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.

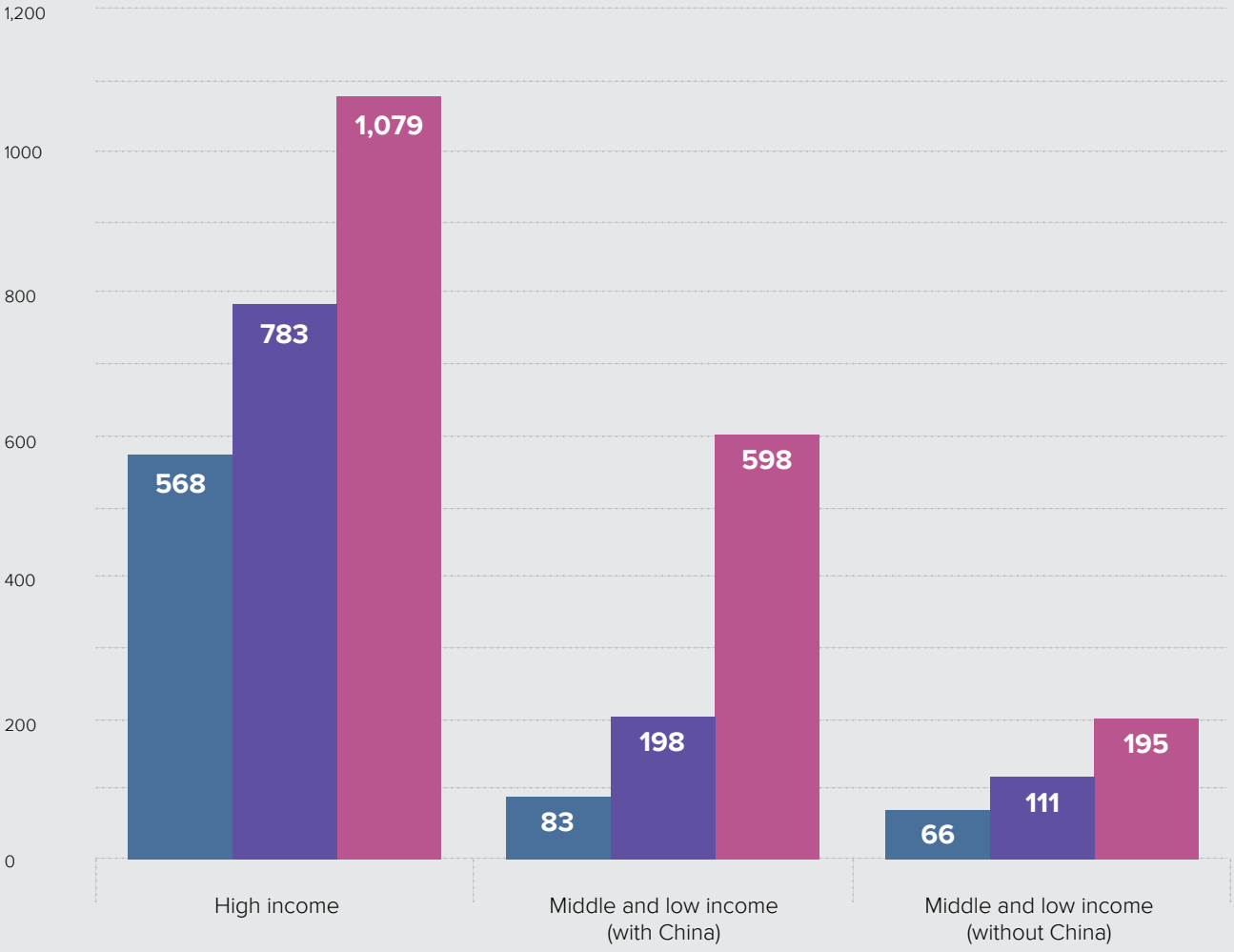
The world share of other emerging economies, such as India, have also substantially increased—from 1.8% in 1996 to 2.9% in 2017. In contrast, the regional R&D shares of Europe, and Latin America and the Caribbean have fallen with the rise of Asian economies. Sub-Saharan Africa continues to have low levels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



