75.0**	**21**	●
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	70.2	58	
4.3.3	Domestic market scale, bn PPP$	1,201.9	22	●

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**38.4**	**38**	
5.1	**Knowledge workers**	**52.3**	**32**	
5.1.1	Knowledge-intensive employment, %	38.6	30	
5.1.2	Firms offering formal training, % firms	34.6	42	
5.1.3	GERD performed by business, % GDP	0.7	30	
5.1.4	GERD financed by business, %	53.1	22	
5.1.5	Females employed w/advanced degrees, %	20.4	23	●
5.2	**Innovation linkages**	**21.7**	**75**	○ ◇
5.2.1	University/industry research collaboration†	35.1	92	○ ◇
5.2.2	State of cluster development†	46.6	64	
5.2.3	GERD financed by abroad, %	5.5	63	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	52	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.4	34	
5.3	**Knowledge absorption**	**41.2**	**37**	
5.3.1	Intellectual property payments, % total trade	1.1	32	
5.3.2	High-tech imports, % total trade	9.3	40	
5.3.3	ICT services imports, % total trade	1.3	56	
5.3.4	FDI net inflows, % GDP	3.0	56	
5.3.5	Research talent, % in business enterprise	47.1	28	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**30.9**	**39**	
6.1	**Knowledge creation**	**24.3**	**36**	
6.1.1	Patents by origin/bn PPP$ GDP	3.9	28	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.3	45	
6.1.3	Utility models by origin/bn PPP$ GDP	0.8	27	
6.1.4	Scientific & technical articles/bn PPP$ GDP	16.5	32	
6.1.5	Citable documents H-index	35.5	25	
6.2	**Knowledge impact**	**43.2**	**36**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.6	16	● ◆
6.2.2	New businesses/th pop. 15–64	1.7	58	
6.2.3	Computer software spending, % GDP	0.3	42	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	10.5	30	
6.2.5	High- & medium-high-tech manufactures, %	0.3	35	
6.3	**Knowledge diffusion**	**25.1**	**39**	
6.3.1	Intellectual property receipts, % total trade	0.2	41	
6.3.2	High-tech net exports, % total trade	6.5	25	●
6.3.3	ICT services exports, % total trade	2.3	47	
6.3.4	FDI net outflows, % GDP	1.6	40	
	CREATIVE OUTPUTS	**32.4**	**46**	
7.1	**Intangible assets**	**42.6**	**58**	
7.1.1	Trademarks by origin/bn PPP$ GDP	38.2	67	○
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	60.8	60	◇
7.1.4	ICTs & organizational model creation†	51.9	73	○ ◇
7.2	**Creative goods & services**	**27.2**	**37**	
7.2.1	Cultural & creative services exports, % total trade	1.1	25	
7.2.2	National feature films/mn pop. 15–69	1.8	69	○ ◇
7.2.3	Entertainment & Media market/th pop. 15–69	11.5	33	◇
7.2.4	Printing & other media, % manufacturing	1.2	54	
7.2.5	Creative goods exports, % total trade	4.4	12	● ◆
7.3	**Online creativity**	**17.4**	**38**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	6.9	46	
7.3.2	Country-code TLDs/th pop. 15–69	25.7	23	●
7.3.3	Wikipedia edits/mn pop. 15–69	34.3	36	
7.3.4	Mobile app creation/bn PPP$ GDP	13.8	34	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

PORTUGAL

GII 2019 rank

32

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
35	31	High	EUR	10.3	328.8	32,006.4	32

		Score/Value	Rank	
	INSTITUTIONS	**81.8**	**22**	
1.1	**Political environment**	**81.2**	**19**	●
1.1.1	Political and operational stability*	86.0	21	
1.1.2	Government effectiveness*	78.8	22	
1.2	**Regulatory environment**	**78.8**	**32**	
1.2.1	Regulatory quality*	66.3	35	
1.2.2	Rule of law*	76.3	25	
1.2.3	Cost of redundancy dismissal, salary weeks	17.0	70	○
1.3	**Business environment**	**85.5**	**19**	●
1.3.1	Ease of starting a business*	90.9	49	
1.3.2	Ease of resolving insolvency*	80.0	15	●
	HUMAN CAPITAL & RESEARCH	**47.7**	**24**	
2.1	**Education**	**59.4**	**27**	
2.1.1	Expenditure on education, % GDP	4.9	52	
2.1.2	Government funding/pupil, secondary, % GDP/cap	27.7	16	●
2.1.3	School life expectancy, years	16.3	27	
2.1.4	PISA scales in reading, maths, & science	497.0	22	
2.1.5	Pupil-teacher ratio, secondary ⊙	9.6	24	
2.2	**Tertiary education**	**44.9**	**24**	
2.2.1	Tertiary enrolment, % gross ⊙	62.9	41	
2.2.2	Graduates in science & engineering, %	29.0	16	●
2.2.3	Tertiary inbound mobility, % ⊙	5.0	41	
2.3	**Research & development (R&D)**	**38.8**	**26**	
2.3.1	Researchers, FTE/mn pop	4,350.5	20	
2.3.2	Gross expenditure on R&D, % GDP	1.3	26	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	43.1	38	
2.3.4	QS university ranking, average score top 3*	30.3	38	
	INFRASTRUCTURE	**56.8**	**31**	
3.1	**Information & communication technologies(ICTs)**	**82.5**	**25**	
3.1.1	ICT access*	80.3	28	
3.1.2	ICT use*	66.8	40	
3.1.3	Government's online service*	93.1	17	
3.1.4	E-participation*	89.9	30	
3.2	**General infrastructure**	**35.9**	**60**	
3.2.1	Electricity output, kWh/mn pop	5,592.2	37	
3.2.2	Logistics performance*	73.9	23	
3.2.3	Gross capital formation, % GDP	17.3	107	○ ◇
3.3	**Ecological sustainability**	**52.0**	**23**	
3.3.1	GDP/unit of energy use	12.3	27	
3.3.2	Environmental performance*	71.9	25	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	4.7	24	
	MARKET SOPHISTICATION	**49.8**	**58**	
4.1	**Credit**	**47.4**	**38**	
4.1.1	Ease of getting credit*	45.0	94	○
4.1.2	Domestic credit to private sector, % GDP	104.1	24	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**33.5**	**105**	○ ◇
4.2.1	Ease of protecting minority investors*	60.0	61	
4.2.2	Market capitalization, % GDP	30.9	47	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	58	○
4.3	**Trade, competition, & market scale**	**68.5**	**40**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	70.3	55	
4.3.3	Domestic market scale, bn PPP$	328.8	51	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**37.3**	**42**	
5.1	**Knowledge workers**	**50.0**	**37**	
5.1.1	Knowledge-intensive employment, %	36.1	35	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.7	29	
5.1.4	GERD financed by business, %	44.4	37	
5.1.5	Females employed w/advanced degrees, %	16.1	40	
5.2	**Innovation linkages**	**27.7**	**53**	
5.2.1	University/industry research collaboration†	54.5	31	
5.2.2	State of cluster development†	54.4	37	
5.2.3	GERD financed by abroad, %	8.0	48	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	64	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.7	31	
5.3	**Knowledge absorption**	**34.3**	**61**	
5.3.1	Intellectual property payments, % total trade	0.9	42	
5.3.2	High-tech imports, % total trade	6.9	72	○
5.3.3	ICT services imports, % total trade	1.1	64	
5.3.4	FDI net inflows, % GDP	3.5	48	
5.3.5	Research talent, % in business enterprise	34.3	38	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**29.8**	**43**	
6.1	**Knowledge creation**	**25.3**	**34**	
6.1.1	Patents by origin/bn PPP$ GDP	2.5	35	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.8	30	
6.1.3	Utility models by origin/bn PPP$ GDP	0.2	40	○
6.1.4	Scientific & technical articles/bn PPP$ GDP	29.3	8	● ◆
6.1.5	Citable documents H-index	30.4	30	
6.2	**Knowledge impact**	**47.0**	**22**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.1	92	○
6.2.2	New businesses/th pop. 15–64	5.0	26	
6.2.3	Computer software spending, % GDP	0.6	9	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	22.8	13	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.3	42	
6.3	**Knowledge diffusion**	**17.1**	**69**	
6.3.1	Intellectual property receipts, % total trade	0.1	47	
6.3.2	High-tech net exports, % total trade	2.7	48	
6.3.3	ICT services exports, % total trade	1.7	61	
6.3.4	FDI net outflows, % GDP	1.3	49	
	CREATIVE OUTPUTS	**39.4**	**32**	
7.1	**Intangible assets**	**58.2**	**13**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	98.4	14	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	7.2	18	●
7.1.3	ICTs & business model creation†	78.6	11	●
7.1.4	ICTs & organizational model creation†	64.8	30	
7.2	**Creative goods & services**	**21.4**	**52**	
7.2.1	Cultural & creative services exports, % total trade	0.6	42	
7.2.2	National feature films/mn pop. 15–69	5.2	41	
7.2.3	Entertainment & Media market/th pop. 15–69	35.5	22	
7.2.4	Printing & other media, % manufacturing	1.2	45	
7.2.5	Creative goods exports, % total trade	1.5	37	
7.3	**Online creativity**	**19.8**	**35**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	18.8	29	
7.3.2	Country-code TLDs/th pop. 15–69	41.7	16	●
7.3.3	Wikipedia edits/mn pop. 15–69	23.4	46	
7.3.4	Mobile app creation/bn PPP$ GDP	2.8	59	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

QATAR

GII 2019 rank

65

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
70	**53**	**High**	**NAWA**	**2.7**	**356.7**	**130,475.1**	**51**

		Score/Value	Rank	
	INSTITUTIONS	**66.2**	**53**	◇
1.1	**Political environment**	**67.6**	**40**	
1.1.1	Political and operational stability*	73.7	50	◇
1.1.2	Government effectiveness*	64.5	39	
1.2	**Regulatory environment**	**68.1**	**62**	◇
1.2.1	Regulatory quality*	53.2	51	◇
1.2.2	Rule of law*	65.5	35	
1.2.3	Cost of redundancy dismissal, salary weeks	23.2	97	◇
1.3	**Business environment**	**62.9**	**91**	◇
1.3.1	Ease of starting a business*	87.7	68	
1.3.2	Ease of resolving insolvency*	38.1	104	◇
	HUMAN CAPITAL & RESEARCH	**28.9**	**70**	◇
2.1	**Education**	**31.9**	**105**	◇
2.1.1	Expenditure on education, % GDP	2.9	106	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap. ◷	10.5	95	○ ◇
2.1.3	School life expectancy, years	11.9	91	◇
2.1.4	PISA scales in reading, maths, & science	407.3	60	
2.1.5	Pupil-teacher ratio, secondary	10.4	34	
2.2	**Tertiary education**	**47.5**	**19**	●
2.2.1	Tertiary enrolment, % gross	16.4	98	◇
2.2.2	Graduates in science & engineering, %	22.9	43	
2.2.3	Tertiary inbound mobility, %	35.3	1	● ◆
2.3	**Research & development (R&D)**	**7.2**	**68**	◇
2.3.1	Researchers, FTE/mn pop. ◷	603.8	63	◇
2.3.2	Gross expenditure on R&D, % GDP ◷	0.5	63	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	10.7	62	
	INFRASTRUCTURE	**58.0**	**28**	●
3.1	**Information & communication technologies(ICTs)**	**75.0**	**44**	
3.1.1	ICT access*	78.9	32	
3.1.2	ICT use*	70.7	32	
3.1.3	Government's online service*	79.2	48	
3.1.4	E-participation*	71.4	65	◇
3.2	**General infrastructure**	**62.3**	**3**	● ◆
3.2.1	Electricity output, kWh/mn pop.	16,461.9	6	● ◆
3.2.2	Logistics performance*	66.0	29	●
3.2.3	Gross capital formation, % GDP	n/a	n/a	
3.3	**Ecological sustainability**	**36.8**	**72**	◇
3.3.1	GDP/unit of energy use	7.0	86	
3.3.2	Environmental performance*	67.8	31	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.3	60	
	MARKET SOPHISTICATION	**44.7**	**82**	◇
4.1	**Credit**	**38.1**	**59**	
4.1.1	Ease of getting credit*	40.0	104	○ ◇
4.1.2	Domestic credit to private sector, % GDP	77.3	40	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**31.6**	**114**	○ ◇
4.2.1	Ease of protecting minority investors*	28.3	127	○ ◇
4.2.2	Market capitalization, % GDP	89.5	16	●
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**64.4**	**55**	
4.3.1	Applied tariff rate, weighted avg., %	4.2	76	
4.3.2	Intensity of local competition†	65.6	79	
4.3.3	Domestic market scale, bn PPP$	356.7	49	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**30.2**	**67**	◇
5.1	**Knowledge workers**	**17.3**	**113**	○ ◇
5.1.1	Knowledge-intensive employment, %	18.1	80	◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ◷	0.1	63	◇
5.1.4	GERD financed by business, % ◷	7.1	76	◇
5.1.5	Females employed w/advanced degrees, % ◷	4.5	92	◇
5.2	**Innovation linkages**	**27.6**	**54**	●
5.2.1	University/industry research collaboration†	64.8	17	●
5.2.2	State of cluster development†	65.4	15	●
5.2.3	GERD financed by abroad, % ◷	1.9	79	◇
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	38	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	68	
5.3	**Knowledge absorption**	**45.7**	**25**	●
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade ◷	6.6	82	
5.3.3	ICT services imports, % total trade	3.9	3	● ◆
5.3.4	FDI net inflows, % GDP	0.6	116	○
5.3.5	Research talent, % in business enterprise ◷	18.6	57	◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**18.4**	**80**	◇
6.1	**Knowledge creation**	**5.1**	**97**	◇
6.1.1	Patents by origin/bn PPP$ GDP	0.1	115	○
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	78	◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.2	90	◇
6.1.5	Citable documents H-index	6.6	85	◇
6.2	**Knowledge impact**	**32.3**	**84**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-1.8	106	○ ◇
6.2.2	New businesses/th pop. 15–64 ◷	1.7	56	
6.2.3	Computer software spending, % GDP	0.3	31	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.3	84	◇
6.2.5	High- & medium-high-tech manufactures, %	0.4	23	●
6.3	**Knowledge diffusion**	**17.9**	**59**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade ◷	0.0	128	○ ◇
6.3.3	ICT services exports, % total trade	0.8	85	
6.3.4	FDI net outflows, % GDP	2.9	24	●
	CREATIVE OUTPUTS	**25.8**	**70**	◇
7.1	**Intangible assets**	**43.6**	**54**	
7.1.1	Trademarks by origin/bn PPP$ GDP	3.3	120	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	66.7	44	
7.1.4	ICTs & organizational model creation†	63.9	33	
7.2	**Creative goods & services**	**13.1**	**75**	◇
7.2.1	Cultural & creative services exports, % total trade	0.3	62	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	25.7	25	
7.2.4	Printing & other media, % manufacturing	1.2	55	
7.2.5	Creative goods exports, % total trade ◷	0.2	88	
7.3	**Online creativity**	**3.0**	**78**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	3.7	60	◇
7.3.2	Country-code TLDs/th pop. 15–69	2.4	61	
7.3.3	Wikipedia edits/mn pop. 15–69 ◷	8.4	66	◇
7.3.4	Mobile app creation/bn PPP$ GDP	0.3	78	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

REPUBLIC OF KOREA (THE)

GII 2019 rank

11

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
13	10	High	SEAO	51.2	2,139.7	41,350.6	12

		Score/Value	Rank	
1	**INSTITUTIONS**	**79.7**	**26**	◇
1.1	**Political environment**	**77.2**	**27**	◇
1.1.1	Political and operational stability*	86.0	21	
1.1.2	Government effectiveness*	72.8	28	◇
1.2	**Regulatory environment**	**72.4**	**45**	◇
1.2.1	Regulatory quality*	71.6	29	◇
1.2.2	Rule of law*	77.2	23	
1.2.3	Cost of redundancy dismissal, salary weeks	27.4	107	○ ◇
1.3	**Business environment**	**89.4**	**6**	
1.3.1	Ease of starting a business*	95.8	11	
1.3.2	Ease of resolving insolvency*	83.0	10	
2	**HUMAN CAPITAL & RESEARCH**	**66.5**	**1**	● ◆
2.1	**Education**	**60.8**	**21**	
2.1.1	Expenditure on education, % GDP	5.3	37	
2.1.2	Government funding/pupil, secondary, % GDP/cap	28.5	14	◆
2.1.3	School life expectancy, years	16.4	24	
2.1.4	PISA scales in reading, maths, & science	519.1	7	
2.1.5	Pupil-teacher ratio, secondary ⊕	13.8	62	○
2.2	**Tertiary education**	**49.4**	**16**	
2.2.1	Tertiary enrolment, % gross ⊕	93.8	4	◆
2.2.2	Graduates in science & engineering, %	29.9	14	◆
2.2.3	Tertiary inbound mobility, %	1.9	76	○ ◇
2.3	**Research & development (R&D)**	**89.3**	**1**	● ◆
2.3.1	Researchers, FTE/mn pop	7,514.4	3	● ◆
2.3.2	Gross expenditure on R&D, % GDP	4.6	2	● ◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	92.6	4	●
2.3.4	QS university ranking, average score top 3*	74.1	9	
3	**INFRASTRUCTURE**	**61.6**	**15**	
3.1	**Information & communication technologies(ICTs)**	**94.0**	**1**	● ◆
3.1.1	ICT access*	90.0	7	
3.1.2	ICT use*	88.1	4	● ◆
3.1.3	Government's online service*	97.9	4	
3.1.4	E-participation*	100.0	1	●
3.2	**General infrastructure**	**55.4**	**7**	
3.2.1	Electricity output, kWh/mn pop	10,910.4	11	
3.2.2	Logistics performance*	72.4	25	
3.2.3	Gross capital formation, % GDP	31.2	18	◆
3.3	**Ecological sustainability**	**35.4**	**77**	○ ◇
3.3.1	GDP/unit of energy use	6.3	98	○
3.3.2	Environmental performance*	62.3	53	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.6	38	
4	**MARKET SOPHISTICATION**	**64.3**	**11**	
4.1	**Credit**	**67.6**	**15**	
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	144.8	11	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**48.7**	**43**	
4.2.1	Ease of protecting minority investors*	73.3	21	
4.2.2	Market capitalization, % GDP	97.8	13	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	39	◇
4.3	**Trade, competition, & market scale**	**76.7**	**17**	
4.3.1	Applied tariff rate, weighted avg., %	5.1	88	○ ◇
4.3.2	Intensity of local competition†	83.9	4	◆
4.3.3	Domestic market scale, bn PPP$	2,139.7	14	

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**57.6**	**10**	
5.1	**Knowledge workers**	**75.3**	**5**	
5.1.1	Knowledge-intensive employment, %	39.1	28	◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	3.6	2	● ◆
5.1.4	GERD financed by business, %	76.2	3	● ◆
5.1.5	Females employed w/advanced degrees, % ⊕	16.2	39	◇
5.2	**Innovation linkages**	**46.1**	**18**	
5.2.1	University/industry research collaboration†	56.5	26	◇
5.2.2	State of cluster development†	59.6	29	
5.2.3	GERD financed by abroad, %	1.3	89	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	40	◇
5.2.5	Patent families 2+ offices/bn PPP$ GDP	14.4	4	◆
5.3	**Knowledge absorption**	**51.5**	**18**	
5.3.1	Intellectual property payments, % total trade	1.6	19	
5.3.2	High-tech imports, % total trade	15.2	13	
5.3.3	ICT services imports, % total trade	0.5	105	○ ◇
5.3.4	FDI net inflows, % GDP	0.8	113	○
5.3.5	Research talent, % in business enterprise	81.3	2	● ◆
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**50.2**	**13**	
6.1	**Knowledge creation**	**63.1**	**8**	
6.1.1	Patents by origin/bn PPP$ GDP	78.2	1	● ◆
6.1.2	PCT patents by origin/bn PPP$ GDP	8.0	1	● ◆
6.1.3	Utility models by origin/bn PPP$ GDP	3.2	7	
6.1.4	Scientific & technical articles/bn PPP$ GDP	20.4	24	
6.1.5	Citable documents H-index	43.3	18	
6.2	**Knowledge impact**	**43.8**	**31**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.1	42	
6.2.2	New businesses/th pop. 15–64	2.6	43	
6.2.3	Computer software spending, % GDP	0.2	62	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	6.2	49	
6.2.5	High- & medium-high-tech manufactures, %	0.6	7	
6.3	**Knowledge diffusion**	**43.8**	**16**	
6.3.1	Intellectual property receipts, % total trade	1.1	18	
6.3.2	High-tech net exports, % total trade	26.4	1	● ◆
6.3.3	ICT services exports, % total trade	0.7	90	○
6.3.4	FDI net outflows, % GDP	2.0	29	
7	**CREATIVE OUTPUTS**	**44.1**	**17**	
7.1	**Intangible assets**	**65.8**	**3**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	89.1	23	
7.1.2	Industrial designs by origin/bn PPP$ GDP	29.7	1	● ◆
7.1.3	ICTs & business model creation†	79.7	10	
7.1.4	ICTs & organizational model creation†	64.0	32	◇
7.2	**Creative goods & services**	**25.7**	**42**	
7.2.1	Cultural & creative services exports, % total trade	0.4	54	
7.2.2	National feature films/mn pop. 15–69 ⊕	8.7	22	
7.2.3	Entertainment & Media market/th pop. 15–69	47.8	19	
7.2.4	Printing & other media, % manufacturing	0.3	98	○ ◇
7.2.5	Creative goods exports, % total trade	3.6	16	
7.3	**Online creativity**	**19.0**	**37**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	8.1	43	◇
7.3.2	Country-code TLDs/th pop. 15–69	9.6	41	◇
7.3.3	Wikipedia edits/mn pop. 15–69	17.7	51	◇
7.3.4	Mobile app creation/bn PPP$ GDP	46.6	12	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

REPUBLIC OF MOLDOVA (THE)

GII 2019 rank

58

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
45	81	Lower middle	EUR	4.0	25.2	7,304.5	48

		Score/Value	Rank	
	INSTITUTIONS	**58.4**	**82**	
1.1	**Political environment**	**43.2**	**96**	
1.1.1	Political and operational stability*	61.4	91	
1.1.2	Government effectiveness*	34.2	97	
1.2	**Regulatory environment**	**57.1**	**91**	
1.2.1	Regulatory quality*	40.9	72	
1.2.2	Rule of law*	35.4	89	
1.2.3	Cost of redundancy dismissal, salary weeks	23.7	98	
1.3	**Business environment**	**74.8**	**47**	◆
1.3.1	Ease of starting a business*	95.6	12	● ◆
1.3.2	Ease of resolving insolvency*	54.1	63	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**30.4**	**64**	
2.1	**Education**	**57.2**	**38**	◆
2.1.1	Expenditure on education, % GDP	6.7	11	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	36.3	7	● ◆
2.1.3	School life expectancy, years	11.6	93	
2.1.4	PISA scales in reading, maths, & science	421.3	51	
2.1.5	Pupil-teacher ratio, secondary	9.9	28	◆
2.2	**Tertiary education**	**30.3**	**66**	
2.2.1	Tertiary enrolment, % gross	41.1	70	
2.2.2	Graduates in science & engineering, % ⊙	22.3	47	
2.2.3	Tertiary inbound mobility, %	4.1	52	◆
2.3	**Research & development (R&D)**	**3.7**	**84**	
2.3.1	Researchers, FTE/mn pop	723.9	56	
2.3.2	Gross expenditure on R&D, % GDP	0.3	78	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**39.4**	**88**	
3.1	**Information & communication technologies(ICTs)**	**72.3**	**52**	◆
3.1.1	ICT access*	72.8	56	◆
3.1.2	ICT use*	53.4	66	◆
3.1.3	Government's online service*	77.1	53	
3.1.4	E-participation*	86.0	37	◆
3.2	**General infrastructure**	**21.2**	**115**	○
3.2.1	Electricity output, kWh/mn pop	1,641.4	85	
3.2.2	Logistics performance*	18.4	106	○
3.2.3	Gross capital formation, % GDP	19.8	95	
3.3	**Ecological sustainability**	**24.8**	**116**	○
3.3.1	GDP/unit of energy use	4.5	112	○ ◇
3.3.2	Environmental performance*	52.0	91	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	111	○

		Score/Value	Rank	
	MARKET SOPHISTICATION	**49.5**	**60**	
4.1	**Credit**	**29.8**	**94**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	27.1	100	
4.1.3	Microfinance gross loans, % GDP	0.5	29	
4.2	**Investment**	**68.3**	**[9]**	
4.2.1	Ease of protecting minority investors*	68.3	30	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**50.2**	**108**	○
4.3.1	Applied tariff rate, weighted avg., % ⊙	3.5	69	
4.3.2	Intensity of local competition†	63.8	86	
4.3.3	Domestic market scale, bn PPP$	25.2	121	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**26.1**	**93**	
5.1	**Knowledge workers**	**33.6**	**76**	
5.1.1	Knowledge-intensive employment, %	26.5	52	◆
5.1.2	Firms offering formal training, % firms	32.4	46	
5.1.3	GERD performed by business, % GDP	0.1	70	
5.1.4	GERD financed by business, %	17.9	70	
5.1.5	Females employed w/advanced degrees, %	13.7	48	
5.2	**Innovation linkages**	**14.8**	**120**	○
5.2.1	University/industry research collaboration†	29.1	109	○
5.2.2	State of cluster development†	28.2	124	○ ◇
5.2.3	GERD financed by abroad, %	3.7	67	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	51	◆
5.3	**Knowledge absorption**	**30.0**	**82**	
5.3.1	Intellectual property payments, % total trade	0.5	61	
5.3.2	High-tech imports, % total trade	7.4	66	
5.3.3	ICT services imports, % total trade	1.9	28	● ◆
5.3.4	FDI net inflows, % GDP	2.2	77	
5.3.5	Research talent, % in business enterprise	6.4	70	○

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**28.7**	**44**	◆
6.1	**Knowledge creation**	**33.2**	**28**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP	3.1	32	◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	49	◆
6.1.3	Utility models by origin/bn PPP$ GDP	5.9	4	● ◆
6.1.4	Scientific & technical articles/bn PPP$ GDP	6.7	66	
6.1.5	Citable documents H-index	4.7	96	
6.2	**Knowledge impact**	**35.0**	**72**	
6.2.1	Growth rate of PPP$ GDP/worker, %	4.2	13	●
6.2.2	New businesses/th pop. 15-64	1.8	54	
6.2.3	Computer software spending, % GDP	0.1	87	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	4.6	60	
6.2.5	High- & medium-high-tech manufactures, %	0.1	71	
6.3	**Knowledge diffusion**	**17.9**	**61**	
6.3.1	Intellectual property receipts, % total trade	0.1	45	
6.3.2	High-tech net exports, % total trade	0.7	74	
6.3.3	ICT services exports, % total trade	4.2	18	●
6.3.4	FDI net outflows, % GDP	0.1	93	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**31.8**	**49**	◆
7.1	**Intangible assets**	**53.4**	**26**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	127.1	7	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	12.2	11	● ◆
7.1.3	ICTs & business model creation†	52.1	98	
7.1.4	ICTs & organizational model creation†	48.3	86	
7.2	**Creative goods & services**	**10.5**	**83**	
7.2.1	Cultural & creative services exports, % total trade	0.9	31	◆
7.2.2	National feature films/mn pop. 15-69 ⊙	0.3	99	○
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.0	68	
7.2.5	Creative goods exports, % total trade	0.2	83	
7.3	**Online creativity**	**9.9**	**52**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	2.0	78	
7.3.2	Country-code TLDs/th pop. 15-69	2.0	67	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	17.1	53	
7.3.4	Mobile app creation/bn PPP$ GDP	24.3	20	● ◆

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ROMANIA

GII 2019 rank

50

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
53	54	Upper middle	EUR	19.6	514.2	26,446.7	49

		Score/Value	Rank	
	INSTITUTIONS	**67.1**	**52**	
1.1	**Political environment**	**51.6**	**75**	
1.1.1	Political and operational stability*	70.2	61	
1.1.2	Government effectiveness*	42.3	84	
1.2	**Regulatory environment**	**77.9**	**35**	◆
1.2.1	Regulatory quality*	55.0	46	
1.2.2	Rule of law*	56.6	47	◆
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**71.9**	**57**	
1.3.1	Ease of starting a business*	83.9	86	
1.3.2	Ease of resolving insolvency*	59.9	47	
	HUMAN CAPITAL & RESEARCH	**29.1**	**69**	
2.1	**Education**	**40.5**	**82**	
2.1.1	Expenditure on education, % GDP	3.1	99	○
2.1.2	Government funding/pupil, secondary, % GDP/cap	16.2	76	
2.1.3	School life expectancy, years	14.3	67	
2.1.4	PISA scales in reading, maths, & science	437.5	47	
2.1.5	Pupil-teacher ratio, secondary ◷	12.1	49	
2.2	**Tertiary education**	**41.4**	**31**	
2.2.1	Tertiary enrolment, % gross ◷	48.0	60	
2.2.2	Graduates in science & engineering, %	28.8	17	●
2.2.3	Tertiary inbound mobility, %	4.8	43	
2.3	**Research & development (R&D)**	**5.3**	**77**	
2.3.1	Researchers, FTE/mn pop	890.2	52	
2.3.2	Gross expenditure on R&D, % GDP	0.5	64	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**54.5**	**35**	◆
3.1	**Information & communication technologies(ICTs)**	**67.6**	**63**	
3.1.1	ICT access*	71.4	61	
3.1.2	ICT use*	62.4	51	◆
3.1.3	Government's online service*	66.0	79	
3.1.4	E-participation*	70.8	67	
3.2	**General infrastructure**	**35.4**	**64**	
3.2.1	Electricity output, kWh/mn pop	3,277.3	60	
3.2.2	Logistics performance*	49.3	47	
3.2.3	Gross capital formation, % GDP	24.3	49	
3.3	**Ecological sustainability**	**60.6**	**6**	● ◆
3.3.1	GDP/unit of energy use	13.0	25	●
3.3.2	Environmental performance*	64.8	41	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	11.7	4	● ◆
	MARKET SOPHISTICATION	**43.2**	**92**	
4.1	**Credit**	**30.2**	**92**	
4.1.1	Ease of getting credit*	80.0	20	
4.1.2	Domestic credit to private sector, % GDP	26.4	103	○
4.1.3	Microfinance gross loans, % GDP ◷	0.0	72	○
4.2	**Investment**	**30.4**	**120**	○ ◇
4.2.1	Ease of protecting minority investors*	60.0	61	
4.2.2	Market capitalization, % GDP ◷	7.9	72	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	76	○
4.3	**Trade, competition, & market scale**	**68.9**	**38**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	62.9	93	○
4.3.3	Domestic market scale, bn PPP$	514.2	39	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**33.6**	**51**	
5.1	**Knowledge workers**	**40.4**	**56**	
5.1.1	Knowledge-intensive employment, %	23.3	63	
5.1.2	Firms offering formal training, % firms	40.7	33	
5.1.3	GERD performed by business, % GDP	0.3	48	
5.1.4	GERD financed by business, %	49.4	27	
5.1.5	Females employed w/advanced degrees, %	11.0	60	
5.2	**Innovation linkages**	**19.2**	**92**	
5.2.1	University/industry research collaboration†	38.7	74	
5.2.2	State of cluster development†	34.5	109	○ ◇
5.2.3	GERD financed by abroad, %	9.9	43	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	70	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	64	
5.3	**Knowledge absorption**	**41.1**	**38**	◆
5.3.1	Intellectual property payments, % total trade	1.0	34	
5.3.2	High-tech imports, % total trade	9.8	34	
5.3.3	ICT services imports, % total trade	2.3	16	● ◆
5.3.4	FDI net inflows, % GDP	2.9	59	
5.3.5	Research talent, % in business enterprise	25.5	48	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**30.3**	**41**	
6.1	**Knowledge creation**	**10.5**	**69**	
6.1.1	Patents by origin/bn PPP$ GDP	2.4	37	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	73	
6.1.3	Utility models by origin/bn PPP$ GDP	0.1	55	○
6.1.4	Scientific & technical articles/bn PPP$ GDP	10.6	43	
6.1.5	Citable documents H-index	13.9	53	
6.2	**Knowledge impact**	**55.2**	**8**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	4.7	11	● ◆
6.2.2	New businesses/th pop. 15–64	5.6	25	
6.2.3	Computer software spending, % GDP	0.3	45	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	25.2	9	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.4	22	● ◆
6.3	**Knowledge diffusion**	**25.1**	**38**	
6.3.1	Intellectual property receipts, % total trade	0.1	57	
6.3.2	High-tech net exports, % total trade	4.2	35	
6.3.3	ICT services exports, % total trade	4.9	10	● ◆
6.3.4	FDI net outflows, % GDP	0.5	66	
	CREATIVE OUTPUTS	**25.8**	**71**	
7.1	**Intangible assets**	**38.6**	**78**	
7.1.1	Trademarks by origin/bn PPP$ GDP	43.1	60	
7.1.2	Industrial designs by origin/bn PPP$ GDP	2.6	45	
7.1.3	ICTs & business model creation†	60.8	61	
7.1.4	ICTs & organizational model creation†	50.0	81	
7.2	**Creative goods & services**	**14.7**	**68**	
7.2.1	Cultural & creative services exports, % total trade	1.5	15	● ◆
7.2.2	National feature films/mn pop. 15–69	2.0	63	
7.2.3	Entertainment & Media market/th pop. 15–69	5.9	45	
7.2.4	Printing & other media, % manufacturing	1.0	65	
7.2.5	Creative goods exports, % total trade	0.7	52	
7.3	**Online creativity**	**11.2**	**50**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	4.6	56	
7.3.2	Country-code TLDs/th pop. 15–69	15.8	32	
7.3.3	Wikipedia edits/mn pop. 15–69	12.5	60	
7.3.4	Mobile app creation/bn PPP$ GDP	16.1	29	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

RUSSIAN FEDERATION (THE)

GII 2019 rank

46

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
59	**41**	**Upper middle**	**EUR**	**144.0**	**4,179.6**	**29,266.9**	**46**

		Score/Value	Rank	
	INSTITUTIONS	**60.9**	**74**	
1.1	**Political environment**	**50.2**	**83**	
1.1.1	Political and operational stability*	61.4	91	○
1.1.2	Government effectiveness*	44.7	76	
1.2	**Regulatory environment**	**56.5**	**95**	○
1.2.1	Regulatory quality*	29.2	103	○
1.2.2	Rule of law*	25.4	111	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	17.3	73	
1.3	**Business environment**	**75.8**	**43**	
1.3.1	Ease of starting a business*	93.0	29	
1.3.2	Ease of resolving insolvency*	58.6	50	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**48.3**	**23**	◆
2.1	**Education**	**57.6**	**35**	
2.1.1	Expenditure on education, % GDP	3.8	86	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	15.5	37	
2.1.4	PISA scales in reading, maths, & science	491.8	26	◆
2.1.5	Pupil-teacher ratio, secondary ⏱	8.8	15	● ◆
2.2	**Tertiary education**	**50.3**	**14**	● ◆
2.2.1	Tertiary enrolment, % gross ⏱	81.8	17	● ◆
2.2.2	Graduates in science & engineering, %	30.9	10	● ◆
2.2.3	Tertiary inbound mobility, %	3.9	54	
2.3	**Research & development (R&D)**	**36.9**	**30**	◆
2.3.1	Researchers, FTE/mn pop	2,851.7	33	◆
2.3.2	Gross expenditure on R&D, % GDP	1.1	33	◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	42.3	40	◆
2.3.4	QS university ranking, average score top 3*	46.7	24	◆

		Score/Value	Rank	
	INFRASTRUCTURE	**47.1**	**62**	
3.1	**Information & communication technologies(ICTs)**	**80.7**	**29**	◆
3.1.1	ICT access*	74.0	51	◆
3.1.2	ICT use*	64.9	45	◆
3.1.3	Government's online service*	91.7	25	◆
3.1.4	E-participation*	92.1	23	◆
3.2	**General infrastructure**	**31.5**	**81**	
3.2.1	Electricity output, kWh/mn pop	7,544.3	28	◆
3.2.2	Logistics performance*	32.4	74	
3.2.3	Gross capital formation, % GDP	21.2	86	
3.3	**Ecological sustainability**	**29.2**	**101**	○ ◇
3.3.1	GDP/unit of energy use	4.3	113	○ ◇
3.3.2	Environmental performance*	63.8	47	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	112	○

		Score/Value	Rank	
	MARKET SOPHISTICATION	**49.4**	**61**	
4.1	**Credit**	**34.6**	**69**	
4.1.1	Ease of getting credit*	80.0	20	
4.1.2	Domestic credit to private sector, % GDP	52.7	62	
4.1.3	Microfinance gross loans, % GDP	0.0	73	○
4.2	**Investment**	**34.7**	**102**	○
4.2.1	Ease of protecting minority investors*	61.7	54	
4.2.2	Market capitalization, % GDP	38.9	39	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	77	○
4.3	**Trade, competition, & market scale**	**78.8**	**11**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	3.6	71	
4.3.2	Intensity of local competition†	70.9	51	
4.3.3	Domestic market scale, bn PPP$	4,179.6	6	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**40.0**	**35**	◆
5.1	**Knowledge workers**	**58.0**	**25**	◆
5.1.1	Knowledge-intensive employment, %	44.3	18	● ◆
5.1.2	Firms offering formal training, % firms ⏱	46.2	27	
5.1.3	GERD performed by business, % GDP	0.7	31	◆
5.1.4	GERD financed by business, %	30.2	58	
5.1.5	Females employed w/advanced degrees, %	26.3	7	● ◆
5.2	**Innovation linkages**	**19.1**	**93**	
5.2.1	University/industry research collaboration†	49.6	40	
5.2.2	State of cluster development†	41.4	89	
5.2.3	GERD financed by abroad, %	2.6	73	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	69	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	52	
5.3	**Knowledge absorption**	**42.7**	**32**	◆
5.3.1	Intellectual property payments, % total trade	1.7	18	● ◆
5.3.2	High-tech imports, % total trade	9.3	39	
5.3.3	ICT services imports, % total trade	1.5	45	
5.3.4	FDI net inflows, % GDP	1.6	92	
5.3.5	Research talent, % in business enterprise	47.1	27	◆

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**27.1**	**47**	
6.1	**Knowledge creation**	**29.9**	**30**	◆
6.1.1	Patents by origin/bn PPP$ GDP	5.8	20	● ◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	47	
6.1.3	Utility models by origin/bn PPP$ GDP	2.5	8	● ◆
6.1.4	Scientific & technical articles/bn PPP$ GDP	6.9	63	
6.1.5	Citable documents H-index	37.4	22	● ◆
6.2	**Knowledge impact**	**33.9**	**77**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.0	63	
6.2.2	New businesses/th pop. 15-64	4.3	29	
6.2.3	Computer software spending, % GDP	0.2	63	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.9	111	○
6.2.5	High- & medium-high-tech manufactures, %	0.3	43	
6.3	**Knowledge diffusion**	**17.6**	**63**	
6.3.1	Intellectual property receipts, % total trade	0.2	39	◆
6.3.2	High-tech net exports, % total trade	2.6	49	
6.3.3	ICT services exports, % total trade	1.3	71	
6.3.4	FDI net outflows, % GDP	1.9	30	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**25.1**	**72**	
7.1	**Intangible assets**	**39.4**	**71**	
7.1.1	Trademarks by origin/bn PPP$ GDP	58.1	38	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.9	69	
7.1.3	ICTs & business model creation†	53.3	91	○
7.1.4	ICTs & organizational model creation†	58.4	49	
7.2	**Creative goods & services**	**9.8**	**88**	
7.2.1	Cultural & creative services exports, % total trade	1.0	27	
7.2.2	National feature films/mn pop. 15-69	1.2	76	
7.2.3	Entertainment & Media market/th pop. 15-69	6.5	43	
7.2.4	Printing & other media, % manufacturing	0.8	78	○
7.2.5	Creative goods exports, % total trade	0.3	68	
7.3	**Online creativity**	**12.1**	**47**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	3.5	61	
7.3.2	Country-code TLDs/th pop. 15-69	13.3	34	
7.3.3	Wikipedia edits/mn pop. 15-69	19.7	49	
7.3.4	Mobile app creation/bn PPP$ GDP	18.1	26	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⏱ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

RWANDA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
123	65	Low	SSF	12.5	27.1	2,280.1	99

		Score/Value	Rank	
	INSTITUTIONS	**68.1**	**50**	● ◆
1.1	**Political environment**	**59.8**	**51**	● ◆
1.1.1	Political and operational stability*	73.7	50	◆
1.1.2	Government effectiveness*	52.9	53	● ◆
1.2	**Regulatory environment**	**70.1**	**51**	● ◆
1.2.1	Regulatory quality*	45.9	63	◆
1.2.2	Rule of law*	49.8	54	◆
1.2.3	Cost of redundancy dismissal, salary weeks	13.0	40	●
1.3	**Business environment**	**74.3**	**52**	● ◆
1.3.1	Ease of starting a business*	91.4	45	●
1.3.2	Ease of resolving insolvency*	57.2	53	● ◆

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**17.8**	**102**	
2.1	**Education**	**43.9**	**74**	◆
2.1.1	Expenditure on education, % GDP	3.2	97	
2.1.2	Government funding/pupil, secondary, % GDP/cap	38.0	4	● ◆
2.1.3	School life expectancy, years	11.2	99	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	20.1	89	
2.2	**Tertiary education**	**9.5**	**112**	
2.2.1	Tertiary enrolment, % gross	7.6	113	○
2.2.2	Graduates in science & engineering, %	13.8	92	
2.2.3	Tertiary inbound mobility, %	1.7	78	
2.3	**Research & development (R&D)**	**0.0**	**120**	○ ◇
2.3.1	Researchers, FTE/mn pop. ⊕	12.3	105	○ ◇
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**40.0**	**87**	◆
3.1	**Information & communication technologies(ICTs)**	**48.7**	**99**	◆
3.1.1	ICT access*	27.8	119	○
3.1.2	ICT use*	19.0	110	
3.1.3	Government's online service*	72.2	67	◆
3.1.4	E-participation*	75.8	59	◆
3.2	**General infrastructure**	**42.0**	**40**	●
3.2.1	Electricity output, kWh/mn pop.	n/a	n/a	
3.2.2	Logistics performance*	42.6	56	◆
3.2.3	Gross capital formation, % GDP	25.0	46	●
3.3	**Ecological sustainability**	**29.1**	**102**	
3.3.1	GDP/unit of energy use	n/a	n/a	
3.3.2	Environmental performance*	43.7	113	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.0	128	○ ◇

		Score/Value	Rank	
	MARKET SOPHISTICATION	**55.2**	**38**	● ◆
4.1	**Credit**	**67.6**	**16**	● ◆
4.1.1	Ease of getting credit*	95.0	3	● ◆
4.1.2	Domestic credit to private sector, % GDP	20.9	111	
4.1.3	Microfinance gross loans, % GDP	6.7	1	● ◆
4.2	**Investment**	**54.2**	**31**	● ◆
4.2.1	Ease of protecting minority investors*	76.7	13	● ◆
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	35	
4.3	**Trade, competition, & market scale**	**44.0**	**120**	○
4.3.1	Applied tariff rate, weighted avg., % ⊕	7.3	99	
4.3.2	Intensity of local competition†	57.9	114	
4.3.3	Domestic market scale, bn PPP$	27.1	119	○

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**36.2**	**[44]**	
5.1	**Knowledge workers**	**34.8**	**[69]**	
5.1.1	Knowledge-intensive employment, %	8.2	103	
5.1.2	Firms offering formal training, % firms ⊕	55.4	12	● ◆
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, %	3.7	94	◆
5.2	**Innovation linkages**	**44.4**	**[23]**	
5.2.1	University/industry research collaboration†	41.5	63	
5.2.2	State of cluster development†	45.8	72	◆
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	n/a	n/a	
5.3	**Knowledge absorption**	**29.4**	**87**	
5.3.1	Intellectual property payments, % total trade ⊕	0.1	99	
5.3.2	High-tech imports, % total trade ⊕	9.8	35	●
5.3.3	ICT services imports, % total trade	0.6	96	
5.3.4	FDI net inflows, % GDP	3.0	57	
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**5.7**	**125**	○ ◇
6.1	**Knowledge creation**	**4.6**	**102**	
6.1.1	Patents by origin/bn PPP$ GDP	0.1	107	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	79	
6.1.3	Utility models by origin/bn PPP$ GDP	0.4	36	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.5	76	
6.1.5	Citable documents H-index	2.6	114	
6.2	**Knowledge impact**	**3.9**	**[123]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64	2.0	51	◆
6.2.3	Computer software spending, % GDP	0.0	103	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.4	122	○
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**8.6**	**113**	
6.3.1	Intellectual property receipts, % total trade ⊕	0.0	85	
6.3.2	High-tech net exports, % total trade ⊕	0.2	94	
6.3.3	ICT services exports, % total trade	0.8	86	
6.3.4	FDI net outflows, % GDP	0.4	74	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**16.9**	**108**	
7.1	**Intangible assets**	**33.0**	**100**	
7.1.1	Trademarks by origin/bn PPP$ GDP	10.3	105	
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊕	0.2	97	
7.1.3	ICTs & business model creation†	60.8	62	◆
7.1.4	ICTs & organizational model creation†	51.0	77	◆
7.2	**Creative goods & services**	**1.5**	**[119]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	105	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade ⊕	0.2	87	
7.3	**Online creativity**	**0.1**	**123**	○
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.1	120	○
7.3.2	Country-code TLDs/th pop. 15–69	0.1	113	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊕	0.2	117	○
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SAUDI ARABIA

GII 2019 rank

68

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
85	**49**	**High**	**NAWA**	**33.6**	**1,856.9**	**55,943.9**	**61**

		Score/Value	Rank	
	INSTITUTIONS	**51.3**	**104**	◇
1.1	**Political environment**	**53.2**	**70**	◇
1.1.1	Political and operational stability*	54.4	111	○ ◇
1.1.2	Government effectiveness*	52.5	55	◇
1.2	**Regulatory environment**	**60.7**	**80**	◇
1.2.1	Regulatory quality*	41.9	71	◇
1.2.2	Rule of law*	49.0	56	◇
1.2.3	Cost of redundancy dismissal, salary weeks	23.7	99	◇
1.3	**Business environment**	**40.0**	**129**	○ ◇
1.3.1	Ease of starting a business*	80.1	107	○ ◇
1.3.2	Ease of resolving insolvency*	0.0	129	○ ◇

	HUMAN CAPITAL & RESEARCH	**45.5**	**29**	●
2.1	**Education**	**63.2**	**[14]**	
2.1.1	Expenditure on education, % GDP ⊙	5.1	43	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years ⊙	16.9	18	●
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	11.0	37	
2.2	**Tertiary education**	**36.1**	**49**	
2.2.1	Tertiary enrolment, % gross	68.9	29	●
2.2.2	Graduates in science & engineering, %	21.9	51	
2.2.3	Tertiary inbound mobility, %	4.9	42	
2.3	**Research & development (R&D)**	**37.3**	**29**	●
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.8	42	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	53.4	26	●
2.3.4	QS university ranking, average score top 3*	40.9	31	●

	INFRASTRUCTURE	**48.9**	**55**	◇
3.1	**Information & communication technologies(ICTs)**	**71.7**	**53**	◇
3.1.1	ICT access*	74.8	44	
3.1.2	ICT use*	61.6	54	◇
3.1.3	Government's online service*	79.2	48	
3.1.4	E-participation*	71.4	65	◇
3.2	**General infrastructure**	**43.2**	**37**	
3.2.1	Electricity output, kWh/mn pop.	10,681.8	12	●
3.2.2	Logistics performance*	44.3	54	◇
3.2.3	Gross capital formation, % GDP	26.6	35	
3.3	**Ecological sustainability**	**31.9**	**86**	◇
3.3.1	GDP/unit of energy use	7.6	83	
3.3.2	Environmental performance*	57.5	75	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.2	110	○ ◇

	MARKET SOPHISTICATION	**51.9**	**47**	
4.1	**Credit**	**34.7**	**68**	◇
4.1.1	Ease of getting credit*	45.0	94	
4.1.2	Domestic credit to private sector, % GDP	54.1	60	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**47.0**	**47**	
4.2.1	Ease of protecting minority investors*	80.0	6	● ◆
4.2.2	Market capitalization, % GDP	66.6	23	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	74	○
4.3	**Trade, competition, & market scale**	**74.0**	**23**	●
4.3.1	Applied tariff rate, weighted avg., %	4.9	84	◇
4.3.2	Intensity of local competition†	74.8	29	●
4.3.3	Domestic market scale, bn PPP$	1,856.9	16	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**34.3**	**[48]**	
5.1	**Knowledge workers**	**37.3**	**[63]**	
5.1.1	Knowledge-intensive employment, % ⊙	27.3	51	◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	5.5	88	◇
5.2	**Innovation linkages**	**30.3**	**45**	
5.2.1	University/industry research collaboration†	48.0	43	
5.2.2	State of cluster development†	62.1	21	●
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	72	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	53	
5.3	**Knowledge absorption**	**35.4**	**[55]**	
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade ⊙	7.6	62	
5.3.3	ICT services imports, % total trade	1.4	53	
5.3.4	FDI net inflows, % GDP	0.9	107	○
5.3.5	Research talent, % in business enterprise	n/a	n/a	

	KNOWLEDGE & TECHNOLOGY OUTPUTS	**17.0**	**87**	◇
6.1	**Knowledge creation**	**12.8**	**63**	
6.1.1	Patents by origin/bn PPP$ GDP	0.7	73	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.4	43	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	6.2	67	◇
6.1.5	Citable documents H-index	18.7	39	
6.2	**Knowledge impact**	**26.5**	**104**	◇
6.2.1	Growth rate of PPP$ GDP/worker, %	-4.0	111	○ ◇
6.2.2	New businesses/th pop. 15–64	0.4	88	○
6.2.3	Computer software spending, % GDP	0.4	28	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.3	103	◇
6.2.5	High- & medium-high-tech manufactures, %	0.4	31	
6.3	**Knowledge diffusion**	**11.8**	**93**	◇
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade ⊙	0.6	75	◇
6.3.3	ICT services exports, % total trade	0.2	118	○ ◇
6.3.4	FDI net outflows, % GDP	1.0	54	

	CREATIVE OUTPUTS	**21.9**	**86**	◇
7.1	**Intangible assets**	**36.9**	**84**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP ⊙	4.3	118	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.3	96	
7.1.3	ICTs & business model creation†	66.5	45	
7.1.4	ICTs & organizational model creation†	61.5	40	
7.2	**Creative goods & services**	**11.7**	**78**	◇
7.2.1	Cultural & creative services exports, % total trade ⊙	0.0	115	○ ◇
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	13.9	30	◇
7.2.4	Printing & other media, % manufacturing	1.3	39	
7.2.5	Creative goods exports, % total trade ⊙	0.4	66	
7.3	**Online creativity**	**2.0**	**84**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	2.8	67	◇
7.3.2	Country-code TLDs/th pop. 15–69	0.6	90	◇
7.3.3	Wikipedia edits/mn pop. 15–69	6.0	74	◇
7.3.4	Mobile app creation/bn PPP$ GDP	0.3	77	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SENEGAL

GII 2019 rank

96

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
81	103	Low	SSF	16.3	60.0	3,651.2	100

		Score/Value	Rank	
	INSTITUTIONS	**60.4**	**75**	◆
1.1	**Political environment**	**49.3**	**86**	◆
1.1.1	Political and operational stability*	70.2	61	◆
1.1.2	Government effectiveness*	38.8	89	◆
1.2	**Regulatory environment**	**64.9**	**67**	
1.2.1	Regulatory quality*	38.0	80	◆
1.2.2	Rule of law*	42.4	68	◆
1.2.3	Cost of redundancy dismissal, salary weeks	14.8	59	
1.3	**Business environment**	**67.1**	**73**	
1.3.1	Ease of starting a business*	89.9	54	
1.3.2	Ease of resolving insolvency*	44.3	84	
	HUMAN CAPITAL & RESEARCH	**20.6**	**93**	◆
2.1	**Education**	**36.8**	**97**	
2.1.1	Expenditure on education, % GDP	6.2	19	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	15.2	83	
2.1.3	School life expectancy, years	9.0	111	○
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	18.9	83	
2.2	**Tertiary education**	**19.4**	**96**	
2.2.1	Tertiary enrolment, % gross	11.2	106	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	8.3	25	● ◆
2.3	**Research & development (R&D)**	**5.7**	**74**	◆
2.3.1	Researchers, FTE/mn pop. ⊙	549.3	65	◆
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.8	48	◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**31.1**	**111**	
3.1	**Information & communication technologies(ICTs)**	**39.0**	**106**	
3.1.1	ICT access*	38.4	106	◆
3.1.2	ICT use*	19.2	109	
3.1.3	Government's online service*	47.9	106	
3.1.4	E-participation*	50.6	103	
3.2	**General infrastructure**	**24.2**	**103**	
3.2.1	Electricity output, kWh/mn pop.	289.2	112	
3.2.2	Logistics performance*	8.8	118	○
3.2.3	Gross capital formation, % GDP	25.9	40	●
3.3	**Ecological sustainability**	**30.1**	**94**	
3.3.1	GDP/unit of energy use	8.3	70	
3.3.2	Environmental performance*	49.5	100	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	105	
	MARKET SOPHISTICATION	**35.6**	**118**	
4.1	**Credit**	**20.7**	**116**	
4.1.1	Ease of getting credit*	30.0	115	○
4.1.2	Domestic credit to private sector, % GDP	29.5	96	
4.1.3	Microfinance gross loans, % GDP	1.2	17	●
4.2	**Investment**	**41.7**	**[65]**	
4.2.1	Ease of protecting minority investors*	41.7	108	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**44.3**	**119**	
4.3.1	Applied tariff rate, weighted avg., %	12.3	123	○
4.3.2	Intensity of local competition†	68.0	68	◆
4.3.3	Domestic market scale, bn PPP$	60.0	93	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**20.2**	**119**	
5.1	**Knowledge workers**	**9.1**	**123**	○
5.1.1	Knowledge-intensive employment, % ⊙	6.4	106	
5.1.2	Firms offering formal training, % firms	17.4	81	
5.1.3	GERD performed by business, % GDP ⊙	0.0	87	○
5.1.4	GERD financed by business, % ⊙	2.1	88	
5.1.5	Females employed w/advanced degrees, % ⊙	1.8	102	
5.2	**Innovation linkages**	**21.5**	**78**	
5.2.1	University/industry research collaboration†	39.8	71	
5.2.2	State of cluster development†	40.3	92	
5.2.3	GERD financed by abroad, % ⊙	7.9	49	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**29.9**	**83**	
5.3.1	Intellectual property payments, % total trade	0.1	95	
5.3.2	High-tech imports, % total trade	5.9	93	
5.3.3	ICT services imports, % total trade	2.6	12	● ◆
5.3.4	FDI net inflows, % GDP	2.4	71	
5.3.5	Research talent, % in business enterprise ⊙	0.1	86	○ ◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**19.4**	**77**	◆
6.1	**Knowledge creation**	**5.1**	**96**	
6.1.1	Patents by origin/bn PPP$ GDP	0.4	80	◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	71	◆
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.0	93	
6.1.5	Citable documents H-index	5.9	90	
6.2	**Knowledge impact**	**34.7**	**75**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.4	19	●
6.2.2	New businesses/th pop. 15–64	0.4	90	
6.2.3	Computer software spending, % GDP	0.3	40	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.9	108	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.2	63	◆
6.3	**Knowledge diffusion**	**18.3**	**58**	◆
6.3.1	Intellectual property receipts, % total trade	0.1	61	
6.3.2	High-tech net exports, % total trade	0.3	89	◆
6.3.3	ICT services exports, % total trade	4.4	12	● ◆
6.3.4	FDI net outflows, % GDP	0.5	65	
	CREATIVE OUTPUTS	**20.8**	**92**	
7.1	**Intangible assets**	**36.9**	**85**	
7.1.1	Trademarks by origin/bn PPP$ GDP	11.4	103	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.8	75	
7.1.3	ICTs & business model creation†	65.3	51	● ◆
7.1.4	ICTs & organizational model creation†	58.1	52	◆
7.2	**Creative goods & services**	**9.0**	**90**	
7.2.1	Cultural & creative services exports, % total trade	0.9	30	● ◆
7.2.2	National feature films/mn pop. 15–69	0.2	104	○ ◇
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	0.8	74	◇
7.2.5	Creative goods exports, % total trade	0.1	102	
7.3	**Online creativity**	**0.4**	**109**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	1.0	95	◆
7.3.2	Country-code TLDs/th pop. 15–69	0.1	111	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.2	114	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SERBIA

GII 2019 rank

57

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
57	**62**	**Upper middle**	**EUR**	**8.8**	**112.5**	**17,555.2**	**55**

		Score/Value	Rank	
	INSTITUTIONS	**68.7**	**47**	◆
1.1	**Political environment**	**58.7**	**55**	
1.1.1	Political and operational stability*	73.7	50	
1.1.2	Government effectiveness*	51.2	59	
1.2	**Regulatory environment**	**70.9**	**49**	
1.2.1	Regulatory quality*	42.2	70	
1.2.2	Rule of law*	41.3	72	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**76.7**	**40**	
1.3.1	Ease of starting a business*	92.6	37	
1.3.2	Ease of resolving insolvency*	60.8	45	
	HUMAN CAPITAL & RESEARCH	**32.4**	**59**	
2.1	**Education**	**43.3**	**77**	
2.1.1	Expenditure on education, % GDP	3.9	83	
2.1.2	Government funding/pupil, secondary, % GDP/cap	11.9	89	○
2.1.3	School life expectancy, years	14.8	57	
2.1.4	PISA scales in reading, maths, & science ⊙	446.6	43	
2.1.5	Pupil-teacher ratio, secondary	8.1	9	● ◆
2.2	**Tertiary education**	**41.7**	**30**	
2.2.1	Tertiary enrolment, % gross	66.5	35	
2.2.2	Graduates in science & engineering, %	26.6	22	
2.2.3	Tertiary inbound mobility, %	4.4	46	
2.3	**Research & development (R&D)**	**12.0**	**50**	
2.3.1	Researchers, FTE/mn pop	2,079.1	39	◆
2.3.2	Gross expenditure on R&D, % GDP	0.9	38	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	2.9	76	
	INFRASTRUCTURE	**49.9**	**54**	
3.1	**Information & communication technologies(ICTs)**	**73.2**	**50**	
3.1.1	ICT access*	76.6	37	◆
3.1.2	ICT use*	61.0	56	
3.1.3	Government's online service*	73.6	57	
3.1.4	E-participation*	81.5	48	
3.2	**General infrastructure**	**30.8**	**84**	
3.2.1	Electricity output, kWh/mn pop	5,469.4	39	◆
3.2.2	Logistics performance*	36.4	64	
3.2.3	Gross capital formation, % GDP	21.3	84	
3.3	**Ecological sustainability**	**45.6**	**43**	
3.3.1	GDP/unit of energy use	6.0	100	○ ◇
3.3.2	Environmental performance*	57.5	73	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	11.1	5	● ◆
	MARKET SOPHISTICATION	**39.6**	**103**	○ ◇
4.1	**Credit**	**28.0**	**98**	○
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	43.0	77	
4.1.3	Microfinance gross loans, % GDP	0.0	65	○
4.2	**Investment**	**38.8**	**82**	
4.2.1	Ease of protecting minority investors*	56.7	79	
4.2.2	Market capitalization, % GDP ⊙	11.5	69	○
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**52.0**	**101**	○ ◇
4.3.1	Applied tariff rate, weighted avg., %	n/a	n/a	
4.3.2	Intensity of local competition†	64.1	84	
4.3.3	Domestic market scale, bn PPP$	112.5	73	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**31.9**	**63**	
5.1	**Knowledge workers**	**36.4**	**67**	
5.1.1	Knowledge-intensive employment, %	28.5	48	
5.1.2	Firms offering formal training, % firms	37.8	36	
5.1.3	GERD performed by business, % GDP	0.3	45	
5.1.4	GERD financed by business, %	10.0	75	○
5.1.5	Females employed w/advanced degrees, %	14.2	45	
5.2	**Innovation linkages**	**26.5**	**61**	
5.2.1	University/industry research collaboration†	38.5	76	
5.2.2	State of cluster development†	42.9	81	
5.2.3	GERD financed by abroad, %	19.9	18	●
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	63	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	57	
5.3	**Knowledge absorption**	**32.9**	**66**	
5.3.1	Intellectual property payments, % total trade	1.0	38	
5.3.2	High-tech imports, % total trade	5.4	99	○
5.3.3	ICT services imports, % total trade	2.1	26	● ◆
5.3.4	FDI net inflows, % GDP	6.5	20	● ◆
5.3.5	Research talent, % in business enterprise	10.6	64	○
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**26.7**	**48**	
6.1	**Knowledge creation**	**21.0**	**40**	
6.1.1	Patents by origin/bn PPP$ GDP	1.7	49	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.2	54	
6.1.3	Utility models by origin/bn PPP$ GDP	0.7	32	
6.1.4	Scientific & technical articles/bn PPP$ GDP	33.1	4	● ◆
6.1.5	Citable documents H-index	10.8	60	
6.2	**Knowledge impact**	**37.8**	**59**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.0	87	○
6.2.2	New businesses/th pop. 15-64	1.8	53	
6.2.3	Computer software spending, % GDP	0.0	108	○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	27.0	6	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.2	47	
6.3	**Knowledge diffusion**	**21.1**	**48**	
6.3.1	Intellectual property receipts, % total trade	0.2	36	◆
6.3.2	High-tech net exports, % total trade	1.6	59	
6.3.3	ICT services exports, % total trade	4.3	13	● ◆
6.3.4	FDI net outflows, % GDP	0.6	62	
	CREATIVE OUTPUTS	**27.2**	**65**	
7.1	**Intangible assets**	**36.0**	**93**	
7.1.1	Trademarks by origin/bn PPP$ GDP	29.1	76	
7.1.2	Industrial designs by origin/bn PPP$ GDP	2.0	51	
7.1.3	ICTs & business model creation†	57.7	77	
7.1.4	ICTs & organizational model creation†	51.7	74	
7.2	**Creative goods & services**	**22.7**	**47**	
7.2.1	Cultural & creative services exports, % total trade	1.4	17	● ◆
7.2.2	National feature films/mn pop. 15-69	5.7	39	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.6	28	
7.2.5	Creative goods exports, % total trade	0.7	51	
7.3	**Online creativity**	**14.2**	**42**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	1.4	90	
7.3.2	Country-code TLDs/th pop. 15-69	4.5	54	
7.3.3	Wikipedia edits/mn pop. 15-69	40.2	35	◆
7.3.4	Mobile app creation/bn PPP$ GDP	23.6	21	◆

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SINGAPORE

GII 2019 rank

8

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
15	**1**	**High**	**SEAO**	**5.8**	**556.2**	**100,344.7**	**5**

		Score/Value	Rank	
	INSTITUTIONS	**94.9**	**1**	● ◆
1.1	**Political environment**	**100.0**	**1**	● ◆
1.1.1	Political and operational stability*	100.0	1	● ◆
1.1.2	Government effectiveness*	100.0	1	● ◆
1.2	**Regulatory environment**	**98.3**	**2**	●
1.2.1	Regulatory quality*	98.7	2	● ◆
1.2.2	Rule of law*	94.6	8	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**86.3**	**17**	
1.3.1	Ease of starting a business*	98.2	3	● ◆
1.3.2	Ease of resolving insolvency*	74.3	25	
	HUMAN CAPITAL & RESEARCH	**63.0**	**5**	◆
2.1	**Education**	**50.3**	**57**	○ ◇
2.1.1	Expenditure on education, % GDP ◷	2.9	104	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap ◷	16.7	73	○ ◇
2.1.3	School life expectancy, years	16.3	26	
2.1.4	PISA scales in reading, maths, & science	551.6	1	● ◆
2.1.5	Pupil-teacher ratio, secondary ◷	11.7	47	○
2.2	**Tertiary education**	**77.1**	**1**	● ◆
2.2.1	Tertiary enrolment, % gross ◷	83.9	13	
2.2.2	Graduates in science & engineering, %	34.5	5	◆
2.2.3	Tertiary inbound mobility, %	27.2	1	● ◆
2.3	**Research & development (R&D)**	**61.6**	**13**	
2.3.1	Researchers, FTE/mn pop. ◷	6,729.7	5	
2.3.2	Gross expenditure on R&D, % GDP ◷	2.2	13	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	48.8	30	
2.3.4	QS university ranking, average score top 3*	68.9	12	
	INFRASTRUCTURE	**65.4**	**7**	
3.1	**Information & communication technologies(ICTs)**	**89.6**	**11**	
3.1.1	ICT access*	87.2	9	
3.1.2	ICT use*	75.8	26	
3.1.3	Government's online service*	98.6	2	●
3.1.4	E-participation*	96.6	13	
3.2	**General infrastructure**	**54.7**	**11**	
3.2.1	Electricity output, kWh/mn pop.	9,209.8	17	
3.2.2	Logistics performance*	90.4	7	
3.2.3	Gross capital formation, % GDP	27.8	30	
3.3	**Ecological sustainability**	**52.1**	**22**	
3.3.1	GDP/unit of energy use	16.4	9	
3.3.2	Environmental performance*	64.2	45	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.4	43	
	MARKET SOPHISTICATION	**73.6**	**5**	◆
4.1	**Credit**	**68.4**	**13**	
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP	128.2	17	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**76.7**	**5**	◆
4.2.1	Ease of protecting minority investors*	80.0	6	◆
4.2.2	Market capitalization, % GDP	220.1	4	◆
4.2.3	Venture capital deals/bn PPP$ GDP	0.2	7	
4.3	**Trade, competition, & market scale**	**75.6**	**19**	
4.3.1	Applied tariff rate, weighted avg., %	0.1	3	● ◆
4.3.2	Intensity of local competition†	78.4	15	
4.3.3	Domestic market scale, bn PPP$	556.2	35	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**63.9**	**4**	● ◆
5.1	**Knowledge workers**	**71.0**	**9**	
5.1.1	Knowledge-intensive employment, %	56.1	1	● ◆
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ◷	1.3	16	
5.1.4	GERD financed by business, % ◷	54.1	19	
5.1.5	Females employed w/advanced degrees, %	17.1	36	◇
5.2	**Innovation linkages**	**49.3**	**14**	
5.2.1	University/industry research collaboration†	70.0	10	
5.2.2	State of cluster development†	68.6	11	
5.2.3	GERD financed by abroad, % ◷	6.8	54	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.2	1	● ◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	2.2	18	
5.3	**Knowledge absorption**	**71.3**	**1**	● ◆
5.3.1	Intellectual property payments, % total trade	3.3	5	◆
5.3.2	High-tech imports, % total trade	21.2	7	◆
5.3.3	ICT services imports, % total trade	2.7	11	
5.3.4	FDI net inflows, % GDP	22.3	8	◆
5.3.5	Research talent, % in business enterprise ◷	50.5	24	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**50.9**	**11**	
6.1	**Knowledge creation**	**33.4**	**27**	◇
6.1.1	Patents by origin/bn PPP$ GDP	3.0	33	◇
6.1.2	PCT patents by origin/bn PPP$ GDP	1.7	20	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	17.5	28	
6.1.5	Citable documents H-index	36.5	23	
6.2	**Knowledge impact**	**53.9**	**11**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.5	33	
6.2.2	New businesses/th pop. 15–64	8.6	16	
6.2.3	Computer software spending, % GDP	0.3	41	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.0	46	○
6.2.5	High- & medium-high-tech manufactures, %	0.8	1	● ◆
6.3	**Knowledge diffusion**	**65.2**	**5**	◆
6.3.1	Intellectual property receipts, % total trade	1.6	15	
6.3.2	High-tech net exports, % total trade	27.4	1	● ◆
6.3.3	ICT services exports, % total trade	2.4	44	
6.3.4	FDI net outflows, % GDP	9.0	8	◆
	CREATIVE OUTPUTS	**38.3**	**34**	◇
7.1	**Intangible assets**	**47.3**	**46**	○ ◇
7.1.1	Trademarks by origin/bn PPP$ GDP	20.1	88	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.1	62	○
7.1.3	ICTs & business model creation†	80.4	7	
7.1.4	ICTs & organizational model creation†	74.6	14	
7.2	**Creative goods & services**	**32.2**	**20**	
7.2.1	Cultural & creative services exports, % total trade	1.9	8	
7.2.2	National feature films/mn pop. 15–69	2.9	57	○
7.2.3	Entertainment & Media market/th pop. 15–69	42.3	20	
7.2.4	Printing & other media, % manufacturing	0.7	80	○
7.2.5	Creative goods exports, % total trade	4.4	11	
7.3	**Online creativity**	**26.4**	**28**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	25.6	23	
7.3.2	Country-code TLDs/th pop. 15–69	11.2	38	◇
7.3.3	Wikipedia edits/mn pop. 15–69	23.8	45	○ ◇
7.3.4	Mobile app creation/bn PPP$ GDP	52.9	10	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SLOVAKIA

GII 2019 rank

37

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
33	42	High	EUR	5.4	191.1	35,129.8	36

		Score/Value	Rank	
1	**INSTITUTIONS**	**73.1**	**38**	
1.1	**Political environment**	**71.6**	**38**	
1.1.1	Political and operational stability*	82.5	32	
1.1.2	Government effectiveness*	66.1	38	
1.2	**Regulatory environment**	**73.2**	**40**	
1.2.1	Regulatory quality*	64.1	37	
1.2.2	Rule of law*	61.5	39	
1.2.3	Cost of redundancy dismissal, salary weeks	18.8	78	
1.3	**Business environment**	**74.5**	**51**	
1.3.1	Ease of starting a business*	82.0	98	○ ◇
1.3.2	Ease of resolving insolvency*	66.9	39	

		Score/Value	Rank	
2	**HUMAN CAPITAL & RESEARCH**	**32.4**	**58**	◇
2.1	**Education**	**48.9**	**63**	
2.1.1	Expenditure on education, % GDP	4.6	58	
2.1.2	Government funding/pupil, secondary, % GDP/cap	19.2	53	
2.1.3	School life expectancy, years	14.5	63	◇
2.1.4	PISA scales in reading, maths, & science	462.8	41	
2.1.5	Pupil-teacher ratio, secondary ⊙	11.2	39	
2.2	**Tertiary education**	**31.8**	**61**	
2.2.1	Tertiary enrolment, % gross ⊙	47.8	61	
2.2.2	Graduates in science & engineering, % ⊙	21.1	57	
2.2.3	Tertiary inbound mobility, %	6.0	37	
2.3	**Research & development (R&D)**	**16.7**	**47**	
2.3.1	Researchers, FTE/mn pop.	2,795.0	34	
2.3.2	Gross expenditure on R&D, % GDP	0.9	40	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	13.8	58	

		Score/Value	Rank	
3	**INFRASTRUCTURE**	**54.2**	**36**	
3.1	**Information & communication technologies(ICTs)**	**74.4**	**47**	
3.1.1	ICT access*	73.9	53	◇
3.1.2	ICT use*	69.1	36	
3.1.3	Government's online service*	73.6	57	◇
3.1.4	E-participation*	80.9	50	
3.2	**General infrastructure**	**34.7**	**65**	
3.2.1	Electricity output, kWh/mn pop.	4,843.8	47	
3.2.2	Logistics performance*	45.1	52	◇
3.2.3	Gross capital formation, % GDP	23.5	60	
3.3	**Ecological sustainability**	**53.5**	**15**	●
3.3.1	GDP/unit of energy use	9.6	59	
3.3.2	Environmental performance*	70.6	27	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	9.0	8	● ◆

		Score/Value	Rank	
4	**MARKET SOPHISTICATION**	**47.4**	**67**	
4.1	**Credit**	**48.7**	**35**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	59.9	55	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**27.0**	**125**	○ ◇
4.2.1	Ease of protecting minority investors*	53.3	87	○
4.2.2	Market capitalization, % GDP ⊙	5.1	73	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	67	○
4.3	**Trade, competition, & market scale**	**66.6**	**47**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	73.7	35	
4.3.3	Domestic market scale, bn PPP$	191.1	63	

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**35.6**	**46**	
5.1	**Knowledge workers**	**47.3**	**40**	
5.1.1	Knowledge-intensive employment, %	32.0	41	
5.1.2	Firms offering formal training, % firms	43.5	28	
5.1.3	GERD performed by business, % GDP	0.5	39	
5.1.4	GERD financed by business, %	46.2	34	
5.1.5	Females employed w/advanced degrees, %	13.9	46	
5.2	**Innovation linkages**	**23.4**	**70**	◇
5.2.1	University/industry research collaboration†	38.3	79	○ ◇
5.2.2	State of cluster development†	46.6	63	
5.2.3	GERD financed by abroad, %	10.7	38	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	71	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.3	38	
5.3	**Knowledge absorption**	**35.9**	**51**	
5.3.1	Intellectual property payments, % total trade	0.8	50	
5.3.2	High-tech imports, % total trade	13.4	15	●
5.3.3	ICT services imports, % total trade	1.0	72	
5.3.4	FDI net inflows, % GDP	4.4	38	
5.3.5	Research talent, % in business enterprise	21.9	54	○

		Score/Value	Rank	
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**34.0**	**29**	
6.1	**Knowledge creation**	**20.2**	**44**	
6.1.1	Patents by origin/bn PPP$ GDP	1.2	58	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.3	46	
6.1.3	Utility models by origin/bn PPP$ GDP	1.9	12	● ◆
6.1.4	Scientific & technical articles/bn PPP$ GDP	13.6	38	
6.1.5	Citable documents H-index	16.3	44	
6.2	**Knowledge impact**	**51.5**	**13**	●
6.2.1	Growth rate of PPP$ GDP/worker, %	1.2	58	
6.2.2	New businesses/th pop. 15–64	4.7	28	
6.2.3	Computer software spending, % GDP	0.3	37	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	21.6	15	● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.6	4	● ◆
6.3	**Knowledge diffusion**	**30.3**	**29**	
6.3.1	Intellectual property receipts, % total trade	0.0	71	○
6.3.2	High-tech net exports, % total trade	9.2	17	●
6.3.3	ICT services exports, % total trade	1.7	62	
6.3.4	FDI net outflows, % GDP	3.5	19	●

		Score/Value	Rank	
7	**CREATIVE OUTPUTS**	**37.1**	**36**	
7.1	**Intangible assets**	**46.6**	**47**	
7.1.1	Trademarks by origin/bn PPP$ GDP	55.7	41	
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.1	41	
7.1.3	ICTs & business model creation†	66.9	41	
7.1.4	ICTs & organizational model creation†	65.0	28	
7.2	**Creative goods & services**	**41.0**	**7**	● ◆
7.2.1	Cultural & creative services exports, % total trade	0.4	57	
7.2.2	National feature films/mn pop. 15–69	6.6	34	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	0.5	91	○ ◇
7.2.5	Creative goods exports, % total trade	8.5	7	● ◆
7.3	**Online creativity**	**14.4**	**41**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	3.0	65	◇
7.3.2	Country-code TLDs/th pop. 15–69	26.6	21	●
7.3.3	Wikipedia edits/mn pop. 15–69	26.8	40	
7.3.4	Mobile app creation/bn PPP$ GDP	10.1	43	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SLOVENIA

GII 2019 rank

31

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
30	33	High	EUR	2.1	76.1	36,745.9	30

		Score/Value	Rank
	INSTITUTIONS	**82.3**	**20**
1.1	**Political environment**	**78.0**	**26**
1.1.1	Political and operational stability*	84.2	25
1.1.2	Government effectiveness*	74.9	25
1.2	**Regulatory environment**	**80.7**	**29**
1.2.1	Regulatory quality*	57.5	44
1.2.2	Rule of law*	73.5	27
1.2.3	Cost of redundancy dismissal, salary weeks	10.7	34
1.3	**Business environment**	**88.3**	**10** ●
1.3.1	Ease of starting a business*	92.9	35
1.3.2	Ease of resolving insolvency*	83.7	9 ●
	HUMAN CAPITAL & RESEARCH	**46.6**	**27**
2.1	**Education**	**60.0**	**25**
2.1.1	Expenditure on education, % GDP	4.9	51
2.1.2	Government funding/pupil, secondary, % GDP/cap	23.9	29
2.1.3	School life expectancy, years	17.4	16
2.1.4	PISA scales in reading, maths, & science	509.3	9 ●
2.1.5	Pupil-teacher ratio, secondary ⊙	9.7	25
2.2	**Tertiary education**	**40.7**	**35**
2.2.1	Tertiary enrolment, % gross ⊙	77.6	20
2.2.2	Graduates in science & engineering, %	25.0	30
2.2.3	Tertiary inbound mobility, %	3.3	61
2.3	**Research & development (R&D)**	**39.3**	**25**
2.3.1	Researchers, FTE/mn pop.	4,467.8	17
2.3.2	Gross expenditure on R&D, % GDP	1.9	19
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	52.3	28
2.3.4	QS university ranking, average score top 3*	10.5	63
	INFRASTRUCTURE	**53.9**	**37**
3.1	**Information & communication technologies(ICTs)**	**76.9**	**39**
3.1.1	ICT access*	80.6	24
3.1.2	ICT use*	65.7	43
3.1.3	Government's online service*	79.9	45
3.1.4	E-participation*	81.5	48
3.2	**General infrastructure**	**37.2**	**56**
3.2.1	Electricity output, kWh/mn pop.	7,721.7	26
3.2.2	Logistics performance*	58.5	34
3.2.3	Gross capital formation, % GDP	20.3	92 ○
3.3	**Ecological sustainability**	**47.5**	**41**
3.3.1	GDP/unit of energy use	9.1	64
3.3.2	Environmental performance*	67.6	33
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	6.3	16
	MARKET SOPHISTICATION	**43.6**	**87** ○ ◇
4.1	**Credit**	**32.4**	**81** ○ ◇
4.1.1	Ease of getting credit*	45.0	94 ○
4.1.2	Domestic credit to private sector, % GDP	44.8	75 ○ ◇
4.1.3	Microfinance gross loans, % GDP	n/a	n/a
4.2	**Investment**	**36.7**	**92** ○
4.2.1	Ease of protecting minority investors*	70.0	27
4.2.2	Market capitalization, % GDP	12.9	67 ○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	50 ○
4.3	**Trade, competition, & market scale**	**61.6**	**60**
4.3.1	Applied tariff rate, weighted avg., %	1.8	23
4.3.2	Intensity of local competition†	73.0	38
4.3.3	Domestic market scale, bn PPP$	76.1	87 ○ ◇

		Score/Value	Rank
	BUSINESS SOPHISTICATION	**44.1**	**27**
5.1	**Knowledge workers**	**63.3**	**20**
5.1.1	Knowledge-intensive employment, %	43.1	20
5.1.2	Firms offering formal training, % firms	41.5	32
5.1.3	GERD performed by business, % GDP	1.4	15
5.1.4	GERD financed by business, %	69.2	6 ● ◆
5.1.5	Females employed w/advanced degrees, %	21.8	20
5.2	**Innovation linkages**	**27.4**	**56**
5.2.1	University/industry research collaboration†	47.1	46
5.2.2	State of cluster development†	47.3	57
5.2.3	GERD financed by abroad, %	10.2	41
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	66 ○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	1.1	26
5.3	**Knowledge absorption**	**41.7**	**35**
5.3.1	Intellectual property payments, % total trade	0.7	58
5.3.2	High-tech imports, % total trade	5.4	103 ○
5.3.3	ICT services imports, % total trade	1.5	41
5.3.4	FDI net inflows, % GDP	3.2	53
5.3.5	Research talent, % in business enterprise	61.8	10 ●
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**30.7**	**40**
6.1	**Knowledge creation**	**31.8**	**29**
6.1.1	Patents by origin/bn PPP$ GDP ⊙	10.2	11 ●
6.1.2	PCT patents by origin/bn PPP$ GDP	1.5	23
6.1.3	Utility models by origin/bn PPP$ GDP ⊙	0.2	47 ○
6.1.4	Scientific & technical articles/bn PPP$ GDP	35.4	2 ● ◆
6.1.5	Citable documents H-index	17.5	42
6.2	**Knowledge impact**	**41.1**	**44**
6.2.1	Growth rate of PPP$ GDP/worker, %	1.5	49
6.2.2	New businesses/th pop. 15-64	3.1	40
6.2.3	Computer software spending, % GDP	0.1	91 ○ ◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	24.1	11 ● ◆
6.2.5	High- & medium-high-tech manufactures, %	0.3	46
6.3	**Knowledge diffusion**	**19.3**	**52**
6.3.1	Intellectual property receipts, % total trade	0.2	40
6.3.2	High-tech net exports, % total trade	4.5	33
6.3.3	ICT services exports, % total trade	1.6	66
6.3.4	FDI net outflows, % GDP	1.0	53
	CREATIVE OUTPUTS	**42.1**	**24**
7.1	**Intangible assets**	**55.3**	**18**
7.1.1	Trademarks by origin/bn PPP$ GDP ⊙	111.2	9 ● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊙	6.4	23
7.1.3	ICTs & business model creation†	68.0	36
7.1.4	ICTs & organizational model creation†	61.9	38
7.2	**Creative goods & services**	**27.3**	**36**
7.2.1	Cultural & creative services exports, % total trade	0.9	32
7.2.2	National feature films/mn pop. 15-69	14.2	8 ●
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a
7.2.4	Printing & other media, % manufacturing	1.7	27
7.2.5	Creative goods exports, % total trade	1.0	44
7.3	**Online creativity**	**30.3**	**25**
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	21.0	28
7.3.2	Country-code TLDs/th pop. 15-69	24.5	25
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	83.0	12 ●
7.3.4	Mobile app creation/bn PPP$ GDP	19.9	22

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SOUTH AFRICA

GII 2019 rank

63

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
68	51	Upper middle	SSF	57.4	790.9	13,675.3	58

		Score/Value	Rank	
1	**INSTITUTIONS**	**65.9**	**55**	
1.1	**Political environment**	**57.2**	**61**	
1.1.1	Political and operational stability*	64.9	79	
1.1.2	Government effectiveness*	53.3	51	
1.2	**Regulatory environment**	**72.6**	**43**	◆
1.2.1	Regulatory quality*	48.2	59	
1.2.2	Rule of law*	46.1	65	
1.2.3	Cost of redundancy dismissal, salary weeks	9.3	25	●
1.3	**Business environment**	**67.9**	**70**	
1.3.1	Ease of starting a business*	81.2	102	○
1.3.2	Ease of resolving insolvency*	54.5	61	
2	**HUMAN CAPITAL & RESEARCH**	**30.4**	**65**	
2.1	**Education**	**44.4**	**71**	
2.1.1	Expenditure on education, % GDP	6.1	20	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	19.5	51	
2.1.3	School life expectancy, years	13.7	71	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	26.8	101	○ ◇
2.2	**Tertiary education**	**21.0**	**92**	
2.2.1	Tertiary enrolment, % gross ⊙	20.5	93	◇
2.2.2	Graduates in science & engineering, %	18.5	70	
2.2.3	Tertiary inbound mobility, %	4.3	49	
2.3	**Research & development (R&D)**	**25.8**	**43**	
2.3.1	Researchers, FTE/mn pop. ⊙	473.1	69	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.8	44	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	46.6	33	◆
2.3.4	QS university ranking, average score top 3*	33.6	33	
3	**INFRASTRUCTURE**	**41.1**	**83**	
3.1	**Information & communication technologies(ICTs)**	**66.3**	**67**	
3.1.1	ICT access*	53.8	80	
3.1.2	ICT use*	43.1	81	
3.1.3	Government's online service*	83.3	37	
3.1.4	E-participation*	84.8	39	
3.2	**General infrastructure**	**32.6**	**71**	
3.2.1	Electricity output, kWh/mn pop.	4,461.7	49	
3.2.2	Logistics performance*	61.4	32	◆
3.2.3	Gross capital formation, % GDP	18.1	102	○
3.3	**Ecological sustainability**	**24.4**	**119**	○ ◇
3.3.1	GDP/unit of energy use	4.8	111	○ ◇
3.3.2	Environmental performance*	44.7	110	○ ◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.6	53	
4	**MARKET SOPHISTICATION**	**58.6**	**19**	● ◆
4.1	**Credit**	**44.0**	**48**	
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	147.7	9	● ◆
4.1.3	Microfinance gross loans, % GDP ⊙	0.0	64	○
4.2	**Investment**	**62.7**	**19**	● ◆
4.2.1	Ease of protecting minority investors*	73.3	21	●
4.2.2	Market capitalization, % GDP	302.1	1	● ◆
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	46	
4.3	**Trade, competition, & market scale**	**69.2**	**36**	
4.3.1	Applied tariff rate, weighted avg., %	4.6	80	
4.3.2	Intensity of local competition†	71.2	48	
4.3.3	Domestic market scale, bn PPP$	790.9	29	●

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**32.7**	**55**	
5.1	**Knowledge workers**	**33.9**	**74**	
5.1.1	Knowledge-intensive employment, %	23.2	64	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ⊙	0.3	46	
5.1.4	GERD financed by business, % ⊙	38.9	48	
5.1.5	Females employed w/advanced degrees, %	10.2	64	
5.2	**Innovation linkages**	**29.9**	**48**	◆
5.2.1	University/industry research collaboration†	54.2	33	◆
5.2.2	State of cluster development†	56.4	32	◆
5.2.3	GERD financed by abroad, % ⊙	13.0	32	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	45	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.3	40	
5.3	**Knowledge absorption**	**34.4**	**60**	
5.3.1	Intellectual property payments, % total trade	2.0	13	● ◆
5.3.2	High-tech imports, % total trade	9.9	32	●
5.3.3	ICT services imports, % total trade	1.2	60	
5.3.4	FDI net inflows, % GDP	0.5	117	○ ◇
5.3.5	Research talent, % in business enterprise ⊙	17.7	59	
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**23.9**	**57**	
6.1	**Knowledge creation**	**19.3**	**48**	
6.1.1	Patents by origin/bn PPP$ GDP	0.9	63	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.3	44	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	10.3	45	
6.1.5	Citable documents H-index	28.4	32	● ◆
6.2	**Knowledge impact**	**37.9**	**58**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.4	97	○
6.2.2	New businesses/th pop. 15–64	10.2	12	● ◆
6.2.3	Computer software spending, % GDP	0.3	48	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	5.5	56	
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.3	40	
6.3	**Knowledge diffusion**	**14.4**	**80**	
6.3.1	Intellectual property receipts, % total trade	0.1	49	
6.3.2	High-tech net exports, % total trade	2.0	55	
6.3.3	ICT services exports, % total trade	0.7	91	
6.3.4	FDI net outflows, % GDP	1.8	32	
7	**CREATIVE OUTPUTS**	**20.8**	**91**	
7.1	**Intangible assets**	**36.3**	**89**	
7.1.1	Trademarks by origin/bn PPP$ GDP	20.9	86	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.3	60	
7.1.3	ICTs & business model creation†	57.2	80	
7.1.4	ICTs & organizational model creation†	58.7	48	
7.2	**Creative goods & services**	**6.9**	**95**	
7.2.1	Cultural & creative services exports, % total trade ⊙	0.2	70	
7.2.2	National feature films/mn pop. 15–69 ⊙	0.8	90	○
7.2.3	Entertainment & Media market/th pop. 15–69	8.8	38	◆
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.8	48	
7.3	**Online creativity**	**3.7**	**73**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	3.0	63	
7.3.2	Country-code TLDs/th pop. 15–69	8.6	42	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	4.2	87	
7.3.4	Mobile app creation/bn PPP$ GDP	0.3	75	○

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SPAIN

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
28	25	High	EUR	46.4	1,867.9	40,138.8	28

		Score/Value	Rank	
	INSTITUTIONS	**78.1**	**30**	
1.1	**Political environment**	**73.5**	**33**	
1.1.1	Political and operational stability*	77.2	44	
1.1.2	Government effectiveness*	71.6	29	
1.2	**Regulatory environment**	**77.9**	**34**	
1.2.1	Regulatory quality*	67.2	34	
1.2.2	Rule of law*	73.1	30	
1.2.3	Cost of redundancy dismissal, salary weeks	17.4	74	○
1.3	**Business environment**	**83.0**	**25**	
1.3.1	Ease of starting a business*	86.9	69	○
1.3.2	Ease of resolving insolvency*	79.1	18	
	HUMAN CAPITAL & RESEARCH	**47.0**	**26**	
2.1	**Education**	**54.3**	**46**	
2.1.1	Expenditure on education, % GDP	4.3	71	○
2.1.2	Government funding/pupil, secondary, % GDP/cap	18.5	57	○
2.1.3	School life expectancy, years	17.9	13	●
2.1.4	PISA scales in reading, maths, & science	491.4	27	
2.1.5	Pupil-teacher ratio, secondary ⊙	11.6	46	
2.2	**Tertiary education**	**41.2**	**33**	
2.2.1	Tertiary enrolment, % gross ⊙	91.2	6	● ◆
2.2.2	Graduates in science & engineering, %	23.9	34	
2.2.3	Tertiary inbound mobility, %	2.7	68	○
2.3	**Research & development (R&D)**	**45.5**	**21**	
2.3.1	Researchers, FTE/mn pop.	2,873.4	32	
2.3.2	Gross expenditure on R&D, % GDP	1.2	31	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	74.2	14	●
2.3.4	QS university ranking, average score top 3*	47.0	23	
	INFRASTRUCTURE	**63.1**	**10**	●
3.1	**Information & communication technologies(ICTs)**	**87.4**	**17**	
3.1.1	ICT access*	80.5	25	
3.1.2	ICT use*	77.2	23	
3.1.3	Government's online service*	93.8	16	
3.1.4	E-participation*	98.3	5	● ◆
3.2	**General infrastructure**	**43.2**	**36**	
3.2.1	Electricity output, kWh/mn pop.	5,853.6	35	
3.2.2	Logistics performance*	82.7	17	
3.2.3	Gross capital formation, % GDP	21.8	77	○
3.3	**Ecological sustainability**	**58.8**	**8**	●
3.3.1	GDP/unit of energy use	12.5	26	
3.3.2	Environmental performance*	78.4	12	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	7.3	13	● ◆
	MARKET SOPHISTICATION	**59.5**	**18**	
4.1	**Credit**	**55.3**	**24**	
4.1.1	Ease of getting credit*	60.0	66	○
4.1.2	Domestic credit to private sector, % GDP	105.7	22	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**44.6**	**58**	
4.2.1	Ease of protecting minority investors*	70.0	27	
4.2.2	Market capitalization, % GDP	63.5	26	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	29	
4.3	**Trade, competition, & market scale**	**78.6**	**14**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	
4.3.2	Intensity of local competition†	75.8	22	
4.3.3	Domestic market scale, bn PPP$	1,867.9	15	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**38.7**	**37**	
5.1	**Knowledge workers**	**52.1**	**34**	
5.1.1	Knowledge-intensive employment, %	33.2	40	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	0.7	32	
5.1.4	GERD financed by business, %	46.7	33	
5.1.5	Females employed w/advanced degrees, %	22.1	19	
5.2	**Innovation linkages**	**26.5**	**60**	
5.2.1	University/industry research collaboration†	42.2	59	
5.2.2	State of cluster development†	54.4	36	
5.2.3	GERD financed by abroad, %	8.1	47	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	55	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.6	32	
5.3	**Knowledge absorption**	**37.5**	**46**	
5.3.1	Intellectual property payments, % total trade	1.2	28	
5.3.2	High-tech imports, % total trade	6.8	74	○
5.3.3	ICT services imports, % total trade	1.6	38	
5.3.4	FDI net inflows, % GDP	1.9	81	○
5.3.5	Research talent, % in business enterprise	37.2	35	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**37.2**	**24**	
6.1	**Knowledge creation**	**34.2**	**25**	
6.1.1	Patents by origin/bn PPP$ GDP	2.2	41	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.8	31	
6.1.3	Utility models by origin/bn PPP$ GDP	1.3	20	
6.1.4	Scientific & technical articles/bn PPP$ GDP	20.0	25	
6.1.5	Citable documents H-index	59.3	12	●
6.2	**Knowledge impact**	**48.5**	**18**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.5	74	○
6.2.2	New businesses/th pop. 15-64	3.2	39	
6.2.3	Computer software spending, % GDP	0.7	6	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	18.0	18	
6.2.5	High- & medium-high-tech manufactures, %	0.4	28	
6.3	**Knowledge diffusion**	**28.9**	**32**	
6.3.1	Intellectual property receipts, % total trade	0.5	27	
6.3.2	High-tech net exports, % total trade	3.9	36	
6.3.3	ICT services exports, % total trade	2.9	35	
6.3.4	FDI net outflows, % GDP	3.7	17	
	CREATIVE OUTPUTS	**39.7**	**31**	
7.1	**Intangible assets**	**56.7**	**14**	●
7.1.1	Trademarks by origin/bn PPP$ GDP	52.8	46	
7.1.2	Industrial designs by origin/bn PPP$ GDP	14.2	7	● ◆
7.1.3	ICTs & business model creation†	74.3	22	
7.1.4	ICTs & organizational model creation†	63.4	34	
7.2	**Creative goods & services**	**21.2**	**54**	
7.2.1	Cultural & creative services exports, % total trade	1.0	28	
7.2.2	National feature films/mn pop. 15-69	7.3	25	
7.2.3	Entertainment & Media market/th pop. 15-69	28.2	24	
7.2.4	Printing & other media, % manufacturing	1.3	41	
7.2.5	Creative goods exports, % total trade	0.9	46	
7.3	**Online creativity**	**24.0**	**30**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	28.0	22	
7.3.2	Country-code TLDs/th pop. 15-69	16.4	30	
7.3.3	Wikipedia edits/mn pop. 15-69	58.8	17	
7.3.4	Mobile app creation/bn PPP$ GDP	12.0	38	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SRI LANKA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
77	**94**	**Lower middle**	**CSA**	**21.0**	**292.8**	**13,397.5**	**88**

		Score/Value	Rank	
	INSTITUTIONS	**50.7**	**107**	
1.1	**Political environment**	**52.6**	**72**	
1.1.1	Political and operational stability*	71.9	58	◆
1.1.2	Government effectiveness*	42.9	80	
1.2	**Regulatory environment**	**33.1**	**127**	○ ◇
1.2.1	Regulatory quality*	38.4	78	
1.2.2	Rule of law*	47.8	60	◆
1.2.3	Cost of redundancy dismissal, salary weeks	58.5	126	○ ◇
1.3	**Business environment**	**66.5**	**77**	
1.3.1	Ease of starting a business*	87.9	67	
1.3.2	Ease of resolving insolvency*	45.1	82	
	HUMAN CAPITAL & RESEARCH	**14.0**	**111**	○
2.1	**Education**	**32.3**	**103**	
2.1.1	Expenditure on education, % GDP	2.8	107	○
2.1.2	Government funding/pupil, secondary, % GDP/cap	10.4	96	○
2.1.3	School life expectancy, years	14.0	70	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	17.4	78	
2.2	**Tertiary education**	**8.0**	**113**	○ ◇
2.2.1	Tertiary enrolment, % gross	19.0	96	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	0.5	96	○
2.3	**Research & development (R&D)**	**1.6**	**95**	
2.3.1	Researchers, FTE/mn pop. ◷	107.0	85	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.1	105	○
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	3.2	75	
	INFRASTRUCTURE	**48.5**	**57**	◆
3.1	**Information & communication technologies(ICTs)**	**50.3**	**94**	
3.1.1	ICT access*	49.7	88	
3.1.2	ICT use*	22.1	103	
3.1.3	Government's online service*	66.7	75	
3.1.4	E-participation*	62.9	82	
3.2	**General infrastructure**	**40.5**	**43**	● ◆
3.2.1	Electricity output, kWh/mn pop.	673.8	102	
3.2.2	Logistics performance*	25.0	89	
3.2.3	Gross capital formation, % GDP	36.8	10	● ◆
3.3	**Ecological sustainability**	**54.7**	**12**	● ◆
3.3.1	GDP/unit of energy use	20.4	5	● ◆
3.3.2	Environmental performance*	60.6	63	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.8	73	
	MARKET SOPHISTICATION	**38.7**	**108**	
4.1	**Credit**	**22.5**	**113**	○
4.1.1	Ease of getting credit*	40.0	104	○ ◇
4.1.2	Domestic credit to private sector, % GDP ◷	45.7	74	
4.1.3	Microfinance gross loans, % GDP	0.4	33	●
4.2	**Investment**	**36.5**	**95**	
4.2.1	Ease of protecting minority investors*	66.7	35	●
4.2.2	Market capitalization, % GDP	23.5	55	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	45	
4.3	**Trade, competition, & market scale**	**57.0**	**80**	
4.3.1	Applied tariff rate, weighted avg., %	8.7	107	
4.3.2	Intensity of local competition†	65.3	80	
4.3.3	Domestic market scale, bn PPP$	292.8	57	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**28.5**	**77**	
5.1	**Knowledge workers**	**26.2**	**95**	
5.1.1	Knowledge-intensive employment, %	20.4	73	
5.1.2	Firms offering formal training, % firms ◷	18.4	78	○ ◇
5.1.3	GERD performed by business, % GDP ◷	0.0	74	
5.1.4	GERD financed by business, % ◷	34.4	55	
5.1.5	Females employed w/advanced degrees, %	9.6	67	
5.2	**Innovation linkages**	**21.8**	**73**	
5.2.1	University/industry research collaboration†	37.9	82	
5.2.2	State of cluster development†	47.1	58	
5.2.3	GERD financed by abroad, % ◷	1.5	87	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	20	● ◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	73	
5.3	**Knowledge absorption**	**37.4**	**47**	●
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade	7.6	61	
5.3.3	ICT services imports, % total trade	2.0	27	● ◆
5.3.4	FDI net inflows, % GDP	1.2	103	
5.3.5	Research talent, % in business enterprise ◷	22.5	52	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**19.9**	**73**	
6.1	**Knowledge creation**	**5.9**	**92**	
6.1.1	Patents by origin/bn PPP$ GDP	1.0	61	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	72	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	2.2	111	○
6.1.5	Citable documents H-index	8.7	75	
6.2	**Knowledge impact**	**32.0**	**85**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.2	40	●
6.2.2	New businesses/th pop. 15–64 ◷	0.5	87	
6.2.3	Computer software spending, % GDP	0.3	32	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.4	83	
6.2.5	High- & medium-high-tech manufactures, % ◷	0.1	87	
6.3	**Knowledge diffusion**	**21.6**	**46**	●
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.2	92	
6.3.3	ICT services exports, % total trade	4.2	16	●
6.3.4	FDI net outflows, % GDP	0.1	95	
	CREATIVE OUTPUTS	**21.8**	**87**	
7.1	**Intangible assets**	**33.5**	**99**	
7.1.1	Trademarks by origin/bn PPP$ GDP ◷	26.3	78	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.0	66	
7.1.3	ICTs & business model creation†	56.9	81	
7.1.4	ICTs & organizational model creation†	47.5	90	
7.2	**Creative goods & services**	**18.8**	**[58]**	
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15–69 ◷	1.0	82	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ◷	2.1	17	●
7.2.5	Creative goods exports, % total trade	0.4	64	
7.3	**Online creativity**	**1.5**	**94**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.8	100	
7.3.2	Country-code TLDs/th pop. 15–69	0.6	89	
7.3.3	Wikipedia edits/mn pop. 15–69 ◷	6.2	72	
7.3.4	Mobile app creation/bn PPP$ GDP	0.5	69	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SWEDEN

GII 2019 rank

2

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
3	4	High	EUR	10.0	542.8	52,984.1	3