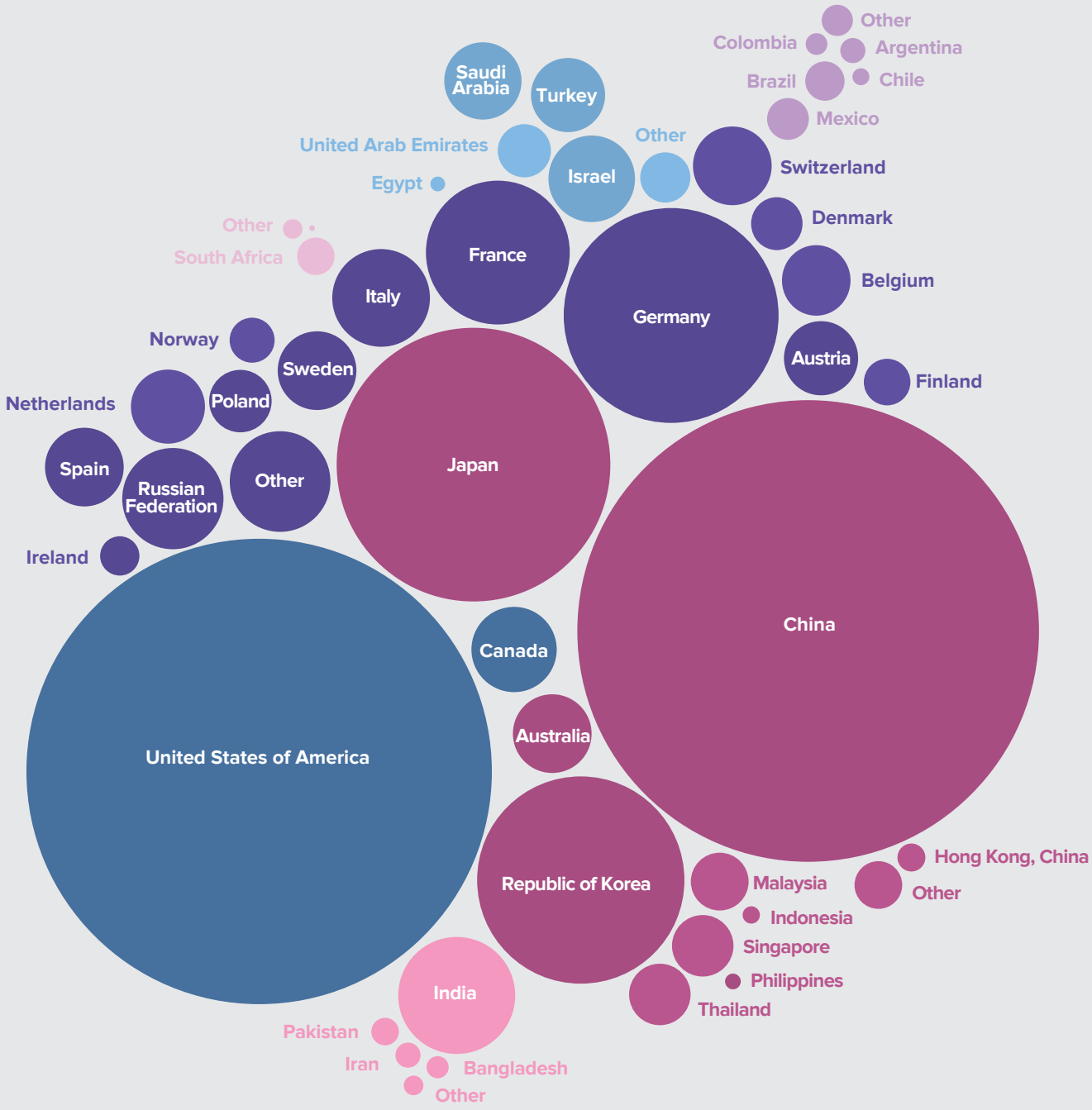
▲ Million 2005 PPP US$

- 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



- Northern America
- Europe
- South East Asia, East Asia, and Oceania
- Northern Africa and Western Asia
- Latin America and the Caribbean
- Central and Southern Asia
- Sub-Saharan Africa

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.

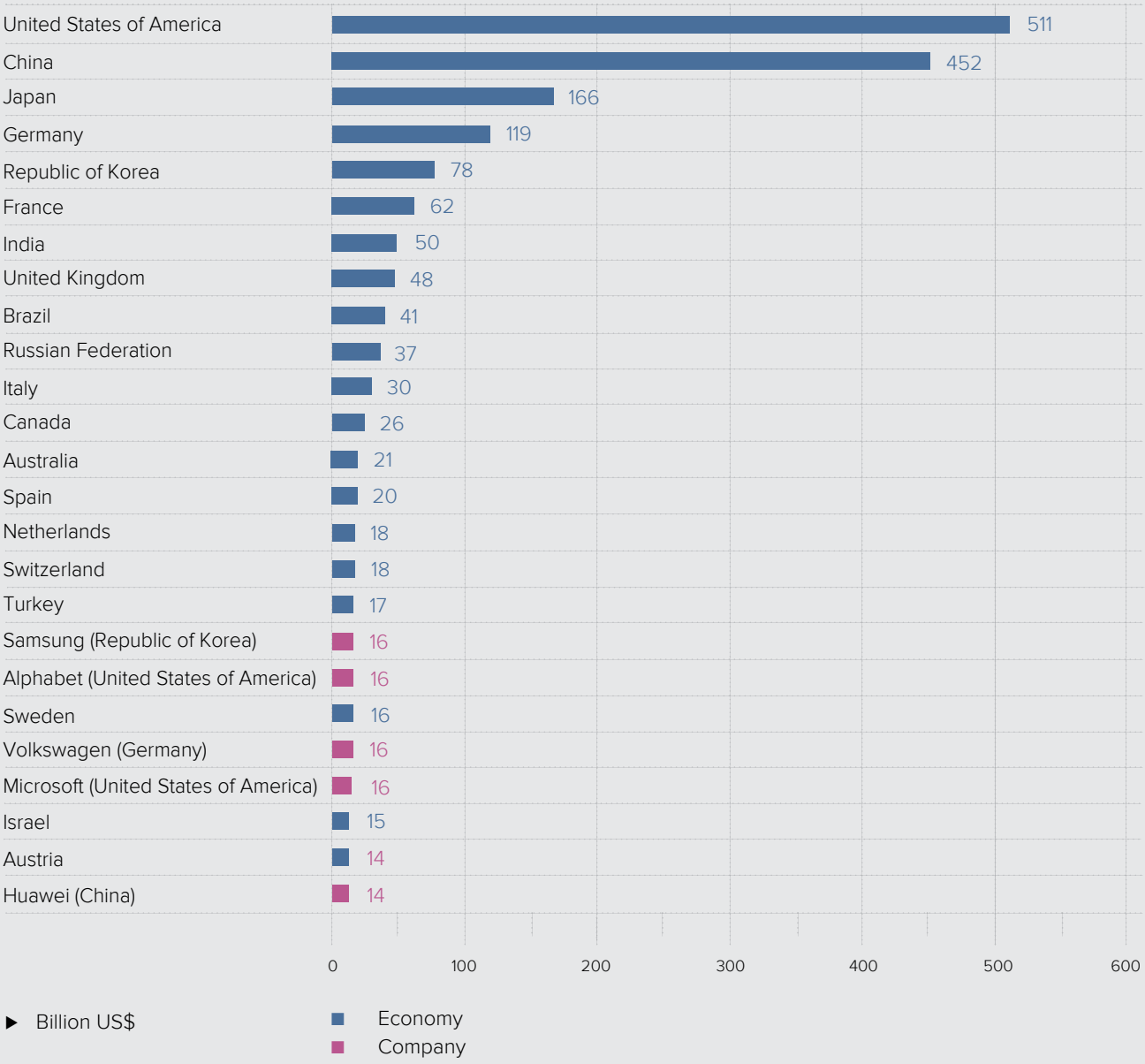
BOX 1

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.

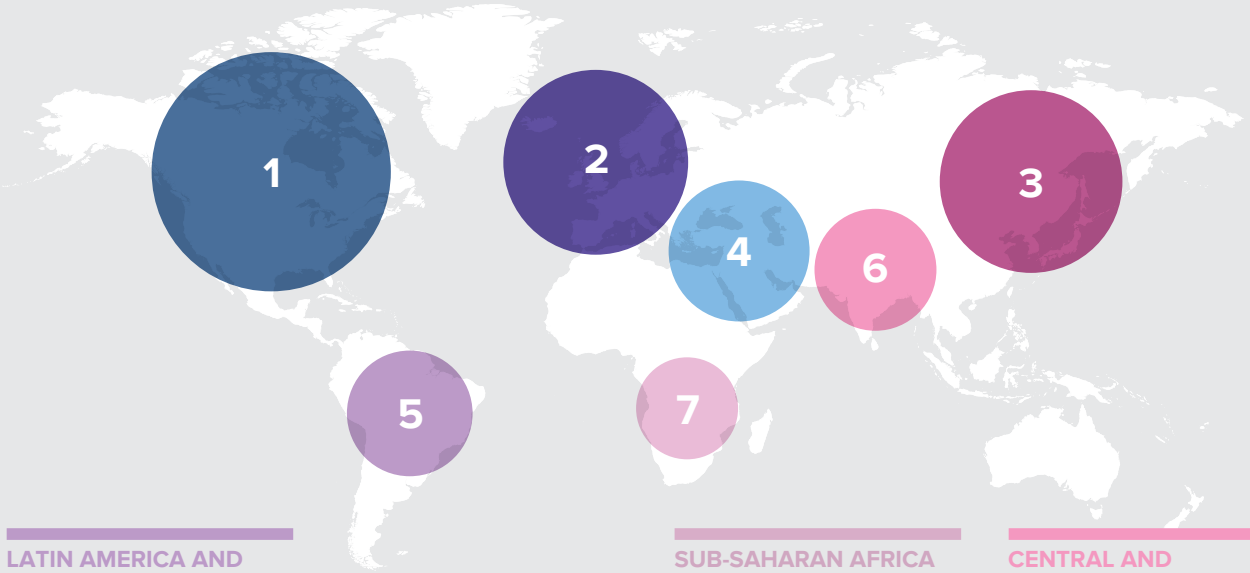
FIGURE 1.4

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	EUROPE	NORTHERN AFRICA AND WESTERN ASIA	SOUTH EAST ASIA, EAST ASIA, AND OCEANIA
1. U.S.	1. Switzerland	1. Israel	1. Singapore
2. Canada	2. Sweden ↑	2. Cyprus	2. Republic of Korea
	3. Netherlands ↓	3. United Arab Emirates	3. Hong Kong, China ★



LATIN AMERICA AND THE CARIBBEAN	SUB-SAHARAN AFRICA	CENTRAL AND SOUTHERN ASIA
1. Chile	1. South Africa	1. India
2. Costa Rica	2. Kenya ↑	2. Iran
3. Mexico	3. Mauritius ↓	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.