		Score/Value	Rank	
	INSTITUTIONS	**90.1**	**9**	
1.1	**Political environment**	**91.1**	**9**	
1.1.1	Political and operational stability*	91.2	12	
1.1.2	Government effectiveness*	91.1	8	
1.2	**Regulatory environment**	**92.0**	**13**	
1.2.1	Regulatory quality*	90.2	10	
1.2.2	Rule of law*	97.6	3	●
1.2.3	Cost of redundancy dismissal, salary weeks	14.4	57	○
1.3	**Business environment**	**87.1**	**14**	
1.3.1	Ease of starting a business*	94.7	16	
1.3.2	Ease of resolving insolvency*	79.5	16	
	HUMAN CAPITAL & RESEARCH	**62.1**	**6**	◆
2.1	**Education**	**67.8**	**6**	◆
2.1.1	Expenditure on education, % GDP	7.6	5	◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	23.6	32	
2.1.3	School life expectancy, years	18.8	8	
2.1.4	PISA scales in reading, maths, & science	495.8	23	
2.1.5	Pupil-teacher ratio, secondary ⊙	12.9	56	○
2.2	**Tertiary education**	**43.1**	**28**	
2.2.1	Tertiary enrolment, % gross ⊙	63.5	39	
2.2.2	Graduates in science & engineering, %	26.6	23	
2.2.3	Tertiary inbound mobility, %	6.6	35	
2.3	**Research & development (R&D)**	**75.3**	**6**	
2.3.1	Researchers, FTE/mn pop.	7,268.2	4	● ◆
2.3.2	Gross expenditure on R&D, % GDP	3.4	3	●
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	80.2	10	
2.3.4	QS university ranking, average score top 3*	59.1	14	
	INFRASTRUCTURE	**69.1**	**2**	● ◆
3.1	**Information & communication technologies(ICTs)**	**89.5**	**12**	
3.1.1	ICT access*	82.7	17	
3.1.2	ICT use*	87.1	6	◆
3.1.3	Government's online service*	94.4	14	
3.1.4	E-participation*	93.8	19	
3.2	**General infrastructure**	**59.8**	**4**	● ◆
3.2.1	Electricity output, kWh/mn pop.	15,902.8	7	
3.2.2	Logistics performance*	93.1	2	●
3.2.3	Gross capital formation, % GDP	26.4	39	
3.3	**Ecological sustainability**	**58.1**	**10**	
3.3.1	GDP/unit of energy use	9.7	57	○
3.3.2	Environmental performance*	80.5	5	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	9.3	7	◆
	MARKET SOPHISTICATION	**62.1**	**14**	
4.1	**Credit**	**59.4**	**19**	
4.1.1	Ease of getting credit*	55.0	77	○
4.1.2	Domestic credit to private sector, % GDP	132.2	15	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**54.6**	**30**	
4.2.1	Ease of protecting minority investors*	68.3	30	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.1	17	
4.3	**Trade, competition, & market scale**	**72.3**	**29**	
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	○
4.3.2	Intensity of local competition†	75.1	25	
4.3.3	Domestic market scale, bn PPP$	542.8	38	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**68.8**	**1**	● ◆
5.1	**Knowledge workers**	**81.8**	**2**	● ◆
5.1.1	Knowledge-intensive employment, %	52.3	5	
5.1.2	Firms offering formal training, % firms	70.3	3	●
5.1.3	GERD performed by business, % GDP	2.4	4	
5.1.4	GERD financed by business, % ⊙	57.3	14	
5.1.5	Females employed w/advanced degrees, %	24.8	12	
5.2	**Innovation linkages**	**66.1**	**2**	● ◆
5.2.1	University/industry research collaboration†	71.8	9	
5.2.2	State of cluster development†	67.6	12	
5.2.3	GERD financed by abroad, % ⊙	6.7	55	○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.2	5	◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	7.2	1	● ◆
5.3	**Knowledge absorption**	**58.4**	**6**	
5.3.1	Intellectual property payments, % total trade	1.7	16	
5.3.2	High-tech imports, % total trade	7.8	59	○
5.3.3	ICT services imports, % total trade	3.3	6	◆
5.3.4	FDI net inflows, % GDP	3.0	55	○
5.3.5	Research talent, % in business enterprise	72.0	4	◆
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**61.8**	**2**	● ◆
6.1	**Knowledge creation**	**73.5**	**2**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP	11.2	10	
6.1.2	PCT patents by origin/bn PPP$ GDP	7.7	1	● ◆
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	30.2	7	◆
6.1.5	Citable documents H-index	59.5	11	
6.2	**Knowledge impact**	**48.0**	**20**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.4	80	○
6.2.2	New businesses/th pop. 15-64	8.1	19	
6.2.3	Computer software spending, % GDP	0.6	11	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.9	38	
6.2.5	High- & medium-high-tech manufactures, %	0.5	14	
6.3	**Knowledge diffusion**	**63.9**	**6**	◆
6.3.1	Intellectual property receipts, % total trade	3.7	1	● ◆
6.3.2	High-tech net exports, % total trade	7.3	23	
6.3.3	ICT services exports, % total trade	6.2	6	◆
6.3.4	FDI net outflows, % GDP	3.9	15	
	CREATIVE OUTPUTS	**51.9**	**7**	
7.1	**Intangible assets**	**56.7**	**15**	
7.1.1	Trademarks by origin/bn PPP$ GDP	55.6	42	
7.1.2	Industrial designs by origin/bn PPP$ GDP	4.1	30	
7.1.3	ICTs & business model creation†	81.9	4	●
7.1.4	ICTs & organizational model creation†	82.7	2	● ◆
7.2	**Creative goods & services**	**31.8**	**23**	
7.2.1	Cultural & creative services exports, % total trade	1.1	26	
7.2.2	National feature films/mn pop. 15-69	10.1	19	
7.2.3	Entertainment & Media market/th pop. 15-69	71.8	5	
7.2.4	Printing & other media, % manufacturing	1.2	47	○
7.2.5	Creative goods exports, % total trade	1.8	30	
7.3	**Online creativity**	**62.5**	**3**	● ◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	43.2	17	
7.3.2	Country-code TLDs/th pop. 15-69	70.9	8	
7.3.3	Wikipedia edits/mn pop. 15-69	106.6	3	● ◆
7.3.4	Mobile app creation/bn PPP$ GDP	64.2	8	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

SWITZERLAND

GII 2019 rank

1

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
1	2	High	EUR	8.5	551.4	64,649.1	1

		Score/Value	Rank	
	INSTITUTIONS	**89.1**	**12**	
1.1	**Political environment**	**95.8**	**2**	● ◆
1.1.1	Political and operational stability*	94.7	4	
1.1.2	Government effectiveness*	96.4	2	● ◆
1.2	**Regulatory environment**	**95.9**	**6**	
1.2.1	Regulatory quality*	92.5	7	
1.2.2	Rule of law*	97.4	4	
1.2.3	Cost of redundancy dismissal, salary weeks	10.1	31	
1.3	**Business environment**	**75.5**	**44**	◇
1.3.1	Ease of starting a business*	88.4	62	○ ◇
1.3.2	Ease of resolving insolvency*	62.7	43	◇
	HUMAN CAPITAL & RESEARCH	**61.9**	**7**	◆
2.1	**Education**	**58.8**	**30**	
2.1.1	Expenditure on education, % GDP	5.1	44	○
2.1.2	Government funding/pupil, secondary, % GDP/cap	24.5	27	
2.1.3	School life expectancy, years	16.2	31	
2.1.4	PISA scales in reading, maths, & science	506.3	13	
2.1.5	Pupil-teacher ratio, secondary ⊙	9.8	27	
2.2	**Tertiary education**	**49.2**	**17**	
2.2.1	Tertiary enrolment, % gross ⊙	57.9	49	○
2.2.2	Graduates in science & engineering, %	24.5	32	
2.2.3	Tertiary inbound mobility, %	17.6	7	
2.3	**Research & development (R&D)**	**77.9**	**4**	◆
2.3.1	Researchers, FTE/mn pop. ⊙	5,257.4	11	
2.3.2	Gross expenditure on R&D, % GDP ⊙	3.4	4	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	92.6	3	●
2.3.4	QS university ranking, average score top 3*	81.6	4	
	INFRASTRUCTURE	**68.2**	**3**	● ◆
3.1	**Information & communication technologies(ICTs)**	**86.5**	**19**	
3.1.1	ICT access*	87.1	10	
3.1.2	ICT use*	89.7	2	● ◆
3.1.3	Government's online service*	84.7	35	
3.1.4	E-participation*	84.3	41	◇
3.2	**General infrastructure**	**47.6**	**28**	
3.2.1	Electricity output, kWh/mn pop.	7,096.9	30	
3.2.2	Logistics performance*	86.0	13	
3.2.3	Gross capital formation, % GDP	24.0	55	○
3.3	**Ecological sustainability**	**70.5**	**3**	● ◆
3.3.1	GDP/unit of energy use	19.2	6	◆
3.3.2	Environmental performance*	87.4	1	● ◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	5.5	21	
	MARKET SOPHISTICATION	**68.4**	**7**	
4.1	**Credit**	**72.8**	**9**	
4.1.1	Ease of getting credit*	60.0	66	○
4.1.2	Domestic credit to private sector, % GDP ⊙	175.3	4	◆
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**59.9**	**21**	
4.2.1	Ease of protecting minority investors*	50.0	93	○ ◇
4.2.2	Market capitalization, % GDP	227.3	1	● ◆
4.2.3	Venture capital deals/bn PPP$ GDP	0.2	10	
4.3	**Trade, competition, & market scale**	**72.6**	**26**	
4.3.1	Applied tariff rate, weighted avg., %	1.7	20	
4.3.2	Intensity of local competition†	75.5	23	
4.3.3	Domestic market scale, bn PPP$	551.4	36	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**67.5**	**2**	● ◆
5.1	**Knowledge workers**	**77.4**	**3**	● ◆
5.1.1	Knowledge-intensive employment, %	52.9	3	● ◆
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ⊙	2.4	5	
5.1.4	GERD financed by business, % ⊙	63.5	10	
5.1.5	Females employed w/advanced degrees, %	18.5	28	
5.2	**Innovation linkages**	**63.0**	**3**	● ◆
5.2.1	University/industry research collaboration†	79.1	3	● ◆
5.2.2	State of cluster development†	74.8	3	● ◆
5.2.3	GERD financed by abroad, % ⊙	10.2	41	○
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.1	13	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	9.6	4	◆
5.3	**Knowledge absorption**	**62.2**	**3**	● ◆
5.3.1	Intellectual property payments, % total trade	3.1	6	◆
5.3.2	High-tech imports, % total trade	6.1	90	○
5.3.3	ICT services imports, % total trade	4.2	1	● ◆
5.3.4	FDI net inflows, % GDP	10.6	13	
5.3.5	Research talent, % in business enterprise ⊙	50.1	25	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**70.3**	**1**	● ◆
6.1	**Knowledge creation**	**84.7**	**1**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP	16.5	5	◆
6.1.2	PCT patents by origin/bn PPP$ GDP	8.3	1	● ◆
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	34.1	3	● ◆
6.1.5	Citable documents H-index	66.6	9	
6.2	**Knowledge impact**	**57.7**	**4**	◆
6.2.1	Growth rate of PPP$ GDP/worker, %	0.8	66	○
6.2.2	New businesses/th pop. 15-64	4.3	30	
6.2.3	Computer software spending, % GDP	0.8	3	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	19.7	17	◆
6.2.5	High- & medium-high-tech manufactures, %	0.6	3	● ◆
6.3	**Knowledge diffusion**	**68.6**	**3**	● ◆
6.3.1	Intellectual property receipts, % total trade	5.2	1	● ◆
6.3.2	High-tech net exports, % total trade	7.2	24	
6.3.3	ICT services exports, % total trade	3.3	27	
6.3.4	FDI net outflows, % GDP	9.6	1	● ◆
	CREATIVE OUTPUTS	**56.6**	**1**	● ◆
7.1	**Intangible assets**	**62.2**	**7**	
7.1.1	Trademarks by origin/bn PPP$ GDP	80.3	26	
7.1.2	Industrial designs by origin/bn PPP$ GDP	8.2	14	
7.1.3	ICTs & business model creation†	84.7	1	● ◆
7.1.4	ICTs & organizational model creation†	77.4	9	
7.2	**Creative goods & services**	**45.5**	**4**	◆
7.2.1	Cultural & creative services exports, % total trade	0.8	37	
7.2.2	National feature films/mn pop. 15-69	19.4	5	◆
7.2.3	Entertainment & Media market/th pop. 15-69	94.1	2	● ◆
7.2.4	Printing & other media, % manufacturing ⊙	1.2	50	○
7.2.5	Creative goods exports, % total trade	3.8	15	
7.3	**Online creativity**	**56.4**	**7**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	59.2	13	
7.3.2	Country-code TLDs/th pop. 15-69	100.0	1	● ◆
7.3.3	Wikipedia edits/mn pop. 15-69	47.4	27	
7.3.4	Mobile app creation/bn PPP$ GDP	34.4	15	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

TAJIKISTAN

GII 2019 rank

100

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
83	107	Low	CSA	9.1	30.5	3,415.8	101

		Score/Value	Rank	
	INSTITUTIONS	**46.0**	**122**	
1.1	**Political environment**	**31.6**	**125**	○
1.1.1	Political and operational stability*	56.1	105	
1.1.2	Government effectiveness*	19.4	124	
1.2	**Regulatory environment**	**45.6**	**116**	◇
1.2.1	Regulatory quality*	13.5	125	○
1.2.2	Rule of law*	10.5	126	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	21.7	92	
1.3	**Business environment**	**60.8**	**102**	
1.3.1	Ease of starting a business*	90.7	51	●
1.3.2	Ease of resolving insolvency*	30.9	116	
	HUMAN CAPITAL & RESEARCH	**24.0**	**87**	◆
2.1	**Education**	**46.3**	**[69]**	
2.1.1	Expenditure on education, % GDP	5.2	40	●
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years ⊙	11.2	97	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	15.4	70	◆
2.2	**Tertiary education**	**24.9**	**80**	◆
2.2.1	Tertiary enrolment, % gross	30.9	83	◆
2.2.2	Graduates in science & engineering, %	22.0	49	
2.2.3	Tertiary inbound mobility, %	0.8	91	
2.3	**Research & development (R&D)**	**0.7**	**110**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	0.1	103	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**29.8**	**115**	
3.1	**Information & communication technologies(ICTs)**	**36.4**	**[112]**	
3.1.1	ICT access*	n/a	n/a	
3.1.2	ICT use*	n/a	n/a	
3.1.3	Government's online service*	34.0	115	
3.1.4	E-participation*	38.8	112	
3.2	**General infrastructure**	**23.4**	**109**	
3.2.1	Electricity output, kWh/mn pop.	1,971.6	77	◆
3.2.2	Logistics performance*	12.9	116	
3.2.3	Gross capital formation, % GDP	22.8	67	
3.3	**Ecological sustainability**	**29.5**	**99**	
3.3.1	GDP/unit of energy use	8.2	73	
3.3.2	Environmental performance*	47.9	102	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.5	85	
	MARKET SOPHISTICATION	**43.7**	**86**	
4.1	**Credit**	**15.4**	**121**	
4.1.1	Ease of getting credit*	40.0	104	
4.1.2	Domestic credit to private sector, % GDP	13.7	121	
4.1.3	Microfinance gross loans, % GDP	0.1	51	
4.2	**Investment**	**66.7**	**[12]**	
4.2.1	Ease of protecting minority investors*	66.7	35	● ◆
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**48.9**	**111**	
4.3.1	Applied tariff rate, weighted avg., %	5.0	85	◆
4.3.2	Intensity of local competition†	61.2	103	
4.3.3	Domestic market scale, bn PPP$	30.5	114	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**22.2**	**114**	
5.1	**Knowledge workers**	**24.4**	**98**	
5.1.1	Knowledge-intensive employment, % ⊙	16.1	87	◆
5.1.2	Firms offering formal training, % firms	33.1	44	●
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, % ⊙	1.6	89	
5.1.5	Females employed w/advanced degrees, % ⊙	4.0	93	◆
5.2	**Innovation linkages**	**18.2**	**104**	
5.2.1	University/industry research collaboration†	46.5	47	●
5.2.2	State of cluster development†	40.2	93	
5.2.3	GERD financed by abroad, % ⊙	0.2	98	◇
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**23.9**	**[107]**	
5.3.1	Intellectual property payments, % total trade	0.0	119	○
5.3.2	High-tech imports, % total trade	n/a	n/a	
5.3.3	ICT services imports, % total trade	0.2	122	◇
5.3.4	FDI net inflows, % GDP	3.5	49	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**21.4**	**68**	◆
6.1	**Knowledge creation**	**20.0**	**45**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP ⊙	0.1	113	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP ⊙	3.7	5	● ◆
6.1.4	Scientific & technical articles/bn PPP$ GDP	1.6	119	◇
6.1.5	Citable documents H-index	0.0	128	○ ◇
6.2	**Knowledge impact**	**31.2**	**89**	
6.2.1	Growth rate of PPP$ GDP/worker, %	5.1	6	● ◆
6.2.2	New businesses/th pop. 15-64	0.2	94	
6.2.3	Computer software spending, % GDP	0.1	93	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.1	128	○ ◇
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.0	102	○ ◇
6.3	**Knowledge diffusion**	**13.0**	**85**	
6.3.1	Intellectual property receipts, % total trade ⊙	0.0	83	
6.3.2	High-tech net exports, % total trade	n/a	n/a	
6.3.3	ICT services exports, % total trade	0.3	113	
6.3.4	FDI net outflows, % GDP	1.7	37	●
	CREATIVE OUTPUTS	**18.1**	**103**	
7.1	**Intangible assets**	**27.6**	**112**	
7.1.1	Trademarks by origin/bn PPP$ GDP ⊙	6.1	112	
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊙	0.0	115	○
7.1.3	ICTs & business model creation†	50.7	102	
7.1.4	ICTs & organizational model creation†	44.4	97	
7.2	**Creative goods & services**	**16.5**	**[65]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	102	
7.2.2	National feature films/mn pop. 15-69 ⊙	1.8	70	◆
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	1.5	30	●
7.2.5	Creative goods exports, % total trade	n/a	n/a	
7.3	**Online creativity**	**0.7**	**105**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	0.1	125	○
7.3.2	Country-code TLDs/th pop. 15-69	0.3	103	
7.3.3	Wikipedia edits/mn pop. 15-69 ⊙	2.6	96	◆
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

THAILAND

GII 2019 rank

43

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
43	47	Upper middle	SEAO	69.2	1,323.2	19,476.5	44

		Score/Value	Rank	
	INSTITUTIONS	**65.8**	**57**	
1.1	**Political environment**	**60.6**	**50**	
1.1.1	Political and operational stability*	70.2	61	
1.1.2	Government effectiveness*	55.9	49	
1.2	**Regulatory environment**	**52.0**	**105**	○
1.2.1	Regulatory quality*	45.7	65	
1.2.2	Rule of law*	47.5	61	
1.2.3	Cost of redundancy dismissal, salary weeks	36.0	120	○ ◇
1.3	**Business environment**	**84.7**	**20**	● ◆
1.3.1	Ease of starting a business*	92.7	36	
1.3.2	Ease of resolving insolvency*	76.6	22	◆

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**34.7**	**52**	
2.1	**Education**	**40.6**	**81**	
2.1.1	Expenditure on education, % GDP ◷	4.1	74	
2.1.2	Government funding/pupil, secondary, % GDP/cap ◷	18.0	62	
2.1.3	School life expectancy, years	15.4	40	
2.1.4	PISA scales in reading, maths, & science	415.3	56	○
2.1.5	Pupil-teacher ratio, secondary	24.2	97	○ ◇
2.2	**Tertiary education**	**37.1**	**45**	
2.2.1	Tertiary enrolment, % gross ◷	49.3	57	
2.2.2	Graduates in science & engineering, %	27.9	20	
2.2.3	Tertiary inbound mobility, %	1.3	83	
2.3	**Research & development (R&D)**	**26.4**	**41**	◆
2.3.1	Researchers, FTE/mn pop. ◷	1,210.4	48	
2.3.2	Gross expenditure on R&D, % GDP ◷	0.8	46	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	46.0	35	◆
2.3.4	QS university ranking, average score top 3*	28.0	39	

		Score/Value	Rank	
	INFRASTRUCTURE	**43.6**	**77**	
3.1	**Information & communication technologies(ICTs)**	**60.8**	**77**	
3.1.1	ICT access*	56.8	77	
3.1.2	ICT use*	57.2	61	
3.1.3	Government's online service*	63.9	85	
3.1.4	E-participation*	65.2	80	
3.2	**General infrastructure**	**37.3**	**54**	
3.2.1	Electricity output, kWh/mn pop.	2,778.4	65	
3.2.2	Logistics performance*	63.0	31	◆
3.2.3	Gross capital formation, % GDP	23.4	61	
3.3	**Ecological sustainability**	**32.7**	**85**	
3.3.1	GDP/unit of energy use	7.6	81	
3.3.2	Environmental performance*	49.9	98	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.8	36	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**56.5**	**32**	◆
4.1	**Credit**	**46.6**	**42**	◆
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	143.8	12	● ◆
4.1.3	Microfinance gross loans, % GDP ◷	0.0	80	○
4.2	**Investment**	**48.9**	**41**	
4.2.1	Ease of protecting minority investors*	75.0	14	● ◆
4.2.2	Market capitalization, % GDP	104.2	10	● ◆
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	71	○
4.3	**Trade, competition, & market scale**	**74.0**	**22**	◆
4.3.1	Applied tariff rate, weighted avg., % ◷	3.5	68	
4.3.2	Intensity of local competition†	74.2	34	
4.3.3	Domestic market scale, bn PPP$	1,323.2	19	●

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**32.3**	**60**	
5.1	**Knowledge workers**	**32.2**	**80**	
5.1.1	Knowledge-intensive employment, % ◷	14.3	90	◇
5.1.2	Firms offering formal training, % firms	18.0	79	○ ◇
5.1.3	GERD performed by business, % GDP ◷	0.6	35	
5.1.4	GERD financed by business, %	75.2	4	● ◆
5.1.5	Females employed w/advanced degrees, % ◷	9.5	69	
5.2	**Innovation linkages**	**21.0**	**81**	
5.2.1	University/industry research collaboration†	52.2	36	◆
5.2.2	State of cluster development†	48.8	53	
5.2.3	GERD financed by abroad, %	0.9	92	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	53	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.1	58	
5.3	**Knowledge absorption**	**43.8**	**30**	◆
5.3.1	Intellectual property payments, % total trade	1.6	20	● ◆
5.3.2	High-tech imports, % total trade ◷	15.3	12	● ◆
5.3.3	ICT services imports, % total trade	0.2	123	○ ◇
5.3.4	FDI net inflows, % GDP	1.6	95	
5.3.5	Research talent, % in business enterprise ◷	56.8	17	◆

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**31.3**	**38**	◆
6.1	**Knowledge creation**	**16.7**	**54**	
6.1.1	Patents by origin/bn PPP$ GDP	0.8	69	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	69	
6.1.3	Utility models by origin/bn PPP$ GDP	1.9	13	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.5	86	
6.1.5	Citable documents H-index	20.2	38	
6.2	**Knowledge impact**	**43.6**	**34**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.9	14	● ◆
6.2.2	New businesses/th pop. 15–64	1.0	71	
6.2.3	Computer software spending, % GDP	0.2	61	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.4	42	
6.2.5	High- & medium-high-tech manufactures, % ◷	0.4	18	◆
6.3	**Knowledge diffusion**	**33.8**	**25**	◆
6.3.1	Intellectual property receipts, % total trade	0.0	72	
6.3.2	High-tech net exports, % total trade ◷	15.0	8	● ◆
6.3.3	ICT services exports, % total trade	0.2	119	○
6.3.4	FDI net outflows, % GDP	2.9	25	◆

		Score/Value	Rank	
	CREATIVE OUTPUTS	**30.0**	**54**	
7.1	**Intangible assets**	**41.5**	**61**	
7.1.1	Trademarks by origin/bn PPP$ GDP	25.2	80	
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.0	42	
7.1.3	ICTs & business model creation†	67.3	39	◆
7.1.4	ICTs & organizational model creation†	60.3	43	◆
7.2	**Creative goods & services**	**33.5**	**18**	● ◆
7.2.1	Cultural & creative services exports, % total trade	0.0	117	○
7.2.2	National feature films/mn pop. 15–69 ◷	1.0	83	
7.2.3	Entertainment & Media market/th pop. 15–69	5.9	44	
7.2.4	Printing & other media, % manufacturing ◷	0.8	76	
7.2.5	Creative goods exports, % total trade ◷	8.7	1	● ◆
7.3	**Online creativity**	**3.5**	**74**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	5.4	52	
7.3.2	Country-code TLDs/th pop. 15–69	0.4	99	
7.3.3	Wikipedia edits/mn pop. 15–69	5.6	80	
7.3.4	Mobile app creation/bn PPP$ GDP	4.4	51	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

TOGO

GII 2019 rank

126

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
128	121	Low	SSF	8.0	13.9	1,745.6	n/a

		Score/Value	Rank	
	INSTITUTIONS	**53.4**	**97**	
1.1	**Political environment**	**34.5**	**121**	
1.1.1	Political and operational stability*	64.9	79	
1.1.2	Government effectiveness*	19.3	125	○
1.2	**Regulatory environment**	**58.1**	**87**	
1.2.1	Regulatory quality*	20.8	115	
1.2.2	Rule of law*	27.5	108	
1.2.3	Cost of redundancy dismissal, salary weeks	13.1	49	●
1.3	**Business environment**	**67.7**	**71**	
1.3.1	Ease of starting a business*	88.7	60	●
1.3.2	Ease of resolving insolvency*	46.7	78	◆
	HUMAN CAPITAL & RESEARCH	**16.0**	**108**	
2.1	**Education**	**36.9**	**95**	
2.1.1	Expenditure on education, % GDP	5.1	46	●
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	15.9	78	
2.1.3	School life expectancy, years	12.6	86	◆
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ⊙	26.2	99	
2.2	**Tertiary education**	**9.6**	**[111]**	
2.2.1	Tertiary enrolment, % gross	12.9	102	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**1.5**	**99**	
2.3.1	Researchers, FTE/mn pop.	38.3	97	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.3	82	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**29.8**	**114**	
3.1	**Information & communication technologies(ICTs)**	**41.3**	**102**	
3.1.1	ICT access*	33.5	113	
3.1.2	ICT use*	21.6	104	◆
3.1.3	Government's online service*	55.6	98	
3.1.4	E-participation*	54.5	98	
3.2	**General infrastructure**	**28.9**	**87**	
3.2.1	Electricity output, kWh/mn pop.	30.5	120	○
3.2.2	Logistics performance*	18.0	108	
3.2.3	Gross capital formation, % GDP	28.2	28	●
3.3	**Ecological sustainability**	**19.2**	**127**	○
3.3.1	GDP/unit of energy use	2.9	117	○
3.3.2	Environmental performance*	41.8	118	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.9	66	◆
	MARKET SOPHISTICATION	**30.6**	**126**	○
4.1	**Credit**	**31.2**	**88**	
4.1.1	Ease of getting credit*	30.0	115	
4.1.2	Domestic credit to private sector, % GDP	39.7	83	◆
4.1.3	Microfinance gross loans, % GDP	2.7	10	● ◆
4.2	**Investment**	**40.0**	**[72]**	
4.2.1	Ease of protecting minority investors*	40.0	114	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**20.7**	**129**	○ ◇
4.3.1	Applied tariff rate, weighted avg., %	13.4	126	○ ◇
4.3.2	Intensity of local competition†	n/a	n/a	
4.3.3	Domestic market scale, bn PPP$	13.9	127	○ ◇

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**19.0**	**[124]**	
5.1	**Knowledge workers**	**22.2**	**[103]**	
5.1.1	Knowledge-intensive employment, % ⊙	7.7	104	
5.1.2	Firms offering formal training, % firms	33.7	43	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	2.5	98	
5.2	**Innovation linkages**	**11.3**	**[127]**	
5.2.1	University/industry research collaboration†	n/a	n/a	
5.2.2	State of cluster development†	n/a	n/a	
5.2.3	GERD financed by abroad, % ⊙	5.5	62	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	51	●
5.2.5	Patent families 2+ offices/bn PPP$ GDP	n/a	n/a	
5.3	**Knowledge absorption**	**23.7**	**109**	
5.3.1	Intellectual property payments, % total trade	0.0	108	
5.3.2	High-tech imports, % total trade	4.3	115	
5.3.3	ICT services imports, % total trade	0.8	87	
5.3.4	FDI net inflows, % GDP	2.7	60	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**10.1**	**119**	
6.1	**Knowledge creation**	**2.5**	**119**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	104	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	99	○ ◇
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.8	94	
6.1.5	Citable documents H-index	0.7	126	○ ◇
6.2	**Knowledge impact**	**3.5**	**[127]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	n/a	n/a	
6.2.2	New businesses/th pop. 15–64 ⊙	0.3	93	
6.2.3	Computer software spending, % GDP	0.1	94	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.3	102	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**24.4**	**41**	● ◆
6.3.1	Intellectual property receipts, % total trade ⊙	0.0	104	
6.3.2	High-tech net exports, % total trade	0.0	123	○ ◇
6.3.3	ICT services exports, % total trade	2.0	55	●
6.3.4	FDI net outflows, % GDP	6.9	9	● ◆
	CREATIVE OUTPUTS	**4.5**	**[128]**	
7.1	**Intangible assets**	**3.8**	**[128]**	
7.1.1	Trademarks by origin/bn PPP$ GDP	11.4	102	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.8	78	
7.1.3	ICTs & business model creation†	n/a	n/a	
7.1.4	ICTs & organizational model creation†	n/a	n/a	
7.2	**Creative goods & services**	**9.9**	**[86]**	
7.2.1	Cultural & creative services exports, % total trade	1.5	16	● ◆
7.2.2	National feature films/mn pop. 15–69	0.7	92	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.0	112	
7.3	**Online creativity**	**0.3**	**118**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.6	104	◆
7.3.2	Country-code TLDs/th pop. 15–69	0.1	120	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.2	118	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

TRINIDAD AND TOBAGO

GII 2019 rank

91

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
99	88	High	LCN	1.4	44.3	32,253.8	96

		Score/Value	Rank	
1	**INSTITUTIONS**	**63.4**	**63**	◇
1.1	**Political environment**	**59.8**	**52**	● ◇
1.1.1	Political and operational stability*	73.7	50	● ◇
1.1.2	Government effectiveness*	52.8	54	● ◇
1.2	**Regulatory environment**	**62.0**	**75**	◇
1.2.1	Regulatory quality*	42.6	68	◇
1.2.2	Rule of law*	43.5	67	◇
1.2.3	Cost of redundancy dismissal, salary weeks	20.5	84	
1.3	**Business environment**	**68.5**	**69**	
1.3.1	Ease of starting a business*	88.6	61	
1.3.2	Ease of resolving insolvency*	48.5	69	
2	**HUMAN CAPITAL & RESEARCH**	**20.5**	**[94]**	
2.1	**Education**	**40.4**	**[84]**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	423.0	50	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**n/a**	**[n/a]**	
2.2.1	Tertiary enrolment, % gross	n/a	n/a	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**0.6**	**114**	◇
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.1	108	○ ◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
3	**INFRASTRUCTURE**	**37.5**	**92**	◇
3.1	**Information & communication technologies(ICTs)**	**62.7**	**73**	◇
3.1.1	ICT access*	74.6	45	●
3.1.2	ICT use*	54.4	65	◇
3.1.3	Government's online service*	63.9	85	◇
3.1.4	E-participation*	57.9	93	◇
3.2	**General infrastructure**	**22.1**	**112**	◇
3.2.1	Electricity output, kWh/mn pop.	7,819.0	23	●
3.2.2	Logistics performance*	16.5	111	◇
3.2.3	Gross capital formation, % GDP	n/a	n/a	
3.3	**Ecological sustainability**	**27.7**	**107**	◇
3.3.1	GDP/unit of energy use	2.2	121	○ ◇
3.3.2	Environmental performance*	67.4	34	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.5	84	◇
4	**MARKET SOPHISTICATION**	**45.6**	**77**	◇
4.1	**Credit**	**27.5**	**100**	◇
4.1.1	Ease of getting credit*	65.0	54	
4.1.2	Domestic credit to private sector, % GDP	40.5	81	◇
4.1.3	Microfinance gross loans, % GDP ⊙	0.0	77	○
4.2	**Investment**	**61.7**	**[20]**	
4.2.1	Ease of protecting minority investors*	61.7	54	●
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**47.5**	**112**	◇
4.3.1	Applied tariff rate, weighted avg., % ⊙	8.6	106	◇
4.3.2	Intensity of local competition†	66.9	74	
4.3.3	Domestic market scale, bn PPP$	44.3	99	◇
5	**BUSINESS SOPHISTICATION**	**26.2**	**92**	◇
5.1	**Knowledge workers**	**34.7**	**70**	◇
5.1.1	Knowledge-intensive employment, % ⊙	29.9	44	●
5.1.2	Firms offering formal training, % firms ⊙	28.0	56	
5.1.3	GERD performed by business, % GDP ⊙	0.0	89	○ ◇
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	12.8	53	●
5.2	**Innovation linkages**	**20.3**	**85**	◇
5.2.1	University/industry research collaboration†	29.7	107	◇
5.2.2	State of cluster development†	43.3	79	◇
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	76	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**23.5**	**110**	◇
5.3.1	Intellectual property payments, % total trade	0.6	59	
5.3.2	High-tech imports, % total trade ⊙	6.3	89	
5.3.3	ICT services imports, % total trade	0.5	108	◇
5.3.4	FDI net inflows, % GDP	-0.4	123	○
5.3.5	Research talent, % in business enterprise	n/a	n/a	
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**14.9**	**103**	◇
6.1	**Knowledge creation**	**2.5**	**118**	◇
6.1.1	Patents by origin/bn PPP$ GDP ⊙	0.1	118	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	62	
6.1.3	Utility models by origin/bn PPP$ GDP ⊙	0.0	63	○ ◇
6.1.4	Scientific & technical articles/bn PPP$ GDP	2.7	106	◇
6.1.5	Citable documents H-index	4.0	102	◇
6.2	**Knowledge impact**	**35.2**	**[71]**	
6.2.1	Growth rate of PPP$ GDP/worker, %	-2.0	109	○ ◇
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	n/a	n/a	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.5	81	◇
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**6.9**	**124**	○ ◇
6.3.1	Intellectual property receipts, % total trade	0.0	84	
6.3.2	High-tech net exports, % total trade ⊙	0.0	119	◇
6.3.3	ICT services exports, % total trade	0.1	121	◇
6.3.4	FDI net outflows, % GDP	0.4	70	
7	**CREATIVE OUTPUTS**	**20.2**	**95**	◇
7.1	**Intangible assets**	**36.1**	**91**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	13.9	97	◇
7.1.2	Industrial designs by origin/bn PPP$ GDP	6.9	19	●
7.1.3	ICTs & business model creation†	52.7	95	◇
7.1.4	ICTs & organizational model creation†	49.8	82	◇
7.2	**Creative goods & services**	**4.9**	**[102]**	
7.2.1	Cultural & creative services exports, % total trade	0.0	101	◇
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	0.7	83	
7.2.5	Creative goods exports, % total trade ⊙	0.1	92	
7.3	**Online creativity**	**3.7**	**72**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	4.3	58	●
7.3.2	Country-code TLDs/th pop. 15–69	1.4	71	◇
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	8.0	67	◇
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

TUNISIA

GII 2019 rank

70

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
65	74	Lower middle	NAWA	11.7	144.2	12,371.7	66

		Score/Value	Rank	
	INSTITUTIONS	**61.1**	**73**	◆
1.1	**Political environment**	**51.6**	**76**	
1.1.1	Political and operational stability*	64.9	79	
1.1.2	Government effectiveness*	44.9	75	
1.2	**Regulatory environment**	**59.4**	**83**	
1.2.1	Regulatory quality*	30.9	98	
1.2.2	Rule of law*	48.3	58	◆
1.2.3	Cost of redundancy dismissal, salary weeks	21.6	90	
1.3	**Business environment**	**72.2**	**56**	◆
1.3.1	Ease of starting a business*	90.2	53	
1.3.2	Ease of resolving insolvency*	54.2	62	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**44.4**	**32**	● ◆
2.1	**Education**	**66.9**	**8**	● ◆
2.1.1	Expenditure on education, % GDP	6.6	13	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap	52.8	1	● ◆
2.1.3	School life expectancy, years	15.1	50	◆
2.1.4	PISA scales in reading, maths, & science	371.4	67	○
2.1.5	Pupil-teacher ratio, secondary ⊙	13.6	60	
2.2	**Tertiary education**	**57.3**	**7**	● ◆
2.2.1	Tertiary enrolment, % gross	32.1	81	
2.2.2	Graduates in science & engineering, %	44.1	2	● ◆
2.2.3	Tertiary inbound mobility, %	2.3	71	
2.3	**Research & development (R&D)**	**9.1**	**60**	
2.3.1	Researchers, FTE/mn pop. ⊙	1,965.0	41	◆
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.6	53	◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**44.2**	**74**	◆
3.1	**Information & communication technologies(ICTs)**	**65.4**	**69**	◆
3.1.1	ICT access*	57.1	76	
3.1.2	ICT use*	44.0	80	
3.1.3	Government's online service*	80.6	44	● ◆
3.1.4	E-participation*	79.8	53	
3.2	**General infrastructure**	**26.2**	**96**	
3.2.1	Electricity output, kWh/mn pop.	1,737.5	83	
3.2.2	Logistics performance*	23.7	98	
3.2.3	Gross capital formation, % GDP	23.1	65	
3.3	**Ecological sustainability**	**41.2**	**51**	◆
3.3.1	GDP/unit of energy use	10.9	43	
3.3.2	Environmental performance*	62.4	51	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.6	55	◆

		Score/Value	Rank	
	MARKET SOPHISTICATION	**39.6**	**104**	
4.1	**Credit**	**33.0**	**76**	
4.1.1	Ease of getting credit*	50.0	87	
4.1.2	Domestic credit to private sector, % GDP	86.2	33	● ◆
4.1.3	Microfinance gross loans, % GDP	0.5	30	
4.2	**Investment**	**33.2**	**107**	○
4.2.1	Ease of protecting minority investors*	56.7	79	
4.2.2	Market capitalization, % GDP	21.0	60	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	28	◆
4.3	**Trade, competition, & market scale**	**52.4**	**99**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	9.4	109	○
4.3.2	Intensity of local competition†	65.0	82	
4.3.3	Domestic market scale, bn PPP$	144.2	72	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**21.3**	**115**	○ ◇
5.1	**Knowledge workers**	**26.7**	**90**	
5.1.1	Knowledge-intensive employment, % ⊙	21.0	72	
5.1.2	Firms offering formal training, % firms	28.9	52	
5.1.3	GERD performed by business, % GDP ⊙	0.1	59	
5.1.4	GERD financed by business, % ⊙	18.9	68	
5.1.5	Females employed w/advanced degrees, % ⊙	6.7	82	
5.2	**Innovation linkages**	**16.0**	**115**	○
5.2.1	University/industry research collaboration†	38.2	80	
5.2.2	State of cluster development†	37.0	100	
5.2.3	GERD financed by abroad, % ⊙	3.9	66	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	105	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	87	
5.3	**Knowledge absorption**	**21.3**	**118**	○
5.3.1	Intellectual property payments, % total trade	0.1	100	○
5.3.2	High-tech imports, % total trade	8.7	48	
5.3.3	ICT services imports, % total trade	0.4	110	○
5.3.4	FDI net inflows, % GDP	1.9	82	
5.3.5	Research talent, % in business enterprise ⊙	4.0	73	○

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**23.0**	**60**	
6.1	**Knowledge creation**	**18.7**	**49**	
6.1.1	Patents by origin/bn PPP$ GDP	1.2	56	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	74	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	23.8	15	● ◆
6.1.5	Citable documents H-index	9.6	71	
6.2	**Knowledge impact**	**34.5**	**76**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.4	52	
6.2.2	New businesses/th pop. 15–64 ⊙	1.7	57	
6.2.3	Computer software spending, % GDP	0.3	34	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	7.6	40	● ◆
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	65	
6.3	**Knowledge diffusion**	**15.8**	**75**	
6.3.1	Intellectual property receipts, % total trade	0.1	51	
6.3.2	High-tech net exports, % total trade	3.7	39	●
6.3.3	ICT services exports, % total trade	1.5	69	
6.3.4	FDI net outflows, % GDP	0.3	85	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**24.1**	**75**	
7.1	**Intangible assets**	**42.1**	**59**	
7.1.1	Trademarks by origin/bn PPP$ GDP	n/a	n/a	
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.1	63	
7.1.3	ICTs & business model creation†	59.6	67	
7.1.4	ICTs & organizational model creation†	42.7	104	
7.2	**Creative goods & services**	**10.5**	**82**	
7.2.1	Cultural & creative services exports, % total trade	0.0	109	○
7.2.2	National feature films/mn pop. 15–69 ⊙	1.4	74	
7.2.3	Entertainment & Media market/th pop. 15–69	0.9	57	○
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	2.0	28	●
7.3	**Online creativity**	**1.6**	**93**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	2.7	70	◆
7.3.2	Country-code TLDs/th pop. 15–69	1.4	72	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	2.9	94	
7.3.4	Mobile app creation/bn PPP$ GDP	0.2	79	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

TURKEY

GII 2019 rank

49

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
49	56	Upper middle	NAWA	81.9	2,314.4	27,956.1	50

		Score/Value	Rank	
	INSTITUTIONS	**57.4**	**85**	
1.1	**Political environment**	**53.8**	**69**	
1.1.1	Political and operational stability*	64.9	79	
1.1.2	Government effectiveness*	48.2	67	
1.2	**Regulatory environment**	**54.1**	**102**	○
1.2.1	Regulatory quality*	42.9	67	
1.2.2	Rule of law*	39.8	76	
1.2.3	Cost of redundancy dismissal, salary weeks	29.8	115	○
1.3	**Business environment**	**64.5**	**82**	
1.3.1	Ease of starting a business*	88.2	63	
1.3.2	Ease of resolving insolvency*	40.7	96	
	HUMAN CAPITAL & RESEARCH	**36.3**	**46**	
2.1	**Education**	**44.0**	**73**	
2.1.1	Expenditure on education, % GDP	4.3	70	
2.1.2	Government funding/pupil, secondary, % GDP/cap	11.5	90	○
2.1.3	School life expectancy, years	17.7	14	● ◆
2.1.4	PISA scales in reading, maths, & science	424.8	49	
2.1.5	Pupil-teacher ratio, secondary ⊙	18.5	81	
2.2	**Tertiary education**	**37.3**	**43**	
2.2.1	Tertiary enrolment, % gross ⊙	103.7	3	● ◆
2.2.2	Graduates in science & engineering, % ⊙	20.2	65	
2.2.3	Tertiary inbound mobility, %	1.3	82	
2.3	**Research & development (R&D)**	**27.7**	**39**	◆
2.3.1	Researchers, FTE/mn pop.	1,385.8	44	
2.3.2	Gross expenditure on R&D, % GDP	1.0	37	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	48.5	31	◆
2.3.4	QS university ranking, average score top 3*	24.8	44	
	INFRASTRUCTURE	**52.2**	**41**	◆
3.1	**Information & communication technologies(ICTs)**	**73.3**	**49**	
3.1.1	ICT access*	65.1	69	
3.1.2	ICT use*	53.3	68	
3.1.3	Government's online service*	88.9	27	◆
3.1.4	E-participation*	86.0	37	
3.2	**General infrastructure**	**43.0**	**38**	◆
3.2.1	Electricity output, kWh/mn pop.	3,761.1	54	
3.2.2	Logistics performance*	50.6	46	◆
3.2.3	Gross capital formation, % GDP	30.7	20	●
3.3	**Ecological sustainability**	**40.4**	**52**	
3.3.1	GDP/unit of energy use	13.3	19	●
3.3.2	Environmental performance*	53.0	88	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.9	67	
	MARKET SOPHISTICATION	**50.8**	**52**	
4.1	**Credit**	**36.0**	**66**	
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP	70.9	44	
4.1.3	Microfinance gross loans, % GDP ⊙	0.0	78	○
4.2	**Investment**	**37.9**	**87**	
4.2.1	Ease of protecting minority investors*	71.7	24	
4.2.2	Market capitalization, % GDP	22.9	56	○
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	78	○ ◇
4.3	**Trade, competition, & market scale**	**78.5**	**15**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	3.5	67	
4.3.2	Intensity of local competition†	80.5	6	● ◆
4.3.3	Domestic market scale, bn PPP$	2,314.4	13	● ◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**29.5**	**71**	
5.1	**Knowledge workers**	**34.6**	**72**	
5.1.1	Knowledge-intensive employment, %	21.0	71	
5.1.2	Firms offering formal training, % firms	28.4	53	
5.1.3	GERD performed by business, % GDP	0.5	37	
5.1.4	GERD financed by business, %	49.4	27	
5.1.5	Females employed w/advanced degrees, %	8.9	72	
5.2	**Innovation linkages**	**18.5**	**97**	
5.2.1	University/industry research collaboration†	37.0	88	
5.2.2	State of cluster development†	44.4	76	
5.2.3	GERD financed by abroad, %	3.5	68	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	95	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	43	
5.3	**Knowledge absorption**	**35.4**	**57**	
5.3.1	Intellectual property payments, % total trade	0.3	74	
5.3.2	High-tech imports, % total trade	9.9	33	
5.3.3	ICT services imports, % total trade	0.2	124	○ ◇
5.3.4	FDI net inflows, % GDP	1.6	89	
5.3.5	Research talent, % in business enterprise	55.7	19	◆
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**23.0**	**59**	
6.1	**Knowledge creation**	**22.2**	**38**	
6.1.1	Patents by origin/bn PPP$ GDP	4.2	27	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.7	32	◆
6.1.3	Utility models by origin/bn PPP$ GDP	1.5	17	
6.1.4	Scientific & technical articles/bn PPP$ GDP	7.8	60	
6.1.5	Citable documents H-index	26.5	35	◆
6.2	**Knowledge impact**	**38.1**	**57**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.7	46	
6.2.2	New businesses/th pop. 15-64	1.2	66	
6.2.3	Computer software spending, % GDP	0.5	20	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	2.8	80	
6.2.5	High- & medium-high-tech manufactures, %	0.3	44	
6.3	**Knowledge diffusion**	**8.8**	**112**	○
6.3.1	Intellectual property receipts, % total trade	0.0	96	○
6.3.2	High-tech net exports, % total trade	1.4	63	
6.3.3	ICT services exports, % total trade	0.1	122	○
6.3.4	FDI net outflows, % GDP	0.4	73	
	CREATIVE OUTPUTS	**34.2**	**40**	◆
7.1	**Intangible assets**	**55.1**	**20**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	98.5	13	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	18.0	1	● ◆
7.1.3	ICTs & business model creation†	58.2	72	
7.1.4	ICTs & organizational model creation†	44.2	98	○
7.2	**Creative goods & services**	**17.8**	**60**	
7.2.1	Cultural & creative services exports, % total trade	0.5	46	
7.2.2	National feature films/mn pop. 15-69	2.6	59	
7.2.3	Entertainment & Media market/th pop. 15-69	5.8	46	
7.2.4	Printing & other media, % manufacturing	0.9	71	
7.2.5	Creative goods exports, % total trade	2.9	21	●
7.3	**Online creativity**	**8.9**	**55**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	11.7	36	◆
7.3.2	Country-code TLDs/th pop. 15-69	1.9	68	
7.3.3	Wikipedia edits/mn pop. 15-69	4.4	85	
7.3.4	Mobile app creation/bn PPP$ GDP	19.0	23	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

UGANDA

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
107	**96**	**Low**	**SSF**	**44.3**	**96.7**	**2,497.6**	**103**

		Score/Value	Rank	
	INSTITUTIONS	**55.2**	**91**	
1.1	**Political environment**	**41.5**	**99**	
1.1.1	Political and operational stability*	59.6	98	
1.1.2	Government effectiveness*	32.4	100	
1.2	**Regulatory environment**	**68.1**	**61**	● ◆
1.2.1	Regulatory quality*	36.0	85	◆
1.2.2	Rule of law*	38.5	79	
1.2.3	Cost of redundancy dismissal, salary weeks	8.7	21	● ◆
1.3	**Business environment**	**56.1**	**114**	
1.3.1	Ease of starting a business*	72.3	118	◇
1.3.2	Ease of resolving insolvency*	39.9	98	
	HUMAN CAPITAL & RESEARCH	**13.4**	**114**	
2.1	**Education**	**18.1**	**[125]**	
2.1.1	Expenditure on education, % GDP	2.6	113	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**21.2**	**91**	
2.2.1	Tertiary enrolment, % gross	4.6	119	○
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	10.7	19	● ◆
2.3	**Research & development (R&D)**	**0.9**	**106**	
2.3.1	Researchers, FTE/mn pop.	26.5	101	○
2.3.2	Gross expenditure on R&D, % GDP	0.2	92	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇
	INFRASTRUCTURE	**36.6**	**96**	◆
3.1	**Information & communication technologies(ICTs)**	**40.5**	**105**	
3.1.1	ICT access*	26.9	120	○
3.1.2	ICT use*	15.9	113	
3.1.3	Government's online service*	56.9	92	
3.1.4	E-participation*	62.4	84	◆
3.2	**General infrastructure**	**38.9**	**48**	●
3.2.1	Electricity output, kWh/mn pop.	n/a	n/a	
3.2.2	Logistics performance*	23.9	96	
3.2.3	Gross capital formation, % GDP	27.2	33	●
3.3	**Ecological sustainability**	**30.2**	**93**	
3.3.1	GDP/unit of energy use	n/a	n/a	
3.3.2	Environmental performance*	44.3	111	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	101	
	MARKET SOPHISTICATION	**45.8**	**74**	◆
4.1	**Credit**	**32.6**	**80**	
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	15.0	116	○
4.1.3	Microfinance gross loans, % GDP	1.9	13	●
4.2	**Investment**	**50.0**	**[39]**	
4.2.1	Ease of protecting minority investors*	50.0	93	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**55.0**	**89**	◆
4.3.1	Applied tariff rate, weighted avg., %	7.3	99	
4.3.2	Intensity of local competition†	72.4	44	● ◆
4.3.3	Domestic market scale, bn PPP$	96.7	78	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**27.3**	**82**	
5.1	**Knowledge workers**	**19.0**	**109**	
5.1.1	Knowledge-intensive employment, %	10.1	100	◆
5.1.2	Firms offering formal training, % firms	34.7	41	●
5.1.3	GERD performed by business, % GDP	0.0	83	◆
5.1.4	GERD financed by business, %	3.4	84	
5.1.5	Females employed w/advanced degrees, %	4.6	91	◆
5.2	**Innovation linkages**	**41.7**	**25**	● ◆
5.2.1	University/industry research collaboration†	42.6	57	●
5.2.2	State of cluster development†	43.1	80	
5.2.3	GERD financed by abroad, %	52.4	1	● ◆
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.0	83	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**21.2**	**119**	○ ◇
5.3.1	Intellectual property payments, % total trade	0.3	79	
5.3.2	High-tech imports, % total trade	6.4	87	
5.3.3	ICT services imports, % total trade	0.6	98	
5.3.4	FDI net inflows, % GDP	2.7	61	●
5.3.5	Research talent, % in business enterprise	4.0	74	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**13.6**	**108**	
6.1	**Knowledge creation**	**6.8**	**83**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	99	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	95	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.1	80	
6.1.5	Citable documents H-index	9.5	72	◆
6.2	**Knowledge impact**	**26.6**	**103**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.4	76	
6.2.2	New businesses/th pop. 15-64	0.7	79	
6.2.3	Computer software spending, % GDP	0.0	123	○
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.1	105	
6.2.5	High- & medium-high-tech manufactures, %	n/a	n/a	
6.3	**Knowledge diffusion**	**7.5**	**115**	
6.3.1	Intellectual property receipts, % total trade	0.0	67	
6.3.2	High-tech net exports, % total trade	0.1	102	
6.3.3	ICT services exports, % total trade	0.6	93	
6.3.4	FDI net outflows, % GDP	0.0	114	
	CREATIVE OUTPUTS	**17.5**	**106**	
7.1	**Intangible assets**	**32.6**	**101**	
7.1.1	Trademarks by origin/bn PPP$ GDP	15.2	95	
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	49.8	106	
7.1.4	ICTs & organizational model creation†	42.7	103	
7.2	**Creative goods & services**	**4.5**	**[104]**	
7.2.1	Cultural & creative services exports, % total trade	0.1	83	
7.2.2	National feature films/mn pop. 15-69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15-69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.5	62	● ◆
7.3	**Online creativity**	**0.2**	**119**	○
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	0.2	115	
7.3.2	Country-code TLDs/th pop. 15-69	0.1	119	○
7.3.3	Wikipedia edits/mn pop. 15-69	0.6	107	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