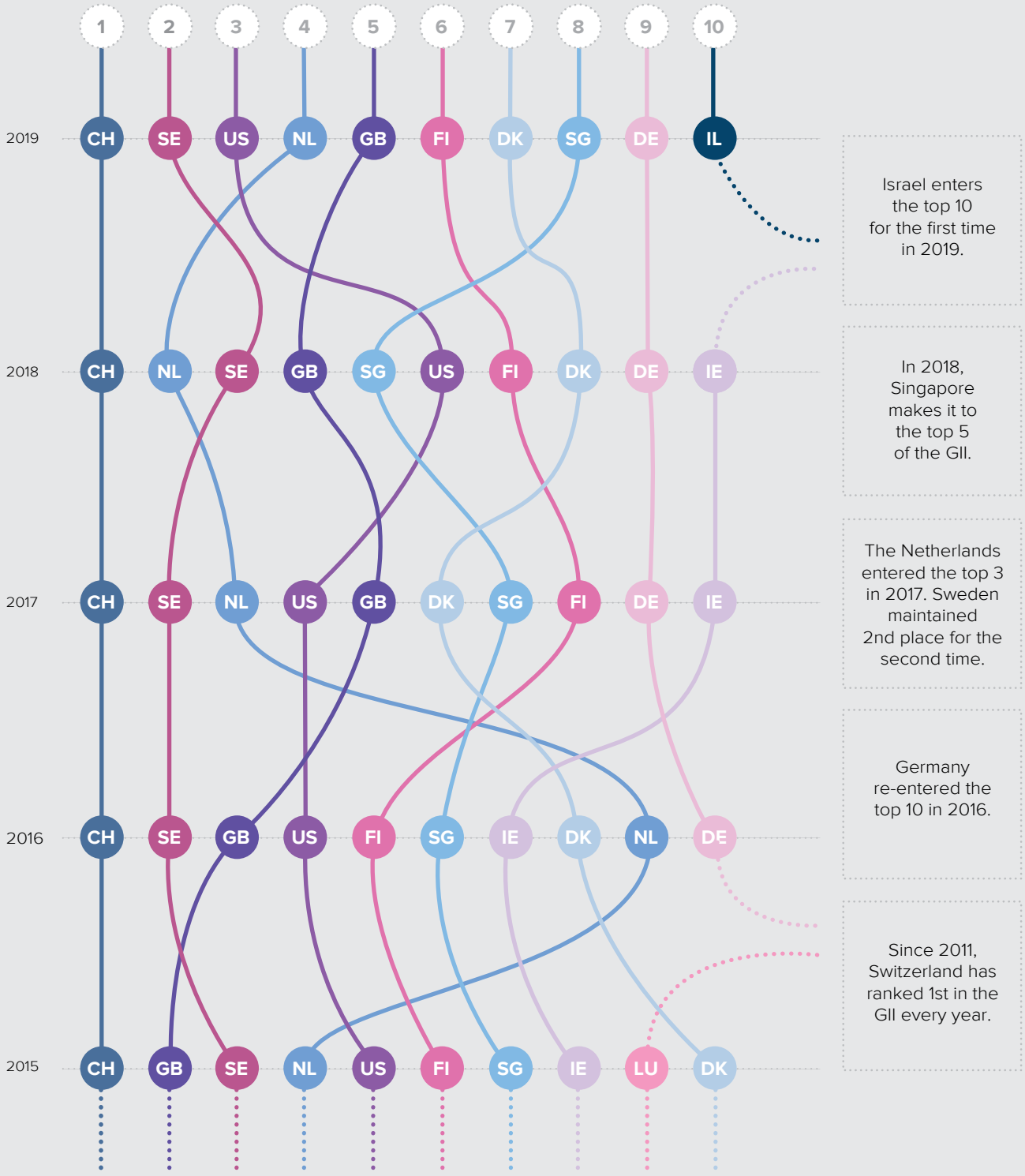
Top 3 innovation economies by income group

HIGH INCOME	UPPER-MIDDLE INCOME	LOWER-MIDDLE INCOME	LOW INCOME
1. Switzerland	1. China	1. Viet Nam ↑	1. Rwanda ↑
2. Sweden ↑	2. Malaysia	2. Ukraine ↓	2. Senegal ↑
3. U.S. ★	3. Bulgaria	3. Georgia ★	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



CH Switzerland
GB United Kingdom
SE Sweden
NL Netherlands
US United States of America
FI Finland
SG Singapore
IE Ireland
LU Luxembourg
DK Denmark
DE Germany
IL Israel

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]