UKRAINE

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
36	82	Lower middle	EUR	44.0	391.5	9,283.4	43

		Score/Value	Rank	
	INSTITUTIONS	**53.9**	**96**	
1.1	**Political environment**	**38.8**	**110**	○
1.1.1	Political and operational stability*	45.6	125	○ ◇
1.1.2	Government effectiveness*	35.4	95	
1.2	**Regulatory environment**	**61.4**	**78**	
1.2.1	Regulatory quality*	33.3	94	
1.2.2	Rule of law*	27.6	107	○
1.2.3	Cost of redundancy dismissal, salary weeks	13.0	42	
1.3	**Business environment**	**61.4**	**99**	
1.3.1	Ease of starting a business*	91.1	48	
1.3.2	Ease of resolving insolvency*	31.7	115	○ ◇
	HUMAN CAPITAL & RESEARCH	**35.6**	**51**	◆
2.1	**Education**	**55.1**	**43**	◆
2.1.1	Expenditure on education, % GDP	5.0	48	
2.1.2	Government funding/pupil, secondary, % GDP/cap	25.7	23	
2.1.3	School life expectancy, years	15.0	52	◆
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	7.2	3	● ◆
2.2	**Tertiary education**	**40.6**	**37**	◆
2.2.1	Tertiary enrolment, % gross	83.4	14	● ◆
2.2.2	Graduates in science & engineering, %	24.2	33	
2.2.3	Tertiary inbound mobility, %	3.2	62	
2.3	**Research & development (R&D)**	**11.2**	**54**	
2.3.1	Researchers, FTE/mn pop	1,119.5	50	◆
2.3.2	Gross expenditure on R&D, % GDP	0.4	67	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	22.0	46	◆
	INFRASTRUCTURE	**36.0**	**97**	
3.1	**Information & communication technologies(ICTs)**	**58.0**	**81**	
3.1.1	ICT access*	66.5	65	◆
3.1.2	ICT use*	39.9	90	
3.1.3	Government's online service*	56.9	92	
3.1.4	E-participation*	68.5	73	
3.2	**General infrastructure**	**26.2**	**95**	
3.2.1	Electricity output, kWh/mn pop	3,620.1	55	◆
3.2.2	Logistics performance*	35.9	65	
3.2.3	Gross capital formation, % GDP	18.8	99	
3.3	**Ecological sustainability**	**23.9**	**120**	○ ◇
3.3.1	GDP/unit of energy use	3.4	115	○ ◇
3.3.2	Environmental performance*	52.9	89	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.6	80	
	MARKET SOPHISTICATION	**43.3**	**90**	
4.1	**Credit**	**30.5**	**91**	
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP	38.4	86	
4.1.3	Microfinance gross loans, % GDP	0.0	79	○
4.2	**Investment**	**31.6**	**115**	○
4.2.1	Ease of protecting minority investors*	58.3	68	
4.2.2	Market capitalization, % GDP	22.2	58	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	62	○
4.3	**Trade, competition, & market scale**	**67.8**	**42**	
4.3.1	Applied tariff rate, weighted avg., %	1.9	51	◆
4.3.2	Intensity of local competition†	64.4	83	
4.3.3	Domestic market scale, bn PPP$	391.5	47	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**34.8**	**47**	◆
5.1	**Knowledge workers**	**45.4**	**45**	◆
5.1.1	Knowledge-intensive employment, %	36.9	33	◆
5.1.2	Firms offering formal training, % firms	22.6	69	
5.1.3	GERD performed by business, % GDP	0.3	50	◆
5.1.4	GERD financed by business, %	30.1	59	
5.1.5	Females employed w/advanced degrees, %	29.9	2	● ◆
5.2	**Innovation linkages**	**27.4**	**55**	
5.2.1	University/industry research collaboration†	41.3	64	
5.2.2	State of cluster development†	37.3	98	
5.2.3	GERD financed by abroad, %	24.4	15	● ◆
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	88	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	41	◆
5.3	**Knowledge absorption**	**31.7**	**73**	
5.3.1	Intellectual property payments, % total trade	0.7	52	
5.3.2	High-tech imports, % total trade	8.8	46	
5.3.3	ICT services imports, % total trade	0.9	79	
5.3.4	FDI net inflows, % GDP	3.2	52	
5.3.5	Research talent, % in business enterprise	25.1	49	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**34.6**	**28**	◆
6.1	**Knowledge creation**	**42.5**	**17**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP	6.2	17	● ◆
6.1.2	PCT patents by origin/bn PPP$ GDP	0.4	38	◆
6.1.3	Utility models by origin/bn PPP$ GDP	24.3	1	● ◆
6.1.4	Scientific & technical articles/bn PPP$ GDP	9.2	54	
6.1.5	Citable documents H-index	15.0	49	
6.2	**Knowledge impact**	**40.1**	**47**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.2	22	
6.2.2	New businesses/th pop. 15–64	1.5	60	
6.2.3	Computer software spending, % GDP	0.5	19	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	3.5	70	
6.2.5	High- & medium-high-tech manufactures, %	0.2	56	
6.3	**Knowledge diffusion**	**21.3**	**47**	
6.3.1	Intellectual property receipts, % total trade	0.2	43	
6.3.2	High-tech net exports, % total trade	2.0	53	
6.3.3	ICT services exports, % total trade	4.8	11	● ◆
6.3.4	FDI net outflows, % GDP	0.1	96	
	CREATIVE OUTPUTS	**33.5**	**42**	◆
7.1	**Intangible assets**	**55.8**	**17**	● ◆
7.1.1	Trademarks by origin/bn PPP$ GDP	128.6	6	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	13.4	8	● ◆
7.1.3	ICTs & business model creation†	49.1	109	○
7.1.4	ICTs & organizational model creation†	55.6	58	
7.2	**Creative goods & services**	**8.8**	**91**	
7.2.1	Cultural & creative services exports, % total trade	0.4	58	
7.2.2	National feature films/mn pop. 15–69	0.6	94	○
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.0	62	
7.2.5	Creative goods exports, % total trade	0.2	82	
7.3	**Online creativity**	**13.6**	**43**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	4.5	57	◆
7.3.2	Country-code TLDs/th pop. 15–69	4.7	51	◆
7.3.3	Wikipedia edits/mn pop. 15–69	31.1	38	◆
7.3.4	Mobile app creation/bn PPP$ GDP	24.3	19	◆

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

UNITED ARAB EMIRATES (THE)

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
58	24	High	NAWA	9.5	732.9	69,381.7	38

		Score/Value	Rank	
	INSTITUTIONS	**78.8**	**28**	
1.1	**Political environment**	**80.5**	**20**	
1.1.1	Political and operational stability*	80.7	35	
1.1.2	Government effectiveness*	80.4	19	
1.2	**Regulatory environment**	**84.2**	**24**	
1.2.1	Regulatory quality*	69.1	32	
1.2.2	Rule of law*	67.5	34	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	● ◆
1.3	**Business environment**	**71.9**	**58**	
1.3.1	Ease of starting a business*	94.1	22	
1.3.2	Ease of resolving insolvency*	49.7	67	
	HUMAN CAPITAL & RESEARCH	**52.4**	**18**	
2.1	**Education**	**61.9**	**[17]**	
2.1.1	Expenditure on education, % GDP	n/a	n/a	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	13.6	72	○ ◇
2.1.4	PISA scales in reading, maths, & science	474.3	37	
2.1.5	Pupil-teacher ratio, secondary ⊕	9.5	23	
2.2	**Tertiary education**	**57.5**	**6**	● ◆
2.2.1	Tertiary enrolment, % gross	n/a	n/a	
2.2.2	Graduates in science & engineering, %	22.0	50	
2.2.3	Tertiary inbound mobility, %	48.6	1	● ◆
2.3	**Research & development (R&D)**	**37.7**	**28**	
2.3.1	Researchers, FTE/mn pop. ⊕	2,406.6	35	
2.3.2	Gross expenditure on R&D, % GDP ⊕	1.0	36	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	69.7	18	
2.3.4	QS university ranking, average score top 3*	31.2	37	
	INFRASTRUCTURE	**59.4**	**21**	
3.1	**Information & communication technologies(ICTs)**	**88.7**	**14**	●
3.1.1	ICT access*	84.8	15	
3.1.2	ICT use*	81.3	13	●
3.1.3	Government's online service*	94.4	14	●
3.1.4	E-participation*	94.4	17	
3.2	**General infrastructure**	**52.7**	**12**	●
3.2.1	Electricity output, kWh/mn pop.	13,980.2	8	●
3.2.2	Logistics performance*	88.5	11	● ◆
3.2.3	Gross capital formation, % GDP	22.5	69	
3.3	**Ecological sustainability**	**36.8**	**71**	◇
3.3.1	GDP/unit of energy use	8.2	72	○
3.3.2	Environmental performance*	58.9	67	◇
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.5	40	
	MARKET SOPHISTICATION	**56.1**	**34**	
4.1	**Credit**	**53.5**	**27**	
4.1.1	Ease of getting credit*	70.0	40	
4.1.2	Domestic credit to private sector, % GDP	78.8	38	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**46.2**	**53**	
4.2.1	Ease of protecting minority investors*	75.0	14	◆
4.2.2	Market capitalization, % GDP	60.4	29	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	32	
4.3	**Trade, competition, & market scale**	**68.6**	**39**	
4.3.1	Applied tariff rate, weighted avg., %	4.8	81	○ ◇
4.3.2	Intensity of local competition†	71.0	49	
4.3.3	Domestic market scale, bn PPP$	732.9	32	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**41.5**	**30**	
5.1	**Knowledge workers**	**40.7**	**55**	
5.1.1	Knowledge-intensive employment, %	18.4	79	○ ◇
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP ⊕	0.7	26	
5.1.4	GERD financed by business, % ⊕	74.3	5	● ◆
5.1.5	Females employed w/advanced degrees, %	8.8	73	○ ◇
5.2	**Innovation linkages**	**41.9**	**24**	
5.2.1	University/industry research collaboration†	55.7	28	
5.2.2	State of cluster development†	69.1	10	● ◆
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	16	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	67	
5.3	**Knowledge absorption**	**42.0**	**34**	
5.3.1	Intellectual property payments, % total trade	0.7	54	
5.3.2	High-tech imports, % total trade ⊕	9.4	38	
5.3.3	ICT services imports, % total trade	0.9	74	
5.3.4	FDI net inflows, % GDP	2.6	67	
5.3.5	Research talent, % in business enterprise ⊕	62.2	8	●
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**22.2**	**63**	
6.1	**Knowledge creation**	**6.4**	**88**	○ ◇
6.1.1	Patents by origin/bn PPP$ GDP	0.1	106	○
6.1.2	PCT patents by origin/bn PPP$ GDP	0.1	60	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.1	101	○ ◇
6.1.5	Citable documents H-index	10.5	62	
6.2	**Knowledge impact**	**34.9**	**73**	
6.2.1	Growth rate of PPP$ GDP/worker, %	1.6	48	
6.2.2	New businesses/th pop. 15–64	2.6	42	
6.2.3	Computer software spending, % GDP	0.3	50	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	6.0	52	
6.2.5	High- & medium-high-tech manufactures, %	0.2	57	
6.3	**Knowledge diffusion**	**25.2**	**37**	
6.3.1	Intellectual property receipts, % total trade	1.0	19	
6.3.2	High-tech net exports, % total trade ⊕	0.1	107	○ ◇
6.3.3	ICT services exports, % total trade	1.8	59	
6.3.4	FDI net outflows, % GDP	4.0	13	●
	CREATIVE OUTPUTS	**31.2**	**50**	
7.1	**Intangible assets**	**40.5**	**66**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	8.7	107	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP ⊕	0.1	108	○
7.1.3	ICTs & business model creation†	71.7	29	
7.1.4	ICTs & organizational model creation†	67.3	24	
7.2	**Creative goods & services**	**35.9**	**13**	●
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15–69	10.6	16	
7.2.3	Entertainment & Media market/th pop. 15–69	19.5	28	
7.2.4	Printing & other media, % manufacturing	1.5	32	
7.2.5	Creative goods exports, % total trade ⊕	4.2	13	● ◆
7.3	**Online creativity**	**7.9**	**57**	◇
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	10.8	38	
7.3.2	Country-code TLDs/th pop. 15–69	7.3	43	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊕	9.9	63	◇
7.3.4	Mobile app creation/bn PPP$ GDP	6.7	47	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊕ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

UNITED KINGDOM (THE)

GII 2019 rank

5

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
4	**6**	**High**	**EUR**	**66.6**	**3,033.7**	**45,704.6**	**4**

		Score/Value	Rank	
	INSTITUTIONS	**87.1**	**14**	
1.1	**Political environment**	**80.2**	**23**	
1.1.1	Political and operational stability*	78.9	42	○ ◇
1.1.2	Government effectiveness*	80.8	18	
1.2	**Regulatory environment**	**93.7**	**11**	
1.2.1	Regulatory quality*	88.0	12	
1.2.2	Rule of law*	90.8	14	
1.2.3	Cost of redundancy dismissal, salary weeks	9.3	25	
1.3	**Business environment**	**87.4**	**13**	
1.3.1	Ease of starting a business*	94.6	17	
1.3.2	Ease of resolving insolvency*	80.3	13	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**59.3**	**9**	
2.1	**Education**	**57.7**	**34**	
2.1.1	Expenditure on education, % GDP	5.5	26	
2.1.2	Government funding/pupil, secondary, % GDP/cap	19.0	55	○
2.1.3	School life expectancy, years	19.0	6	●
2.1.4	PISA scales in reading, maths, & science	499.9	21	
2.1.5	Pupil-teacher ratio, secondary ⊙	19.4	87	○ ◇
2.2	**Tertiary education**	**52.4**	**11**	
2.2.1	Tertiary enrolment, % gross ⊙	59.4	47	○
2.2.2	Graduates in science & engineering, %	26.3	25	
2.2.3	Tertiary inbound mobility, %	18.1	6	◆
2.3	**Research & development (R&D)**	**67.8**	**9**	
2.3.1	Researchers, FTE/mn pop.	4,377.0	19	
2.3.2	Gross expenditure on R&D, % GDP	1.7	22	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	86.8	8	
2.3.4	QS university ranking, average score top 3*	95.2	2	● ◆

		Score/Value	Rank	
	INFRASTRUCTURE	**64.4**	**8**	
3.1	**Information & communication technologies(ICTs)**	**93.0**	**3**	● ◆
3.1.1	ICT access*	92.9	3	● ◆
3.1.2	ICT use*	82.7	9	
3.1.3	Government's online service*	97.9	4	●
3.1.4	E-participation*	98.3	5	
3.2	**General infrastructure**	**39.3**	**44**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	5,041.5	44	○
3.2.2	Logistics performance*	90.0	9	
3.2.3	Gross capital formation, % GDP	17.2	109	○ ◇
3.3	**Ecological sustainability**	**61.0**	**5**	● ◆
3.3.1	GDP/unit of energy use	14.7	14	
3.3.2	Environmental performance*	79.9	6	●
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	6.0	19	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**76.0**	**4**	● ◆
4.1	**Credit**	**70.4**	**10**	
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP	136.2	14	
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**75.4**	**6**	● ◆
4.2.1	Ease of protecting minority investors*	75.0	14	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.3	4	● ◆
4.3	**Trade, competition, & market scale**	**82.0**	**5**	●
4.3.1	Applied tariff rate, weighted avg., %	1.8	23	○
4.3.2	Intensity of local competition†	79.9	9	
4.3.3	Domestic market scale, bn PPP$	3,033.7	9	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**54.3**	**16**	
5.1	**Knowledge workers**	**67.5**	**12**	
5.1.1	Knowledge-intensive employment, %	48.6	7	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	1.1	18	
5.1.4	GERD financed by business, %	51.8	25	
5.1.5	Females employed w/advanced degrees, %	22.8	16	
5.2	**Innovation linkages**	**50.1**	**13**	
5.2.1	University/industry research collaboration†	72.7	7	
5.2.2	State of cluster development†	69.8	9	
5.2.3	GERD financed by abroad, %	15.6	26	
5.2.4	JV-strategic alliance deals/bn PPP$ GDP	0.1	12	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	2.3	17	
5.3	**Knowledge absorption**	**45.4**	**27**	
5.3.1	Intellectual property payments, % total trade	1.5	23	
5.3.2	High-tech imports, % total trade	11.9	20	
5.3.3	ICT services imports, % total trade	1.8	30	
5.3.4	FDI net inflows, % GDP	4.7	34	
5.3.5	Research talent, % in business enterprise	37.9	33	○ ◇

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**56.6**	**8**	
6.1	**Knowledge creation**	**66.9**	**5**	●
6.1.1	Patents by origin/bn PPP$ GDP	6.4	16	
6.1.2	PCT patents by origin/bn PPP$ GDP	1.9	19	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	23.8	16	
6.1.5	Citable documents H-index	100.0	1	● ◆
6.2	**Knowledge impact**	**55.2**	**7**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.5	75	○
6.2.2	New businesses/th pop. 15-64	15.7	6	◆
6.2.3	Computer software spending, % GDP	0.7	4	●
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	12.8	26	
6.2.5	High- & medium-high-tech manufactures, %	0.4	21	
6.3	**Knowledge diffusion**	**47.7**	**12**	
6.3.1	Intellectual property receipts, % total trade	2.6	8	
6.3.2	High-tech net exports, % total trade	9.0	18	
6.3.3	ICT services exports, % total trade	3.2	28	
6.3.4	FDI net outflows, % GDP	1.8	31	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**52.2**	**6**	●
7.1	**Intangible assets**	**58.3**	**12**	
7.1.1	Trademarks by origin/bn PPP$ GDP	56.2	40	○
7.1.2	Industrial designs by origin/bn PPP$ GDP	7.9	16	
7.1.3	ICTs & business model creation†	80.4	8	
7.1.4	ICTs & organizational model creation†	79.1	6	●
7.2	**Creative goods & services**	**40.4**	**8**	
7.2.1	Cultural & creative services exports, % total trade	2.0	6	● ◆
7.2.2	National feature films/mn pop. 15-69	6.3	35	
7.2.3	Entertainment & Media market/th pop. 15-69	62.0	9	
7.2.4	Printing & other media, % manufacturing	2.0	19	
7.2.5	Creative goods exports, % total trade	2.9	20	
7.3	**Online creativity**	**51.6**	**11**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15-69	60.7	12	
7.3.2	Country-code TLDs/th pop. 15-69	73.1	7	
7.3.3	Wikipedia edits/mn pop. 15-69	69.3	13	
7.3.4	Mobile app creation/bn PPP$ GDP	25.9	18	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

UNITED REPUBLIC OF TANZANIA (THE)

GII 2019 rank

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Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
73	115	Low	SSF	59.1	175.9	3,443.7	92

		Score/Value	Rank	
	INSTITUTIONS	**53.4**	**98**	
1.1	**Political environment**	**40.2**	**104**	
1.1.1	Political and operational stability*	57.9	101	
1.1.2	Government effectiveness*	31.3	106	
1.2	**Regulatory environment**	**64.2**	**70**	
1.2.1	Regulatory quality*	26.4	106	
1.2.2	Rule of law*	34.6	92	
1.2.3	Cost of redundancy dismissal, salary weeks	9.3	25	● ◆
1.3	**Business environment**	**55.8**	**115**	
1.3.1	Ease of starting a business*	72.7	117	◇
1.3.2	Ease of resolving insolvency*	39.0	103	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**10.0**	**125**	◇
2.1	**Education**	**24.5**	**117**	
2.1.1	Expenditure on education, % GDP ◷	3.5	94	
2.1.2	Government funding/pupil, secondary, % GDP/cap ◷	12.4	87	
2.1.3	School life expectancy, years	7.7	116	○ ◇
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	17.1	76	
2.2	**Tertiary education**	**2.5**	**[124]**	
2.2.1	Tertiary enrolment, % gross ◷	3.9	122	○
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**2.8**	**88**	◆
2.3.1	Researchers, FTE/mn pop. ◷	18.3	104	○
2.3.2	Gross expenditure on R&D, % GDP ◷	0.5	60	● ◆
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**33.2**	**108**	
3.1	**Information & communication technologies(ICTs)**	**38.3**	**110**	
3.1.1	ICT access*	26.0	121	
3.1.2	ICT use*	9.0	123	◇
3.1.3	Government's online service*	56.3	95	
3.1.4	E-participation*	61.8	88	
3.2	**General infrastructure**	**35.9**	**61**	●
3.2.1	Electricity output, kWh/mn pop.	125.9	117	
3.2.2	Logistics performance*	n/a	n/a	
3.2.3	Gross capital formation, % GDP	30.5	21	●
3.3	**Ecological sustainability**	**25.5**	**114**	
3.3.1	GDP/unit of energy use	5.2	106	
3.3.2	Environmental performance*	50.8	96	◆
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	103	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**35.7**	**117**	
4.1	**Credit**	**23.6**	**110**	
4.1.1	Ease of getting credit*	65.0	54	● ◆
4.1.2	Domestic credit to private sector, % GDP ◷	14.4	118	
4.1.3	Microfinance gross loans, % GDP	0.1	55	
4.2	**Investment**	**30.4**	**121**	◇
4.2.1	Ease of protecting minority investors*	45.0	104	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	65	◇
4.3	**Trade, competition, & market scale**	**53.1**	**96**	◆
4.3.1	Applied tariff rate, weighted avg., % ◷	8.6	105	
4.3.2	Intensity of local competition†	59.4	109	
4.3.3	Domestic market scale, bn PPP$	175.9	68	◆

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**25.1**	**99**	
5.1	**Knowledge workers**	**13.5**	**119**	
5.1.1	Knowledge-intensive employment, % ◷	3.4	112	
5.1.2	Firms offering formal training, % firms	30.7	50	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, % ◷	0.1	98	○ ◇
5.1.5	Females employed w/advanced degrees, % ◷	0.4	113	
5.2	**Innovation linkages**	**38.0**	**32**	●
5.2.1	University/industry research collaboration†	45.7	49	●
5.2.2	State of cluster development†	48.7	54	● ◆
5.2.3	GERD financed by abroad, % ◷	42.0	6	●
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	108	○
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**23.8**	**108**	
5.3.1	Intellectual property payments, % total trade	0.0	113	
5.3.2	High-tech imports, % total trade	7.2	68	
5.3.3	ICT services imports, % total trade	0.3	115	
5.3.4	FDI net inflows, % GDP	2.9	58	●
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**14.9**	**102**	
6.1	**Knowledge creation**	**5.1**	**98**	
6.1.1	Patents by origin/bn PPP$ GDP ◷	0.0	126	○ ◇
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	93	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.1	104	
6.1.5	Citable documents H-index	8.6	76	◆
6.2	**Knowledge impact**	**33.5**	**78**	
6.2.1	Growth rate of PPP$ GDP/worker, %	3.1	24	●
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.0	126	○
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.9	110	
6.2.5	High- & medium-high-tech manufactures, %	0.1	86	
6.3	**Knowledge diffusion**	**6.2**	**127**	○
6.3.1	Intellectual property receipts, % total trade	0.0	101	
6.3.2	High-tech net exports, % total trade	0.2	101	
6.3.3	ICT services exports, % total trade	0.2	117	
6.3.4	FDI net outflows, % GDP	0.0	115	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**28.7**	**[59]**	
7.1	**Intangible assets**	**50.3**	**[34]**	
7.1.1	Trademarks by origin/bn PPP$ GDP	n/a	n/a	
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	53.3	90	
7.1.4	ICTs & organizational model creation†	47.2	93	
7.2	**Creative goods & services**	**13.9**	**[72]**	
7.2.1	Cultural & creative services exports, % total trade ◷	0.0	114	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	1.7	25	●
7.2.5	Creative goods exports, % total trade ◷	0.1	96	
7.3	**Online creativity**	**0.1**	**122**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.1	119	
7.3.2	Country-code TLDs/th pop. 15–69	0.1	112	
7.3.3	Wikipedia edits/mn pop. 15–69 ◷	0.2	115	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

UNITED STATES OF AMERICA (THE)

GII 2019 rank

3

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
6	3	High	NAC	326.8	20,513.0	62,605.6	6

		Score/Value	Rank	
1	**INSTITUTIONS**	**89.7**	**11**	
1.1	**Political environment**	**84.2**	**16**	
1.1.1	Political and operational stability*	84.2	25	
1.1.2	Government effectiveness*	84.2	14	
1.2	**Regulatory environment**	**93.9**	**9**	
1.2.1	Regulatory quality*	85.6	15	
1.2.2	Rule of law*	89.9	15	
1.2.3	Cost of redundancy dismissal, salary weeks	8.0	1	●
1.3	**Business environment**	**91.1**	**2**	● ◆
1.3.1	Ease of starting a business*	91.2	47	
1.3.2	Ease of resolving insolvency*	90.9	3	● ◆
2	**HUMAN CAPITAL & RESEARCH**	**55.7**	**12**	
2.1	**Education**	**54.5**	**45**	
2.1.1	Expenditure on education, % GDP ◷	5.0	50	
2.1.2	Government funding/pupil, secondary, % GDP/cap ◷	22.5	39	
2.1.3	School life expectancy, years	16.3	29	
2.1.4	PISA scales in reading, maths, & science	487.6	29	◇
2.1.5	Pupil-teacher ratio, secondary ◷	14.7	67	○ ◇
2.2	**Tertiary education**	**34.6**	**53**	
2.2.1	Tertiary enrolment, % gross ◷	88.8	8	
2.2.2	Graduates in science & engineering, %	17.9	73	○
2.2.3	Tertiary inbound mobility, %	5.0	40	
2.3	**Research & development (R&D)**	**77.9**	**3**	● ◆
2.3.1	Researchers, FTE/mn pop. ◷	4,256.3	23	
2.3.2	Gross expenditure on R&D, % GDP	2.8	9	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	100.0	1	● ◆
2.3.4	QS university ranking, average score top 3*	99.0	1	● ◆
3	**INFRASTRUCTURE**	**59.2**	**23**	
3.1	**Information & communication technologies(ICTs)**	**89.7**	**8**	
3.1.1	ICT access*	84.8	14	
3.1.2	ICT use*	77.2	21	
3.1.3	Government's online service*	98.6	2	●
3.1.4	E-participation*	98.3	5	
3.2	**General infrastructure**	**49.4**	**19**	
3.2.1	Electricity output, kWh/mn pop.	13,000.9	9	
3.2.2	Logistics performance*	85.2	14	
3.2.3	Gross capital formation, % GDP	21.1	87	○
3.3	**Ecological sustainability**	**38.4**	**64**	◇
3.3.1	GDP/unit of energy use	8.1	74	○
3.3.2	Environmental performance*	71.2	26	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.3	106	○ ◇
4	**MARKET SOPHISTICATION**	**87.0**	**1**	● ◆
4.1	**Credit**	**94.6**	**1**	● ◆
4.1.1	Ease of getting credit*	95.0	3	● ◆
4.1.2	Domestic credit to private sector, % GDP ◷	192.2	3	● ◆
4.1.3	Microfinance gross loans, % GDP	n/a	n/a	
4.2	**Investment**	**73.7**	**7**	◆
4.2.1	Ease of protecting minority investors*	64.7	47	
4.2.2	Market capitalization, % GDP	150.3	5	
4.2.3	Venture capital deals/bn PPP$ GDP	0.4	1	● ◆
4.3	**Trade, competition, & market scale**	**92.7**	**1**	● ◆
4.3.1	Applied tariff rate, weighted avg., %	1.7	18	
4.3.2	Intensity of local competition†	84.3	3	● ◆
4.3.3	Domestic market scale, bn PPP$	20,513.0	2	● ◆

		Score/Value	Rank	
5	**BUSINESS SOPHISTICATION**	**62.7**	**7**	
5.1	**Knowledge workers**	**76.4**	**4**	◆
5.1.1	Knowledge-intensive employment, %	47.3	11	
5.1.2	Firms offering formal training, % firms	n/a	n/a	
5.1.3	GERD performed by business, % GDP	2.0	8	
5.1.4	GERD financed by business, %	63.6	9	
5.1.5	Females employed w/advanced degrees, %	26.3	6	◆
5.2	**Innovation linkages**	**54.3**	**9**	
5.2.1	University/industry research collaboration†	80.9	1	● ◆
5.2.2	State of cluster development†	79.5	1	● ◆
5.2.3	GERD financed by abroad, %	6.2	58	○
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	9	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	3.3	15	
5.3	**Knowledge absorption**	**57.3**	**7**	
5.3.1	Intellectual property payments, % total trade	1.8	15	
5.3.2	High-tech imports, % total trade	17.2	9	◆
5.3.3	ICT services imports, % total trade	1.5	40	
5.3.4	FDI net inflows, % GDP	2.4	72	○
5.3.5	Research talent, % in business enterprise ◷	71.0	5	◆
6	**KNOWLEDGE & TECHNOLOGY OUTPUTS**	**59.7**	**4**	◆
6.1	**Knowledge creation**	**72.3**	**3**	● ◆
6.1.1	Patents by origin/bn PPP$ GDP	15.1	6	◆
6.1.2	PCT patents by origin/bn PPP$ GDP	2.7	12	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	10.5	44	◇
6.1.5	Citable documents H-index	100.0	1	● ◆
6.2	**Knowledge impact**	**60.4**	**2**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	0.9	64	○
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	1.1	1	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	1.5	99	○ ◇
6.2.5	High- & medium-high-tech manufactures, %	0.5	10	
6.3	**Knowledge diffusion**	**46.5**	**15**	
6.3.1	Intellectual property receipts, % total trade	5.0	1	● ◆
6.3.2	High-tech net exports, % total trade	5.8	27	
6.3.3	ICT services exports, % total trade	1.6	65	
6.3.4	FDI net outflows, % GDP	1.8	33	
7	**CREATIVE OUTPUTS**	**45.5**	**15**	
7.1	**Intangible assets**	**50.3**	**32**	
7.1.1	Trademarks by origin/bn PPP$ GDP	22.0	85	○ ◇
7.1.2	Industrial designs by origin/bn PPP$ GDP	1.2	61	
7.1.3	ICTs & business model creation†	81.0	6	
7.1.4	ICTs & organizational model creation†	83.7	1	● ◆
7.2	**Creative goods & services**	**43.8**	**5**	◆
7.2.1	Cultural & creative services exports, % total trade	2.5	5	◆
7.2.2	National feature films/mn pop. 15–69	2.9	58	◇
7.2.3	Entertainment & Media market/th pop. 15–69	100.0	1	● ◆
7.2.4	Printing & other media, % manufacturing	1.5	31	
7.2.5	Creative goods exports, % total trade	3.3	17	
7.3	**Online creativity**	**37.5**	**19**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	100.0	1	● ◆
7.3.2	Country-code TLDs/th pop. 15–69	2.4	62	◇
7.3.3	Wikipedia edits/mn pop. 15–69	26.1	42	◇
7.3.4	Mobile app creation/bn PPP$ GDP	30.1	17	

NOTES: ● indicates a strength; ○ a weakness; ◆ a strength relative to the other top 25-ranked GII economies; ◇ a weakness relative to the other top 25-ranked GII economies; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

URUGUAY

GII 2019 rank

62

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
61	66	High	LCN	3.5	81.6	23,274.1	62

		Score/Value	Rank	
	INSTITUTIONS	**69.3**	**44**	
1.1	**Political environment**	**65.8**	**44**	
1.1.1	Political and operational stability*	84.2	25	●
1.1.2	Government effectiveness*	56.6	48	◇
1.2	**Regulatory environment**	**70.6**	**50**	
1.2.1	Regulatory quality*	59.6	41	
1.2.2	Rule of law*	61.9	38	
1.2.3	Cost of redundancy dismissal, salary weeks	20.8	87	
1.3	**Business environment**	**71.4**	**61**	
1.3.1	Ease of starting a business*	89.8	55	
1.3.2	Ease of resolving insolvency*	53.0	64	
	HUMAN CAPITAL & RESEARCH	**28.7**	**71**	◇
2.1	**Education**	**54.8**	**44**	
2.1.1	Expenditure on education, % GDP ⊙	4.4	66	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	16.3	25	●
2.1.4	PISA scales in reading, maths, & science	430.0	48	
2.1.5	Pupil-teacher ratio, secondary ⊙	12.7	54	
2.2	**Tertiary education**	**24.1**	**83**	◇
2.2.1	Tertiary enrolment, % gross ⊙	62.4	43	
2.2.2	Graduates in science & engineering, %	13.2	95	○ ◇
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**7.1**	**69**	◇
2.3.1	Researchers, FTE/mn pop.	667.7	62	◇
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.4	69	◇
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	12.0	61	
	INFRASTRUCTURE	**51.0**	**49**	◇
3.1	**Information & communication technologies(ICTs)**	**81.7**	**27**	●
3.1.1	ICT access*	75.1	42	
3.1.2	ICT use*	71.4	31	
3.1.3	Government's online service*	88.9	27	●
3.1.4	E-participation*	91.6	26	●
3.2	**General infrastructure**	**23.6**	**107**	○ ◇
3.2.1	Electricity output, kWh/mn pop.	3,848.3	53	
3.2.2	Logistics performance*	29.1	83	◇
3.2.3	Gross capital formation, % GDP	17.8	104	○ ◇
3.3	**Ecological sustainability**	**47.7**	**40**	
3.3.1	GDP/unit of energy use	13.0	24	●
3.3.2	Environmental performance*	64.7	43	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	3.0	32	
	MARKET SOPHISTICATION	**39.9**	**101**	◇
4.1	**Credit**	**23.5**	**111**	○ ◇
4.1.1	Ease of getting credit*	60.0	66	
4.1.2	Domestic credit to private sector, % GDP	26.3	105	○ ◇
4.1.3	Microfinance gross loans, % GDP ⊙	0.0	67	○
4.2	**Investment**	**43.3**	**[61]**	
4.2.1	Ease of protecting minority investors*	43.3	105	○ ◇
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**52.8**	**97**	◇
4.3.1	Applied tariff rate, weighted avg., %	6.3	97	◇
4.3.2	Intensity of local competition†	61.5	101	◇
4.3.3	Domestic market scale, bn PPP$	81.6	86	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**27.7**	**81**	◇
5.1	**Knowledge workers**	**33.3**	**78**	◇
5.1.1	Knowledge-intensive employment, %	22.2	67	◇
5.1.2	Firms offering formal training, % firms ⊙	48.6	23	
5.1.3	GERD performed by business, % GDP ⊙	0.0	80	○ ◇
5.1.4	GERD financed by business, %	4.6	81	○ ◇
5.1.5	Females employed w/advanced degrees, %	10.1	65	◇
5.2	**Innovation linkages**	**18.3**	**101**	◇
5.2.1	University/industry research collaboration†	34.9	93	◇
5.2.2	State of cluster development†	37.0	101	◇
5.2.3	GERD financed by abroad, %	7.4	52	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	79	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.2	49	
5.3	**Knowledge absorption**	**31.4**	**77**	
5.3.1	Intellectual property payments, % total trade	0.8	48	
5.3.2	High-tech imports, % total trade	7.1	71	
5.3.3	ICT services imports, % total trade	2.5	15	●
5.3.4	FDI net inflows, % GDP	0.8	112	○
5.3.5	Research talent, % in business enterprise	0.7	80	○ ◇
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**21.5**	**67**	
6.1	**Knowledge creation**	**9.4**	**72**	◇
6.1.1	Patents by origin/bn PPP$ GDP	0.3	87	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP	0.3	38	
6.1.4	Scientific & technical articles/bn PPP$ GDP	9.2	52	
6.1.5	Citable documents H-index	9.9	68	
6.2	**Knowledge impact**	**36.3**	**66**	
6.2.1	Growth rate of PPP$ GDP/worker, %	2.0	44	
6.2.2	New businesses/th pop. 15–64	2.1	50	
6.2.3	Computer software spending, % GDP	0.2	68	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	14.6	23	●
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	72	◇
6.3	**Knowledge diffusion**	**18.7**	**54**	
6.3.1	Intellectual property receipts, % total trade	0.2	32	
6.3.2	High-tech net exports, % total trade	0.9	70	
6.3.3	ICT services exports, % total trade	3.0	30	●
6.3.4	FDI net outflows, % GDP	1.4	43	
	CREATIVE OUTPUTS	**29.2**	**57**	
7.1	**Intangible assets**	**41.7**	**60**	
7.1.1	Trademarks by origin/bn PPP$ GDP	47.4	51	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.7	81	
7.1.3	ICTs & business model creation†	66.8	43	
7.1.4	ICTs & organizational model creation†	58.4	50	
7.2	**Creative goods & services**	**16.6**	**64**	
7.2.1	Cultural & creative services exports, % total trade	1.6	12	●
7.2.2	National feature films/mn pop. 15–69 ⊙	4.7	45	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing ⊙	1.1	56	
7.2.5	Creative goods exports, % total trade	0.1	106	○
7.3	**Online creativity**	**16.7**	**39**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	6.4	50	
7.3.2	Country-code TLDs/th pop. 15–69	9.8	39	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	68.1	14	●
7.3.4	Mobile app creation/bn PPP$ GDP	4.6	50	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

VIET NAM

GII 2019 rank

42

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
37	63	Lower middle	SEAO	96.5	707.6	7,510.5	45

		Score/Value	Rank	
	INSTITUTIONS	**58.6**	**81**	
1.1	**Political environment**	**58.6**	**57**	◆
1.1.1	Political and operational stability*	82.5	32	◆
1.1.2	Government effectiveness*	46.6	71	◆
1.2	**Regulatory environment**	**57.3**	**90**	
1.2.1	Regulatory quality*	31.3	97	
1.2.2	Rule of law*	48.2	59	◆
1.2.3	Cost of redundancy dismissal, salary weeks	24.6	101	○
1.3	**Business environment**	**59.9**	**106**	○
1.3.1	Ease of starting a business*	84.8	80	
1.3.2	Ease of resolving insolvency*	34.9	110	○

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**31.1**	**61**	
2.1	**Education**	**61.2**	**[18]**	
2.1.1	Expenditure on education, % GDP ⊙	5.7	24	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	502.0	20	◆
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**24.7**	**81**	
2.2.1	Tertiary enrolment, % gross ⊙	28.3	85	
2.2.2	Graduates in science & engineering, %	22.7	46	
2.2.3	Tertiary inbound mobility, %	0.2	104	○
2.3	**Research & development (R&D)**	**7.4**	**67**	
2.3.1	Researchers, FTE/mn pop.	700.8	58	
2.3.2	Gross expenditure on R&D, % GDP	0.5	61	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	9.9	64	

		Score/Value	Rank	
	INFRASTRUCTURE	**42.0**	**82**	
3.1	**Information & communication technologies(ICTs)**	**57.5**	**82**	
3.1.1	ICT access*	48.8	90	
3.1.2	ICT use*	38.7	92	
3.1.3	Government's online service*	73.6	57	
3.1.4	E-participation*	69.1	70	
3.2	**General infrastructure**	**39.3**	**45**	
3.2.1	Electricity output, kWh/mn pop.	1,778.1	81	
3.2.2	Logistics performance*	56.6	38	◆
3.2.3	Gross capital formation, % GDP	27.5	32	
3.3	**Ecological sustainability**	**29.2**	**100**	
3.3.1	GDP/unit of energy use	6.7	92	
3.3.2	Environmental performance*	47.0	104	○
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.2	45	◆

		Score/Value	Rank	
	MARKET SOPHISTICATION	**57.0**	**29**	◆
4.1	**Credit**	**68.6**	**11**	● ◆
4.1.1	Ease of getting credit*	75.0	29	
4.1.2	Domestic credit to private sector, % GDP	130.7	16	● ◆
4.1.3	Microfinance gross loans, % GDP	3.9	8	● ◆
4.2	**Investment**	**33.1**	**108**	○
4.2.1	Ease of protecting minority investors*	55.0	84	
4.2.2	Market capitalization, % GDP	36.9	41	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	37	
4.3	**Trade, competition, & market scale**	**69.3**	**35**	◆
4.3.1	Applied tariff rate, weighted avg., %	2.7	61	
4.3.2	Intensity of local competition†	63.2	90	
4.3.3	Domestic market scale, bn PPP$	707.6	33	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**30.0**	**69**	
5.1	**Knowledge workers**	**22.8**	**102**	○
5.1.1	Knowledge-intensive employment, %	1.1	117	○ ◇
5.1.2	Firms offering formal training, % firms	22.2	70	○
5.1.3	GERD performed by business, % GDP	0.4	42	◆
5.1.4	GERD financed by business, %	64.1	8	● ◆
5.1.5	Females employed w/advanced degrees, %	6.1	83	
5.2	**Innovation linkages**	**20.0**	**86**	
5.2.1	University/industry research collaboration†	38.6	75	
5.2.2	State of cluster development†	45.2	74	
5.2.3	GERD financed by abroad, %	4.5	64	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	49	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	84	
5.3	**Knowledge absorption**	**47.1**	**23**	● ◆
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech imports, % total trade	26.5	1	● ◆
5.3.3	ICT services imports, % total trade	0.0	126	○ ◇
5.3.4	FDI net inflows, % GDP	6.2	23	●
5.3.5	Research talent, % in business enterprise	24.1	51	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**35.6**	**27**	◆
6.1	**Knowledge creation**	**8.1**	**80**	
6.1.1	Patents by origin/bn PPP$ GDP	0.9	65	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	82	
6.1.3	Utility models by origin/bn PPP$ GDP	0.4	35	
6.1.4	Scientific & technical articles/bn PPP$ GDP	5.6	74	
6.1.5	Citable documents H-index	11.7	57	
6.2	**Knowledge impact**	**56.5**	**5**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	6.0	3	● ◆
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.3	38	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	8.3	37	◆
6.2.5	High- & medium-high-tech manufactures, %	0.4	27	◆
6.3	**Knowledge diffusion**	**42.1**	**18**	● ◆
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	32.9	1	● ◆
6.3.3	ICT services exports, % total trade	0.1	125	○ ◇
6.3.4	FDI net outflows, % GDP	0.4	71	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**32.3**	**47**	◆
7.1	**Intangible assets**	**43.7**	**53**	
7.1.1	Trademarks by origin/bn PPP$ GDP	85.3	24	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	2.7	43	
7.1.3	ICTs & business model creation†	56.1	83	
7.1.4	ICTs & organizational model creation†	54.4	63	
7.2	**Creative goods & services**	**28.8**	**32**	◆
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15–69 ⊙	1.2	78	
7.2.3	Entertainment & Media market/th pop. 15–69	1.3	56	○
7.2.4	Printing & other media, % manufacturing	0.9	70	
7.2.5	Creative goods exports, % total trade	5.9	10	● ◆
7.3	**Online creativity**	**13.0**	**44**	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	2.4	74	◆
7.3.2	Country-code TLDs/th pop. 15–69	1.8	69	
7.3.3	Wikipedia edits/mn pop. 15–69	7.1	70	
7.3.4	Mobile app creation/bn PPP$ GDP	42.9	13	● ◆

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

YEMEN

GII 2019 rank

129

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
129	129	Low	NAWA	28.9	73.3	2,377.2	n/a

		Score/Value	Rank	
	INSTITUTIONS	**27.5**	**129**	○ ◇
1.1	**Political environment**	**0.0**	**129**	○ ◇
1.1.1	Political and operational stability*	0.0	129	○ ◇
1.1.2	Government effectiveness*	0.0	129	○ ◇
1.2	**Regulatory environment**	**36.0**	**124**	◇
1.2.1	Regulatory quality*	3.0	128	◇
1.2.2	Rule of law*	0.0	129	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	27.4	107	◇
1.3	**Business environment**	**46.5**	**127**	◇
1.3.1	Ease of starting a business*	67.0	125	◇
1.3.2	Ease of resolving insolvency*	25.9	125	◇

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**12.5**	**[117]**	
2.1	**Education**	**26.0**	**[116]**	
2.1.1	Expenditure on education, % GDP ⊙	5.2	42	●
2.1.2	Government funding/pupil, secondary, % GDP/cap ⊙	12.0	88	
2.1.3	School life expectancy, years ⊙	9.0	110	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**11.4**	**109**	
2.2.1	Tertiary enrolment, % gross ⊙	10.0	109	
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, % ⊙	4.3	50	●
2.3	**Research & development (R&D)**	**0.0**	**[120]**	
2.3.1	Researchers, FTE/mn pop.	n/a	n/a	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**21.5**	**128**	◇
3.1	**Information & communication technologies(ICTs)**	**10.8**	**[129]**	
3.1.1	ICT access*	n/a	n/a	
3.1.2	ICT use*	n/a	n/a	
3.1.3	Government's online service*	9.7	128	○ ◇
3.1.4	E-participation*	11.8	128	○ ◇
3.2	**General infrastructure**	**2.5**	**128**	◇
3.2.1	Electricity output, kWh/mn pop.	182.9	114	
3.2.2	Logistics performance*	9.4	117	
3.2.3	Gross capital formation, % GDP	5.9	125	○ ◇
3.3	**Ecological sustainability**	**51.2**	**26**	● ◆
3.3.1	GDP/unit of energy use	21.3	4	● ◆
3.3.2	Environmental performance*	n/a	n/a	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.0	128	○ ◇

		Score/Value	Rank	
	MARKET SOPHISTICATION	**35.0**	**119**	
4.1	**Credit**	**0.4**	**129**	○ ◇
4.1.1	Ease of getting credit*	0.0	129	○ ◇
4.1.2	Domestic credit to private sector, % GDP ⊙	5.6	126	○ ◇
4.1.3	Microfinance gross loans, % GDP	0.1	56	●
4.2	**Investment**	**53.3**	**[32]**	
4.2.1	Ease of protecting minority investors*	53.3	87	●
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**51.2**	**102**	
4.3.1	Applied tariff rate, weighted avg., %	5.0	87	● ◆
4.3.2	Intensity of local competition†	50.4	123	◇
4.3.3	Domestic market scale, bn PPP$	73.3	89	●

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**16.3**	**[129]**	
5.1	**Knowledge workers**	**6.7**	**[127]**	
5.1.1	Knowledge-intensive employment, % ⊙	1.6	116	
5.1.2	Firms offering formal training, % firms	14.3	85	◇
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ⊙	1.1	106	
5.2	**Innovation linkages**	**15.8**	**[117]**	
5.2.1	University/industry research collaboration†	19.5	125	○ ◇
5.2.2	State of cluster development†	29.9	121	◇
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**26.3**	**98**	
5.3.1	Intellectual property payments, % total trade	1.6	21	● ◆
5.3.2	High-tech imports, % total trade ⊙	6.3	88	●
5.3.3	ICT services imports, % total trade	0.4	109	
5.3.4	FDI net inflows, % GDP	-0.8	124	◇
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**3.8**	**128**	◇
6.1	**Knowledge creation**	**2.1**	**122**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	98	
6.1.2	PCT patents by origin/bn PPP$ GDP	n/a	n/a	
6.1.3	Utility models by origin/bn PPP$ GDP ⊙	0.0	65	○ ◇
6.1.4	Scientific & technical articles/bn PPP$ GDP	3.1	103	
6.1.5	Citable documents H-index	1.9	119	
6.2	**Knowledge impact**	**0.6**	**129**	○ ◇
6.2.1	Growth rate of PPP$ GDP/worker, %	-11.1	112	○ ◇
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.0	110	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.0	129	○ ◇
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.0	104	○ ◇
6.3	**Knowledge diffusion**	**8.8**	**111**	
6.3.1	Intellectual property receipts, % total trade ⊙	0.2	35	● ◆
6.3.2	High-tech net exports, % total trade ⊙	0.1	117	
6.3.3	ICT services exports, % total trade	0.7	89	
6.3.4	FDI net outflows, % GDP	0.0	110	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**9.0**	**127**	
7.1	**Intangible assets**	**17.9**	**126**	
7.1.1	Trademarks by origin/bn PPP$ GDP	39.9	66	● ◆
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.3	94	
7.1.3	ICTs & business model creation†	24.3	125	○ ◇
7.1.4	ICTs & organizational model creation†	21.7	125	○ ◇
7.2	**Creative goods & services**	**0.0**	**[129]**	
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	0.0	63	○ ◇
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade ⊙	0.0	123	
7.3	**Online creativity**	**0.4**	**113**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.4	113	
7.3.2	Country-code TLDs/th pop. 15–69	0.0	126	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	1.1	102	
7.3.4	Mobile app creation/bn PPP$ GDP	0.3	76	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ZAMBIA