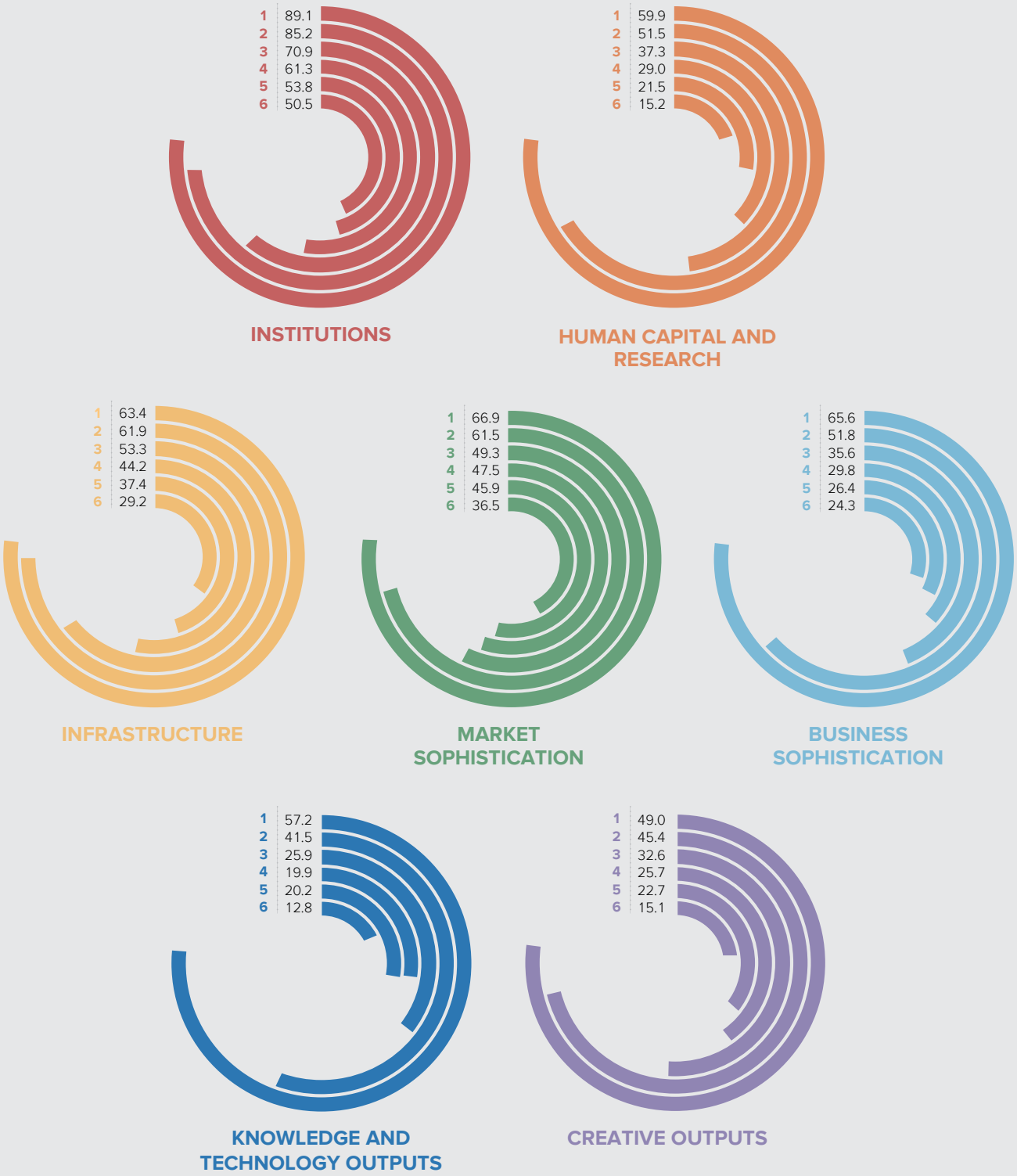
3. Regional divide

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

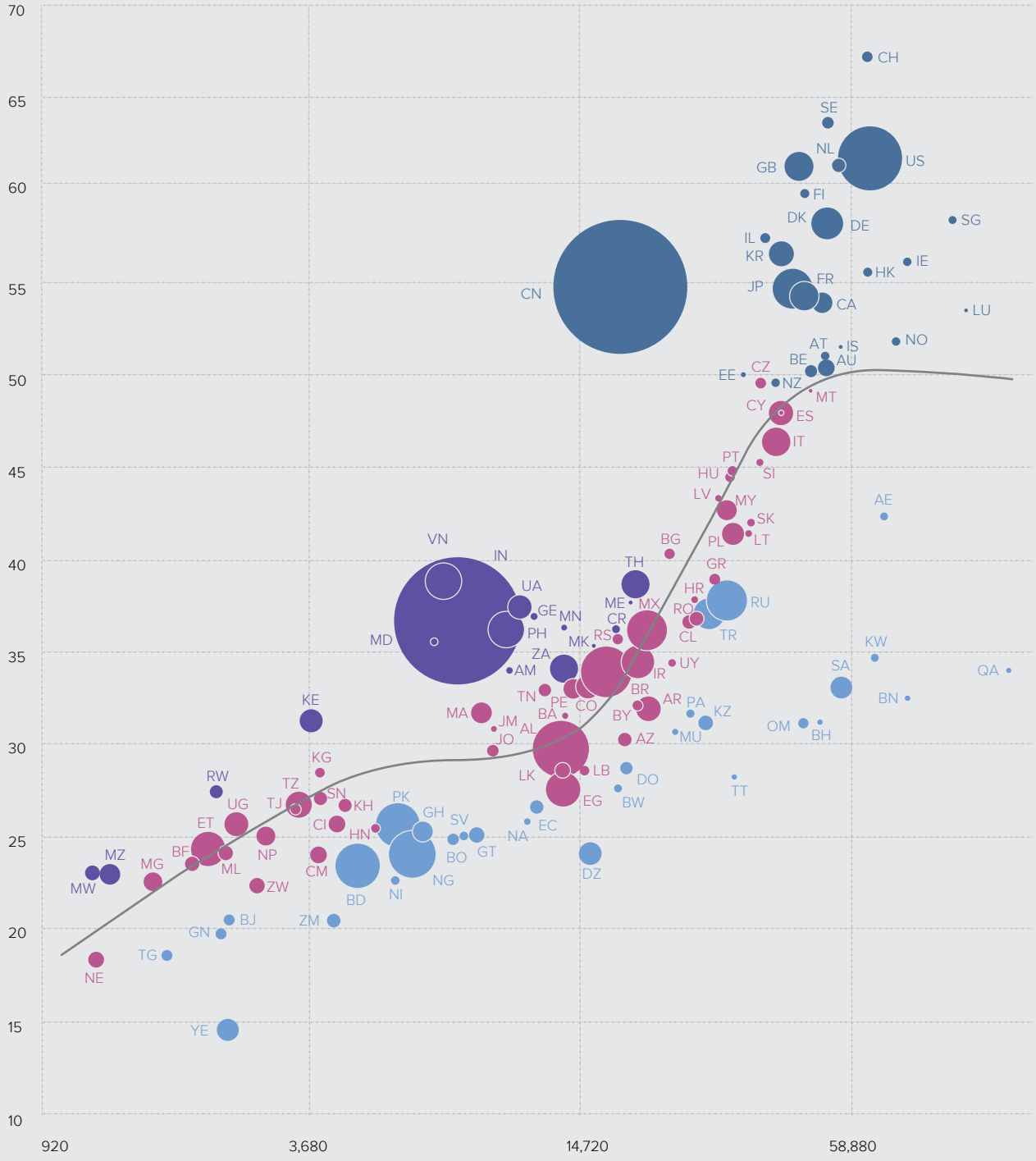
10 best-ranked economies by income group (rank)

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
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
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.

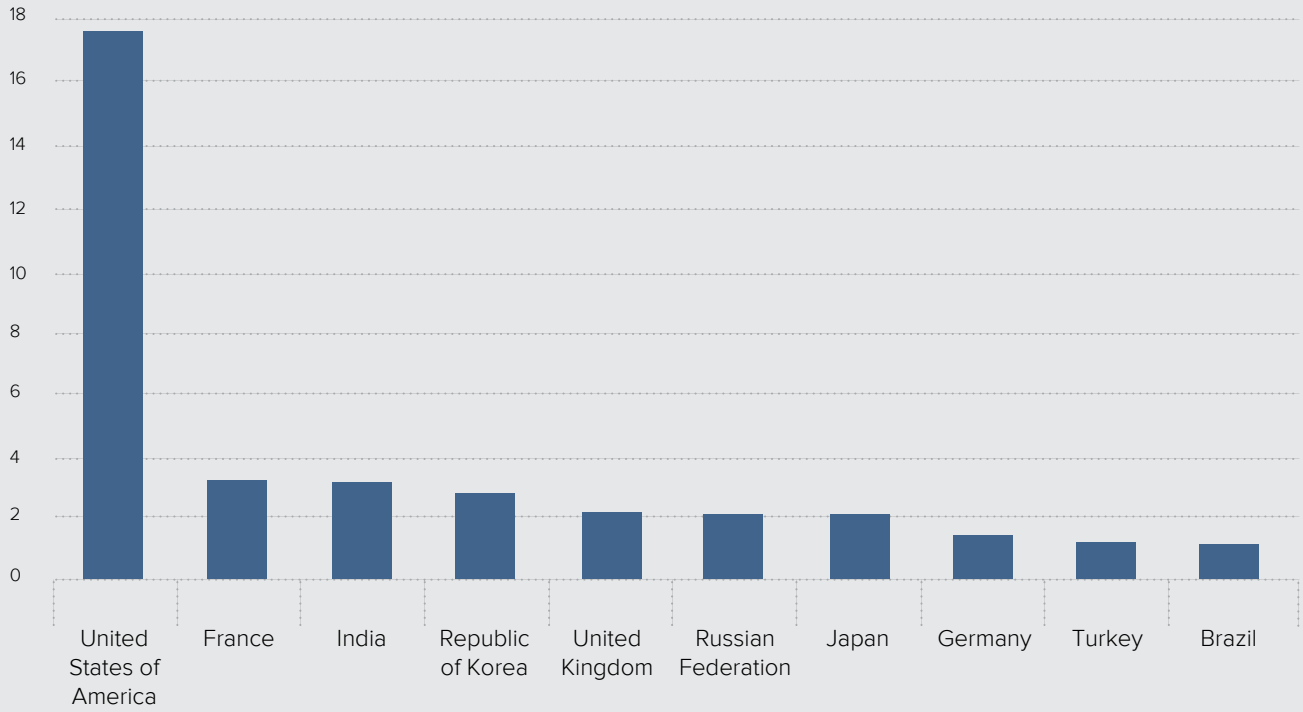
Since last year, in collaboration with App Annie and its mobile data platform, which tracks Google Play store and iOS App Store activity in each economy, the GII has been generating performance metrics based on the creation of mobile apps (Appendix IV). In absolute numbers, the U.S. is the uncontested 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



▲ Global app download (billions) produced by local companies

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.