GII 2019 rank

124

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
121	126	Lower middle	SSF	17.6	73.2	4,103.5	n/a

		Score/Value	Rank	
	INSTITUTIONS	**47.1**	**120**	
1.1	**Political environment**	**43.2**	**97**	
1.1.1	Political and operational stability*	66.7	74	●
1.1.2	Government effectiveness*	31.5	105	
1.2	**Regulatory environment**	**34.4**	**125**	○ ◇
1.2.1	Regulatory quality*	29.4	101	
1.2.2	Rule of law*	37.7	81	●
1.2.3	Cost of redundancy dismissal, salary weeks	50.6	124	○ ◇
1.3	**Business environment**	**63.7**	**86**	
1.3.1	Ease of starting a business*	85.1	78	●
1.3.2	Ease of resolving insolvency*	42.4	87	

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**1.4**	**[129]**	
2.1	**Education**	**0.0**	**[129]**	
2.1.1	Expenditure on education, % GDP ⊙	1.1	119	○ ◇
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	**Tertiary education**	**2.6**	**[123]**	
2.2.1	Tertiary enrolment, % gross ⊙	4.0	121	○ ◇
2.2.2	Graduates in science & engineering, %	n/a	n/a	
2.2.3	Tertiary inbound mobility, %	n/a	n/a	
2.3	**Research & development (R&D)**	**1.5**	**98**	
2.3.1	Researchers, FTE/mn pop. ⊙	41.0	94	
2.3.2	Gross expenditure on R&D, % GDP ⊙	0.3	81	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**36.6**	**95**	
3.1	**Information & communication technologies(ICTs)**	**35.8**	**114**	◇
3.1.1	ICT access*	31.1	116	◇
3.1.2	ICT use*	24.5	101	
3.1.3	Government's online service*	47.9	106	
3.1.4	E-participation*	39.9	110	◇
3.2	**General infrastructure**	**48.0**	**25**	● ◆
3.2.1	Electricity output, kWh/mn pop.	704.9	101	
3.2.2	Logistics performance*	21.6	103	
3.2.3	Gross capital formation, % GDP	44.4	3	● ◆
3.3	**Ecological sustainability**	**25.9**	**113**	
3.3.1	GDP/unit of energy use	5.3	105	
3.3.2	Environmental performance*	51.0	95	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	0.4	95	

		Score/Value	Rank	
	MARKET SOPHISTICATION	**37.7**	**112**	◇
4.1	**Credit**	**32.7**	**79**	●
4.1.1	Ease of getting credit*	95.0	3	● ◆
4.1.2	Domestic credit to private sector, % GDP	11.2	123	○ ◇
4.1.3	Microfinance gross loans, % GDP	0.0	63	
4.2	**Investment**	**26.8**	**126**	○ ◇
4.2.1	Ease of protecting minority investors*	50.0	93	
4.2.2	Market capitalization, % GDP ⊙	13.6	65	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	49	●
4.3	**Trade, competition, & market scale**	**53.5**	**94**	
4.3.1	Applied tariff rate, weighted avg., % ⊙	6.2	96	
4.3.2	Intensity of local competition†	66.4	75	●
4.3.3	Domestic market scale, bn PPP$	73.2	90	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**17.1**	**127**	○ ◇
5.1	**Knowledge workers**	**12.9**	**121**	◇
5.1.1	Knowledge-intensive employment, %	2.0	115	○ ◇
5.1.2	Firms offering formal training, % firms	28.2	55	●
5.1.3	GERD performed by business, % GDP ⊙	0.0	85	
5.1.4	GERD financed by business, % ⊙	3.2	86	
5.1.5	Females employed w/advanced degrees, %	5.8	86	
5.2	**Innovation linkages**	**17.4**	**111**	
5.2.1	University/industry research collaboration†	31.6	102	
5.2.2	State of cluster development†	42.1	85	
5.2.3	GERD financed by abroad, % ⊙	1.6	83	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	n/a	n/a	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	93	○ ◇
5.3	**Knowledge absorption**	**21.1**	**121**	
5.3.1	Intellectual property payments, % total trade	0.0	112	◇
5.3.2	High-tech imports, % total trade	5.7	95	
5.3.3	ICT services imports, % total trade	0.7	94	
5.3.4	FDI net inflows, % GDP	4.7	35	●
5.3.5	Research talent, % in business enterprise ⊙	4.9	71	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**12.1**	**115**	◇
6.1	**Knowledge creation**	**3.9**	**107**	
6.1.1	Patents by origin/bn PPP$ GDP	0.2	102	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	86	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	2.7	107	
6.1.5	Citable documents H-index	5.7	92	
6.2	**Knowledge impact**	**23.6**	**108**	
6.2.1	Growth rate of PPP$ GDP/worker, %	0.0	88	◇
6.2.2	New businesses/th pop. 15–64	1.1	68	
6.2.3	Computer software spending, % GDP	0.0	112	◇
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	0.6	118	◇
6.2.5	High- & medium-high-tech manufactures, % ⊙	0.1	78	
6.3	**Knowledge diffusion**	**8.8**	**110**	
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	0.4	85	
6.3.3	ICT services exports, % total trade	0.4	104	
6.3.4	FDI net outflows, % GDP	-0.2	120	○ ◇

		Score/Value	Rank	
	CREATIVE OUTPUTS	**13.4**	**121**	◇
7.1	**Intangible assets**	**25.4**	**120**	◇
7.1.1	Trademarks by origin/bn PPP$ GDP	15.6	94	
7.1.2	Industrial designs by origin/bn PPP$ GDP	0.4	88	
7.1.3	ICTs & business model creation†	45.2	115	◇
7.1.4	ICTs & organizational model creation†	37.3	118	◇
7.2	**Creative goods & services**	**2.5**	**[113]**	
7.2.1	Cultural & creative services exports, % total trade	0.3	63	●
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.0	116	
7.3	**Online creativity**	**0.1**	**125**	○
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.1	123	○ ◇
7.3.2	Country-code TLDs/th pop. 15–69	0.1	115	
7.3.3	Wikipedia edits/mn pop. 15–69 ⊙	0.1	120	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ⊙ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

ZIMBABWE

GII 2019 rank

122

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2018 rank
110	123	Low	SSF	16.9	36.3	2,787.6	113

		Score/Value	Rank	
	INSTITUTIONS	**37.6**	**127**	○ ◇
1.1	**Political environment**	**27.6**	**127**	○
1.1.1	Political and operational stability*	47.4	123	
1.1.2	Government effectiveness*	17.7	127	○
1.2	**Regulatory environment**	**39.3**	**122**	◇
1.2.1	Regulatory quality*	0.0	129	○ ◇
1.2.2	Rule of law*	9.9	127	○ ◇
1.2.3	Cost of redundancy dismissal, salary weeks	25.3	102	◇
1.3	**Business environment**	**45.9**	**128**	○ ◇
1.3.1	Ease of starting a business*	66.5	126	◇
1.3.2	Ease of resolving insolvency*	25.3	127	○ ◇

		Score/Value	Rank	
	HUMAN CAPITAL & RESEARCH	**27.8**	**76**	◆
2.1	**Education**	**51.4**	**56**	● ◆
2.1.1	Expenditure on education, % GDP ◷	7.5	6	● ◆
2.1.2	Government funding/pupil, secondary, % GDP/cap ◷	31.0	12	● ◆
2.1.3	School life expectancy, years ◷	10.2	106	
2.1.4	PISA scales in reading, maths, & science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary ◷	22.5	93	
2.2	**Tertiary education**	**31.6**	**62**	● ◆
2.2.1	Tertiary enrolment, % gross ◷	8.5	111	
2.2.2	Graduates in science & engineering, % ◷	30.2	13	● ◆
2.2.3	Tertiary inbound mobility, % ◷	0.5	95	
2.3	**Research & development (R&D)**	**0.3**	**115**	
2.3.1	Researchers, FTE/mn pop. ◷	88.7	87	
2.3.2	Gross expenditure on R&D, % GDP	n/a	n/a	
2.3.3	Global R&D companies, avg. exp. top 3, mn US$	0.0	43	○ ◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○ ◇

		Score/Value	Rank	
	INFRASTRUCTURE	**21.7**	**127**	○ ◇
3.1	**Information & communication technologies(ICTs)**	**29.9**	**120**	
3.1.1	ICT access*	36.0	108	◆
3.1.2	ICT use*	23.4	102	◆
3.1.3	Government's online service*	32.6	116	
3.1.4	E-participation*	27.5	120	
3.2	**General infrastructure**	**15.0**	**124**	
3.2.1	Electricity output, kWh/mn pop.	436.8	107	
3.2.2	Logistics performance*	2.6	120	○ ◇
3.2.3	Gross capital formation, % GDP	18.7	100	
3.3	**Ecological sustainability**	**20.2**	**123**	
3.3.1	GDP/unit of energy use	2.7	119	○
3.3.2	Environmental performance*	43.4	114	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	1.5	58	● ◆

		Score/Value	Rank	
	MARKET SOPHISTICATION	**38.4**	**109**	
4.1	**Credit**	**27.6**	**99**	
4.1.1	Ease of getting credit*	55.0	77	
4.1.2	Domestic credit to private sector, % GDP	n/a	n/a	
4.1.3	Microfinance gross loans, % GDP	0.0	70	
4.2	**Investment**	**n/a**	**[n/a]**	
4.2.1	Ease of protecting minority investors*	n/a	n/a	
4.2.2	Market capitalization, % GDP	n/a	n/a	
4.2.3	Venture capital deals/bn PPP$ GDP	n/a	n/a	
4.3	**Trade, competition, & market scale**	**49.2**	**109**	
4.3.1	Applied tariff rate, weighted avg., % ◷	5.0	86	◆
4.3.2	Intensity of local competition†	58.4	111	
4.3.3	Domestic market scale, bn PPP$	36.3	108	

		Score/Value	Rank	
	BUSINESS SOPHISTICATION	**20.6**	**117**	
5.1	**Knowledge workers**	**15.5**	**[117]**	
5.1.1	Knowledge-intensive employment, % ◷	1.1	118	○ ◇
5.1.2	Firms offering formal training, % firms	26.4	59	
5.1.3	GERD performed by business, % GDP	n/a	n/a	
5.1.4	GERD financed by business, %	n/a	n/a	
5.1.5	Females employed w/advanced degrees, % ◷	5.7	87	◆
5.2	**Innovation linkages**	**19.3**	**91**	
5.2.1	University/industry research collaboration†	26.7	118	◇
5.2.2	State of cluster development†	26.6	125	○ ◇
5.2.3	GERD financed by abroad, %	n/a	n/a	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.1	21	● ◆
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	74	
5.3	**Knowledge absorption**	**27.1**	**93**	
5.3.1	Intellectual property payments, % total trade	0.2	86	
5.3.2	High-tech imports, % total trade	6.8	75	
5.3.3	ICT services imports, % total trade	0.9	80	
5.3.4	FDI net inflows, % GDP	1.6	93	
5.3.5	Research talent, % in business enterprise	n/a	n/a	

		Score/Value	Rank	
	KNOWLEDGE & TECHNOLOGY OUTPUTS	**17.5**	**83**	
6.1	**Knowledge creation**	**6.8**	**84**	
6.1.1	Patents by origin/bn PPP$ GDP ◷	0.2	90	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	85	
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a	
6.1.4	Scientific & technical articles/bn PPP$ GDP	7.0	62	● ◆
6.1.5	Citable documents H-index	6.5	86	
6.2	**Knowledge impact**	**38.7**	**54**	● ◆
6.2.1	Growth rate of PPP$ GDP/worker, %	-0.3	95	
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.4	22	● ◆
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	4.3	62	● ◆
6.2.5	High- & medium-high-tech manufactures, % ◷	0.2	49	● ◆
6.3	**Knowledge diffusion**	**7.0**	**123**	
6.3.1	Intellectual property receipts, % total trade ◷	0.0	68	
6.3.2	High-tech net exports, % total trade	0.2	98	
6.3.3	ICT services exports, % total trade	0.2	114	
6.3.4	FDI net outflows, % GDP	0.1	94	

		Score/Value	Rank	
	CREATIVE OUTPUTS	**13.3**	**123**	
7.1	**Intangible assets**	**24.4**	**122**	
7.1.1	Trademarks by origin/bn PPP$ GDP ◷	4.8	117	
7.1.2	Industrial designs by origin/bn PPP$ GDP	n/a	n/a	
7.1.3	ICTs & business model creation†	42.7	118	
7.1.4	ICTs & organizational model creation†	29.7	123	○ ◇
7.2	**Creative goods & services**	**4.0**	**[108]**	
7.2.1	Cultural & creative services exports, % total trade	0.2	71	
7.2.2	National feature films/mn pop. 15–69	n/a	n/a	
7.2.3	Entertainment & Media market/th pop. 15–69	n/a	n/a	
7.2.4	Printing & other media, % manufacturing	n/a	n/a	
7.2.5	Creative goods exports, % total trade	0.3	73	● ◆
7.3	**Online creativity**	**0.4**	**112**	
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	0.4	111	
7.3.2	Country-code TLDs/th pop. 15–69	0.7	88	
7.3.3	Wikipedia edits/mn pop. 15–69 ◷	0.3	113	
7.3.4	Mobile app creation/bn PPP$ GDP	n/a	n/a	

NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question. ◷ indicates that the economy's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org. Square brackets [ ] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level.

APPENDIX III

SOURCES AND DEFINITIONS

This appendix complements the country/economy profiles and the online data tables by providing, for each of the 80 indicators included in the Global Innovation Index (GII) this year, its title, description, definition, and source.

For all 129 economies in the GII in 2019, the most recent values, within the period 2009 to 2018, were used for each indicator with a few noted exceptions (see Appendix IV). The year provided next to the indicator description corresponds to the year when data were most frequently available for economies. When more than one year is considered, the period is indicated at the end of the indicators source in parentheses.

Of the 80 indicators, 57 variables are hard data, 18 are composite indicators from third party data providers, marked with (∗), and 5 are survey questions from the World Economic Forum's Executive Opinion Survey (EOS), marked with (†). In some cases, additional markings are provided at the end of the indictor description. Instances marked with "[a]" signal indicators that were assigned half weights and those marked "[b]" are indicators where higher scores indicate poorer outcomes, commonly known as "bads". Details on the computation can be found in Appendix IV.

Some indicators received special treatment by way of scaling during computation to be comparable across economies. Scaling of indicators by other comparable indicators or through division by gross domestic product (GDP) in current U.S. dollars, purchasing power parity GDP in international dollars (PPP$ GDP), population, total exports, total trade, and so on. Details are provided in this appendix. In all cases, the scaling factor used was the value that corresponded to the same year of the indicator.

1 Institutions

1.1 Political environment

1.1.1 Political and operational stability

Political, legal, operational or security risk index*[ab] | 2018

Index that measures the likelihood and severity of political, legal, operational or security risks impacting business operations. Scores are annualized and standardized.

Source: IHS Markit, *Country Risk Scores*, aggregated for end Q1, Q2, Q3, and Q4 2018. (https://ihsmarkit.com/industry/economics-country-risk.html).

1.1.2 Government effectiveness

Government effectiveness index* | 2017

Index that reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Scores are standardized.

Source: World Bank, *Worldwide Governance Indicators*, 2018 update. (http://info.worldbank.org/governance/wgi/#home).

1.2 Regulatory environment

1.2.1 Regulatory quality

Regulatory quality index*[a] | 2017

Index that reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private-sector development. Scores are standardized.

Source: World Bank, *Worldwide Governance Indicators,* 2018 update. (http://info.worldbank.org/governance/wgi/#home).

1.2.2 Rule of law

Rule of law index*[a] | 2017

Index that reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Scores are standardized.

Source: World Bank, *Worldwide Governance Indicators,* 2018 update. (http://info.worldbank.org/governance/wgi/#home).

1.2.3 Cost of redundancy dismissal

Sum of notice period and severance pay for redundancy dismissal (salary in weeks, averages for workers with 1, 5, and 10 years of tenure, with a minimum threshold of 8 weeks)[b] | 2018

Redundancy costs measure the cost of advance notice requirements and severance payments due when terminating a redundant worker, expressed in weeks of salary. The average value of notice requirements and severance payments applicable to a worker with 1 year of tenure, a worker with 5 years, and a worker with 10 years is also considered. One month is recorded as 4 and 1/3 weeks. If the redundancy cost adds up to 8 or fewer weeks of salary, a value of 8 is assigned but the actual number of weeks is published. If the cost adds up to more than 8 weeks of salary, the score is the number of weeks.

Source: World Bank, *Doing Business 2019: Training for Reform*, 2019. (http://www.doingbusiness.org/en/reports/global-reports/doing-business-2019).

1.3 Business environment

1.3.1 Ease of starting a business

Ease of starting a business (score)* | 2018

The ranking of economies on the ease of starting a business is determined by sorting their scores. These scores are the simple average of the scores for each of the component indicators. The World Banks Doing Business records all procedures officially required, or commonly done in practice, for an entrepreneur to start up and formally operate an industrial or commercial business, as well as the time and cost to complete these procedures and the paid-in minimum capital requirement. These procedures include obtaining all necessary licenses and permits and completing any required notifications, verifications, or inscriptions for the company and employees with relevant authorities. Data are collected from limited liability companies based in the largest business cities. For 11 economies, namely Bangladesh, Brazil, China, India, Indonesia, Japan, Mexico, Nigeria, Pakistan, the Russian Federation, and the United States, the data are also collected for the second-largest business city.

Source: World Bank, *Doing Business 2019: Training for Reform*, 2019. (http://www.doingbusiness.org/en/reports/global-reports/doing-business-2019).

1.3.2 Ease of resolving insolvency

Ease of resolving insolvency (score)* | 2018

The ranking of economies on the ease of resolving insolvency is determined by sorting their scores. These scores are the simple average of the scores for the recovery rate and the strength of insolvency framework index. The recovery rate is recorded as cents on the dollar recovered by secured creditors through reorganization, liquidation, or debt enforcement (foreclosure or receivership) proceedings. The calculation takes into account the outcome: whether the business emerges from the proceedings as a going concern or the assets are sold piecemeal. Then the costs of the proceedings are deducted (1 cent for each percentage point of the value of the debtor's estate). Finally, the value lost as a result of the time that the money remains tied up in insolvency proceedings is taken into account, including the loss of value due to depreciation of a hotel's furniture. Consistent with international accounting practice, the annual depreciation rate for furniture is taken to be 20%. The furniture is assumed to account for a quarter of the total value of assets. The recovery rate is the present value of the remaining proceeds, based on end-2017 lending rates from the International Monetary Fund's *International Financial Statistics,* supplemented with data from central banks and the Economist Intelligence Unit. If an economy had zero cases a year over the past five years involving a judicial reorganization, judicial liquidation, or debt enforcement procedure (foreclosure or receivership), the economy receives a "no practice" mark on the time, cost, and outcome indicators. This means that creditors are unlikely to recover their money through a formal legal process. The recovery rate for "no practice" economies is zero. In addition, a "no practice" economy receives a score of "zero". on the strength of the insolvency framework index even if its legal framework includes provisions related to insolvency proceedings (liquidation or reorganization). The strength of the insolvency framework index is based on four other indices: commencement of proceedings index, management of debtor's assets index, reorganization proceedings index, and creditor participation index.

Source: World Bank, *Doing Business 2019: Training for Reform*, 2019. (http://www.doingbusiness.org/en/reports/global-reports/doing-business-2019).

2 Human capital and research

2.1 Education

2.1.1 Expenditure on education

Government expenditure on education (% of GDP) | 2015

Total general (local, regional and central) government expenditure on education (current, capital, and transfers), expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government. Algeria Egypt, Saudi Arabia, Yemen, and Zambia use data for 2008.

Source: UNESCO Institute for Statistics, *UIS online database* (2008–17). (http://data.uis.unesco.org/).

2.1.2 Government funding per secondary student

Government funding per secondary student (% of GDP per capita) | 2015

Total general (local, regional and central, current and capital) initial government funding of education per student, which includes transfers paid (such as scholarships to students), but excludes transfers received, in this case international transfers to government for education (when foreign donors provide education sector budget support or other support integrated in the government budget). This is then expressed as a share of GDP per capita, in US$.

Source: UNESCO Institute for Statistics, *UIS online database* (2009-17). (http://data.uis.unesco.org/).

2.1.3 School life expectancy

School life expectancy, primary to tertiary education, both sexes (years) | 2016

Total number of years of schooling that a child of a certain age can expect to receive in the future, assuming that the probability of his or her being enrolled in school at any particular age is equal to the current enrolment ratio for that age. For a child of a certain age, the school life expectancy is calculated as the sum of the age-specific enrolment rates for primary to tertiary levels of education. The part of the enrolment that is not distributed by age is divided by the school-age population for the primary to tertiary level of education in which they are enrolled, and multiplied by the duration of that level of education. The result is then added to the sum of the age-specific enrolment rates. A relatively high value indicates a greater probability that children will spend more years in education and a higher overall retention within the education system. It must be noted that the expected number of years spent in school does not necessarily coincide with the expected number of grades of education completed, because of grade repetition. Botswana and Cambodia use data for 2008.

Source: UNESCO Institute for Statistics, *UIS online database* (2008–18). (http://data.uis.unesco.org).

2.1.4 Assessment in reading, mathematics, and science

PISA average scales in reading, mathematics, and science[a] | 2015

The Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA) develops triennial international surveys that examine 15-year-old students' performance in reading, mathematics, and science. The scores are calculated in each year so that the mean is 500 and the standard deviation 100.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem, and Israeli settlements in the West Bank under the terms of international law. B-S-J-G (China) refers to the four PISA-participating China provinces: Beijing, Shanghai, Jiangsu, and Guangdong. CABA (Argentina) refers to the adjudicated region of Ciudad Autónoma de Buenos Aires. FYROM refers to North Macedonia. Russia refers to the Russian Federation. 2015 scores from the United Arab Emirates are from Dubai. 2010 scores from India are from Himachal Pradesh and Tamil Nadu (average); 2010 scores from the Bolivarian Republic of Venezuela are from Miranda.

The results of adjudication and subsequent further examinations showed that the PISA Technical Standards were met in all countries and economies that participated in PISA 2015 except for the following countries: In Albania, the PISA assessment was conducted in accordance with the operational standards and guidelines of the OECD. However, because of the ways in which the data were captured, it was not possible to match the data in the test with the data from the student questionnaire. As a result, Albania cannot be included in analyses that relate students' responses from the questionnaires to the test results. In Argentina, the PISA assessment was conducted in accordance with the operational standards and guidelines of the OECD. However, there was a significant decline in the proportion of 15-year-olds who were covered by the test, both in absolute and relative numbers. There had been a re-structuring of Argentina's secondary schools, except for those in the adjudicated region of Ciudad Autónoma de Buenos Aires, which is likely to have affected the coverage of eligible schools listed in the sampling frame. As a result, Argentina's results may not be comparable with those of other countries or with results for Argentina from previous years. In Kazakhstan, the national coders were found to be lenient in marking. Consequently the human-coded items did not meet PISA standards and were excluded from the international data. Since human-coded items form an important part of the constructs that are tested by PISA, the exclusion of these items resulted in a significantly smaller coverage of the PISA test. As a result, Kazakhstan's results may not be comparable with those of other countries or with results for Kazakhstan from previous years. In Malaysia, the PISA assessment was conducted in accordance with the operational standards and guidelines of the OECD. However, the weighted response rate among the initially sampled Malaysian schools of 51% falls well short of the standard PISA response rate of 85%. Therefore the results may not be comparable to those of other countries or to results for Malaysia from previous years.

Source: OECD Programme for International Student Assessment (PISA) (2010–15). (www.pisa.oecd.org/).

2.1.5 Pupil-teacher ratio, secondary

Pupil-teacher ratio, secondary[a,b] | 2017

The number of pupils enrolled in secondary school divided by the number of secondary school teachers (regardless of their teaching assignment). Where the data are missing for some countries, the ratios for upper-secondary are reported; if these are also missing, the ratios for lower-secondary are reported instead. Argentina uses data for 2008.

Source: UNESCO Institute for Statistics, *UIS online database* (2008–18). (http://data.uis.unesco.org).

2.2 Tertiary education

2.2.1 Tertiary enrolment

School enrolment, tertiary (% gross)[a] | 2017

The ratio of total tertiary enrolment, regardless of age, to the population of the age group that officially corresponds to the tertiary level of education. Tertiary education, whether or not at an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level. The school enrolment ratio can exceed 100%
as a result of grade repetition and the inclusion of over-aged and under-aged students because of early or late entrants.

Source: UNESCO Institute for Statistics, *UIS online database* (2010–18). (http://data.uis.unesco.org).

2.2.2 Graduates in science and engineering

Tertiary graduates in science, engineering, manufacturing, and construction (% of total tertiary graduates) | 2016

The share of all tertiary-level graduates in natural sciences, mathematics, statistics, information and technology, manufacturing, engineering, and construction as a percentage of all tertiary-level graduates.

Source: UNESCO Institute for Statistics, *UIS online database* (2010–18). (http://data.uis.unesco.org).

2.2.3 Tertiary inbound mobility

Tertiary inbound mobility rate (%)[a] | 2016

The number of students from abroad studying in a given country as a percentage of the total tertiary-level enrolment in that country. Philippines uses data from 2008.

Source: UNESCO Institute for Statistics, *UIS online database* (2008–17). (http://data.uis.unesco.org).

2.3 Research and development (R&D)

2.3.1 2.3.1 Researchers FTE

Researchers, full-time equivalent (FTE) (per million population) | 2017

Researchers per million population, full-time equivalent. Researchers in R&D are professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned. Postgraduate PhD students (ISCED97 level 6) engaged in R&D are included. Special tabulation based on UNESCO, Eurostat, and OECD data. Albania and Zambia use data for 2008.

Source: UNESCO Institute for Statistics, *UIS online database*; Eurostat, Eurostat data base, 2019; OECD, *Main Science and Technology Indicators MSTI database, 2019* (2008–17). (http://data.uis.unesco.org; https://ec.europa.eu/eurostat/data/database; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

2.3.2 Gross expenditure on R&D (GERD)

Gross expenditure on R&D (% of GDP) | 2017

Total domestic intramural expenditure on R&D during a given period as a percentage of GDP. "Intramural R&D expenditure" is all expenditure for R&D performed within a statistical unit or sector of the economy during a specific period, whatever the source of funds. Special tabulation based on UNESCO, Eurostat, and OECD data. Albania and Zambia use data for 2008

Source: UNESCO Institute for Statistics, *UIS online database;* Eurostat, *Eurostat data base, 2019*; OECD, *Main Science and Technology Indicators MSTI database, 2019* (2008–17). (http://data.uis.unesco.org; https://ec.europa.eu/eurostat/data/database; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

2.3.3 Global R&D companies, average expenditure, top 3

Average expenditure of the top 3 global companies by R&D, mn US$* | 2018

Average expenditure on R&D of the top three global companies. If a country has fewer than three global companies listed, the figure is either the average of the sum of the two companies listed or the total for a single listed company. A score of 0 is given to countries with no listed companies.

Source: EU JRC Industrial R&D Investment Scoreboard 2018. (http://iri.jrc.ec.europa.eu/scoreboard18.html).

2.3.4 QS university ranking average score of top 3 universities

Average score of the top 3 universities at the QS world university ranking* | 2018

Average score of the top three universities per country. If fewer than three universities are listed in the QS ranking of the global top 1000 universities, the sum of the scores of the listed universities is divided by three, thus implying a score of zero for the non-listed universities.

Source: QS Quacquarelli Symonds Ltd, *QS World University Ranking 2017/2018, Top Universities*. (https://www.topuniversities.com/university-rankings/world-university-rankings/2018).

3 Infrastructure

3.1 Information and communication technologies (ICTs)

3.1.1 ICT access

ICT access index* | 2018

The ICT access index, previously part of the ITU ICT Development Index, is a composite index that weights five ICT indicators (20% each): (1) Fixed telephone subscriptions per 100 inhabitants; (2) Mobile cellular telephone subscriptions per 100 inhabitants; (3) International Internet bandwidth (bit/s) per Internet user; (4) Percentage of households with a computer; and (5) Percentage of households with Internet access.

Source: GII calculations based on the World Telecommunication/ICT Indicators Database(Released January 18, 2019) following the methodology of the International Telecommunication Union, ICT Development Index 2017. (http://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017.aspx).

3.1.2 ICT use

ICT use index* | 2018

The ICT use index, previously part of the ITU ICT Development Index, is a composite index that weights three ICT indicators (33% each): (1) Percentage of individuals using the Internet; (2) Fixed (wired)-broadband Internet subscriptions per 100 inhabitants; (3) Active mobile-broadband subscriptions per 100 inhabitants.

Source: GII calculations based on the World Telecommunication/ICT Indicators Database (Released January 18, 2019) following the methodology of the International Telecommunication Union, ICT Development Index 2017. (http://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017.aspx).

3.1.3 Government's online service

Government's online service index* | 2018

The Online Services Index component of the E-Government Development Index is a composite indicator measuring the use of ICTs by governments in delivering public services at the national level. The 2018 Online Service Questionnaire (OSQ) consists of a list of 140 questions. To arrive at a set of Online Service Index values for 2018, a total of 206 online United Nations Volunteer (UNV) researchers from 89 countries covering 66 languages, assessed each country's national website in the native language, including the national portal, e-services portal and e-participation portal, as well as the websites of the related ministries of education, labour, social services, health, finance and environment, as applicable. The total number of points scored by each country is normalized to a range of 0 to 1. The online index value for a given country is equal to the actual total score less the lowest total score divided by the range of total score values for all countries.

Note: The precise meaning of these values varies from one edition of the Survey to the next as understanding of the potential of e-government changes and the underlying technology evolves. Read about the methodology at https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2018-Survey/E-Government%20Survey%202018_Annexes.pdf .

Source: United Nations Public Administration Network, *e-Government Survey 2018*. (https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government-Development-Index).

3.1.4 Online e-participation

E-Participation Index* | 2018

The E-Participation Index (EPI) is derived as a supplementary index to the United Nations E-Government Survey. It extends the dimension of the Survey by focusing on the government use of online services in providing information to its citizens or "e-information sharing", interacting with stakeholders or "e-consultation" and engaging in decision-making processes or "e-decision-making." A country's EPI reflects the e-participation mechanisms that are deployed by the government as compared to all other countries. The purpose of this measure is not to prescribe any specific practice, but rather to offer insight into how different countries are using online tools in promoting interaction between the government and its citizens, as well as among the citizens, for the benefit of all. As the EPI is a qualitative assessment based on the availability and relevance of participatory services available on government websites, the comparative ranking of countries is for illustrative purposes and only serves as an indicator of the broad trends in promoting citizen engagement. As with the EGDI, the EPI is not intended as an absolute measurement of e-participation, but rather, as an attempt to capture the e-participation performance of counties relative to one another at a point in time. The index ranges from 0 to 1, with 1 showing greater e-participation. Mathematically, the EPI is normalized by taking the total score value for a given country, subtracting the lowest total score for any country in the Survey and dividing by the range of total score values for all countries.

Note: The precise meaning of these values varies from one edition of the Survey to the next as understanding of the potential of e-government changes and the underlying technology evolves. Read about the methodology at https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2018-Survey/E-Government%20Survey%202018_Annexes.pdf.

Source: United Nations Public Administration Network, *e-Government Survey 2018*. (https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2018).

3.2 General infrastructure

3.2.1 Electricity output

Electricity output (kWh per mn population)[a] 2016

Electricity production, measured at the terminals of all alternator sets in a station. In addition to hydropower, coal, oil, gas, and nuclear power generation, this indicator covers generation by geothermal, solar, wind, and tide and wave energy, as well as that from combustible renewables and waste. Production includes the output of electric plants that are designed to produce electricity only as well as that of combined heat and power plants. Electricity output in KWh is scaled by population.

Source: International Energy Agency (IEA) *World Energy Balances on-line data service, 2018 edition* (2016–17). (http://www.iea.org/statistics/).

3.2.2 Logistics performance

Logistics Performance Index*[a] | 2018

A multidimensional assessment of logistics performance, the Logistics Performance Index (LPI) ranks 160 countries combining data on six core performance components into a single aggregate measure—including customs performance, infrastructure quality, and timeliness of shipments. The data used in the ranking comes from a survey of logistics professionals who are asked questions about the foreign countries in which they operate. The LPI's six components are: (1) the efficiency of customs and border management clearance ("Customs"); (2) the quality of trade and transport infrastructure ("Infrastructure"); (3) the ease of arranging competitively priced shipments ("International shipments"); (4) the competence and quality of logistics services ("Services Quality"); (5) the ability to track and trace consignments ("Tracking and tracing"); and (6) the frequency with which shipments reach consignees within scheduled or expected delivery times ("Timeliness"). The LPI consists therefore of both qualitative and quantitative measures and helps build profiles of logistics friendliness for these countries.

Source: World Bank and Turku School of Economics, *Logistics Performance Index 2018*; Arvis et al., 2018, *Connecting to Compete 2018: Trade Logistics in the Global Economy–The Logistics Performance Index and its Indicators*. (https://openknowledge.worldbank.org/bitstream/handle/10986/29971/LPI2018.pdf).

3.2.3 Gross capital formation

Gross capital formation (% of GDP) | 2018

Gross capital formation is expressed as a ratio of total investment in current local currency to GDP in current local currency. Investment or gross capital formation is measured by the total value of the gross fixed capital formation and changes in inventories and acquisitions less disposals of valuables for a unit or sector, on the basis of the System of National Accounts (SNA) of 1993.

Source: International Monetary Fund, *World Economic Outlook Database, October 2018* (PPP$ GDP). (https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

3.3 Ecological sustainability

3.3.1 GDP per unit of energy use

GDP per unit of energy use (2010 PPP$ per kg of oil equivalent) | 2016

Purchasing power parity gross domestic product (PPP$ GDP) per kilogram of oil equivalent of energy use. Total primary energy supply (TPES) is made up of production + imports − exports − international marine bunkers − international aviation bunkers +/– stock changes.

Source: International Energy Agency (IEA) *World Energy Balances on-line data service, 2017 edition* (2016–17). (http://www.iea.org/statistics/).

3.3.2 Environmental performance

Environmental Performance Index* | 2018

The 2018 Environmental Performance Index (EPI) ranks 180 countries on 24 performance indicators across ten issue categories covering environmental health and ecosystem vitality. These metrics provide a gauge at a national scale of how close countries are to established environmental policy goals. The EPI thus offers a scorecard that highlights leaders and laggards in environmental performance, gives insight on best practices, and provides guidance for countries that aspire to be leaders in sustainability. The index ranges from 0 to 100, with 100 indicating best performance.

Source: Yale University and Columbia University *Environmental Performance Index 2018*. (http://epi.yale.edu/).

3.3.3 ISO 14001 environmental certificates

ISO 14001 Environmental management systems—Requirements with guidance for use: Number of certificates issued (per billion PPP$ GDP)[a] | 2017

ISO 14001:2015 specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance. ISO 14001 is intended for use by an organization seeking to manage its environmental responsibilities in a systematic manner that contributes to the environmental pillar of sustainability. ISO 14001 helps an organization achieve the intended outcomes of its environmental management system, which provide value for the environment, the organization itself, and interested parties. Consistent with the organization's environmental policy, the intended outcomes of an environmental management system include enhancement of environmental performance, fulfillment of compliance obligations, and achievement of environmental objectives. ISO 14001 is applicable to any organization, regardless of size, type, or nature, and applies to the environmental aspects of its activities, products, and services that the organization determines it can either control or influence from a life cycle perspective. ISO 14001 does not state specific environmental performance criteria. ISO 14001 can be used in whole or in part to systematically improve environmental management. Claims of conformity to ISO 14001, however, are not acceptable unless all its requirements are incorporated into an organization's environmental management system and fulfilled without exclusion. The data are reported per billion PPP$ GDP.

Source: International Organization for Standardization, *The ISO Survey of certifications to management system standards, 2017;* International Monetary Fund, *World Economic Outlook Database, October 2018* (PPP$ GDP) (https://www.iso.org/the-iso-survey.html ; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

4 Market sophistication

4.1 Credit

4.1.1 Ease of getting credit

Ease of getting credit* | 2018

The ranking of economies on the ease of getting credit is determined by sorting their scores for getting credit. These scores are the score for the sum of the strength of the legal rights index (range 0–12) and the depth of credit information index (range 0–8). *Doing Business* measures the legal rights of borrowers and lenders with respect to secured transactions through one set of indicators and the reporting of credit information through another. The first set of indicators measures whether certain features that facilitate lending exist within the applicable collateral and bankruptcy laws. The second set measures the coverage, scope, and accessibility of credit information available through credit reporting service providers such as credit bureaus or credit registries. Although *Doing Business* compiles data on getting credit for public registry coverage (% of adults) and for private bureau coverage (% of adults), these indicators are not included in the ranking.

Source: World Bank, *Doing Business 2019: Training for Reform*. (http://www.doingbusiness.org/en/reports/global-reports/doing-business-2019).

4.1.2 Domestic credit to private sector

Domestic credit to private sector (% of GDP) | 2017

"Domestic credit to private sector" refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of non-equity securities, and trade credits and other accounts receivable, that establish a claim for repayment. For some countries these claims include credit to public enterprises. The financial corporations include monetary authorities and deposit money banks, as well as other financial corporations where data are available (including corporations that do not accept transferable deposits but do incur such liabilities as time and savings deposits). Examples of other financial corporations are finance and leasing companies, money lenders, insurance corporations, pension funds, and foreign exchange companies.

Source: International Monetary Fund, International Financial Statistics and data files; and World Bank and OECD GDP estimates; extracted from the World Bank's *World Development Indicators* database (2013-2017). (http://data.worldbank.org/).

4.1.3 Microfinance institutions gross loan portfolio

Microfinance institutions: Gross loan portfolio (% of GDP) | 2017

Combined gross loan balances of microfinance institution (current US$) in a country as a percentage of its GDP (current US$).

Source: Microfinance Information Exchange, *Mix Market database*; International Monetary Fund, *World Economic Outlook Database, October 2018* (current US$ GDP) (2011-2018). (https://reports.themix.org/; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

4.2 Investment

4.2.1 Ease of protecting minority investors

Ease of protecting minority investors* | 2018

This ranking is the simple average of the scores for the extent of conflict of interest regulation index and the extent of shareholder governance index. The extent of conflict of interest regulation index measures the protection of shareholders against directors' misuse of corporate assets for personal gain by distinguishing three dimensions of regulation that address conflicts of interest: transparency of related-party transactions (extent of disclosure index), shareholders' ability to sue and hold directors liable for self-dealing (extent of director liability index), and access to evidence and allocation of legal expenses in shareholder litigation (ease of shareholder suits index). The extent of shareholder governance index measures shareholders' rights in corporate governance by distinguishing three dimensions of good governance: shareholders' rights and role in major corporate decisions (extent of shareholder rights index); governance safeguards protecting shareholders from undue board control and entrenchment (extent of ownership and control index); and corporate transparency on ownership stakes, compensation, audits, and financial prospects (extent of corporate transparency index). The index also measures whether a subset of relevant rights and safeguards are available in limited companies. The data come from a questionnaire administered to corporate and securities lawyers and are based on securities regulations, company laws, civil procedure codes, and court rules of evidence.

Source: World Bank, *Doing Business 2019: Training for Reform*. (http://www.doingbusiness.org/en/reports/global-reports/doing-business-2019).

4.2.2 Market capitalization

Market capitalization of listed domestic companies (% of GDP, three-year average)[a] | 2017

Market capitalization (also known as "market value") is the share price times the number of shares outstanding (including their several classes) for listed domestic companies. Investment funds, unit trusts, and companies whose only business goal is to hold shares of other listed companies are excluded. Data are the average of the end-of-year values for the last three years with the exception of Jamaica (averages for two years: 2010 and 2011); Ukraine (2010, 2011), and Zambia (2011)

Source: World Federation of Exchanges database; extracted from the World Bank's *World Development Indicators* database (2011–17). (http://data.worldbank.org/).

4.2.3 Venture capital deals

Venture capital per investment location: Number of deals (per billion PPP$ GDP)[a] | 2018

Thomson Reuters data on private equity deals, per deal, with information on the location of investment, investment company, investor firms, and funds, among other details. The series corresponds to a query on venture capital deals from January 1, 2018 to December 31, 2018, with the data collected by investment location, for a total of 14,856 deals in 78 countries in 2018. The data are reported per billion PPP$ GDP.

Source: Thomson Reuters, *Thomson One Banker Private Equity* database; International Monetary Fund, *World Economic Outlook Database* October 2018 (PPP$ GDP). (https://www.thomsonone.com); https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

4.3 Trade, competition, and market scale

4.3.1 Applied tariff rate, weighted average

Tariff rate, applied, weighted average, all products (%)[a,b] | 2017

"Weighted mean applied tariff" is the average of effectively applied rates weighted by the product import shares corresponding to each partner country. Data are classified using the Harmonized System of trade at the six- or eight-digit level. Tariff line data were matched to Standard International Trade Classification (SITC) revision 3 codes to define commodity groups and import weights. To the extent possible, specific rates have been converted to their ad valorem equivalent rates and have been included in the calculation of weighted mean tariffs. Effectively applied tariff rates at the six- and eight-digit product level are averaged for products in each commodity group. When the effectively applied rate is unavailable, the most favoured nation rate is used instead.

Source: World Bank, based on data from United Nations Conference on Trade and Development's Trade Analysis and Information System (TRAINS) database and the World Trade Organization's (WTO) Integrated Data Base (IDB) and Consolidated Tariff Schedules (CTS) database; extracted from World Bank *World Development Indicators* database (2011–17). (http://data.worldbank.org/).

4.3.2 Intensity of local competition

Average answer to the survey question: In your country, how intense is competition in the local markets? [1 = not intense at all; 7 = extremely intense][†a] | 2018

Source: World Economic Forum, *Executive Opinion Survey 2018*. (https://www.weforum.org/reports/the-global-competitveness-report-2018).

4.3.3 Domestic market scale

Domestic market scale as measured by GDP, bn PPP$ | 2018

The domestic market size is measured by gross domestic product (GDP) based on the purchasing-power-parity (PPP) valuation of country GDP, in current international dollars (billions).

Source: World Bank, International Monetary Fund, *World Economic Outlook Database* October 2018 (PPP$ GDP). (https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

5 Business sophistication

5.1 Knowledge workers

5.1.1 Employment in knowledge-intensive services
Employment in knowledge-intensive services (% of workforce) | 2017

Sum of people in categories 1 to 3 as a percentage of total people employed, according to the International Standard Classification of Occupations (ISCO). Categories included in ISCO-08 are: 1 Managers, 2 Professionals, and 3 Technicians and associate professionals (years 2009–18). Where ISCO-08 data were not available, ISCO-88 data were used. Categories included in ISCO-88 are: 1 Legislators, senior officials and managers; 2 Professionals; 3 Technicians and associate professionals (2009–18). Nigeria uses data from 2013.

Source: International Labour Organization *ILOSTAT Database of Labour Statistics* (2009–18). (http://www.ilo.org/ilostat/).

5.1.2 Firms offering formal training
Firms offering formal training (% of firms) | 2013

The percentage of firms offering formal training programs for their permanent, full-time employees in the sample of firms in the World Bank's Enterprise Survey in each country.

Source: World Bank, *Enterprise Surveys* (2009–17). (http://www.enterprisesurveys.org/).

5.1.3 GERD performed by business enterprise
GERD: Performed by business enterprise (% of total GDP)[a] | 2017

Gross expenditure on R&D performed by business enterprise as a percentage of GDP. For the definition of GERD see indicator 2.3.2. Islamic Republic of Iran and Zambia use data for 2008.

Source: UNESCO Institute for Statistics, *UIS online database*; Eurostat, *Eurostat database, 2019*; OECD, *Main Science and Technology Indicators MSTI database, 2019* (2008–17). (http://data.uis.unesco.org; https://ec.europa.eu/eurostat/data/database; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

5.1.4 GERD financed by business enterprise
GERD: Financed by business enterprise (% of total GERD)[a] | 2016

Gross expenditure on R&D financed by business enterprise as a percentage of total gross expenditure on R&D. For the definition of GERD see indicator 2.3.2. Albania, Australia, Islamic Republic of Iran, and Zambia use data for 2008.

Source: UNESCO Institute for Statistics, *UIS online database*; Eurostat, *Eurostat database, 2019*; OECD, *Main Science and Technology Indicators MSTI database, 2019* (2008–17). (http://data.uis.unesco.org; https://ec.europa.eu/eurostat/data/database; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

5.1.5 Females employed with advanced degrees
Females employed with advanced degrees, % total employed (25+ years old)[a] | 2017

The percentage of females employed with advanced degrees out of total employed. The employed comprise all persons of working age who, during a specified brief period, were in one of the following categories: (1) paid employment (whether at work or with a job but not at work); or (2) self-employment (whether at work or with an enterprise but not at work). Data are disaggregated by level of education, which refers to the highest level of education completed, classified according to the International Standard Classification of Education (ISCE). Data for Canada are based on Table 14-10-0020-01 of the country's Labour Force Survey estimates.

Source: International Labour Organization, *ILOSTAT Annual Indicators;* Statistics Canada. Table 14-10-0020-01 Unemployment rate, participation rate and employment rate by educational attainment, annual (x 1,000), accessed February 21, 2019 (2009–18). (http://www.ilo.org/ilostat/; http://www.statcan.gc.ca/).

5.2 Innovation linkages

5.2.1 University/industry research collaboration
Average answer to the survey question: In your country, to what extent do businesses and universities collaborate on research and development (R&D)? [1 = do not collaborate at all; 7 = collaborate extensively][†a] | 2018

Source: World Economic Forum, *Executive Opinion Survey 2018*. (https://www.weforum.org/reports/the-global-competitiveness-report-2017-2018).

5.2.2 State of cluster development
Average answer to the survey question on the role of clusters in the economy: In your country, how widespread are well-developed and deep clusters (geographic concentrations of firms, suppliers, producers of related products and services, and specialized institutions in a particular field)? [1 = non-existent; 7 = widespread in many fields][†] | 2018

Source: World Economic Forum, *Executive Opinion Survey 2018*. (https://www.weforum.org/reports/the-global-competitiveness-report-2017-2018).

5.2.3 GERD financed by abroad
GERD: Financed by abroad (% of total GERD) | 2016

Percentage of gross expenditure on R&D financed by abroad—that is, with foreign financing as a percentage of total gross expenditure on R&D in a country. For the definition of GERD see indicator 2.3.2. Albania, Australia, Burundi, and Zambia use data for 2008.

Source: UNESCO Institute for Statistics, *UIS online database*; Eurostat, *Eurostat database, 2019*; OECD, *Main Science and Technology Indicators MSTI database, 2019* (2008–18). (http://data.uis.unesco.org; https://ec.europa.eu/eurostat/data/database; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

5.2.4 Joint venture/strategic alliance deals
Joint ventures/strategic alliances: Number of deals, fractional counting (per billion PPP$ GDP)[a] | 2018

Thomson Reuters data on joint ventures/strategic alliances deals, per deal, with details on the country of origin of partner firms, among others. The series corresponds to a query on joint venture/strategic alliance deals from January 1, 2018 to December 31, 2018, for a total of 6,880 deals announced in 2017, with firms headquartered in 110 participating economies. Each participating nation of each company in a deal (n countries per deal) gets, per deal, a score equivalent to 1/n (with the effect that all country scores add up to 6,880). The data are reported per billion PPP$ GDP.

Source: Thomson Reuters, *Thomson One Banker Private Equity, SDC Platinum* database; International Monetary Fund *World Economic Outlook Database*, October 2018 (PPP$ GDP). (http://banker.thomsonib.com; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

5.2.5 Patent families filed in two offices
Number of patent families filed by residents in at least two offices (per billion PPP$ GDP) | 2015

A “patent family” is a set of interrelated patent applications filed in one or more countries or jurisdictions to protect the same invention. Patent families containing applications filed in at least two different offices is a subset of patent families where protection of the same invention is sought in at least two different countries. In this report, “patent families data” refers to patent applications filed by residents in at least two IP offices; the data are scaled by PPP$ GDP (billions). A “patent” is a set of exclusive rights granted by law to applicants for inventions that are new, non-obvious, and commercially applicable. A patent is valid for a limited period of time (generally 20 years), during which patent holders can commercially exploit their inventions on an exclusive basis. In return, applicants are obliged to disclose their inventions to the public in a manner that enables others, skilled in the art, to replicate the invention. The patent system is designed to encourage innovation by providing innovators with time-limited exclusive legal rights, thus enabling them to appropriate the returns from their innovative activity.

Source: World Intellectual Property Organization, *Intellectual Property Statistics*; International Monetary Fund, *World Economic Outlook Database*, October 2018 (PPP$ GDP). (http://www.wipo.int//ipstats/; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

5.3 Knowledge absorption

5.3.1 Intellectual property payments
Charges for use of intellectual property i.e., payments (%, total trade, three-year average)[a] | 2017

Charges for the use of intellectual property not included elsewhere payments (% of total trade), average of three most recent years or available data. Value according to the Extended Balance of Payments Services Classification EBOPS 2010—that is, code SH charges for the use of intellectual property not included elsewhere as a percentage of total trade. “Total trade” is defined as the sum of total imports code G goods and code SOX commercial services (excluding government goods and services not included elsewhere) plus total exports of code G goods and code SOX commercial services (excluding government goods and services not included elsewhere), divided by 2. According to the sixth edition of the International Monetary Fund’s Balance of Payments Manual, the item “Goods” covers general merchandise, net exports of goods under merchanting, and non-monetary gold. The “commercial services” category is defined as being equal to “services” minus “government goods and services not included elsewhere”. Receipts are between residents and non-residents for the use of proprietary rights (such as patents, trademarks, copyrights, industrial processes and designs including trade secrets, franchises), and for licenses to reproduce or distribute (or both) intellectual property embodied in produced originals or prototypes (such as copyrights on books and manuscripts, computer software, cinematographic works, and sound recordings) and related rights (such as for live performances and television, cable, or satellite broadcast). Data for Armenia is for (2012-14), Azerbaijan and Guinea (2011, 2012, 2015), Islamic Republic of Iran (2013-15), Niger (2009, 2014-15), and Rwanda (2008).