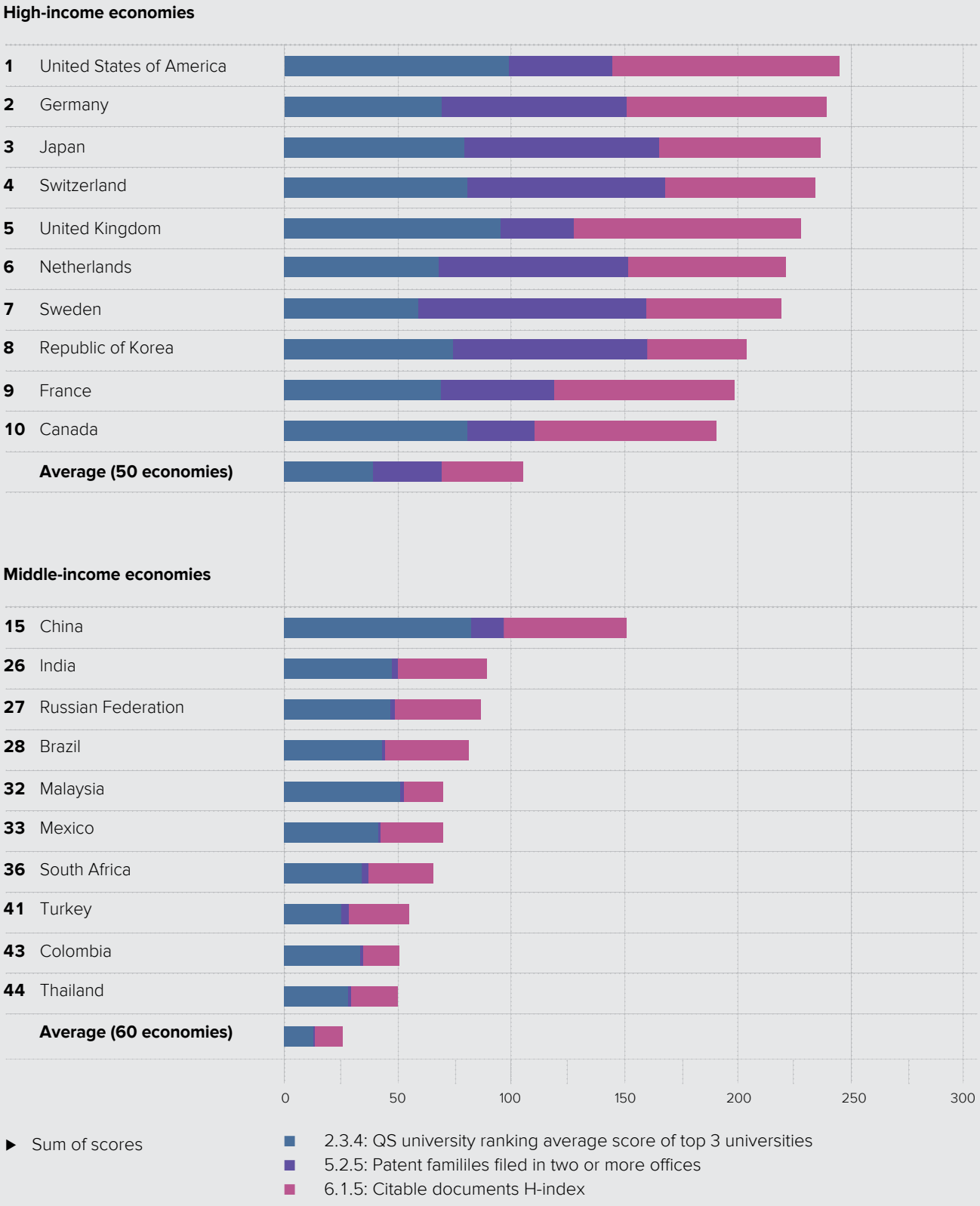
Among the high-income economies, the U.S. regains the top rank for quality of innovation, moving ahead of Japan, which moves down to 3rd this year. Germany is 2nd for the first time, above both Japan and Switzerland. The U.K. is stable at 5th, while the Netherlands moves up to 6th—its highest ranking 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).

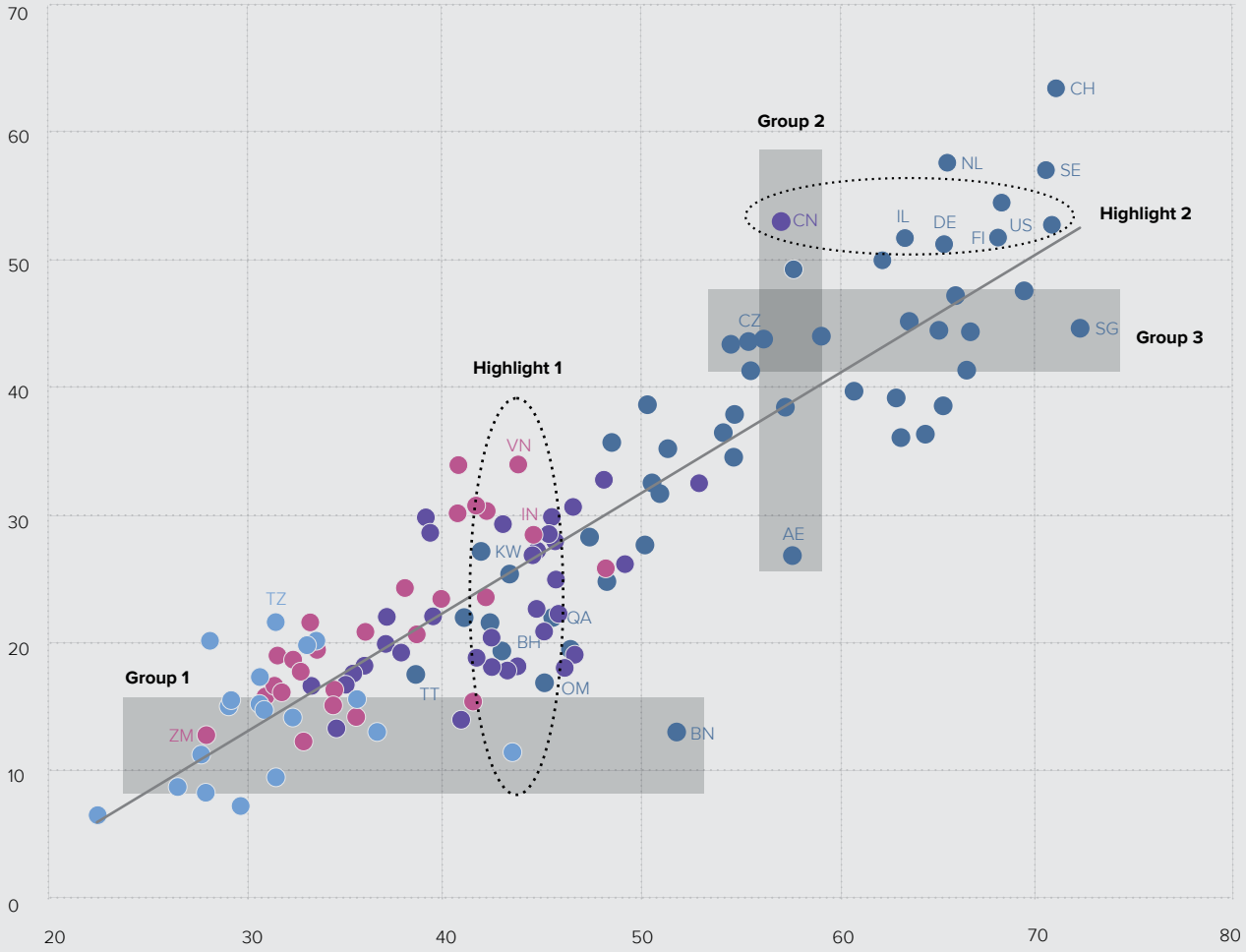
India ranks 52nd in the GII this year, gaining five positions since 2018. It remains 1st in the region and moves up to the 4th position in the GII rankings among lower-middle-income economies. India has also outperformed on innovation relative to its GDP per capita for nine years in a row, as shown in 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	CZ	Czech Republic	NL	Netherlands	TZ	United Republic of Tanzania
BH	Bahrain	DE	Germany	OM	Oman	US	United States of America
BN	Brunei Darussalam	FI	Finland	QA	Qatar	VN	Viet Nam
CH	Switzerland	IL	Israel	SE	Sweden	ZM	Zambia
CN	China	IN	India	SG	Singapore		
		KW	Kuwait	TT	Trinidad and Tobago		