Source: World Trade Organization, *Trade in Commercial Services* database, based on the sixth (2009) edition of the International Monetary Fund’s *Balance of Payments and International Investment Position Manual* and *Balance of Payments* database (2009–17). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx; http://www.oecd.org/std/its/EBOPS-2010.pdf).

5.3.2 High-tech imports
High-tech imports (% of total trade) | 2017

High-technology imports as a percentage of total trade. High-technology exports and imports contain technical products with a high intensity of R&D, defined by the Eurostat classification, which is based on Standard International Trade Classification (SITC) Revision 4 and the Organisation for Economic Co-operation and Development (OECD) definition. Commodities belong to the following sectors: aerospace; computers & office machines; electronics; telecommunications; pharmacy; scientific instruments; electrical machinery; chemistry; non-electrical machinery; and armament.

Source: World Trade Organization, United Nations, *Comtrade database*; Eurostat, *Annex 5: High-tech aggregation by SITC Rev. 4*, April 2009 (2015-2017). (http://comtrade.un.org/; http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an5.pdf).

5.3.3 ICT services imports
Telecommunications, computers, and information services imports (% of total trade) | 2017

Telecommunications, computer and information services as a percentage of total trade according to the Organisation for Economic Co-operation and Development (OECD)'s Extended Balance of Payments Services Classification EBOPS 2010, coded SI: Telecommunications, computer and information services. For the definition of total trade see indicator 5.3.1.

Source: World Trade Organization, *Trade in Commercial Services* database, based on the sixth (2009) edition of the International Monetary Fund's *Balance of Payments and International Investment Position Manual* and *Balance of Payments* database (2015-17). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx; http://www.oecd.org/std/its/EBOPS-2010.pdf).

5.3.4 Foreign direct investment net inflows
Foreign direct investment (FDI), net inflows (% of GDP, three-year average) | 2017

Foreign direct investment is the average of the most recent three years of net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, and is divided by GDP.

Source: International Monetary Fund, *International Financial Statistics* and *Balance of Payments* databases, World Bank, International Debt Statistics, and World Bank and OECD GDP estimates; extracted from the World Bank's *World Development Indicators* database, 2019. (http://data.worldbank.org/).

5.3.5 Research talent in business enterprise
Researchers in business enterprise per thousand population (%) | 2017

"Full-time equivalent (FTE) researchers in the business enterprise sector" refers to researchers as professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems, as well as in the management of these projects, broken down by the sectors in which they are employed (business enterprise, government, higher education, and private non-profit organizations). In the context of R&D statistics, the business enterprise sector includes all firms, organizations, and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price, and the private non-profit institutions mainly serving them; the core of this sector is made up of private enterprises. This also includes public enterprises. Oman uses data for 2015.

Source: UNESCO Institute for Statistics, *UIS online database*; Eurostat, *Eurostat database, 2019*; OECD, *Main Science and Technology Indicators MSTI database, 2019* (2008–17). (http://data.uis.unesco.org; https://ec.europa.eu/eurostat/data/database; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

6 Knowledge and technology outputs

6.1 Knowledge creation

6.1.1 Patent applications by origin
Number of resident patent applications filed at a given national or regional patent office (per billion PPP$ GDP)[a] | 2017

"Patent" is defined in the description of indicator 5.2.5. A "resident patent application" refers to an application filed with an IP office or an office acting on behalf of the state or jurisdiction in which the first-named applicant has residence. For example, an application filed with the Japan Patent Office (JPO) by a resident of Japan is considered a resident application for Japan. Similarly, an application filed with the European Patent Office (EPO) by an applicant who resides in any of the EPO member states, for example Germany, is considered a resident application for that member state (Germany).

Source: World Intellectual Property Organization, *Intellectual Property Statistics*; International Monetary

Fund, *World Economic Outlook Database*, October 2018 (PPP$ GDP) (2010–17). (http://www.wipo.int/ipstats/; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

6.1.2 PCT international applications by origin

Number of international patent applications filed by residents at the Patent Cooperation Treaty (per billion PPP$ GDP)[a] | 2018

These are the number of Patent Cooperation Treaty (PCT) international patent applications filed through the WIPO-administered Patent Cooperation Treaty in 2018. A "PCT international application" refers to a patent application filed through the WIPO-administered Patent Cooperation Treaty (PCT) during the international phase outlined by the PCT System. The origin of PCT applications are defined by the residence of the first-named applicant. The PCT System facilitates the filing of patent applications worldwide, making it possible to seek patent protection for an invention simultaneously in each of a large number of countries by first filing a single international patent application. Data is available only for those economies adhered to PCT.

Source: World Intellectual Property Organization, *Intellectual Property Statistics*; International Monetary Fund, *World Economic Outlook Database,* October 2018 (PPP$ GDP). (http://www.wipo.int/ipstats/; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

6.1.3 Utility models by origin

Number of utility model applications filed by residents at the national patent office (per billion PPP$ GDP) | 2017

These are the number of resident utility model applications iled at a given national or regional patent office in 2017 A "resident UM application" refers to an application filed with an IP office of, or an office acting on behalf of, the state or jurisdiction in which the first-named applicant has residence. For example, an application filed with the IP office of Germany by a resident of Germany is considered a resident application for Germany. A "utility model grant" is a special form of patent right issued by a state or jurisdiction to an inventor or the inventor's assignee for a fixed period of time. The terms and conditions for granting a utility model are slightly different from those for normal patents and include a shorter term of protection and less stringent patentability requirements. A utility model is sometimes referred to in certain countries as "petty patents", "short-term patents", or "innovation patents". Data is available only for those economies with a utility models system.

Source: World Intellectual Property Organization, *Intellectual Property Statistics*; International Monetary Fund, *World Economic Outlook Database*, October 2018 (PPP$ GDP) (2010–17). (http://www.wipo.int/ipstats/; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

6.1.4 Scientific and technical publications

Number of scientific and technical journal articles (per billion PPP$ GDP)[a] | 2018

The number of scientific and engineering articles published in those fields, including: agriculture, astronomy, astrophysics, automation control systems, biochemistry molecular biology, biodiversity conservation, biotechnology applied microbiology, cell biology, chemistry, computer science, construction building technology, dentistry oral surgery medicine, engineering, environmental sciences, ecology, evolutionary biology, food science technology, general internal medicine, life sciences biomedicine and other topics, marine freshwater biology, materials science, mathematical computational biology, mathematics, metallurgy and metallurgical engineering, meteorology atmospheric science, microbiology, nuclear science and technology, physics, plant sciences, radiology nuclear medicine medical imaging, reproductive biology, research experimental medicine, science technology and other topics, telecommunications, transportation, and veterinary sciences. Article counts are from a set of journals covered by the Science Citation Index (SCI) and the Social Sciences Citation Index (SSCI). Articles are classified by year of publication and assigned to each country/economy on basis of the institutional address(es) listed in the article. Articles are counted on a count basis (rather than a fractional basis)—that is, for articles with collaborating institutions from multiple countries/economies, each country/economy receives credit on the basis of its participating institutions. The data are reported per billion PPP$ GDP.

Source: *Clarivate Analytics*, special tabulations from Thomson Reuters, Web of Science, Science Citation Index (SCI), and Social Sciences Citation Index (SSCI); International Monetary Fund, *World Economic Outlook Database*, October 2018 (PPP$ GDP). (https://apps.webofknowledge.com; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

6.1.5 Citable documents H-index

The H-index is the economy's number of published articles (H) that have received at least H citations | 2018

The H-index expresses the journal's number of articles (H) that have received at least H citations. It quantifies both journal scientific productivity and scientific impact, and is also applicable to scientists, journals, and so on. The H-index is tabulated from the number of citations received in subsequent years by articles published in a given year, divided by the number of articles published that year.

Source: SCImago (2019) SJR—SCImago Journal & Country Rank. Retrieved February 2019. (http://www.scimagojr.com).

6.2 Knowledge impact

6.2.1 Growth rate of GDP per person engaged

Growth rate of GDP per person engaged (%, three-year average) | 2018

Growth rate of real GDP per person employed (constant 1990 PPP$), average of three last available years. Growth of gross domestic product (GDP) per person engaged provides a measure of labour productivity (defined as output per unit of labour input). GDP per person employed is GDP divided by total employment in the economy. PPP$ GDP is Constant 1990 in US dollar, expressed in 1990 GK PPP, Millions. While this is a relatively robust measure, it does not correct for part-time jobs as it merely counts people who are employed. Hence, GDP per person employed is somewhat underestimated in countries with a higher share of part-time workers, which are mostly OECD countries.

Source: The Conference Board Total Economy Database™ Output, Labor and Labor Productivity, 1950–2018, November 2018. (https://www.conference-board.org/data/economydatabase/).

6.2.2 New business density

New business density (new registrations per thousand population 15–64 years old)[a] | 2016

Number of new firms, defined as firms registered in the current year of reporting, per thousand population aged 15–64 years old. Kenya used data for 2008

Source: World Bank, *Doing Business 2018, Entrepreneurship* (2008–16). (http://www.doingbusiness.org/data/exploretopics/entrepreneurship).

6.2.3 Total computer software spending

Total computer software spending (% of GDP)[a] | 2018

Computer software spending includes the total value of purchased or leased packaged software such as operating systems, database systems, programming tools, utilities, and applications. It excludes expenditures for internal software development and outsourced custom software development. The data are a combination of actual figures and estimates. Data are reported as a percentage of GDP.

Source: IHS Markit, *Information and Communication Technology Database*. (https://www.ihs.com/index.html).

6.2.4 ISO 9001 quality certificates

ISO 9001 Quality management systems—Requirements: Number of certificates issued (per billion PPP$ GDP)[a] | 2017

ISO 9001:2015 specifies requirements for a quality management system when an organization needs to demonstrate its ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements, and aims to enhance customer satisfaction through the effective application of the system, including processes for improving the system and assuring conformity to customer and applicable statutory and regulatory requirements. All the requirements of ISO 9001:2015 are generic and are intended to be applicable to any organization, regardless of its type or size, or the products and services it provides. The data are reported per billion PPP$ GDP. Refer to indicator 3.3.3 for more details.

Source: International Organization for Standardization (ISO), *The ISO Survey of certifications to management system standards, 2017*; International Monetary Fund, *World Economic Outlook* database, October 2018 (PPP$ GDP). (http://www.iso.org; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

6.2.5 High-tech and medium-high-tech output

High-tech and medium-high-tech output (% of total manufactures output)[a] | 2016

High-tech and medium-high-tech output as a percentage of total manufactures output, on the basis of the Organisation for Economic Co-operation and Development (OECD) classification of Technology Intensity Definition, itself based on International Standard Industrial Classification ISIC Revision 4 and ISIC Revision 3. ISIC Revision 4 data were preferred; when not available or not reported for a given country, ISIC Revision 3 data were used. For all ISIC three-digit classification codes included in the definition of high-tech and medium-high-tech output reported as missing for a given country, but for which four-digit level data were available, the three-digit values were calculated as the sum of all four-digit codes that were available. No data were available for Botswana or Lebanon. Cameroon uses data for 2008.

Source: United Nations Industrial Development Organization (UNIDO), *Industrial Statistics Database*, 3- and 4-digit level of International Standard Industrial Classification ISIC Revision 4 and Revision 3 (INDSTAT4 2018); OECD, Directorate for Science, Technology and Industry, Economic Analysis and Statistics Division, "ISIC Rev. 3 and Rev. 4 Technology Intensity Definition: Classification of Manufacturing Industries into Categories Based on R&D Intensities" (2008–16). (http://www.unido.org/statistics.html; http://stat.unido.org/content/focus/classification-of-manufacturing-sectors-by-technological-intensity-%2528isic-revision-4%2529;jsessionid=4DB1A3A5812144CACC956F4B8137C1CF; http://www.oecd.org/sti/ind/48350231.pdf).

6.3 Knowledge diffusion

6.3.1 Intellectual property receipts

Charges for use of intellectual property i.e., receipts (% total trade, three-year average)[a] | 2017

Charges for the use of intellectual property not included elsewhere receipts (% of total trade), average of three most recent years or available data. Value according to the Extended Balance of Payments Services Classification EBOPS 2010—that is, code SH charges for the use of intellectual property not included elsewhere as a percentage of total trade. Receipts are between residents and non-residents for the use of proprietary rights (such as patents, trademarks, copyrights, industrial processes, and designs including trade secrets, franchises), and for licenses to reproduce or distribute (or both) intellectual property embodied in produced originals or prototypes (such as copyrights on books and manuscripts, computer software, cinematographic works, and sound recordings) and related rights (such as for live performances and television, cable, or satellite broadcast). For definition of total trade see indicator 5.3.1. Data for Armenia is for (2015), Azerbaijan (2011-12, 2014), Benin (2014-16), Burundi (2014-15, 2017), Côte d'Ivoire (2014-16), Guinea (2013), Islamic Republic of Iran (2013-15), Mali (2011-12, 2017), Mozambique (2009, 2011 -12), Niger (2015-16), Rwanda (2009), Tajikistan (2009, 2014), Togo (2010), Turkey (2017), and Yemen (2009, 2016).

Source: World Trade Organization, *Trade in Commercial Services* database, based on the sixth (2009) edition of the International Monetary Fund's *Balance of Payments and International Investment Position Manual* and *Balance of Payments* database (2009–17). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx; http://www.oecd.org/std/its/EBOPS-2010.pdf).

6.3.2 High-tech exports

High-tech net exports (% of total trade)[a] | 2017

High-technology exports minus re-exports (% of total trade). See indicator 5.3.2 for details.

Source: World Trade Organization, United Nations, *Comtrade* database; Eurostat, *Annex 5: High-tech aggregation by SITC Rev. 4*, April 2009 (2015–17). (http://comtrade.un.org/; https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an5.pdf).

6.3.3 ICT services exports

Telecommunications, computers, and information services exports (% of total trade)[a] | 2017

Telecommunications, computer and information services (% of total trade) according to the Extended Balance of Payments Services Classification EBOPS 2010, coded SI: Telecommunications, computer and information services.

Source: World Trade Organization, *Trade in Commercial Services* database, based on the sixth (2009) edition of the International Monetary Fund's *Balance of Payments and International Investment Position Manual and Balance of Payments* database (2015-17). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx; http://www.oecd.org/std/its/EBOPS-2010.pdf).

6.3.4 Foreign direct investment net outflows

Foreign direct investment (FDI), net outflows (% of GDP, three-year average)[a] | 2017

"Foreign direct investment" refers to the average of the most recent three years of direct investment equity flows in an economy. It is the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy. Ownership of 10 percent or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship. This series shows net outflows of investment from the reporting economy to the rest of the world, and is divided by GDP. The two extreme bottom outliers in Malta and Iceland were given n/a due to a verified low quality of their time series for that indicator.

Source: International Monetary Fund, *International Financial Statistics* and *Balance of Payments* databases, World Bank, International Debt Statistics, and World Bank and OECD GDP estimates; extracted from the World Bank's *World Development Indicators* database (2016–17). (http://data.worldbank.org/).

7 Creative outputs

7.1 Intangible assets

7.1.1 Trademark application class count by origin

Number of trademark applications issued to residents at a given national or regional office (per billion PPP$ GDP) | 2017

The count of trademark applications is based on the total number of goods and services classes specified in resident trademark applications filed at a given national or regional office in 2017. Data refer to trademark application class counts—the number of classes specified in resident trademark applications—and include those filed at both the national office and the regional office, where applicable. Data are scaled by PPP$ GDP (billions).
A "trademark" is a sign used by the owner of certain products or provider of certain services to distinguish them from the products or services of other companies. A trademark can consist of words and/or combinations of words, such as slogans, names, logos, figures and

images, letters, numbers, sounds and moving images, or a combination thereof. The procedures for registering trademarks are governed by the legislation and procedures of national and regional IP offices. Trademark rights are limited to the jurisdiction of the IP office that registers the trademark. Trademarks can be registered by filing an application at the relevant national or regional office(s) or by filing an international application through the Madrid System. A resident trademark application is one that is filed with an IP office or an office acting on behalf of the state or jurisdiction in which the applicant has residence. For example, an application filed with the Japan Patent Office (JPO) by a resident of Japan is considered a resident application for Japan. Similarly, an application filed with the Office for Harmonization in the Internal Market (OHIM) by an applicant who resides in any of the EU member states, such as France, is considered a resident application for that member state (France).

Source: World Intellectual Property Organization, *Intellectual Property Statistics*; International Monetary Fund, *World Economic Outlook Database*, October 2018 (PPP$ GDP) (2010–17). (http://www.wipo.int//ipstats/; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

7.1.2 Industrial designs by origin

Number of designs contained in industrial design applications filed at a given national or regional office (per billion PPP$ GDP)[a] | 2017

This indicator refers to the number of designs contained in industrial design applications filed at a given national or regional office in 2017. Data refer to industrial design application counts—the number of designs contained in applications—and include designs contained in resident industrial design applications filed at both the national office and at the regional office, where applicable. “Resident design counts” refers to the number of designs contained in applications filed with the IP office of or at an office acting on behalf of the state or jurisdiction in which the applicant has residence. For example, an application filed with the Japan Patent Office (JPO) by a resident of Japan is considered a resident application for Japan. Similarly, an application filed with the Office for Harmonization in the Internal Market (OHIM) by an applicant who resides in any of the OHIM member states, such as Italy, is considered as a resident application for that member state (Italy).

Source: World Intellectual Property Organization, *Intellectual Property Statistics*; International Monetary Fund, *World Economic Outlook Database*, October 2018 (PPP$ GDP) (2010–17). (http://www.wipo.int//ipstats/; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx).

7.1.3 ICTs and business model creation

Average answer to the question: In your country, to what extent do ICTs enable new business models? [1 = not at all; 7 = to a great extent][†] | 2018

Source: World Economic Forum, *Executive Opinion Survey 2018*. (Forthcoming at https://www.weforum.org).

7.1.4 ICTs and organizational model creation

Average answer to the question: In your country, to what extent do ICTs enable new organizational models (e.g., virtual teams, remote working, telecommuting) within companies? [1 = not at all; 7 = to a great extent][†] | 2018

Source: World Economic Forum, *Executive Opinion Survey 2018*. (Forthcoming at https://www.weforum.org).

7.2 Creative goods and services[a]

7.2.1 Cultural and creative services exports

Cultural and creative services exports (% of total trade)[a] | 2017

Creative services exports (% of total exports) according to the Extended Balance of Payments Services Classification EBOPS 2010—that is, EBOPS code SI3 Information services; code SJ22 Advertising, market research, and public opinion polling services; code SK1 Audiovisual and related services; and code SK24 Other personal cultural and recreational services as a percentage of total trade. See 5.3.1 for a full definition of total trade. On the score for the United States of America (U.S.), this includes SI3 Information services; the category Movies & TV programming from Table 2.1 (U.S. Trade in Services, BEA) is used in the absence of available data for code SK1 Audiovisual and related services (the category Movies & TV programming is specific to the U.S. in BPM6 statistics and does not have a code); the category Sports and performing arts (U.S. Trade in Services, BEA) is used instead of code SK24; the category Advertising (U.S. Trade in Services, BEA) is used instead of code SJ22. Costa Rica, Cyprus, Ecuador, Guinea, Malta, Mexico, Togo show values used in the GII 2018. Due to quality considerations data for the United Arab Emirates is not considered.

Source: World Trade Organization, *Trade in Commercial Services* database, based on the sixth (2009) edition of the International Monetary Fund’s *Balance of Payments and International Investment Position Manual* and *Balance of Payments* database; Bureau of Economic Analysis (BEA) released October 2017. (2016-2017). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx; http://www.oecd.org/std/its/EBOPS-2010.pdf; https://www.bea.gov/iTable/iTable.cfm).

7.2.2 National feature films produced

Number of national feature films produced (per million population 15–69 years old)[a] | 2017

A film with a running time of 60 minutes or longer. It includes works of fiction, animation, and documentaries. It is intended for commercial exhibition in cinemas. Feature films produced exclusively for television broadcasting, as well as newsreels and advertising films, are excluded. Data are reported per million population 15–69 years old. El Salvador uses data for 2008.

Source: UNESCO Institute for Statistics, *UIS online database*; United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2017 Revision* (population) (2008-2017). (http://data.uis.unesco.org; http://esa.un.org/unpd/wpp/).

7.2.3 Entertainment and media market

Global entertainment and media market (per thousand population 15–69 years old)*[a] | 2017

The Global entertainment and media outlook (the Outlook) provides a single comparable source of five-year forecast and five-year historic consumer and advertiser spending data and commentary for 17 entertainment and media segments, across 63 countries. Two new datasets have been added to this year's Outlook. Podcasts are covered for the first time, with data for both monthly listeners and advertising revenue for 20 markets. Additionally, the E-sports dataset has been deepened with the addition of E-sports media rights, providing a richer picture of this fast-emerging market. A number of changes have also been made to the segmentation of the Outlook to better reflect the shape of the modern entertainment and media market. The Music and Radio segments have been merged along with the new Podcasts data to create the new Music, Radio and Podcasts segment, reflecting the growing interconnectedness of the audio entertainment market. And the Video games segment has been merged with E-sports to create the new Video games and e-sports segment, capturing the close relationship between the two markets. The names of a number of segments have also been changed: OOH advertising is now simply OOH, and Internet video is now OTT video. None of the data contained in these segments has been affected. Finally, Venezuela has been removed from the Outlook for this year due to the difficulty of accurately measuring the entertainment and media market in that country given its current political and economic environment.

A total of 63 countries are represented within the Outlook spread across North America, Western Europe, Central Europe, the Middle East and North Africa, Latin America, and Asia Pacific. The score and rankings for the Global Media Expenditures for the 63 countries considered in the Outlook report are based on advertising and consumer digital and non-digital data in US$ millions at average 2018 exchange rates for the year 2018. These results are reported normalized per thousand population, 15–69 years old, for the year 2018. The figures for Algeria, Bahrain, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, the Islamic Republic of Iran, Malta, Tunisia, and Yemen were estimated from a total corresponding to Middle East and North Africa (MENA) countries using a breakdown of total GDP (current US$) for the above-mentioned countries to define referential percentages.

Source: Calculations were derived from PwC's *Global Entertainment and Media Outlook, 2018–2022*; United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2017 Revision* (population); *World Economic Outlook Database,* October 2018 (current US$ GDP); Middle East & North Africa in the World Bank's *DataBank*. (http://www.pwc.com/outlook ; http://esa.un.org/unpd/wpp/ ; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx; http://data.worldbank.org/region/middle-east-and-north-africa).

7.2.4 Printing publications and other media output

Printing publications and other media (% of manufactures total output) | 2016

Printing, and reproduction of recorded media output (ISIC Revision 4 Division 18, group 181 with class 1811 and 1812 and group 182 with class 1820) as a percentage of total manufacturing output (ISIC Revision 4, section C). Where data for ISIC Revision 4 were not available, data from ISIC Revision 3 were used (ISIC Revision 3 group 222, classes 2221, 2222, and 2230). For a more robust coverage data for Argentina (2002), Ghana (2003), Trinidad and Tobago (2006), Pakistan (2006), Madagascar (2006), and Lebanon (2007) is used from years prior to 2008. Chile used data for 2015.

Source: United Nations Industrial Development Organization, *Industrial Statistics Database;* 4-digit level of International Standard Industrial Classification ISIC Revision 4 (INDSTAT4 2018) and ISIC Revision 3 (INDSTAT2 2018). (2002–17). (http://www.unido.org/statistics.html; http://data.un.org/).

7.2.5 Creative goods exports

Creative goods exports (% of total trade) | 2017

Total value of creative goods exports, net of re-exports (current US$) over total trade. Creative goods as defined in 2009 UNESCO Framework for Cultural Statistics, Table 3, *International trade of cultural goods and services based on the 2007 Harmonised System (HS 2007)*. For the definition of total trade see indicator 5.3.1.

Source: United Nations, *Comtrade* database; 2009 UNESCO Framework for Cultural Statistics, Table 3, *International trade of cultural goods and services based on the 2007 Harmonised System (HS 2007*); World Trade Organization, *Trade in Commercial Services* database, itself based on the sixth (2009) edition of the International Monetary Fund's *Balance of Payments and International*

Investment Position Manual and *Balance of Payments* database (2013–17). (http://comtrade.un.org/; http://www.uis.unesco.org/culture/Documents/framework-cultural-statistics-culture-2009-en.pdf; http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx; http://www.oecd.org/sdd/its/EBOPS-2010.pdf).

7.3 Online creativity[a]

7.3.1 Generic top-level domains (gTLDs)

Generic top-level domains (gTLDs) (per thousand population 15–69 years old) | 2018

A generic top-level domain (gTLD) is one of the categories of top-level domains (TLDs) maintained by the Internet Assigned Numbers Authority (IANA) for use in the Internet. Generic TLDs can be unrestricted (.com, .info, .net, and .org) or restricted—that is, used on the basis of fulfilling eligibility criteria (.biz, .name, and .pro). Of these, the statistic covers the five generic domains .biz, .info, .org, .net, and .com. Generic domains .name and .pro, and sponsored domains (.arpa, .aero, .asia, .cat, .coop, .edu, .gov, .int, .jobs, .mil, .museum, .tel, .travel, and .xxx) are not included. Neither are country-code top-level domains (refer to indicator 7.3.2). The statistic represents the total number of registered domains (i.e., net totals by December 2018, existing domains + new registrations – expired domains). Data are collected on the basis of a 4% random sample of the total population of domains drawn from the root zone files (a complete listing of active domains) for each TLD. The geographic location of a domain is determined by the registration address for the domain name registrant that is returned from a whois query. These registration data are parsed by country and postal code and then aggregated to any number of geographic levels such as county, city, or country/economy. The original hard data were scaled by thousand population 15–69 years old. For confidentiality reasons, only normalized values are reported; while relative positions are preserved, magnitudes are not.

Source: ZookNIC Inc; United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2017 Revision* (population). (http://www.zooknic.com; http://esa.un.org/unpd/wpp/).

7.3.2 Country-code top-level domains (ccTLDs)

Country-code top-level domains (ccTLDs) (per thousand population 15–69 years old) | 2018

A country-code top-level domain (ccTLD) is one of the categories of top-level domains (TLDs) maintained by the Internet Assigned Numbers Authority (IANA) for use in the Internet. Country-code TLDs are two-letter domains especially designated for a particular economy, country, or autonomous territory (there are 255 ccTLDs, in various alphabets/characters). The statistic represents the total number of registered domains (i.e., net totals by December 2018, existing domains + new registrations – expired domains). Data are collected from the registry responsible for each ccTLD and represent the total number of domain registrations in the ccTLD. Each ccTLD is assigned to the country with which it is associated rather than based on the registration address of the registrant. ZookNIC reports that, for the ccTLDs it covers, 85–100% of domains that are registered in the same country; the only exceptions are the ccTLDs that have been licensed for commercial worldwide use. Data are reported per thousand population 15–69 years old. For confidentiality reasons, only normalized values are reported; while relative positions are preserved, magnitudes are not.

Source: ZookNIC Inc; United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2017 Revision* (population). (http://www.zooknic.com; http://esa.un.org/unpd/wpp/).

7.3.3 Wikipedia yearly edits

Wikipedia yearly edits by country (per million population 15–69 years old) | 2017

Data extracted from Wikimedia Foundation's internal data sources. For every country with more than 100,000 edit counts in 2017, the data from 2017 are used; otherwise, for every country with more than 100,000 edit counts in 2016, the data from 2016 are used. For all other countries, the data from 2014 are used. The data exclude both contributions to the extent that is identifiable in the data sources. Data are reported per million population 15–69 years old.

Source: Wikimedia Foundation; United Nations, Department of Economic and Social Affairs, Population Division (2014–17). *World Population Prospects: The 2017 Revision* (population). (https://wikimediafoundation.org; https://esa.un.org/unpd/wpp/).

7.3.4 Mobile apps creation

Global downloads of mobile apps (scaled by per billion PPP $ GDP) | 2018

Global downloads of mobile apps, by origin of the headquarters of the developer/firm, scaled by PPP$ GDP (billions). Global downloads are compiled by App Annie Intelligence, public data sources, and the company's proprietary forecast model based on data from Google play store and iOS App store in each country between January 1, 2018 and December 31, 2018. Since data for China are not available for Google play store and only for iOS App store, data from China are treated as missing and considered "n/a".

Source: Source: App Annie Intelligence; International Monetary Fund, *World Economic Outlook Database*, October 2018 (PPP$ GDP) (2010–17). (https://www.appannie.com/en/; https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx)

APPENDIX IV

ADJUSTMENTS TO THE GLOBAL INNOVATION INDEX FRAMEWORK, YEAR-ON-YEAR COMPARABILITY OF RESULTS, AND TECHNICAL NOTES

Adjustments to the Global Innovation Index framework

The Global Innovation Index (GII) is a cross-economy performance assessment, compiled on an annual basis, which continuously seeks to update and improve the way innovation is measured. The GII report pays special attention to making the statistics used in the Economy Profiles and Data Tables accessible by providing data sources and definitions, and detailing the computation methodology (Appendix II, III, and IV). This segment summarizes the changes made this year and provides an assessment of the impact these changes have on the comparability of rankings.

The GII model is revised every year in a transparent exercise. This year no change was made at either the pillar or the sub-pillar level.

Beyond the use of the World Intellectual Property Organization (WIPO) data, we collaborate with public international bodies, such as the International Energy Agency, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Industrial Development Organization (UNIDO), the World Trade Organization (WTO), and the Joint Research Centre of the European Commission (JRC). We also collaborate with private organizations, such as the International Organization for Standardization (ISO), IHS Markit, Bureau van Dijk (BvD), ZookNIC Inc, Thomson Reuters, Wikimedia Foundation, and AppAnnie to obtain the best globally available data on innovation.

Table A-IV.1 provides a summary of adjustments to the GII 2019 framework. A total of seven indicators were modified this year. One indicator was replaced, five underwent methodological changes, and one's methodology changed at source.

Methodology and data

The nature of the 2019 adjustments are detailed below:

Indicator **1.1.1: Political stability and safety** from the World Banks World Governance Indicators, which measures the perception of the likelihood of political instability and/or politically motivated violence, including terrorism, was replaced in 2019 by the indicator Political and operational stability. The political, legal, and operational or security risk index developed by IHS Markit measures the likelihood and severity of these risks in relation to their impact on business operations.

TABLE A-IV.1

Changes to the GII 2019 framework

GII 2018		Adjustment	GII 2019	
1.1.1	Political stability & safety	Replaced	1.1.1	Political & operational stability
3.3.2	Environmental performance	Indicator changed at source	3.3.2	Environmental performance
5.3.1	Intellectual property payments, % total trade	Methodology change	5.3.1	Intellectual property payments, % total trade (3 year avg.)
5.3.2	High-tech imports, % total trade	Methodology change	5.3.2	High-tech imports, % total trade
6.2.1	Growth rate of PPP$ GDP/worker, %	Methodology change	6.2.1	Growth rate of PPP$ GDP/worker, % (3 year avg.)
6.3.1	Intellectual property receipts, % total trade	Methodology change	6.3.1	Intellectual property receipts, % total trade (3 year avg.)
7.3.4	Mobile app creation/bn PPP$ GDP	Methodology change	7.3.4	Mobile app creation/bn PPP$ GDP

Source: Global Innovation Database, Cornell, INSEAD, and WIPO.
Notes: Refer to Appendix I and III for a detailed explanation of terminology and acronyms. Refer to Appendix III for a detailed explanation of methodological changes at source.

Indicator **3.3.2: Environmental performance** is an index produced by Yale University and Columbia University that measures environmental health and ecosystem vitality. This year, the methodology changed, therefore the scores calculated under the old methodology are not comparable to the new scores.

The methodology underpinning indicators 5.3.1 and 6.3.1, Intellectual property payments and Receipts, respectively, was updated. This year, the GII considers the average of the three most recent years in order to avoid excessive volatility.

Data for indicator **5.3.2: High-tech net imports** are sourced directly from the United Nations Comtrade rather than from the World Integrated Trade Solutions (WITS). The change affects the calculation for net totals.

For indicator **6.2.1: Growth rate of GDP PPP$ per worker**, the methodology changed to capture the average of the three most recent years to produce a more stable variable.

Indicator **7.3.4: Mobile app creation**, introduced last year to measure the number of mobile apps created in an economy, was adjusted this year to measure the global downloads of mobile apps by origin of the headquarters of the developer or producing firm.

Missing values

Since its inception, one of the core missions of the GII is to increase awareness of the importance of submitting timely data. In recent years, the GII has had a positive influence on data collection, helping improve the number of data points submitted to international data agencies. In the GII 2019, with the inclusion of three economies in the GII sample, coverage remains relatively close to the level seen last year, with 10% of data points missing.

When it comes to economy coverage, the objective is to include as many as possible. However, it is also important to maintain a good level of data coverage within each of these economies. Because the GII results depend on data availability (Appendix V), which in turn affects the overall GII rankings, the threshold rule for economies with missing data and the minimum coverage necessary per sub-pillar were progressively tightened in 2016 and 2017 (Appendix IV: Technical Notes).

The motivation behind the introduction of these adjustments is because of data availability, which, historically, was less satisfactory when considering innovation outputs in the GII. For instance, this year, 13.2% of all economies show data coverage of less than 75% but exhibit over 66% coverage in the Output Sub-Index, while only 3.2% of these economies have this coverage range in the Input Sub-Index.

In addition to the economies featured last year, three new economies, Burundi, Ethiopia, and Nicaragua, are included in the GII 2019 because data coverage has improved above the 66% threshold in the 27 variables of the Output Sub-Index.

Despite the requirement for a minimum level of coverage, for several economies the number of missing data points remains very high. Table A-IV.2 lists the economies with the highest number of missing data points (20 or more).

Conversely, Table A-IV.3 lists economies with the best data coverage. These economies are missing five data points at the most while others are missing none.

For the last three years, more stringent rules were introduced, resulting in significant data coverage improvements for various economies. Table A-IV.4 shows economies with improved data coverage from 2016 to 2019. At the same time, fewer economies witnessed a decline in data coverage, as shown in Table A-IV.5.

Year-on-year comparability of results—sources of change in the rankings

The GII compares the performance of national innovation systems across economies, and presents the changes in economy rankings over time.

Importantly, scores and rankings from one year to the next are not directly comparable (see GII 2013, Annex 2, for a full explanation). Making inferences about absolute or relative performance based on year-on-year differences in rankings can be misleading. Each ranking reflects the relative positioning of a particular economy based on the conceptual framework, data coverage, and the sample of economies in a given year, also reflecting changes in the underlying indicators at source and in data availability.

A few factors influence year-on-year rankings of an economy:

- the actual performance of the economy in question;
- adjustments made to the GII framework;
- data updates, the treatment of outliers, and missing values; and
- the inclusion or exclusion of economies in the sample.

Additionally, the following characteristics complicate the time-series analysis based on simple GII scores or rankings:

- **Missing values.** The GII produces relative index scores, which means that a missing value for one economy affects the index score of other economies. Because the number of missing values decreases every year, this problem reduces over time.
- **Reference year.** The data underlying the GII do not refer to a single year but to several years depending on the latest available year for any given variable. In addition, the reference years for different variables are not the same for each economy. The motivation for this approach is that it widens the set of data points for cross-economy comparability.
- **Normalization factor.** Most GII variables are normalized using either GDP or population, with the intention to enable cross-economy comparability. Yet, this implies that year-on-year changes in individual variables may be driven either by the variable's numerator or by its denominator.
- **Consistent data collection**. Measuring the change of year-on-year performance relies on the consistent collection of data over time. Changes in the definition of variables or in the data collection process could create movements in the rankings that are unrelated to performance.

TABLE A-IV.2

GII economies with the most missing values

Economy	Number of missing values	Economy	Number of missing values	Economy	Number of missing values
Niger	23	Guinea	21	Togo	20
Nicaragua	22	Nepal	21	Yemen	20
		Trinidad and Tobago	20		

Source: Global Innovation Database, Cornell, INSEAD, and WIPO.

TABLE A-IV.3

GII economies with the fewest missing values

Economy	Number of missing values	Economy	Number of missing values	Economy	Number of missing values
Turkey	0	Bulgaria	2	Morocco	3
Romania	0	Argentina	2	Costa Rica	3
Thailand	0	Indonesia	2	Tunisia	3
Malaysia	0	Italy	2	Cyprus	4
Chile	0	Portugal	2	Lithuania	4
Mexico	0	Philippines	2	Luxembourg	4
Colombia	0	Kazakhstan	2	United States of America	4
Russian Federation	1	Finland	3	United Kingdom	4
Poland	1	Israel	3	Republic of Moldova	4
Hungary	1	Estonia	3	New Zealand	4
Republic of Korea	2	Sweden	3	Malta	4
France	2	Singapore	3	Latvia	4
Ukraine	2	Denmark	3	Greece	4
Slovenia	2	Switzerland	3	South Africa	4
Czech Republic	2	Serbia	3	Egypt	4
Austria	2	Netherlands	3	Canada	5
Brazil	2	Norway	3	Ireland	5
Spain	2	Australia	3	Japan	5
Germany	2	India	3	Panama	5
Slovakia	2	Croatia	3	Kenya	5
		Belgium	3		

Source: Global Innovation Database, Cornell, INSEAD, and WIPO.

TABLE A-IV.4

Indicator coverage improvement, from 2016 to 2019, in % and number

Economy	2016-2019	Improvement	Number
Brunei Darussalam	From 30 to 18	15.7%	12
Algeria	From 17 to 7	25.6%	10
United Arab Emirates	From 17 to 8	22.2%	9
Mozambique	From 20 to 11	18.1%	9
Burkina Faso	From 23 to 14	15.3%	9
Zimbabwe	From 26 to 17	13.2%	9
Yemen	From 29 to 20	11.6%	9
Cambodia	From 20 to 12	15.7%	8
Honduras	From 21 to 13	14.8%	8
Burundi	From 27 to 19	11.1%	8
Iran, Islamic Republic of	From 16 to 9	17.5%	7
Jordan	From 17 to 10	16.2%	7
Bahrain	From 18 to 11	15.1%	7
Montenegro	From 18 to 11	15.1%	7
Tunisia	From 9 to 3	30.7%	6
Malta	From 10 to 4	26.3%	6
Albania	From 12 to 6	20.6%	6
El Salvador	From 14 to 8	17.0%	6
Zambia	From 19 to 13	11.9%	6
Tajikistan	From 22 to 16	10.1%	6
Togo	From 26 to 20	8.4%	6
Trinidad and Tobago*	From 25 to 20	7.2%	5
Spain	From 7 to 2	34.1%	5
Netherlands	From 8 to 3	27.9%	5
Morocco	From 8 to 3	27.9%	5
Ghana	From 16 to 11	11.7%	5
Namibia	From 18 to 13	10.3%	5
Rwanda	From 22 to 17	8.2%	5
Côte d'Ivoire	From 23 to 18	7.8%	5
Malawi	From 23 to 18	7.8%	5
Benin	From 24 to 19	7.5%	5
Nicaragua	From 27 to 22	6.6%	5

Source: Global Innovation Database, Cornell, INSEAD, and WIPO.
Notes: Annualized growth. *Period: 2017 to 2019.

TABLE A-IV.5

Indicator coverage decline, from 2016 to 2019, in % and number

Economy	2016-2019	Improvement	Number
Madagascar	From 15 to 18	6.3%	3
Uganda	From 13 to 16	7.2%	3
Japan	From 2 to 5	35.7%	3
South Africa	From 2 to 4	26.0%	2

Source: Global Innovation Database, Cornell, INSEAD, and WIPO.
Note: Annualized growth.

A detailed economy study based on the GII database and the economy profile over time, coupled with analytical work on the ground, including innovation actors and decision makers, yields the best results in terms of grasping an economy's innovation performance over time as well as in identifying possible avenues for improvement.

Technical notes

Audit by the European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC).

The JRC-COIN has extensively researched the complexity of composite indicators that rank economies' performances along policy lines. For the ninth consecutive year, the JRC-COIN has performed a thorough "robustness" and "sensitivity" analysis of the GII to assess structural changes that are made to the list of indicators by the GII developing team (Table A-IV.1).

The recommendations from the JRC-COIN audit on the GII 2018 model were reviewed and incorporated into the GII 2019 model. This year, for an economy to feature in the GII 2019, the minimum symmetric data coverage is at least 35 indicators in the Innovation Input Sub-Index (66%) and 18 indicators in the Innovation Output Sub-Index (66%), with scores for at least two sub-pillars per pillar. In 2019, consideration was given to whether scores for all sub-pillars, for all pillars, would be required for economies to be considered in the GII. Ultimately, this rule was not applied this year, but will be reviewed again in 2020 and implemented if applicable.

A final audit of the GII 2019 model was performed in June 2019 (Appendix V).

Composite indicators

The GII relies on seven pillars, each divided into three sub-pillars, of which include two to five individual indicators. Sub-pillar scores are calculated using the weighted average of its individual indicators. Pillar scores are calculated using the weighted average of its sub-pillar scores.

The notion of weights as important coefficients was revised this year to ensure a greater statistical coherence of the model, following the recommendations of the JRC-COIN.[1]

The GII includes three indices:

1. The Innovation Input Sub-Index is the average of the first five pillar scores.
2. The Innovation Output Sub-Index is the average of the last two pillar scores.
3. The Global Innovation Index is the average of the Input and Output Sub-Indices.

Economy rankings are provided for indicators, sub-pillars, pillars, and index scores.

This year, following the advice of the JRC-COIN, the GII introduced a more statistically fitting alternative to analyzing the relation between innovation inputs and outputs. This approach replaces the Innovation Efficiency Ratio analysis (see Chapter 1, Figure 1.8 and relevant segment).[2]

Individual indicators

The GII 2019 model includes 80 indicators, which fall in three categories:

1. quantitative/objective/hard data (57 indicators),
2. composite indicators/index data (18 indicators), and
3. survey/qualitative/subjective/soft data (5 indicators).

Hard data

Hard data (57 indicators) are drawn from a variety of public and private sources. These include, among others, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Industrial Development Organization (UNIDO), the World Intellectual Property Organization (WIPO), the World Bank, the Joint Research Centre of the European Commission (JRC), PwC, Bureau van Dijk (BvD), Thomson Reuters, IHS Markit, Wikimedia Foundation, and AppAnnie.

Indicators are often correlated with population, gross domestic product (GDP), or some other size-related factor; they require scaling by a relevant size indicator for economy comparisons to be valid. Most indicators are either scaled at source or do not need to be scaled; for the rest, the scaling factor was chosen to represent a fair picture of economy differences. Scaling affected 40 indicators, which can be broadly divided into four groups:

1. Indicators scaled by GDP in current US$: 2.1.1, 2.3.2, 3.2.3, 4.1.2, 4.1.3, 4.2.2, 5.1.3, 5.3.4, 6.2.3, and 6.3.4.[3]

2. The count variables 3.3.3, 4.2.3, 5.2.4, 5.2.5, 6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.2.4, 7.1.1, 7.1.2, and 7.3.4 are scaled by GDP in purchasing power parity current international dollars. This choice of denominator was dictated by a willingness to appropriately account for differences in development stages; in addition, scaling these variables by population would improperly bias results to the detriment of economies with a large young or ageing population.[4]

3. Variables 3.2.1, 5.1.5, 6.2.2, 7.2.2, 7.2.3, 7.3.1, 7.3.2, and 7.3.3 are scaled by population. Total population for 3.2.1, population 25+ years old for 5.1.5, population 15–64 years old for 6.2.2, and population 15–69 years old for the remaining.[5]

4. Sectoral indicators 5.3.1, 5.3.2, 5.3.3, 6.3.1, 6.3.2, 6.3.3, 7.2.1, and 7.2.5 are scaled by total trade; and indicators 6.2.5 and 7.2.4 by the total unit used to measure the particular statistic.[6]

Indices

Composite indicators are collected from a series of specialized agencies and academic institutions, such as the World Bank, the UN Public Administration Network (UNPAN), and Yale and Columbia Universities. Statisticians discourage the use of an “index within an index” on two main grounds: the distorting effect of the different computing methodologies used and the risk of duplicating variables. The normalization procedure partially solves the former (more on this below). To avoid the mistake of including a particular indicator more than once (directly and indirectly through a composite indicator), only indices with a narrow focus (18 in total) were selected.

Any additional disadvantage is outweighed by what is gained with model parsimony, acknowledgement of expert opinion, and focus on multi-dimensional phenomena that can hardly be captured by a single indicator.[7]

Survey data

Survey data are drawn from the World Economic Forum’s Executive Opinion Survey (EOS). Survey questions are drafted to capture subjective perceptions on specific topics; five EOS questions were retained to capture phenomena strongly linked to innovative activities for which hard data are nonexistent or have low coverage for economies.

Economy coverage and missing data

This year the GII covers 129 economies, selected based on the availability of data and achieves the same percentage of indicator coverage as in the GII 2018 (Appendix IV: Technical Notes)

For each economy, only the most recent yearly data was considered. As a rule, the GII enforced the cut-off year to be 2009 for considering data at the indicator level. A few exceptions were made for years prior to the cut-off year.[8]

For the sake of transparency and replicability of results, no additional effort was made to fill missing values. Missing values are indicated with “n/a” and are not considered in the sub-pillar score. However, the JRC-COIN audit assessed the robustness of the GII modelling choices (i.e., no imputation of missing data, fixed predefined weights, and arithmetic averages) by imputing missing data, applying random weights, and using geometric averages. Since 2012, based on this assessment, a confidence interval has been provided for each ranking in the GII as well as the Input and Output Sub-Indices (Appendix V).

Treatment of series with outliers

Potentially problematic indicators with outliers that could polarize results and unduly bias the rankings were treated according to the rules listed below, as per the recommendations of the JRC-COIN. This affected 29 indicators; 27 out of the 57 hard data indicators and 2 out of the 18 composite indicators.

First rule: selection

Problematic indicators were identified by skewness or kurtosis. The problematic indicators had either:

- an absolute value of skewness greater than 2.25, or
- a kurtosis greater than 3.5.[9]

Second rule: treatment

Series with one to five outliers (24 cases) were winsorized; the values distorting the indicator distribution were assigned the next highest value, up to the level where skewness and/or kurtosis entered within the ranges specified above.[10]

With two exceptions (see note 10) for series with five or more outliers, skewness and/or kurtosis entered within the ranges specified above after multiplication by a given factor *f* and transformation by natural logs.[11] Since only “goods” were affected (i.e., indicators for which higher values indicate better outcomes, as opposed to “bads”), the formula used was:

$$\ln\left[\frac{(Max \times f - 1)(\text{economy value} - Min)}{Max - Min} + 1\right]^{12}$$

...where “min” and “max” are the minimum and maximum indicator sample values.

For one case, neither winsorization nor multiplication by a given factor plus log transformation brought the series within the desired parameters.[12] For this particular case a variant of a Box-Cox transformation, defined as Yeo-Johnson, was applied to the entire series with a λ=0.6. The formula used was:

$$y_i^{(\lambda)} = ((y_i + 1)^{\lambda} - 1) / \lambda^{14}$$

where $0 \leq \lambda \leq 2$; $\lambda \neq 0$; $y \geq 0$; and y_i = economy value

Normalization

The 80 indicators were then normalized into the [0, 100] range, with higher scores representing better outcomes. Normalization was according to the min-max method; where the min and max values were given by the minimum and maximum indicator sample values respectively. The exception for index and survey data, for which the original series range of values was kept as min and max values (for example, [0, 1] for UNPAN indices; [1, 7] for the World Economic Forum Executive Opinion Survey questions; [0, 100] for World Bank’s World Governance Indicators; etc.). The following formula was applied:

$$\text{Goods}: \frac{\text{economy value} - Min}{Max - Min} \times 100$$

$$\text{Bads}: \frac{Max - \text{economy value}}{Max - Min} \times 100$$

Notes:

1 Paruolo, P. et al. (2013) show that a theoretical inconsistency exists between the real theoretical meaning of weights and the meaning generally attributed to them by the standard practice in constructing composite indicators that use them as importance coefficients in combination with linear aggregation rules. The approach followed in the GII this year, as last year, is to assign weights of 0.5 or 1.0 to each component in a composite to ensure the highest correlations between them (i.e., indicator/sub-pillar, sub-pillar/pillar, etc.). Two sub-pillars (7.2 Creative goods and services, and 7.3 Online creativity) and 35 indicators (1.1.1, 1.2.1, 1.2.2, 2.1.4, 2.1.5, 2.2.1, 2.2.3, 3.2.1, 3.2.2, 3.3.3, 4.2.2, 4.2.3, 4.3.1, 4.3.2, 5.1.3, 5.1.4, 5.1.5, 5.2.1, 5.2.4, 5.3.1, 6.1.1, 6.1.2, 6.1.4, 6.2.2, 6.2.3, 6.2.4, 6.2.5, 6.3.1, 6.3.2, 6.3.3, 7.1.2, 7.2.1, 7.2.2, and 7.2.3) are weighted 0.5; the rest have a weight of 1. This year the weights for three indicators were adjusted to provide higher statistical coherence (5.2.5 Patent families 2+ offices and 6.1.5 Citable documents H-index now have a weight of 1 and 6.3.4FDI net outflows a weight of 0.5).

2 To account for differences in development, other composite indicators use weighting schemes differentiated by income level.

3 These indicators are expenditure on education (2.1.1); gross expenditure on R&D (GERD) (2.3.2); gross capital formation (3.2.3); domestic credit to private sector (4.1.2); microfinance institutions' gross loan portfolio (4.1.3); market capitalization (4.2.2); GERD performed by business enterprise (5.1.3); foreign direct investment net inflows (5.3.4); total computer software spending (6.2.3); and foreign direct investment net outflows (6.3.4).

4 These count variables are mainly indicators that increase disproportionately with economic growth. They include: ISO 14001 environmental certificates (3.3.3); venture capital deals; (4.2.3) joint venture/strategic alliance deals; (5.2.4) patent families filed in two or more offices (5.2.5); patent applications by origin (6.1.1); PCT international applications by origin (6.1.2); utility model applications by origin (6.1.3); scientific and technical publications (6.1.4); ISO 9001 quality certificates (6.2.4); trademark application class count by origin (7.1.1); industrial designs by origin (7.1.2); and mobile app creation (7.3.4)

5 These variables are electricity output (3.2.1); females employed with advanced degrees (5.1.5); new business density (6.2.2); national feature films produced (7.2.2); entertainment and media market (7.2.3); generic (7.3.1) and country-code (7.3.2) top-level Internet domains; and Wikipedia yearly edits (7.3.3).

6 Intellectual property payments (5.3.1); high-tech net imports (5.3.2); ICT services imports (5.3.3); intellectual property receipts (6.3.1); high-tech net exports (6.3.2); ICT services exports (6.3.3); cultural and creative services exports (7.2.1); and creative goods exports (7.2.5) were scaled by total trade; high-tech and medium-high-tech output (6.2.5) and printing and other media (7.2.4) were scaled by total manufactures output.

7 For example, GII sub-pillar 3.1 Information and communication technologies (ICTs) is composed of four indices: ICT Access and Use sub-indices, and UNPAN's Government Online Service and E-Participation indices. The first two, previously part of ITU's ICT Development Index, are now produced by the GII independently from other components from that original index, following the methodology of the ITU's ICT Development Index 2017. Similarly, the Online Service Index is a component of UNPAN's E-Government Development Index together with two indices on Telecommunication Infrastructure and Human Capital that were not considered, as they duplicate GII pillars 3 and 2, respectively. The e-Participation Index was developed separately by UNPAN in 2010.

8 A total of 37 economies in 14 indicators show data that is previous to 2009. These are Saudi Arabia (2008), Egypt (2008), Algeria (2008), Zambia (2008), Yemen (2008) in Expenditure on education (2.1.1); Botswana (2008) and Cambodia (2008) in School life expectancy (2.1.3); Argentina (2008) in Pupil-teacher ratio (2.1.5); Philippines (2008) in Tertiary inbound mobility (2.2.3); Albania (2008) and Zambia (2008) in Researchers (2.3.1) and Gross expenditure on R&D (2.3.2); Iran (Islamic Republic of) (2008), Zambia (2008) in GERD performed by business (5.1.3); Australia (2008), Iran (Islamic Republic of) (2008), Albania (2008), Zambia (2008) in GERD financed by business (5.1.4); Australia (2008), Albania (2008), Zambia (2008), Burundi (2008) in GERD financed by abroad (5.2.3); Iran (Islamic Republic of) (2008), Panama (2008), Ecuador (2008), Zambia (2008) in Research talent (5.3.5); Kenya (2008) in New businesses (6.2.2); Cameroon (2008) in High- & medium-high-tech manufactures (6.2.5); El Salvador (2008) in National feature films (7.2.2); and Argentina (2002), Lebanon (2007), Trinidad and Tobago (2006), Pakistan (2006), Ghana (2003), Cameroon (2008), and Madagascar (2006) in Printing & other media (7.2.4).

9 Based on Groeneveld and Meeden (1984), which sets the criteria of absolute skewness above 1 and kurtosis above 3.5. The skewness criterion was relaxed to account for the small sample at hand (129 economies).

10 This distributional issue affects the following variables: 3.2.1, 4.2.3, 5.3.2, 5.3.3, 6.1.5, and 7.2.4 (1 outlier); 4.2.2, 5.2.4, 5.3.1, 6.1.3, 7.1.2, 7.2.1, 7.2.2, 7.3.2, and 7.3.4 (2 outliers); 2.2.3, 6.1.1, and 6.3.3 (3 outliers); 4.1.3 and 5.2.5 (4 outliers); and 6.1.2, 6.3.1, and 7.2.5 (5 outliers). The treatment criterion was relaxed this year to allow two series (6.3.2 and 6.3.4) with 6 outliers. For two particular economies—Malta and Iceland— values were removed for indicator 6.3.4. The reason for this was twofold: first, the data did not seem to capture the noted historic trend for these economies for this variable; second, the data produced a distortion in skewness and kurtosis for the indicator that neither winsorization nor any transformation could adequately correct.

11 This distributional issue affects variables 2.3.3 and 4.3.3 (factor f of 1).

12 These formulas achieve two things: converting all series into "goods" and scaling the series to the range [1, max] so that natural logs are positive starting at 0. Where "min" and "max" are the minimum and maximum indicator sample values.

The corresponding formula for bads is:

$$\ln \left[\frac{(Max \times f - 1)(Max - economy\ value)}{Max - Min} + 1 \right.$$

13 This distributional issue affected variable 5.3.4 Foreign direct investment net inflows.

14 For negative values in that series the formula used was:

$$y_i^{(\lambda)} = -\left[(-y_i + 1)^{(2-\lambda)} - 1 \right] / (2 - \lambda)$$

where $0 \leq \lambda \leq 2$; $\lambda \neq 2$; $y < 0$; λ; and y_i = economy value

References:

Groeneveld, R. A., & Meeden, G. (1984). Measuring Skewness and Kurtosis. *The Statistician, 33*, 391–99.

Paruolo P., Saisana, M., & Saltelli, A. (2013). Ratings and Rankings: Voodoo or Science?. *Journal of the Royal Statistical Society, A 176*(2), doi: 0964–1998/13/176000.

JOINT RESEARCH CENTRE (JRC) STATISTICAL AUDIT OF THE 2019 GLOBAL INNOVATION INDEX

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Conceptual and practical challenges are inevitable when trying to understand and model the fundamentals of innovation at the national level worldwide. In its 12th edition, the Global Innovation Index (GII) 2019 considers these conceptual challenges in Chapter 1 and deals with practical challenges—related to data quality and methodological choices—by grouping economy-level data over 129 economies; and across 80 indicators into 21 sub-pillars, 7 pillars, 2 sub-indices and, finally, an overall index. This appendix offers detailed insights into the practical issues related to the construction of the GII, analysing the statistical soundness of the calculations and assumptions made to arrive at the final index rankings. Statistical soundness should be regarded as a necessary but not sufficient condition for a sound GII; since the correlations underpinning the majority of the statistical analyses carried out herein "need not necessarily represent the real influence of the individual indicators on the phenomenon being measured".[1] Consequently, the development of the GII must be nurtured by a dynamic iterative dialogue between the principles of statistical and conceptual soundness or, to put it another way, between the theoretical understanding of innovation and the empirical observations of the data underlying the variables.

The European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC) in Ispra has been invited for the ninth consecutive year to audit the GII. As in previous editions, the present JRC-COIN audit focuses on the statistical soundness of the multi-level structure of the index as well as on the impact of key modeling assumptions on the results.[2] The independent statistical assessment of the GII provided by the JRC-COIN guarantees the transparency and reliability of the index for both policy-makers and other stakeholders, thus facilitating more accurate priority setting and policy formulation in the innovation field.

As in past GII reports, the JRC-COIN analysis complements the economy rankings with confidence intervals for the GII, the Innovation Input Sub-Index, and the Innovation Output Sub-Index, in order to better appreciate the robustness of these ranks to the computation methodology. Finally, the JRC-COIN analysis includes an assessment of the added value of the GII and a measure of distance to the efficient frontier of innovation by using data envelopment analysis.

Conceptual and statistical coherence in the GII framework

An earlier version of the GII model was assessed by the JRC-COIN in April/May 2019. Fine-tuning suggestions were taken into account in the final computation of the rankings in an iterative process with the JRC-COIN aimed at setting the foundation for a balanced index. The entire process followed four steps (Figure A-V.1).

Step 1: conceptual consistency

Eighty indicators were selected for their relevance to a specific innovation pillar based on literature review, expert opinion, economy coverage, and timeliness. To represent a fair picture of economy differences, indicators were scaled either at source or by the GII team, as appropriate, and where needed. For example, Expenditure on education (indicator 2.1.1) is expressed as a percentage of GDP, while Government funding per pupil at secondary level (indicator 2.1.2), is expressed as a percentage of GDP per capita.

Step 2: data checks

The data, which were most recently released within the period 2008 to 2018, were used for each economy: 78% of the available data refer to 2017 or more recent years. The exception are data values for six economies: Argentina, Lebanon, Trinidad and Tobago, Pakistan, Ghana, and Madagascar, on Printing & other media, % manufacturing (indicator 7.2.4) that refer to the period 2002 to 2007. The JRC-COIN recommendation was to offer an explanation behind the choice to use data that may not reflect recent advances in the relevant field in these economies (Appendix III). In past editions, until 2015, economies were included if data availability was at least 60% across all variables in the GII framework. More stringent criterion were adopted in 2016, following the JRC-COIN recommendation in past GII audits, where economies were only included if data availability was at least 66% within each of the two sub-indices (i.e., 35 out of 53 variables within the Input Sub-Index and 18 out of the 27 variables in the Output Sub-Index) and where at least two of the three sub-pillars in each pillar could be computed. These

FIGURE A-V.1

Conceptual and statistical coherence in the GII 2019 framework

STEP 4.
QUALITATIVE REVIEW

Internal qualitative review (INSEAD, WIPO, and Cornell University)

External qualitative review (JRC-COIN, international experts)

STEP 3.
STATISTICAL COHERENCE

Treatment of pairs of highly collinear variables as a single indicator

Assessment of grouping indicators into sub-pillars, pillars, sub-indices, and the GII

Use of weights as scaling coefficients to ensure statistical coherence

Assessment of arithmetic average assumption

Assessment of potential redundancy of information in the overall GII

STEP 2.
DATA CHECKS

Check for data recency (78% of available data refer to 2017 and 2018)

Availability requirements per economy: coverage ≥66% for the Input and the Output Sub-Indices, separately and data availability for at least two sub-pillars per pillar

Check for reporting errors (interquartile range)

Outlier identification (skewness and kurtosis) and treatment (winsorisation or logarithmic transformation)

Direct contact with data providers

STEP 1.
CONCEPTUAL CONSISTENCY

Compatibility with existing literature on innovation and pillar definition

Use of scaling factors (denominators) per indicator to represent a fair picture of country differences (e.g., GDP, population)

Source: European Commission, Joint Research Centre, 2019.

criterion aim to ensure that economy scores for the GII and for the two Input and Output Sub-Indices are not particularly sensitive to missing values (as was the case for the Output Sub-Index scores of several economies in past editions).
In practice, data availability for all economies included in the GII 2019 is good: 80% of data is available for 87% of the economies (equivalent to 112 economies out of 129). Potentially problematic indicators that could bias the overall results were identified on the basis of two measures related to the shape of the distributions: skewness and kurtosis. Since 2011, and decided jointly with the JRC-COIN, values were treated if the indicators had absolute skewness greater than 2.0 and kurtosis greater than 3.5.
In 2017, and after having analyzed data in the GII 2011 to the GII 2017, a less stringent criterion were adopted. An indicator was only treated if the absolute skewness was greater than 2.25 and kurtosis greater than 3.5.[3] These indicators were treated either by winsorization or by natural logarithm (in cases of more than five outliers; Appendix IV: Technical Notes). In 2018, an exceptional behaviour for FDI net outflows (indicator 6.3.4) was observed (Chapter 1, Annex 3, JRC Audit, 2018) and from 2018 on, it was recommended to adjust the GII rule for the treatment of outliers as follows:

(a) for indicators with absolute skewness greater than 2.25 and kurtosis greater than 3.5, apply either winsorization or the natural logarithm (in case of more than five outliers);
(b) for indicators with absolute skewness of less than 2.25 and kurtosis greater than 10.0, produce scatterplots to identify potentially problematic values that need to be considered as outliers and treated accordingly.

Step 3: statistical coherence

Weights as scaling coefficients

Jointly decided between the JRC-COIN and the GII team in 2012, weights of 0.5 or 1.0 were to be scaling coefficients and not importance coefficients, with the aim of arriving at sub-pillar and pillar scores that were balanced in their underlying components (i.e., that indicators and sub-pillars can explain a similar amount of variance in their respective sub-pillars/pillars). Becker, W. et al. (2017) and Paruolo, P. et al. (2013) show that, in weighted arithmetic averages, the ratio of two nominal weights gives the rate of substitutability between two indicators, and hence can be used to reveal the relative importance of individual indicators. This importance can then be compared with ex-post measures of variables' importance, such as the non-linear Pearson correlation ratio. As a result of this analysis, 35 out of 80 indicators and two sub-pillars—7.2 Creative goods and services and 7.3 Creation of online content—were assigned half weights, while all other indicators and sub-pillars were assigned a weight of 1.0. In past GII editions, despite this weighting adjustment, a small number of indicators (seven in the GII 2017 edition) were found to be non-influential in the GII framework, implying that they could not explain at least 9% of economy variation in the respective sub-pillar scores.[4] This year, as it was the case also in 2018, all 80 indicators are found to be sufficiently influential in the GII framework, which is worthy highlighting as a very positive feature of this year's GII framework.

Principal components analysis and reliability item analysis

Principal component analysis (PCA) was used to assess to what extent the conceptual framework is confirmed by statistical approaches. PCA results confirm the presence of a single latent dimension in each of the seven pillars (one component with an eigenvalue greater than 1.0) that captures between close to 55% (pillar 4: Market sophistication) up to 83% (pillar 1: Institutions) of the total variance in the three underlying sub-pillars. Furthermore, results confirm the expectation that the sub-pillars are more correlated to their own pillar than to any other pillar and that all correlation coefficients are close to or greater than 0.70. (Table A-V.1).

The five input pillars share a single statistical dimension that summarizes 82% of the total variance, and the five loadings (correlation coefficients) of these pillars are very similar to each other (0.84–0.93). This similarity suggests that the five pillars make roughly equal contributions to the variation of the Innovation Input Sub-Index scores, as envisaged by the developing team. The reliability of the Input Sub-Index, measured by the Cronbach alpha value, is very high at 0.94—well above the 0.70 threshold for a reliable aggregate.[5]

The two output pillars—Knowledge and technology outputs and Creative outputs—are strongly correlated to each other (0.80); they are also both strongly correlated with the Innovation Output Sub-index (0.94 to 0.96).

Finally, an important part of the analysis relates to clarifying the importance of the Input and Output Sub-Indices with respect to variation in the GII scores. The GII is built as a simple arithmetic average of the five input sub-pillars and the two output sub-pillars, which implies that the input-related pillars have a weight of 5/7 versus a weight of 2/7 for the output-related pillars. Yet this does not imply that the Input aspect is more important than the output aspect in determining the variation of the GII scores. In fact, the Pearson correlation coefficient of either the Input or the Output Sub-Index with the overall GII is 0.97 (and the two sub-indices have a correlation of 0.89), which suggests that the sub-indices are effectively placed on equal footing.

Overall, the tests so far show that the grouping of variables into sub-pillars, pillars, and an overall index is statistically coherent in the GII 2019 framework, and that the GII has a balanced structure at each aggregation level. Furthermore, this year, all 80 indicators are found to be sufficiently influential in the GII framework, namely each indicator explains at least 9% of countries variation in the respective sub-pillar scores, which is worthy highlighting as a very positive feature of this year's GII framework.[6]

Added value of the GII

As already discussed, the Input and Output Sub-Indices correlate strongly with each other and with the overall GII. Furthermore, the five pillars in the Input Sub-Index have a very high statistical

TABLE A-V.1

Statistical coherence in the GII: correlations between sub-pillars and pillars

	Sub-pillar	Institutions	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Knowledge & technology outputs	Creative outputs
Innovation Input Sub-index	1.1. Political environment	0.95	0.81	0.88	0.73	0.82	0.73	0.82
	1.2. Regulatory environment	0.92	0.70	0.72	0.63	0.74	0.64	0.74
	1.3. Business environment	0.86	0.69	0.70	0.63	0.68	0.65	0.61
	2.1. Education	0.60	0.81	0.61	0.50	0.57	0.55	0.55
	2.2. Tertiary education	0.62	0.81	0.69	0.52	0.50	0.52	0.56
	2.3. Research and development (R&D)	0.77	0.88	0.76	0.69	0.88	0.86	0.74
	3.1. Information and communication technologies (ICTs)	0.81	0.84	0.94	0.71	0.74	0.71	0.78
	3.2. General infrastructure	0.56	0.54	0.70	0.48	0.50	0.50	0.48
	3.3. Ecological sustainability	0.64	0.56	0.75	0.44	0.61	0.56	0.69
	4.1. Credit	0.70	0.62	0.61	0.88	0.62	0.55	0.62
	4.2. Investment	0.35	0.26	0.21	0.63	0.28	0.23	0.21
	4.3. Trade, competition, and market scale	0.53	0.68	0.71	0.68	0.61	0.66	0.59
	5.1. Knowledge workers	0.79	0.83	0.79	0.69	0.89	0.78	0.75
	5.2. Innovation linkages	0.63	0.57	0.53	0.52	0.81	0.67	0.66
	5.3. Knowledge absorption	0.65	0.64	0.62	0.49	0.85	0.80	0.65
Innovation Output Sub-index	6.1. Knowledge creation	0.71	0.81	0.69	0.65	0.84	0.90	0.79
	6.2. Knowledge impact	0.54	0.60	0.59	0.47	0.57	0.80	0.60
	6.3. Knowledge diffusion	0.65	0.65	0.64	0.54	0.82	0.88	0.66
	7.1. Intangible assets	0.62	0.61	0.68	0.53	0.63	0.66	0.88
	7.2. Creative goods and services	0.67	0.61	0.69	0.59	0.65	0.64	0.82
	7.3. Online creativity	0.80	0.72	0.73	0.59	0.82	0.76	0.84

Source: European Commission Joint Research Centre, 2019.

TABLE A-V.2

Statistical coherence in the GII: correlations between sub-pillars and pillars

	Innovation Input Sub-Index					Innovation Output Sub-Index	
Rank differences (positions)	Institutions %	Human capital and research %	Infrastructure %	Market sophistication %	Business sophistication %	Knowledge & technology outputs %	Creative outputs %
More than 30	12.4%	10.1%	10.1%	24.0%	11.6%	10.1%	7.0%
20-29	13.2%	13.2%	10.1%	17.8%	14.0%	12.4%	10.1%
10-19	28.7%	30.2%	24.0%	30.2%	20.2%	25.6%	21.7%
10 or more*	54.3%	53.5%	44.2%	72.1%	45.7%	48.1%	38.8%
5-9	22.5%	24.0%	29.5%	7.0%	19.4%	25.6%	27.1%
Less than 5	20.9%	22.5%	25.6%	17.1%	31.0%	22.5%	30.2%
Same rank	2.3%	0.0%	0.8%	3.9%	3.9%	3.9%	3.9%
Total**	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson correlation coefficient with the GII	0.90	0.90	0.89	0.78	0.92	0.93	0.92

Source: European Commission Joint Research Centre, 2019.
Notes: *This column is the sum of the prior three rows. **This column is the sum of all white rows.

reliability. These results—the strong correlation between Input and Output Sub-Indices and the high statistical reliability of the five input pillars—may be interpreted by some as a sign of redundancy of information in the GII. The tests conducted by the JRC-COIN confirm that this is not the case. In fact, for more than 44% (up to 72%) of the 129 economies included in the GII 2019, the GII ranking and any of the seven pillar rankings differ by 10 positions or more (Table A-V.2). This is a desired outcome because it demonstrates the added value of the GII ranking, which helps to highlight other aspects of innovation that do not emerge directly by looking into the seven pillars separately. At the same time, this result points to the value of duly taking into account the GII pillars, sub-pillars, and individual indicators on their own merit. By doing so, economy-specific strengths and bottlenecks on innovation can be identified and serve as an input for evidence-based policymaking.

Step 4: qualitative review

Finally, the GII results—including overall economy classifications and relative performances in terms of the Innovation Input or Output Sub-Indices—were evaluated to verify that the overall results are, to a great extent, consistent with current evidence, existing research, and prevailing theory. Notwithstanding these statistical tests and the positive outcomes on the statistical coherence of the GII structure, the GII model is and has to remain open for future improvements as better data, more comprehensive surveys and assessments, and new relevant research studies become available.

The impact of modeling assumptions on the GII results

An important part of the GII statistical audit is to check the effect of varying assumptions inside plausible ranges. Modeling assumptions with a direct impact on the GII scores and rankings relate to:

- setting up an underlying structure for the index based on a battery of pillars,
- choosing the individual variables to be used as indicators,
- deciding whether (and how) or not to impute missing data,
- deciding whether (and how) or not to treat outliers,
- selecting the normalization approach to be applied,
- choosing the weights to be assigned, and
- deciding on the aggregation rule to be implemented.

The rationale for these choices is manifold. For instance, expert opinion coupled with statistical analysis is behind the selection of the individual indicators, common practice and ease of interpretation suggests the use of a min-max normalization approach in the [0–100] range, the treatment of outliers is driven by statistical analysis, and simplicity and parsimony criteria seem to advocate for not imputing missing data. The unavoidable uncertainty stemming from the above-mentioned modeling choices is accounted for in the robustness assessment carried out by the JRC-COIN. More precisely, the methodology applied herein allows for the joint and simultaneous analysis of the impact of such choices on the aggregate scores, resulting in error estimates and confidence intervals calculated for the GII 2019 individual economy rankings.

As suggested in the relevant literature on composite indicators,[7] the robustness assessment was based on Monte Carlo simulation and multi-modeling approaches, applied to "error-free" data where potential outliers and eventual errors and typos have already been corrected in a preliminary stage. In particular, the three key modeling issues considered in the assessment of the GII were the treatment of missing data, the pillar weights, and the aggregation formula used at the pillar level.

Monte Carlo simulation comprised 1,000 runs of different sets of weights for the seven pillars in the GII. The weights were assigned to the pillars based on uniform continuous distributions centered in the reference values. The ranges of simulated weights were defined by considering both the need for a wide enough interval to allow for meaningful robustness checks and the need to respect the underlying principle of the GII that the Input and the Output Sub-Indices should be placed on equal footings. As a result of these considerations, the limit values of uncertainty for the five input pillars are between 10% and 30%; the limit values for the two output pillars are between 40% and 60%. (Table A-V.3).

The GII developing team, for transparency and replicability, has always opted not to estimate missing data. The "no imputation" choice, which is common in similar contexts, might encourage economies not to report low data values. Yet this is not the case for the GII. After 12 editions of the GII, the index-developing team has not encountered any intentional no-reporting strategy. The consequence of the "no imputation" choice in an arithmetic average is that it is equivalent to replacing an indicator's missing value for a given economy with the respective sub-pillar score. Hence, the available data (indicators) in the incomplete pillar may dominate, sometimes biasing the ranks up or down. To test the impact of the "no imputation" choice, the JRC-COIN estimated missing data using the Expectation Maximization (EM) algorithm that was applied within each GII pillar.[8]

Regarding the aggregation formula, decision-theory practitioners challenge the use of simple arithmetic averages because of their fully compensatory nature, in which a comparative high advantage on a few indicators can compensate a comparative disadvantage on many indicators.[9] To assess the impact of this compensability issue, the JRC-COIN relaxed the strong perfect substitutability assumption inherent in the arithmetic average and considered instead the geometric average, which is a partially compensatory approach that rewards economies with balanced profiles and motivates economies to improve in the GII pillars in which they perform poorly, and not just in *any* GII pillar.[10]

Four models were tested based on the combination of no imputation versus EM imputation, and arithmetic versus geometric average, combined with 1,000 simulations per model (random weights versus fixed weights), for a total of 4,000 simulations for the GII and each of the two sub-indices (Table A-V.3 for a summary of the uncertainties considered).

Uncertainty analysis results

The main results of the robustness analysis are shown in Figure A-V.2 with median ranks and 90% confidence intervals computed across the 4,000 Monte Carlo simulations for the GII and the two sub-indices. The figure orders economies inn ascending order (best to worst) according to their reference rank (black line), the dot being the median rank over the simulations.

TABLE A-V.3

Uncertainty parameters: missing values, aggregation and weights

	Reference	Alternative
I. Uncertainty in the treatment of missing values	No estimation of missing data	Expectation Maximization (EM)
II. Uncertainty in the aggregation formula at pillar level	Arithmetic average	Geometric average
III. Uncertainty intervals for the GII pillar weights		

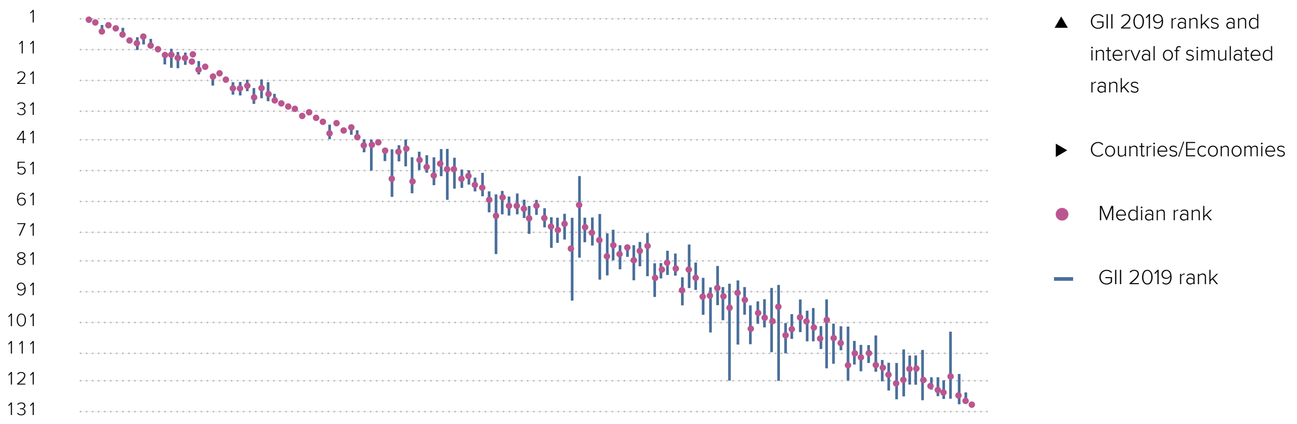
GII Sub-Index	Pillar	Reference value for the weight	Distribution assigned for robustness analysis
Innovation Input	Institutions	0.2	U[0.1,0.3]
	Human capital and research	0.2	U[0.1,0.3]
	Infrastructure	0.2	U[0.1,0.3]
	Market sophistication	0.2	U[0.1,0.3]
	Business sophistication	0.2	U[0.1,0.3]
Innovation Output	Knowledge and technology outputs	0.5	U[0.4,0.6]
	Creative outputs	0.5	U[0.4,0.6]

Source: European Commission Joint Research Centre, 2019.

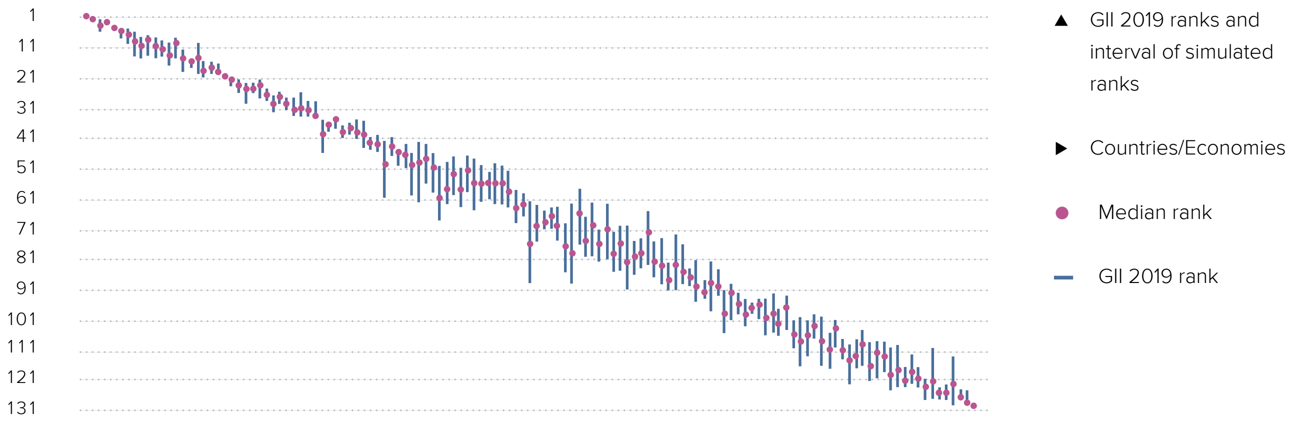
FIGURE A-V.2

Robustness analysis of the GII and Input and Output Sub-Indices

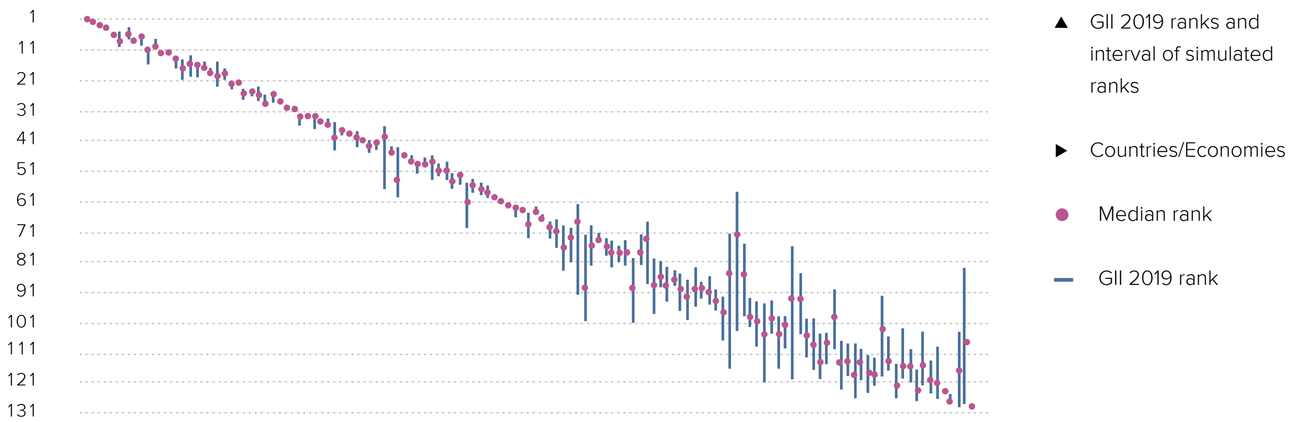
GII rank vs. median rank, 90% confidence intervals



Input rank vs. median rank, 90% confidence intervals



Output rank vs. median rank, 90% confidence



Source: European Commission Joint Research Centre, 2019.
Notes: Median ranks and intervals are calculated over 4,000 simulated scenarios combining simulated weights, imputation versus no imputation of missing values, and geometric versus arithmetic average at the pillar level. The Spearman rank correlation between the median rank and the GII 2019 rank is 0.997; between the median rank and Innovation Input 2019 rank it is 0.997; and between the median rank and the Innovation Output 2019 rank it is 0.992.

All published GII 2019 ranks lay within the simulated 90% confidence intervals, and for most economies these intervals are narrow enough for meaningful inferences to be drawn: there is a shift of fewer than 10 positions for 98 of the 129 economies. However, it is also true that ranks for a few economies vary significantly with changes in weights and aggregation formula and because of the estimation of missing data. Nine economies, Brunei Darussalam, Belarus, Panama, Rwanda, Paraguay, Tajikistan, Namibia, El Salvador, and Togo have 90% confidence interval widths of 20 positions (up to 32 positions in the case of Rwanda and Namibia). Consequently, their GII ranks—between the 71st (Brunei Darussalam) and 126th position (Togo) in the GII classification—should be interpreted cautiously and certainly not taken at face value. This is a remarkable improvement compared to GII versions until 2016, where more than 40 economies had confidence interval widths of more than 20 positions. The improvement in the confidence that one can attach to the GII 2019 ranks is the direct result of the developers' choice since 2016 to adopt a more stringent criterion for an economy's inclusion, which requires at least 66% data availability within each of the two sub-indices. Some caution is also warranted in the Input Sub-Index for 3 economies— Panama, Bosnia and Herzegovina, and Rwanda —that have 90% confidence interval widths over 20 (up to 27 for Rwanda). The Output Sub-Index is slightly more sensitive to the methodological choices: 13 economies, Mongolia, Belarus, Panama, Mauritius, Lebanon, Trinidad and Tobago, Paraguay, the United Republic of Tanzania, Namibia, El Salvador, Ethiopia, Togo, and the Niger, have 90% confidence interval widths over 20 (up to 46 for Belarus). This sensitivity is mostly the consequence of the estimation of missing data and the fact that there are only two pillars: this means that changes to the imputation method, weights, or aggregation formula have a more notable impact on economy ranks in the Innovation Output Sub-Index.

Although ranks for a few economies, in the GII 2019 overall or in the two sub-indices, appear to be sensitive to the methodological choices, the published rankings for the vast majority can be considered as representative of the plurality of scenarios simulated herein. Taking the median rank as the yardstick for an economy's expected rank in the realm of the GII's unavoidable methodological uncertainties, 75% of the economies are found to shift fewer than three positions with respect to the median rank in the GII, or in the Input and Output Sub-Index.

For full transparency and information, Table A-V.4 reports the GII 2019 Index and Input and Output Sub-Indices economy ranks together with the simulated 90% confidence intervals in order to better appreciate the robustness of the results to the choice of weights, of the aggregation formula and the impact of estimating missing data (where applicable).

Emphasizing the identification of and relation between input and output indicators seems irresistible from a policy perspective since doing so may possibly shed light on the effectiveness of innovation systems and policies. Yet, last year's statistical audit concluded that innovation efficiency ratios, calculated as ratios of indices, have to be approached with care. The reason was that the simulated 90% confidence intervals for most economies were too wide for meaningful inferences to be drawn: there was a shift of more than 20 positions for 50% of the economies. Hence, whilst propagating the uncertainty in the two GII sub-indices over to their sum the GII had a modest impact to the rankings, this same uncertainty propagation over to their ratio had a very high impact on the economy ranks. This is not a challenge specific to the GII framework per se but a statistical property that comes with ratios of composite indicators. In this present audit, the JRC-COIN complements the GII team for having opted to drop the Efficiency Ratio in this year's publication, drawing instead policy inference on the Input-Output performance in a similar way as per the plot of GII scores against the economies' level of economic development and commenting on those pairs/groups of economies that have similar Innovation Input level but very different Innovation Output level, and vice versa.

Sensitivity analysis results

Complementary to the uncertainty analysis, sensitivity analysis has been used to identify which of the modeling assumptions have the highest impact on certain country ranks. Table A-V.5 summarizes the impact of changes of the EM imputation method and/or the geometric aggregation formula, with fixed weights at their reference values (as in the original GII). Similar to last year's results, this year neither the GII nor the Input or Output Sub-Index are found to be heavily influenced by the imputation of missing data, or the aggregation formula. Depending on the combination of the choices made, only nine economies, Belarus, Paraguay, Namibia, El Salvador, Togo, the Niger, Brunei Darussalam, Rwanda, the United Republic of Tanzania, shift rank by 20 positions or more.

All in all, the published GII 2019 ranks are reliable and for most economies the simulated 90% confidence intervals are narrow enough for meaningful inferences to be drawn. Nevertheless, the readers of the GII 2019 report should consider economy ranks in the GII 2019 and in the Input and Output Sub-Indices not only at face value but also within the 90% confidence intervals in order to better appreciate to what degree an economy's rank depends on the modeling choices. These confidence intervals have to be taken into account also when comparing economy rank changes from one year to another at the GII or Innovation Sub-indices level in order to avoid drawing erroneous conclusions on economies' ascent or descent in the overall classifications. Since 2016, following the JRC-COIN recommendation in past GII audits, the developers' choice to apply the 66% indicator coverage threshold separately to the Input and Output Sub-Indices in the GII 2019 has led to a net increase in the reliability of economy ranks for the GII and the two sub-indices. Furthermore, the adoption in 2017 of less stringent criterion for the skewness and kurtosis (greater than 2.25 in absolute value and greater than 3.5, respectively) has not introduced any bias in the estimates.

TABLE A-V.4

GII 2019 and Input/Output Sub-Indices: ranks and 90% confidence intervals

	GII 2019		Input Sub-Index		Output Sub-Index	
	Rank	Interval	Rank	Interval	Rank	Interval
Switzerland	1	[1, 1]	2	[2, 3]	1	[1, 1]
Sweden	2	[2, 2]	4	[2, 4]	3	[3, 3]
United States of America	3	[3, 6]	3	[2, 6]	6	[5, 10]
Netherlands	4	[3, 5]	11	[8, 15]	2	[2, 2]
United Kingdom	5	[3, 5]	6	[6, 8]	4	[4, 5]
Finland	6	[4, 6]	7	[5, 10]	7	[4, 8]
Denmark	7	[7, 9]	5	[4, 6]	12	[11, 13]
Singapore	8	[7, 11]	1	[1, 2]	15	[14, 21]
Germany	9	[7, 9]	12	[9, 14]	9	[7, 9]
Israel	10	[8, 10]	17	[10, 20]	8	[7, 9]
Republic of Korea	11	[10, 12]	10	[7, 14]	13	[12, 13]
Ireland	12	[12, 16]	20	[17, 20]	10	[10, 16]
Hong Kong, China	13	[11, 17]	8	[6, 14]	16	[13, 20]
China	14	[12, 17]	26	[22, 28]	5	[5, 6]
Japan	15	[12, 16]	14	[8, 15]	17	[15, 20]
France	16	[14, 16]	16	[15, 18]	14	[14, 17]
Canada	17	[15, 19]	9	[8, 15]	22	[21, 24]
Luxembourg	18	[16, 18]	23	[22, 26]	11	[8, 11]
Norway	19	[19, 23]	13	[10, 17]	27	[26, 29]
Iceland	20	[18, 20]	22	[22, 24]	18	[15, 18]
Austria	21	[20, 21]	19	[16, 20]	25	[24, 26]
Australia	22	[22, 26]	15	[12, 19]	31	[30, 31]
Belgium	23	[22, 26]	21	[20, 21]	24	[24, 27]
Estonia	24	[21, 25]	27	[25, 29]	19	[17, 20]
New Zealand	25	[24, 29]	18	[16, 21]	32	[32, 36]
Czech Republic	26	[21, 27]	29	[26, 30]	21	[17, 21]
Malta	27	[22, 28]	32	[26, 34]	20	[15, 23]
Cyprus	28	[26, 29]	28	[27, 33]	23	[22, 23]
Spain	29	[28, 29]	25	[23, 26]	28	[25, 28]
Italy	30	[30, 30]	30	[28, 32]	29	[28, 29]
Slovenia	31	[31, 32]	33	[29, 34]	30	[30, 31]
Portugal	32	[32, 33]	31	[28, 34]	35	[34, 36]
Hungary	33	[31, 33]	39	[36, 40]	26	[23, 28]
Latvia	34	[34, 35]	36	[36, 39]	34	[32, 37]
Malaysia	35	[34, 36]	34	[29, 34]	39	[38, 40]
United Arab Emirates	36	[36, 41]	24	[23, 30]	58	[55, 59]
Slovakia	37	[36, 37]	42	[41, 45]	33	[32, 34]
Lithuania	38	[37, 39]	38	[37, 41]	40	[38, 43]
Poland	39	[37, 39]	37	[35, 38]	41	[40, 42]
Bulgaria	40	[38, 40]	45	[41, 47]	38	[37, 39]
Greece	41	[41, 45]	40	[35, 41]	54	[52, 57]
Viet Nam	42	[41, 51]	63	[58, 69]	37	[35, 44]
Thailand	43	[41, 43]	47	[43, 51]	43	[42, 44]
Croatia	44	[44, 48]	46	[45, 50]	52	[49, 53]
Montenegro	45	[44, 60]	55	[51, 64]	46	[43, 60]
Russian Federation	46	[43, 48]	41	[36, 44]	59	[56, 60]
Ukraine	47	[41, 50]	82	[65, 83]	36	[34, 37]
Georgia	48	[47, 59]	44	[42, 61]	60	[59, 60]
Turkey	49	[45, 51]	56	[47, 59]	49	[48, 52]
Romania	50	[46, 52]	54	[47, 60]	53	[48, 54]
Chile	51	[47, 56]	43	[40, 46]	62	[61, 63]
India	52	[44, 53]	61	[50, 63]	51	[46, 54]
Mongolia	53	[44, 61]	73	[67, 80]	44	[36, 57]
Philippines	54	[47, 57]	76	[63, 81]	42	[41, 45]
Costa Rica	55	[51, 57]	68	[64, 71]	48	[46, 49]
Mexico	56	[51, 56]	59	[52, 61]	55	[53, 55]
Serbia	57	[54, 58]	62	[52, 64]	57	[54, 58]
Republic of Moldova	58	[52, 60]	81	[74, 84]	45	[43, 46]
North Macedonia	59	[58, 65]	52	[50, 68]	63	[63, 66]
Kuwait	60	[59, 79]	75	[71, 82]	56	[55, 70]
Iran (Islamic Republic of)	61	[58, 66]	86	[73, 91]	47	[45, 47]
Uruguay	62	[60, 66]	66	[63, 75]	61	[61, 62]
South Africa	63	[59, 66]	51	[46, 59]	68	[68, 73]
Armenia	64	[61, 67]	85	[82, 91]	50	[47, 50]
Qatar	65	[63, 72]	53	[49, 63]	70	[69, 84]

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TABLE A-V.4

GII 2019 and Input/Output Sub-Indices: ranks and 90% confidence intervals, continued

	GII 2019		Input Sub-Index		Output Sub-Index	
	Rank	Interval	Rank	Interval	Rank	Interval
Brazil	66	[61, 66]	60	[49, 63]	67	[66, 68]
Colombia	67	[64, 70]	58	[50, 62]	76	[73, 79]
Saudi Arabia	68	[67, 77]	49	[42, 62]	85	[83, 94]
Peru	69	[67, 75]	48	[46, 60]	86	[84, 89]
Tunisia	70	[66, 74]	74	[62, 80]	65	[65, 73]
Brunei Darussalam	71	[67, 94]	35	[35, 46]	120	[110, 121]
Belarus	72	[53, 80]	50	[43, 56]	95	[58, 104]
Argentina	73	[67, 75]	72	[58, 76]	75	[72, 75]
Morocco	74	[67, 76]	83	[75, 87]	66	[63, 66]
Panama	75	[66, 87]	79	[70, 91]	72	[62, 92]
Bosnia and Herzegovina	76	[72, 86]	71	[63, 89]	79	[74, 82]
Kenya	77	[71, 81]	89	[81, 95]	64	[64, 65]
Bahrain	78	[76, 84]	69	[64, 75]	87	[85, 97]
Kazakhstan	79	[76, 80]	64	[59, 67]	92	[90, 97]
Oman	80	[76, 88]	57	[48, 65]	101	[99, 116]
Jamaica	81	[75, 83]	84	[74, 89]	69	[67, 76]
Mauritius	82	[72, 86]	67	[65, 71]	96	[75, 99]
Albania	83	[82, 93]	70	[69, 85]	93	[92, 107]
Azerbaijan	84	[82, 87]	77	[72, 85]	90	[88, 93]
Indonesia	85	[78, 86]	87	[76, 89]	78	[76, 81]
Jordan	86	[79, 86]	91	[82, 98]	71	[70, 81]
Dominican Republic	87	[87, 96]	90	[88, 94]	88	[87, 100]
Lebanon	88	[76, 90]	92	[84, 93]	82	[68, 89]
Sri Lanka	89	[82, 91]	94	[89, 101]	77	[74, 83]
Kyrgyzstan	90	[87, 99]	78	[70, 85]	111	[108, 119]
Trinidad and Tobago	91	[90, 105]	88	[84, 90]	99	[95, 121]
Egypt	92	[83, 96]	106	[99, 107]	74	[69, 82]
Botswana	93	[90, 101]	80	[75, 86]	117	[106, 117]
Rwanda	94	[89, 121]	65	[62, 89]	123	[114, 124]
Paraguay	95	[88, 109]	95	[92, 99]	94	[72, 116]
Senegal	96	[90, 99]	103	[101, 110]	81	[72, 82]
United Republic of Tanzania	97	[96, 109]	115	[108, 120]	73	[72, 101]
Cambodia	98	[95, 102]	104	[100, 116]	84	[81, 89]
Ecuador	99	[94, 103]	98	[94, 101]	98	[94, 109]
Tajikistan	100	[90, 112]	107	[100, 116]	83	[80, 98]
Namibia	101	[89, 121]	99	[94, 106]	103	[76, 120]
Uganda	102	[102, 112]	96	[94, 103]	107	[105, 120]
Côte d'Ivoire	103	[99, 107]	110	[107, 114]	91	[86, 95]
Honduras	104	[94, 105]	101	[97, 106]	104	[85, 104]
Pakistan	105	[98, 108]	113	[104, 116]	89	[83, 96]
Ghana	106	[97, 108]	109	[101, 110]	97	[93, 103]
Guatemala	107	[103, 110]	105	[101, 113]	102	[99, 110]
El Salvador	108	[94, 117]	97	[95, 99]	116	[92, 119]
Nepal	109	[102, 115]	93	[91, 105]	119	[103, 120]
Bolivia (Plurinational State of)	110	[103, 111]	102	[93, 104]	113	[110, 120]
Ethiopia	111	[103, 121]	124	[123, 127]	80	[80, 101]
Mali	112	[108, 116]	120	[112, 122]	100	[94, 105]
Algeria	113	[109, 118]	100	[92, 105]	118	[115, 126]
Nigeria	114	[109, 115]	116	[108, 118]	105	[100, 112]
Cameroon	115	[106, 118]	112	[107, 117]	106	[100, 117]
Bangladesh	116	[114, 121]	117	[110, 124]	108	[105, 115]
Burkina Faso	117	[115, 124]	111	[109, 122]	115	[113, 122]
Malawi	118	[115, 127]	119	[116, 123]	112	[108, 126]
Mozambique	119	[111, 126]	118	[109, 123]	114	[112, 124]
Nicaragua	120	[113, 122]	108	[105, 117]	122	[104, 122]
Madagascar	121	[113, 122]	122	[120, 127]	109	[90, 109]
Zimbabwe	122	[111, 127]	123	[110, 127]	110	[107, 123]
Benin	123	[120, 124]	114	[108, 121]	125	[123, 125]
Zambia	124	[120, 126]	126	[113, 129]	121	[117, 127]
Guinea	125	[121, 127]	127	[124, 127]	124	[109, 126]
Togo	126	[105, 127]	121	[116, 123]	128	[83, 128]
Niger	127	[119, 129]	125	[122, 127]	127	[104, 129]
Burundi	128	[125, 128]	128	[124, 129]	126	[125, 128]
Yemen	129	[128, 129]	129	[128, 129]	129	[128, 129]

Source: European Commission Joint Research Centre, 2019.
Notes: Confidence intervals are calculated over 4,000 simulated scenarios combining simulated weights, imputation versus no imputation of missing values, and geometric versus arithmetic average at the pillar level.

TABLE A-V.5

Sensitivity analysis: impact of modeling choices on countries with most sensitive ranks

Index or Sub-Index	Uncertainty tested (pillar level only)	Spearman rank correlation between the two series	Number of economies that improve: by more than 20 positions	Number of economies that improve: between 10 and 20 positions	Number of economies that deteriorate: by more than 20 positions	Number of economies that deteriorate: between 10 and 20 positions
GII	Geometric vs. arithmetic average	0.991	0	1	2[3]	2
	EM imputation vs. no imputation of missing data	0.992	0	4	0	5
	Geometric average and EM imputation vs. arithmetic average and missing values	0.989	0	5	0	7
Input Sub-Index	Geometric vs. arithmetic average	0.996	0	1	0	2
	EM imputation vs. no imputation of missing data	0.993	0	2	0	3
	Geometric average and EM imputation vs. arithmetic average and missing values	0.990	0	3	1[4]	6
Output Sub-Index	Geometric vs. arithmetic average	0.996	0	0	1[5]	3
	EM imputation vs. no imputation of missing data	0.969	5[1]	8	1[6]	11
	Geometric average and EM imputation vs. arithmetic average and missing values	0.969	4[2]	9	1[7]	15

Source: European Commission Joint Research Centre, 2019.
Notes:
1 Belarus, Paraguay, Namibia, El Salvador, Togo
2 Belarus, El Salvador, Togo, the Niger
3 Brunei Darussalam, Rwanda
4 Rwanda
5 Paraguay
6 United Republic of Tanzania
7 United Republic of Tanzania

Efficiency frontier in the GII by Data Envelopment Analysis

Is there a way to benchmark economies' multi-dimensional performance on innovation without imposing a fixed and common set of weights that may not be fair to a particular economy?

Several innovation-related policy issues at the national level entail an intricate balance between global priorities and economy-specific strategies. Comparing the multi-dimensional performance on innovation by subjecting economies to a fixed and common set of weights may prevent acceptance of an innovation index on grounds that a given weighting scheme might not be fair to a particular economy. An appealing feature of the Data Envelopment Analysis (DEA) literature applied in real decision-making settings is to determine endogenous weights that maximize the overall score of each decision-making unit given a set of other observations.

In this segment, the assumption of fixed pillar weights common to all economies is relaxed once more; this time economy-specific weights that maximize an economies' global innovation score are determined endogenously by DEA.[11] In theory, each economy is free to decide on the relative contribution of each innovation pillar to its score, so as to achieve the best possible score in a computation that reflects its innovation strategy. In practice, the DEA method assigns a higher (lower) contribution to those pillars in which an economy is relatively strong (weak). Reasonable constraints on the weights are applied to preclude the possibility of an economy achieving a perfect score by assigning a zero weight to weak pillars: for each economy, the share of each pillar score (i.e., the pillar score multiplied by the DEA weight over the total score) has upper and lower bounds of 5% and 20% respectively. The DEA score is then measured as the weighted average of all seven innovation pillar scores, where the weights are the economy-specific DEA weights, compared to the best performance among all other economies with those same weights. The DEA score can be interpreted as a measure of the "distance to the efficient frontier".

Table A-V.6 presents the pie shares and DEA scores for the top 25 economies in the GII 2019, next to the GII 2019 ranks. All pie shares are in accordance with the starting point of granting leeway to each economy when assigning shares, while not violating the (relative) upper and lower bounds. The pie shares are quite diverse, reflecting the different national innovation strategies. These pie shares can also be seen to reflect economies' comparative advantage in certain GII pillars vis-à-vis

TABLE A-V.6

Pie shares (absolute terms) and efficiency scores for the top 25 economies in the GII 2019

	Input pillars					Output pillars					
	Institutions	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative outputs	Efficient frontier score (DEA)	Efficient frontier rank DEA)	GII rank	Difference from GII rank
Switzerland	0.07	0.17	0.12	0.06	0.19	0.19	0.19	1.00	1	1	0
Sweden	0.20	0.20	0.20	0.05	0.20	0.05	0.10	0.99	2	2	0
United States of America	0.20	0.20	0.10	0.20	0.20	0.05	0.05	0.97	3	3	0
Netherlands	0.20	0.05	0.20	0.05	0.20	0.10	0.20	0.93	8	4	-4
United Kingdom	0.20	0.20	0.20	0.20	0.05	0.05	0.10	0.96	5	5	0
Finland	0.20	0.20	0.20	0.05	0.20	0.05	0.10	0.95	6	6	0
Denmark	0.20	0.20	0.20	0.20	0.10	0.05	0.05	0.95	6	7	1
Singapore	0.20	0.20	0.20	0.20	0.10	0.05	0.05	0.97	3	8	5
Germany	0.20	0.20	0.20	0.10	0.05	0.05	0.20	0.91	10	9	-1
Israel	0.20	0.20	0.10	0.20	0.20	0.05	0.05	0.89	12	10	-2
Republic of Korea	0.20	0.20	0.20	0.20	0.10	0.05	0.05	0.91	10	11	1
Ireland	0.20	0.05	0.20	0.10	0.20	0.20	0.05	0.86	17	12	-5
Hong Kong, China	0.20	0.05	0.20	0.20	0.10	0.05	0.20	0.92	9	13	4
China	0.05	0.05	0.20	0.20	0.20	0.10	0.20	0.83	22	14	-8
Japan	0.20	0.10	0.20	0.20	0.20	0.05	0.05	0.89	12	15	3
France	0.20	0.20	0.20	0.20	0.05	0.05	0.10	0.88	15	16	1
Canada	0.20	0.20	0.20	0.20	0.10	0.05	0.05	0.89	12	17	5
Luxembourg	0.20	0.05	0.20	0.10	0.20	0.05	0.20	0.85	19	18	-1
Norway	0.20	0.20	0.20	0.20	0.05	0.05	0.10	0.87	16	19	3
Iceland	0.20	0.10	0.20	0.20	0.05	0.05	0.20	0.83	22	20	-2
Austria	0.20	0.20	0.20	0.10	0.20	0.05	0.05	0.85	19	21	2
Australia	0.20	0.20	0.20	0.20	0.05	0.05	0.10	0.86	17	22	5
Belgium	0.20	0.20	0.20	0.20	0.10	0.05	0.05	0.82	24	23	-1
Estonia	0.20	0.10	0.20	0.20	0.05	0.05	0.20	0.80	25	24	-1
New Zealand	0.20	0.20	0.20	0.20	0.05	0.05	0.10	0.84	21	25	4

Source: European Commission, Joint Research Centre, 2019.
Notes: Pie shares are in absolute terms, bounded by 0.05 and 0.20 for all seven innovation pillars. In the GII 2019, however, the five input pillars each have a fixed weight of 0.10; the two output pillars each have a fixed weight of 0.25. Darker colors represent higher contribution of those pillars to the overall DEA score as a result of a country's stronger performance in those pillars, which may help to evidence economy-specific strategies.

all other economies and all pillars. For example, Switzerland is the only economy this year that obtains a perfect DEA score of 1.00, followed closely by Sweden (DEA score of 0.99). In the case of Switzerland this is achieved by assigning 17 to 19% of its DEA score to a mix of input and output pillars, namely Human capital and research, Business sophistication, Knowledge and technology outputs, and Creative outputs. Instead, merely 6% to 12% of Switzerland's DEA score comes from three input pillars, namely Institutions, Infrastructure, and Market sophistication. Using a different mix, Sweden would assign 20% of its DEA score to four input pillars—Institutions, Human capital and research, Infrastructure, and Business sophistication—while merely 5 to 10% of its DEA score comes from the two output pillars capturing Knowledge and technology outputs, and Creative Outputs, and from the input pillar measuring Market sophistication. Switzerland and Sweden are closely followed by the United States of America, Singapore, United Kingdom, Finland, and Denmark, who score between 0.95 (Denmark) and 0.97 (the United States of America and Singapore) in terms of efficiency. Figure A-V.3 shows how close the DEA scores and the GII 2019 scores are for all 129 economies (Pearson correlation of 0.993).

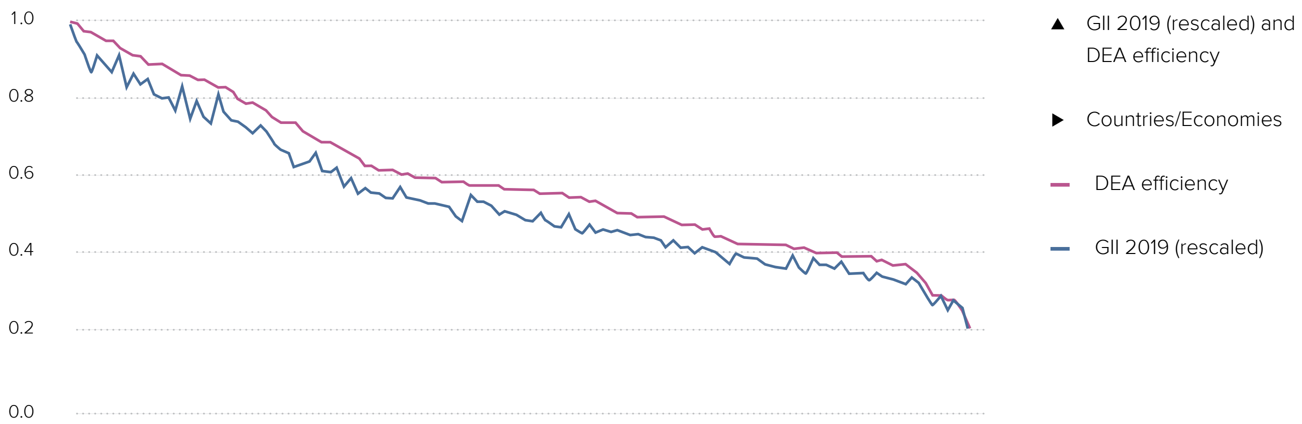
Conclusion

The JRC-COIN analysis suggests that the conceptualized multi-level structure of the GII 2019—with its 80 indicators, 21 sub-pillars, 7 pillars, 2 sub-indices, up to an overall index—is statistically sound and balanced: that is, each sub-pillar makes a similar contribution to the variation of its respective pillar. This year, the refinements made by the developing team have helped to enhance the already strong statistical coherence in the GII framework where for all 80 indicators their capacity to distinguish economies' performance is maintained at the sub-pillar level or higher.

The no-imputation choice for not treating missing values, common in relevant contexts and justified on grounds of transparency and replicability, can at times have an undesirable impact on some economy scores, with the additional negative side-effect that it may encourage economies not to report low data values. The adoption, since 2016, by the GII team of a more

FIGURE A-V.3

GII 2019 scores and DEA "distance to the efficient frontier" scores



Source: European Commission Joint Research Centre, 2019
Note: For comparison purposes, the GII scores were rescaled by dividing them with the best performer (Switzerland) in the overall GII 2019.

stringent data coverage threshold (at least 66% for the input- and output-related indicators, separately) has notably improved the confidence in the economy ranks for the GII and the two sub-indices.

Additionally, the choice of the GII team, which was made in 2012, to use weights as scaling coefficients during the index development constitutes a significant departure from the traditional, yet erroneous, vision of weights as a reflection of indicators' importance in a weighted average. It is hoped that such a consideration will be made also by other developers of composite indicators to avoid situations where bias sneaks in when least expected.

The strong correlations between the GII components are proven not to be a sign of redundancy of information in the GII. For more than 44% (up to 72%) of the 129 economies included in the GII 2019, the GII ranking and the rankings of any of the seven pillars differ by 10 positions or more. This demonstrates the added value of the GII ranking, which helps to highlight other components of innovation that do not emerge directly by looking into the seven pillars separately. At the same time, this finding points to the value of duly considering the GII pillars, sub-pillars, and individual indicators on their own merit. By doing so, economy-specific strengths and bottlenecks in innovation can be identified and serve as an input for evidence-based policy making.

All published GII 2019 ranks lie within the simulated 90% confidence intervals that consider the unavoidable uncertainties in the estimation of missing data, the weights (fixed vs. simulated), and the aggregation formula (arithmetic vs. geometric average) at the pillar level. For the vast majority of economies these intervals are narrow enough for meaningful inferences to be drawn: the intervals comprise fewer than 10 positions for 76% (98 out of 129) of the economies. Some caution is needed mainly for nine countries—Brunei Darussalam, Belarus, Panama, Rwanda, Paraguay, Tajikistan, Namibia, El Salvador, Togo—with ranks that are highly sensitive to the methodological choices. The Input and the Output Sub-Indices have the same modest degree of sensitivity to the methodological choices related to the imputation method, weights, or aggregation formula. Economy ranks, either in the GII 2019 or in the two sub-indices, can be considered representative of the many possible scenarios: 75% of economies shift fewer than three positions with respect to the median rank in the GII or either of the Input and Output Sub-Indices.

All things considered, the present JRC-COIN audit findings confirm that the GII 2019 meets international quality standards for statistical soundness, which indicates that the GII index is a reliable benchmarking tool for innovation practices at the economy level around the world.

Finally, the "distance to the efficient frontier" measure calculated with Data Envelopment Analysis can be used as a measure of efficiency, and a suitable approach to benchmark economies' multidimensional performance on innovation without imposing a fixed and common set of weights that may not be fair to particular economy. The choice of the GII team to abandon the efficiency ratio (ratio of Output to Input Sub-index) is particularly applaudable. In fact, ratios of composite indicators (Output to

Input Sub-Index in this case) come with much higher uncertainty than the sum of the components (Input plus Output Sub-Index, equivalent to the GII). For this reason, developers and users of indices alike need to take efficiency ratios of this nature with great care. The GII should not be the ultimate and definitive ranking of economies with respect to innovation. On the contrary, the GII best represents an ongoing attempt by Cornell University, INSEAD, and the World Intellectual Property Organization to find metrics and approaches that better capture the richness of innovation, continuously adapting the GII framework to reflect the improved availability of statistics and the theoretical advances in the field. In any case, the GII should be regarded as a sound attempt, matured over 12 years of constant refinements, to pave the way for better and more informed innovation policies worldwide.

Notes:

1 OECD/EC JRC, 2008.

2 The JRC analysis was based on the recommendations of the OECD/EC JRC (2008) Handbook on Composite Indicators and on more recent research from the JRC. The JRC audits on composite indicators are conducted upon request of the index developers and are available at https://ec.europa.eu/jrc/en/coin and https://composite-indicators.jrc.ec.europa.eu

3 Groeneveld, R.A., et al., 1984: set the criteria for absolute skewness above 1 and kurtosis above 3.5. The skewness criterion was relaxed in the GII case after having conducted ad-hoc tests in the GII 2008-2018 timeseries.

4 An indicator can explain 9% of the economy's variation in the GII sub-pillar scores if the Pearson correlation coefficient between the two series is 0.3.

5 Nunnally, 1978.

6 See footnote 4.

7 Saisana et al., 2005; Saisana et al., 2011; Vértesy, 2016; Vértesy et al., 2016; Montalto et al., 2019.

8 The Expectation-Maximization (EM) algorithm (Little, R.J., et al., 2002; Schneider, T., 2001) is an iterative procedure that finds the maximum likelihood estimates of the parameter vector by repeating two steps: (1) The expectation E-step: Given a set of parameter estimates, such as a mean vector and covariance matrix for a multivariate normal distribution, the E-step calculates the conditional expectation of the complete-data log likelihood given the observed data and the parameter estimates. (2) The maximization M-step: Given a complete-data log likelihood, the M-step finds the parameter estimates to maximize the complete-data log likelihood from the E-step. The two steps are iterated until the iterations converge.

9 Munda, 2008.

10 In the geometric average, pillars are multiplied as opposed to summed in the arithmetic average. Pillar weights appear as exponents in the multiplication. All pillar scores were greater than zero, hence there was no reason to rescale them to avoid zero values that would have led to zero geometric averages.

11 A question that arises from the GII approach is whether there is a way to benchmark economies' multi-dimensional performance on innovation without imposing a fixed and common set of weights that may not be fair to an economy. The original question in the DEA literature was how to measure each unit's relative efficiency in production compared to a sample of peers, given observations on input and output quantities and, often, no reliable information on prices (Charnes, A. et al., 1985). A notable difference between the original DEA question and the one applied here is that no differentiation between inputs and outputs is made (Cherchye, L. et al., 2008; Melyn, W. et al., 1991). To estimate DEA-based distance to the efficient frontier scores, we consider the m = 7 pillars in the GII 2019 for n = 129 economies, with y_{ij} the value of pillar j in economy i. The objective is to combine the pillar scores per economy into a single number, calculated as the weighted average of the m pillars, where w_i represents the weight of the i-th pillar. In absence of reliable information about the true weights, the weights that maximize the DEA-based scores are endogenously determined. This gives the following linear programming problem for each economy j:

$$Y_i = \max_{wij} \frac{\sum_{j=1}^{7} y_{ij} w_{ij}}{\max_{y_c \in \{dataset\}} \sum_{j=1}^{7} y_{cj} w_{ij}} \qquad \text{(bounding constraint)}$$

Subject to

$$w_{ij} \geq 0 \text{ , where } j = 1,\ldots,7 \text{ , } i = 1,\ldots.,129 \qquad \text{(non-negativity constraint)}$$

In this basic programming problem, the weights are non-negative and an economy's score is between 0 (worst) and 1 (best).

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APPENDIX VI

ABOUT THE AUTHORS

Marcos Álvarez-Díaz is a Researcher at the European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) of the Joint Research Centre of the European Commission, Italy, and Associate Professor of Economics at the University of Vigo, Spain. He holds a PhD, a Master of Philosophy, and a Master of Arts in Economics from Columbia University, New York in the United States of America. He has worked as Researcher at the Economic Research Center of the savings bank Caixa de Balears and served as Assistant Professor at the University of the Balearic Islands, Spain. He is the recipient of awards and honors such as the William Vickrey prize from Columbia University and the Alexandre Pedrós award from the Review of Public Economics. He has coauthored and authored scientific articles dealing with the modeling and forecasting of economic and financial time series.

Giovanni Anelli joined CERN's Knowledge Transfer Group in 2010 as Technology Transfer Officer and was appointed Head of the Knowledge Transfer Group in August 2011. Previously, he worked for three years for LEM SA. and prior to this, he worked for 10 years in CERN's Microelectronics Group in the Physics Department, where he designed several low-noise low-power analog and mixed signal VLSI circuits for High-Energy Physics applications. Mr. Anelli received a Master of Science in Electronics Engineering from the Polytechnic of Milan, Italy, in 1997, a PhD in Electronics Engineering with honors from the Polytechnic of Grenoble, France, in 2000 and an Executive Master of Business Administration from Ecole des Hautes Etudes Commerciales (HEC) Paris, France, in 2008. He is author and coauthor of more than 70 publications and is an IEEE senior member.

Jack Bauersachs is Professor of Finance at Technische Hochschule Deggendorf where he directs the International Management Programme. Prior to joining the university, he founded Promax Corp. and New World Cuisine, Inc., producers of sports nutritional products and organic snacks. He was previously Head of Corporate Finance for RAF Financial Corp. and Associate Professor of Economics at Colorado State University, United States of America. He earned his PhD with honors in Econometrics at the University of Colorado and is a Chartered Financial Analyst.

Kyle Bergquist is a Data Analyst in the Economics and Statistics Division of the World Intellectual Property Organization (WIPO). He holds a Master of Science in Economics from the University of Neuchâtel, Switzerland, and a Bachelor of Arts in Political Science from the University of Nevada, United States of America. Prior to working at WIPO, Mr. Bergquist was a data analyst for the patient safety department at CRICO, the malpractice insurance company for the Harvard medical community, where his research focused on the occurrence and prevention of adverse medical events as well as risk assessment. His research topics of interest are intellectual property, environmental policy, and economic geography.

Claire Biot leads the Life Sciences Industry organization of Dassault Systèmes, which aims to provide the life sciences ecosystem with agile digital solutions to tackle main current challenges, including personalized health, total quality, operational excellence in development and manufacturing, knowledge capitalization, and re-inventing the value chain. Ms. Biot holds a Master of Science in Engineering from Ecole Polytechnique, Paris, France, and a Master of Science in Biological Sciences from the Watson School of Biological Sciences, Cold Spring Harbor Laboratory in New York, United States of America. She studied cancer immunotherapy at Institut Pasteur, Paris, France, where she graduated with a PhD in immunology in 2012. She began her career at the French Ministry of Health as Head of Division, Health Products Pricing and Reimbursement in 2012. She then joined Greater Paris University Hospitals, AP-HP, Paris, France, in 2015 as Managing Director of the Health Products and Technologies Central Agency, allowing her to build proficiency in health products development, manufacturing, and procurement as well as patient care. She has been an active member in several World Health Organization (WHO) working groups on health products. She joined Dassault Systèmes in March 2019.

Krithpaka Boonfueng is the Deputy Executive Director of Innovation System at the National Innovation Agency (NIA) in Thailand. She graduated in 1994 with a Bachelor of Laws from Thammasat University, Thailand, with second class honors; in 1997 with a Master of Laws in Business Law from Chulalongkorn University, Thailand; in 1998 as a Barrister-at-Law from the Thai Bar Association; in 1999 with a Bachelor of Laws in International Business Law from the American University, United States of America; in 2000 with a Bachelor of Laws from the University of Pennsylvania, United States of America; and in 2003 as a Doctor of Juridical Science (SJD) from the American University, United States of America. She received the Thai Government Scholarship to study intellectual property law in the United States of America. After graduating, she launched her career at the National Science and Technology Development Agency (NSTDA) as an intellectual property specialist for 12 years and then worked at the Biodiversity-Based Economy Development Office (Public Organization) as the Director of Legal Development and Intellectual Property Management Group from 2015 to 2018. She was on the Board of Directors of the Defense Technology Institute of the Ministry of Defense from 2012 to 2017. She is a part-time lecturer to Masters students at various Thai institutions, namely the Thammasat University Graduate School of Management and Innovation, the King Mongkut's University of Technology Thonburi, and the School of Law at Ramkhamhaeng University and Bangkok University, Thailand. Moreover, she is the Associate Judge of the Central Intellectual Property and International Trade Court in Thailand. Her expertise includes Intellectual Property Law, Electronic Commerce and Internet Law, and Intellectual Property and Innovation Management.

Robson Braga de Andrade is President of the National Confederation of Industry (CNI), Director of the Social Services for the Industry (SESI), President of the Board of the National Service for Industrial Training (SENAI) and President of the Orteng Group, a leading company that produces equipment for the segments of energy, oil, gas, mining, steel, sanitation, telecommunications, and transport for over 30 years. He is a member of the Economic and Social Development Council of the Presidency of the Republic (CDES); member of the National Council of Industrial Development (CNDI); Vice-President of CNI from 2002 to 2010, President of the State Federation of Industries of Minas Gerais (FIEMG) from 2002 to 2010; member of Minas Gerais State Economic and Social Development Council; Director of the Latin American Business Council (CEAL) from 2004 to 2006; President of the Association of the Electrical Appliances and Electronics Industry (Sinaees) from 2004 to 2010; member of the Brazilian Association of Infrastructure and Basic Industries (ABDIB) Strategic Council from 2001 to 2003; and member of the Brazilian Association of Electric and Electronic ndustry (Abinee) Board from 2001 to 2004. He graduated as a Mechanical Engineer from the Federal University of Minas Gerais (UFMG) and has postgraduate diplomas in Strategic Management for Business Leaders of the Dom Cabral Foundation, in Minas Gerais State, and of INSEAD, France.

Manuela Cirilli joined CERN's Knowledge Transfer Group in 2010 as Technical Coordinator of an EU-funded project on medical imaging, and she was appointed Section Leader for Medical Applications in 2016. She is also Chair of CERN's Medical Applications Project Forum. Prior to this, she was an experimental researcher in particle physics. She joined CERN in 1997 as a PhD student and the ATLAS collaboration in 2001. She has extensive experience in detector construction and commissioning, data analysis, and databases. Ms. Cirilli holds a PhD in Particle Physics from the Scuola Normale Superiore in Pisa, Italy, as well as a Master of Science in Communication and Journalism from the University of Ferrara, Italy. She is coauthor of more than 320 peer-reviewed publications, including the article on the discovery of the Higgs boson by the ATLAS collaboration. In parallel to her scientific career, she has engaged in science communication and popularization since the early 2000s, for a variety of audiences and stakeholders of all ages. She is a teacher and coach in science communication, science writing, and public speaking. Ms. Cirilli is also actively involved in promoting STEM careers among young women and girls.

Francis S. Collins, MD, PhD is the Director of the National Institutes of Health (NIH) in the United States of America. In this role, he oversees the work of the largest supporter of biomedical research in the world, spanning the spectrum from basic to clinical research. Dr. Collins is a physician-geneticist noted for his landmark discoveries of disease genes and his leadership of the international Human Genome Project, which culminated in April 2003 with the completion of a finished sequence of the human DNA instruction book. He served as Director of the National Human Genome Research Institute at the NIH from 1993 to 2008. Before coming to the NIH, Dr. Collins was a Howard Hughes Medical Institute Investigator at the University of Michigan in the United States of America. He is an elected member of the Institute of Medicine and the National Academy of Sciences, was awarded the Presidential Medal of Freedom in November 2007, and received the National Medal of Science in 2009.

Marcos Domínguez-Torreiro is a Research Fellow at the Competence Centre on Composite Indicators and Scoreboards (COIN) of the Joint Research Centre of the European Commission, Italy, where he conducts research and policy support tasks in the field of Econometrics and Applied Statistics. After his undergraduate studies in Economics and Business Administration, he completed his doctoral thesis in Applied Economics at the University of Vigo, Spain. His past work experience is in the private sector, universities, and public administration. He has coauthored books and research articles dealing with finance, consumer behavior, environmental and natural resource economics, rural development, and institutional economics.

Soumitra Dutta is Professor of Management and the former founding dean of the Cornell SC Johnson College of Business (April 2016 to January 2018). Previously, he was the Anne and Elmer Lindseth Dean of the Samuel Curtis Johnson Graduate School of Management. Prior to coming to Cornell in 2012, he was on the faculty and leadership team of INSEAD, a leading international business school in France and Singapore. He is an authority on technology and innovation policy, is the co-editor and author of *The Global Information Technology Report*, published by the World Economic Forum and *The Global Innovation Index*, published by the World Intellectual Property Organization—two influential reports in technology and innovation policy. Mr. Dutta is on the global boards of Sodexo and Dassault Systèmes. He is also a member of the Shareholder Council of Chicago-based ZS Associates. In addition, he is a member of the advisory boards of several business schools including HEC, Montreal; ESADE, Barcelona; and ESCP, Paris. He has co-founded two firms, including Fisheye Analytics, which WPP group acquired. He is currently Chair of the Board of Directors of the Global Business School Network, a Washington, D.C. based not-for-profit organization focused on improving management capacity in emerging markets. He was previously the Chair of AACSB, the leading global body for the accreditation of business schools. Mr. Dutta is a member of the Davos Circle, an association of long-time participants in the World Economic Forum Annual Meeting in Davos, and has engaged in a number of multi-stakeholder initiatives to shape global, regional, and industry agendas. He is also currently the co-chair of the World Economic Forum's Global Future Council on Innovation Ecosystems. Mr. Dutta received a Bachelor of Technology in Electrical Engineering and Computer Science from the Indian Institute of Technology (IIT), New Delhi, a Master of Science in both Business Administration and Computer Science, and a PhD in Computer Science from the University of California at Berkeley. In 2017, he received the Distinguished Alumnus Award from his alma mater IIT Delhi.

Mahdi Elyasi graduated from the Sharif University of Technology with a degree in Industrial Engineering. He obtained his PhD in Technology Management (policymaking) from Allameh Tabataba'i University, Tehran, Iran, and is a member of the University's scientific board in the fields of technology management, and science and technology policymaking. He has over 10 years of experience in training, research, and executive activities in governmental and private bodies, is a member of the board of directors of technology management and knowledge management associations, and has written various research essays.

Rafael Escalona Reynoso has been Lead Researcher for *The Global Innovation Index* since October 2013. His previous professional experience was as Economic, Science and Technology Policy Advisor to the Senate of Mexico, and as a member of the Trade and Foreign Investment Advisory Board at the office of the President of Mexico. His research experience at Cornell University includes comparative studies between Mexico and Spain on the regulatory aspects of modern biotechnology and the biosafety of genetically modified organisms (GMOs), and on the reach of intellectual property rights (IPRs) in the information technologies era. He holds a PhD in Regional Planning and a Master of Public Administration from Cornell University as well as a Bachelor of Arts in Economics from Universidad Panamericana in Mexico.

Kiarash Fartash holds a PhD in Management of Technology with specialization in science and technology (S&T) policymaking from Allameh Tabataba'i University, Tehran, Iran. He has authored more than 20 research papers and has played a major part in many international STI policy studies, of which his role in the preparation of Iran Science, Technology and Innovation Policy Review, published by UNCTAD in 2016, was instrumental. Since 2013, he has coordinated at a national level with all key organizations and institutions in Iran to address the country's challenges and deficiencies based on *The Global Innovation Index (GII)* report rationales as well as improving quality, data, and the international reporting system of Iran's statistics relevant to GII indicators.

Carsten Fink is the Chief Economist of the World Intellectual Property Organization (WIPO) based in Geneva. Before joining WIPO, he was Professor of International Economics at the University of St. Gallen, Switzerland. He has also held the positions of Visiting Professor at the Fondation Nationale des Sciences Politiques (Sciences Po) in Paris and Visiting Senior Fellow at the Group d'Economie Mondiale, a research institute at Sciences Po. Prior to his academic appointments, Dr. Fink worked for more than 10 years at the World Bank. Among other positions, he was Senior Economist in the International Trade Team of the World Bank Institute, working out of the World Bank's office in Geneva, and Economist in the Trade Division of the World Bank's research department, based in Washington, D.C. Dr. Fink's research work—focused on intellectual property, innovation, and international trade—has been published in academic journals and books. He holds a Doctorate in Economics from the University of Heidelberg in Germany and a Master of Science in Economics from the University of Oregon in the United States of America.

Antanina Garanasvili is a Research Economist at Bournemouth University, the Centre for Intellectual Property Policy & Management (CIPPM). She also serves as an independent consultant to Cornell University for *The Global Innovation Index*. Her main area of expertise is in applied microeconomics and industrial organization, with a focus on innovation and intellectual property economics. Dr. Garanasvili has previously worked with economist teams at EUIPO (European Union Intellectual Property Office), EPO (European Patent Office) and WIPO (World Intellectual Property Office). She held the position of visiting PhD researcher at Queen Mary University of London and holds a PhD in Economics from the Università di Padova, Italy.

Francesca Guadagno is an Economist and International Consultant. Her research interests cover the broad area of innovation and development, with a focus on the role of public policies. She has considerable experience in policy-oriented research, working with the Asian Development Bank, the Dutch Ministry of Foreign Affairs, the Gates Foundation, the E15 Initiative, ECDPM, UNIDO, UNCTAD, and WIPO. Dr. Guadagno holds a Master of Economics and Management of Innovation from Bocconi University in Milan, Italy; a Master of Management of Innovation from the Rotterdam School of Management, the Netherlands; and a PhD in Innovation Studies and Development from UNU-MERIT and Maastricht University School of Business and Economics.

Cashelle Hardman graduated with a Bachelor of Commerce from the University of Pretoria, South Africa in 2014. She pursued a career in the field of Human Resources Management thereafter, an area in which she had worked for roughly five years, including at the World Intellectual Property Organization (WIPO), before assuming her current role as Project Manager for *The Global Innovation Index* in 2018.

Mohamed Hassany is Assistant to the Egyptian Minister of Health and Population for public health initiatives in Egypt, and Executive Director of the National Committee for Control of Viral Hepatitis. Previously, he was Vice-Dean of Scientific Research and Training. He has many international peer-reviewed publications/book chapters in the field of viral hepatitis and serves as an editorial board member and reviewer of many international peer reviewed journals. In 2019, he was awarded the State Encouragement Award in medical science in Egypt.

Patrick Johnson is Vice-President of Corporate Science & Research at Dassault Systèmes (3DS). His mission is to define the scientific bases of the company's solutions, invent new disruptive technologies for the Industry Renaissance, and animate the group's global research ecosystem. Mr. Johnson joined 3DS in 1996 and has held various positions in research and development (R&D), from Product Lifecycle Management infrastructure to virtual product design solutions for the CATIA flagship brand. In 2001, he became head of the Knowledgeware department and, convinced by the potential of artificial intelligence and knowledge management, played a key role with major breakthroughs currently used in multiple industrial sectors, such as intelligent morphing templates, and industrial processes capitalization & reuse automation. After two years as Executive Assistant to the CEO Bernard Charlès, he was named Head of Corporate Research in 2004. Since then he has launched the development of multiple original technologies, which has resulted in more than 30 innovative products and 60 patents, transformed industry & scientific practices and significantly grown the global innovation ecosystem that promotes the creation of public/private partnerships with prestigious research institutes and organizations. In addition, he launched an entirely new field of diversification for 3DS, following 'BioIntelligence'—a very large European research program, resulting in a suite of collaborative applications for the life sciences sector, the acquisition of key player and the creation of the BIOVIA brand with a worldwide R&D lab in modeling, simulation, and big data for life sciences. A graduate of ENSAE, Mr. Johnson is based at 3DS world headquarters near Paris. He is or has been a member of the scientific boards of INRIA, IMT, ARISS, International Society of Computational Biology, IRCAM, Comité de Culture Mathematics of the Institut Henri Poincaré, and Personnalité associée of the Economic, Social and Environmental Council (CESE).

David Kaslow, MD, is PATH's Vice-President for Essential Medicines, which includes PATH's Drug Development Program and the PATH Center for Vaccine Innovation and Access (CVIA). As the Director of CVIA, he leads PATH's work to accelerate the development and introduction of lifesaving vaccines for the most vulnerable children and communities around the world. Dr. Kaslow has more than 25 years of experience in vaccine research and development. Before joining PATH in 2012 as Director of MVI's work to drive the development of safe and effective vaccines against malaria, he held key advisory positions with MVI and the Bill & Melinda Gates Foundation related to malaria vaccines. Prior to that, he oversaw project leadership and management of Merck Research Laboratories' vaccine pipeline and founded the Malaria Vaccine Development Unit at the National Institutes of Health. As a basic research scientist, Dr. Kaslow completed the molecular cloning and characterization of several proteins involved in malaria parasite sexual development. He has also directed product development, including field studies, of several malaria vaccine candidates. Outside the malaria field, Dr. Kaslow has contributed to the vaccine application of tools originally developed for gene therapy. He holds or co-holds more than a dozen patents and has published more than 150 scientific papers. Dr. Kaslow received his medical degree from the University of California, San Francisco.

Pratap Khedkar is a Managing Principal and Global Leader for the Biopharmaceuticals Practice at ZS Associates, a management consulting firm focusing on healthcare. He has also been a member of the ZS Associates Board since 2012. Mr. Khedkar has 20 years of experience in the healthcare industry, helping multiple organizations on issues related to commercial strategy and effectiveness. More recently, he has worked on developing effective strategies and analytics for changing customers in the new healthcare ecosystem. A recognized healthcare industry expert, Mr. Khedkar regularly contributes his insights to publications including *The Wall Street Journal, Bloomberg Businessweek, Business Insider, Medical Marketing & Media, NPR, Pharmaceutical Executive* and others. Currently, his thought leadership work focuses on topics as diverse as healthcare policy; life sciences companies' new commercial and organizational models; the evolving relationships between patients, providers and payers, and the life sciences organizations that serve them. He holds a PhD in Computer Science and Artificial Intelligence from the University of California at Berkeley, as well as a B. Tech. in Computer Science and Engineering from the Indian Institute of Technology, Delhi.

Bruno Lanvin is INSEAD's Executive Director for Global Indices. From 2007 to 2015, he was the Executive Director of INSEAD's eLab, managing INSEAD's teams in Paris, Singapore and Abu Dhabi, and then Executive Director for INSEAD's European Competitiveness Initiative (IECI). From 2000 to 2007, Dr. Lanvin worked for the World Bank, where he was inter alia Senior Advisor for E-strategies and Regional Coordinator in Europe and Central Asia for information and communication technology (ICT) and e-government issues. He also headed the Capacity Building Practice of the World Bank's Global ICT Department and was Chairman of the Bank's e-Thematic Group. From June 2001 to December 2003, he was the Manager of the Information for Development Program (infoDev) at the World Bank. In 2000, Dr. Lanvin was appointed Executive Secretary of the G8-DOT Force. Until then, he was Head of Electronic Commerce in the United Nations Conference on Trade and Development (UNCTAD) in Geneva, and occupied various senior positions including Chief of the Cabinet of the Director General of the United Nations in New York, Head of Strategic Planning, and later Chief of the SME Trade Competitiveness Unit of UNCTAD/SITE. He was the main drafter, team leader, and editor of *Building Confidence: Electronic Commerce and Development*, published in January 2000. Since 2002, he has been coauthoring *The Global Information Technology Report* (Cornell University-INSEAD-World Economic Forum), and is currently the co-editor of *The Global Innovation Index Report* (Cornell University-INSEAD-WIPO). In 2013, he created and launched the first edition of the *Global Talent Competitiveness Index* (GTCI), and is still the co-editor of this annual report. He holds a Bachelor of Arts in Mathematics and Physics from the University of Valenciennes, France, a Masters of Business Administration from Ecole des Hautes Etudes Commerciales (HEC) in Paris, France, a PhD in Economics from the University of Paris I (La Sorbonne) in France, and is an alumnus of INSEAD (IDP-C). A frequent speaker at high-level meetings, he advises several global companies and governments and has been a member of numerous boards for many years, including those of ICANN, IDA-Infocomm, GovTech, IP-Watch, AAID, and the Bin Rashid Foundation for Government Innovation.

Chaiyatorn Limapornvanich is Head of Innovation Foresight at the National Innovation Agency (NIA) in Thailand. Based on his educational background in electrical engineering and information science, he started his career as a web developer and then became a research assistant. He joined NIA in 2004 and secured a scholarship for his doctoral studies in 2009 at the University of Surry, United Kingdom. With extensive experience collaboratively working with innovative companies, he decided to conduct his doctoral research on Knowledge Management and graduated in 2013. At present, his research focuses are in the areas of Strategic Foresight and Innovation Management, and his professional interests have been expanded to organizational learning and development.

Valencia Lyle received a Master's in Public Health from Columbia University's Mailman School of Public Health, New York in the United States of America. Since then, Ms. Lyle has been building her proficiency in health system strengthening and global health research. She further strengthened her expertise in these areas after joining the Health Management Information System (HMIS) Unit of the Rwanda Ministry of Health (MOH) from July 2017 until March 2019. As Vital Statistics Knowledge Management Officer, she provided support to Rwanda's MOH/HMIS Unit staff through analyzing data, coordinating e-learning system activities, and contributing to health system related reporting and research. Her medley of past and current work experiences drive her enthusiasm for integrating technology into health systems to achieve health and gender equity.

Huateng (Pony) Ma is one of Tencent's co-founders and currently serves as Chairman of the Board and Chief Executive Officer. He oversees the strategic development, business positioning, and management of Tencent. In 2018, Mr. Ma topped *Fortune*'s list of "China's 50 Most Influential Business Leaders" and was named one of the "Best-Performing CEOs in the World 2017" by *Harvard Business Review*. Mr. Ma received his Bachelor of Science in Computer Science from Shenzhen University, China, in 1993.

Sébastien Massart is Head of Corporate Strategy at Dassault Systèmes. Among his previous positions, he was Senior Industrial Advisor to former French President François Hollande, where he contributed to the definition and implementation of major orientations and policies for industry transformation at the national level. Mr. Massart also formerly served as Technical Advisor for Industrial Affairs in the private office of the French Minister of Defense. He began his career at Deloitte Consulting in Paris. He then became a French State civil servant, Head of Economic Development at a regional level, and then Adviser to the Chairman of the French Financial Markets Authority (AMF), in charge of strategic planning. At that time, he was notably involved in European multilateral negotiations regarding the new regulation of derivatives markets after the financial crisis. He then joined the French State Shareholding Agency (A.P.E.) at the French Ministry for Economy, where he oversaw a portfolio of companies including Airbus Group, Nexter, Eurenco, and Monnaie de Paris. Mr. Massart holds an engineering degree from Ecole Polytechnique (Paris-Saclay University) and is a graduate of Ecole Normale Supérieure, Paris, France, in Theoretical Physics and Philosophy.

Brandy R. Matthews, MD, FAAN, joined Eli Lilly and Company in 2015 after serving as Associate Professor of Clinical Neurology and the Neurology Residency Program Director at the Indiana University School of Medicine, Clinical Assistant Professor at Marian University College of Osteopathic Medicine, and clinical investigator at the Indiana Alzheimer Disease Center, United States of America. She completed a Bachelor of Science in psychology/theatre, graduating *summa cum laude* from Ball State University in 1994. She obtained her Doctorate of Medicine at Indiana University School of Medicine in 2001 with induction into the Alpha Omega Alpha Medical Honor Society. Dr. Matthews was a Neurology Resident at Mayo Clinic Graduate School of Medicine from 2002 to 2005, where she served as Chief Neurology Resident before her National Institutes of Health-funded research fellowship in Clinical Behavioral Neurology at University of California, San Francisco School of Medicine between 2005 and 2007. As a Clinical Instructor in Neurology at Mayo Clinic College of Medicine and at the University of California, San Francisco, she was active in the education of medical students and residents before returning to Indiana to assume a leadership role in Graduate Medical Education. As a diplomate of the American Board of Psychiatry and Neurology and a Fellow of the American Academy of Neurology, she has served leadership roles in both organizations. Dr. Matthews has published and presented nationally and internationally on a broad range of neuroscience topics, with a focus on Alzheimer's disease and related dementias and a special interest in the intersection of Neurology and the Arts. During her tenure at Eli Lilly, she has been actively engaged across the global Alzheimer's disease effort, collaborating with medical and non-medical colleagues while maintaining her special interests in medical education and exploring opportunities to prepare the external environment for new therapies for patients with neurodegenerative diseases. She cares for patients and families affected by neurodegenerative dementia in her biweekly volunteer clinic at Indiana University Health.

Carlos Melles is an agronomist, researcher, and cooperative executive director. He was a member of congress for six consecutive legislatures, and throughout his career has stood up for agribusiness, cooperatives, and micro and small business causes. At the lower chamber of Brazilian Congress, he was president of the Micro Business Special Committee, which approved the Micro and Small Business General Act in 2006. It is worth noting that Mr. Melles was the reading clerk for the bills in 2018: *Individual Micro Entrepreneur* (MEI, in Portuguese) and *Simple Credit Business* (ESC, in Portuguese). In the Federal Government, he was Minister of State of Sports and Tourism in 2000 and, in the Minas Gerais State Government, he was Secretary of State of Transport and Public Developments in 2011.

Andrew Muhire is Sector M&E and Report Lead Specialist at the Rwanda Ministry of Health (MoH). During his tenure, Mr. Muhire has been dedicated to providing innovative solutions to support health workers and improve data collection methods. With 7 years of experience managing the Health Management Information System (HMIS), Mr. Muhire has spearheaded several initiatives to safeguard the collection of high quality data to bolster the effectiveness of data driven policymaking. One of Mr. Muhire's most notable achievements includes serving as a member of the task force that customized the first web-based system (DHIS2) for the MoH. Additional components of his core role include disseminating information regarding public health trends and best practices, using data to improve healthcare delivery throughout Rwanda, and strategically integrating technology into building the capacity of health workers.

Kieran Murphy is President and CEO of GE Healthcare, a $20 billion business unit of General Electric that provides transformational medical technologies and solutions to the global healthcare industry. GE Healthcare supports customers in over 100 countries with a broad range of services and systems, from diagnostic imaging, monitoring, and digital solutions through to molecular diagnostics and life sciences. Prior to this, Mr. Murphy was President and Chief Executive Officer of GE Healthcare Life Sciences. He was appointed CEO in May 2011 and oversaw significant revenue growth and geographic expansion of the molecular medicine business. Mr. Murphy joined GE Healthcare in 2008 from Whatman plc., a $230 million global supplier of filters and membranes for laboratory research, life sciences, and medical diagnostic applications. Mr. Murphy has over twenty years' experience in the global life sciences and biotechnology industry beginning his career with Janssen Pharmaceuticals, a division of Johnson and Johnson, followed by leadership roles with Mallinckrodt, veterinary medicines provider Vericore, Novartis, Adprotech, ML Laboratories, and Innovata plc.

Patrick Ndimubanzi is Minister of State for Primary Health Care of the Ministry of Health in Rwanda. Dr. Ndimubanzi is a Public Health specialist with experience in designing and implementing strategies to tackle the HIV/AIDS pandemic and other infectious and non-infectious diseases. A medical doctor by profession, he holds a Master of Science, majoring in Epidemiology from the University of Oklahoma, Health Sciences Center.

Mostafa Monier Othman is Technical Officer in the Minister of Health's Technical Office in Egypt. He holds a Master of e-Health Management and two postgraduate diplomas in Public Health and Quality Management. Prior to working in the Ministry of Health, he was a health research consultant for WHO/EMRO. During his seven-year experience, he worked on health system strengthening topics.

Nicolas Pécuchet, MD, PhD, is Head of Genomic Sciences at Dassault Systèmes. Dr. Pécuchet's team focuses on translating genomic innovations and disruptive technologies into clinical benefit for patients. His work is based on strong interactions and partnerships with research institutes and healthcare institutes to build collaborative research programs. Among his previous positions, he served as a clinical oncologist at the European Georges Pompidou Hospital and Clinical Investigator and Director of the clinical trial in kidney cancer. As Founding member of Assistance Publique – Hôpitaux de Paris (AP-HP) Molecular Tumor Board, he actively supports delivering precision medicine to a large number of patients. His translational research on cancer genomics and liquid biopsy have been published in *Plos Medicine, Annals of Oncology, Clinical Chemistry* and *Clinical Cancer Research*. Dr. Pécuchet is a graduate of Paris Descartes University and Paris Descartes Medical School and was awarded the Chancellery prize of the Universities of Paris.

Lorena Puica is an academic, investment professional, extreme athlete, and the Founding CEO of the world leading preventive platform iamYiam.com. Prior to founding iamYiam, Ms. Puica achieved five degrees in mathematics, economics, and finance from Universities in Romania, Germany, the United Kingdom, and the United States of America, including being one of the youngest to receive the CFA designation. She published a book on microfinance at the age of 26 and created a decade-long career with Allianz SE—the global Insurer in Group Development and Long Term Strategy, KPMG—the global consulting firm focused on post-merger integrations, and Morningstar—the global investment firm as Director of Strategy and Business development working with portfolios of over £200billion. At the same time, Ms. Puica was an extreme athlete with 2 world record events—running 7 marathons on 7 continents in 7 days and climbing Kilimanjaro in 2,5 days.

Anais Rassat is Communication and Marketing Officer in the Knowledge Transfer group at CERN. She holds a PhD in astrophysics and worked for 12 years on ground- and space-based telescope projects at the Swiss Federal Institute of Technology in Lausanne (EPFL), the French Alternative Energies and Atomic Energy Commission (CEA), and University College London. During this time, she managed international science working groups and teams, and acted as project manager of scientific research projects. She has authored and coauthored over 40 publications related to astrophysics, cosmology, or cosmostatistics. She now drives the development and implementation of the Knowledge Transfer group's communication and marketing strategy. She is passionate about technology, innovation, science policy, and entrepreneurship.

David A. Ricks has served as Chief Executive Officer of Eli Lilly and Company since January 1, 2017. He became Chairperson of the board of directors on June 1, 2017. A 20-year Eli Lilly veteran, Mr. Ricks served as president of Eli Lilly Bio-Medicines from 2012 to 2016. Previously, he was President of Eli Lilly in the United States of America, the company's largest affiliate, from 2009 to 2012. He served as President and General Manager of Eli Lilly China, operating in one of the world's fastest-growing emerging markets, from 2008 to 2009. And he was General Manager of Eli Lilly Canada from 2005 to 2008, after roles as director of pharmaceutical marketing and national sales director in that country. Mr. Ricks joined Eli Lilly in 1996 as a Business Development Associate and held several management roles in U.S. marketing and sales before moving to Eli Lilly Canada. Mr. Ricks earned a Bachelor of Science from Purdue University in 1990 and a Master of Business Administration from Indiana University in 1996. Mr. Ricks is the President of the International Federation of Pharmaceutical Manufacturers & Associations (IFPMA) as well as serves on the board of the Pharmaceutical Research and Manufacturers of America (PhRMA), the Central Indiana Corporate Partnership, the Elanco Board of Directors, and the Adobe Board of Directors. He chairs the Riley Children's Foundation Board of Governors.

Lorena Rivera León is the Program Officer of *The Global Innovation Index* (GII) at the Economics and Statistics Division of the World Intellectual Property Organization (WIPO). She has worked as a researcher, policy analyst, and consultant in the field of research and innovation for over 13 years, including for various services of the European Commission, UNESCO, the OECD, and the Inter-American Development Bank. Prior to joining WIPO, she was involved in the design and development of various innovation and entrepreneurship scoreboards at the European level, including the Regional Ecosystems Scoreboard of the European Cluster Observatory and the Regional Innovation Scoreboard of the European Union. At WIPO she acts as Lead Researcher of the GII, including the review of data, the construction and the development of the statistical model, and the undertaking of related data computations. She also provides *ad hoc* technical advice to countries on innovation metrics and innovation policy and performance. Lorena is currently finalizing her PhD in Economics and Policy Studies of Technical Change at UNU-MERIT in the Netherlands. She received her Master of Arts jointly from the Department of Economics, University of British Columbia, Canada and the Université Pierre-Mendès-France in Grenoble.

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Devi Prasad Shetty is the Chairperson and Founder of Narayana Hrudayalaya (NH) Ltd. He graduated with a Bachelor of Medicine and Surgery from Kasturba Medical College in Mangalore and has worked as MS (General Surgery) at Kasturba Medical College, Mangalore; Cardiac surgeon at National Health Service, the United Kingdom; Professor of International Health at the University of Minnesota Medical School, the United States of America; Professor at Rajiv Gandhi University of Health Sciences, Karnataka; Fellow of Royal College of Surgeons England (FRCS England); Former Governor at the Medical Council of India; and Chairman, Board of Governors, Indian Institute of Management, Bengaluru. Dr. Shetty was the first surgeon in India to perform heart surgery on newborn babies and introduced minimally invasive surgery using a microchip camera to close holes in the heart. He pioneered operations for complex heart conditions like pulmonary endarterectomy, redo heart surgery, valve repairs in newborn babies, and aortic aneurysm surgeries. He also pioneered the concept of Health City—one shared campus with a few thousand beds, consisting of different medical specialties sharing a common infrastructure. He launched India's first telemedicine program in partnership with ISRO to offer cardiac care across remote locations in India and Africa, which treated over 53,000 patients free of charge. He created the world's first micro-health insurance called Yeshaswini, which became the model for many state government's health reimbursement schemes. He is the Representative of the President of India in the Board of Governors of Indira Gandhi National Open University and was nominated to the Board of Governors of Medical Council of India between 2010 and 2011. He has been awarded the Ernst & Young Entrepreneur of the Year, 2003; Padma Shri, 2003; Padma Bhushan, 2012; Medical Council of India Dr. B. C. Roy Award, 2003; World Economic Forum Social Entrepreneurship Award, 2005; The Economist Innovation Award, 2011; and the Nikkei Innovation Award, 2014.

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Hala Zaid is the Minister of Health and Population in Egypt and has more than 20 years of experience in medical practice, health system development, planning, and evaluation. With a Doctorate of Business Administration (DBA), among others, paired with extensive practical experience at the Ministry of Health and Population, she developed a deeper understanding of the current challenges and needs of the healthcare system in Egypt. Her experience in setting and implementing effective strategic plans, lean management, and business development has given her the unique opportunity to lead health management in complex environments.

In 2019, the Global Innovation Index (GII) presents its 12th edition dedicated to the theme *Creating Healthy Lives—The Future of Medical Innovation*. This edition sheds light on the role of medical innovation as it determines the future of healthcare in the next decades.

Innovation is widely recognized as a central driver of economic growth and development.

The aim of the Global Innovation Index (GII) is to provide insightful data on innovation and, in turn, to assist economies in evaluating their innovation performance and making informed innovation policy considerations.

The GII has been impactful on three fronts. First, it helps place innovation firmly on the policy map, in particular for low- and middle-income economies. As a result, leaders regularly refer to innovation and their innovation rankings as part of their economic policy strategies.

Second, the GII allows economies to assess the relative performance of their national innovation system. Economies invest resources to analyze their GII results and metrics in cross-ministerial task forces and then design appropriate policy reactions, such as addressing weak R&D funding or innovation linkages.

Third, the GII continues to provide a strong impetus for economies to prioritize and collect innovation metrics. By experimenting with new data and evaluating existing innovation metrics, the GII also aims to shape the innovation measurement agenda.

The GII is co-published by Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), a specialized agency of the United Nations. The 2019 edition of the GII draws on the expertise of its Knowledge Partners: the Confederation of Indian Industry (CII), Dassault Systèmes—The 3DEXPERIENCE Company, and the Brazilian National Confederation of Industry (CNI) and the Brazilian Micro and Small Business Support Service (SEBRAE), as well as an Advisory Board of eminent international experts. For the ninth consecutive year, the Joint Research Centre (JRC) of the European Commission audited the GII calculations.

The GII is concerned primarily with improving the journey towards a better way to measure and understand innovation and with identifying targeted policies and good practices that foster innovation.

The full report and the GII Mobile Apps—Android and iOS—can be downloaded at **https://globalinnovationindex.org**.

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