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).

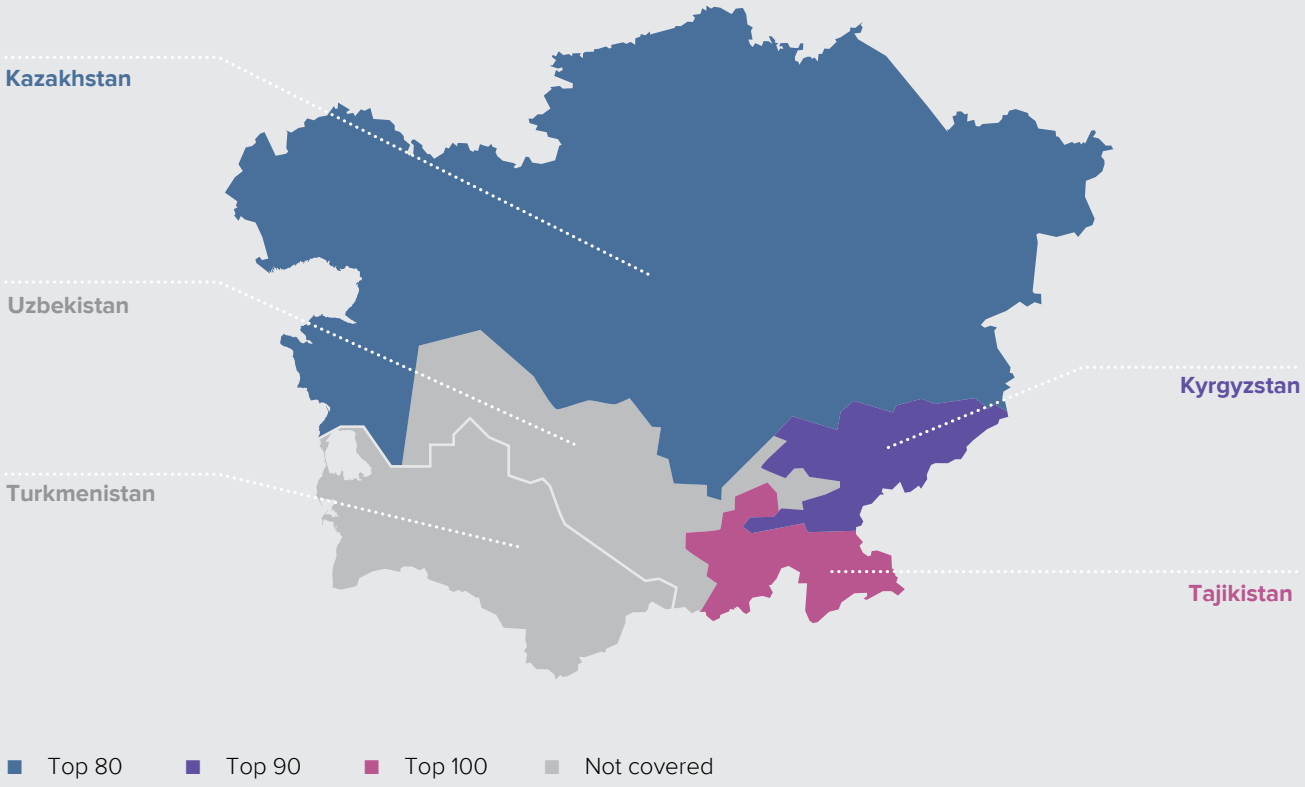
While India improved in the GII ranking, some relative weaknesses still persist. These include Environmental performance, New businesses, and Entertainment and media market.

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.

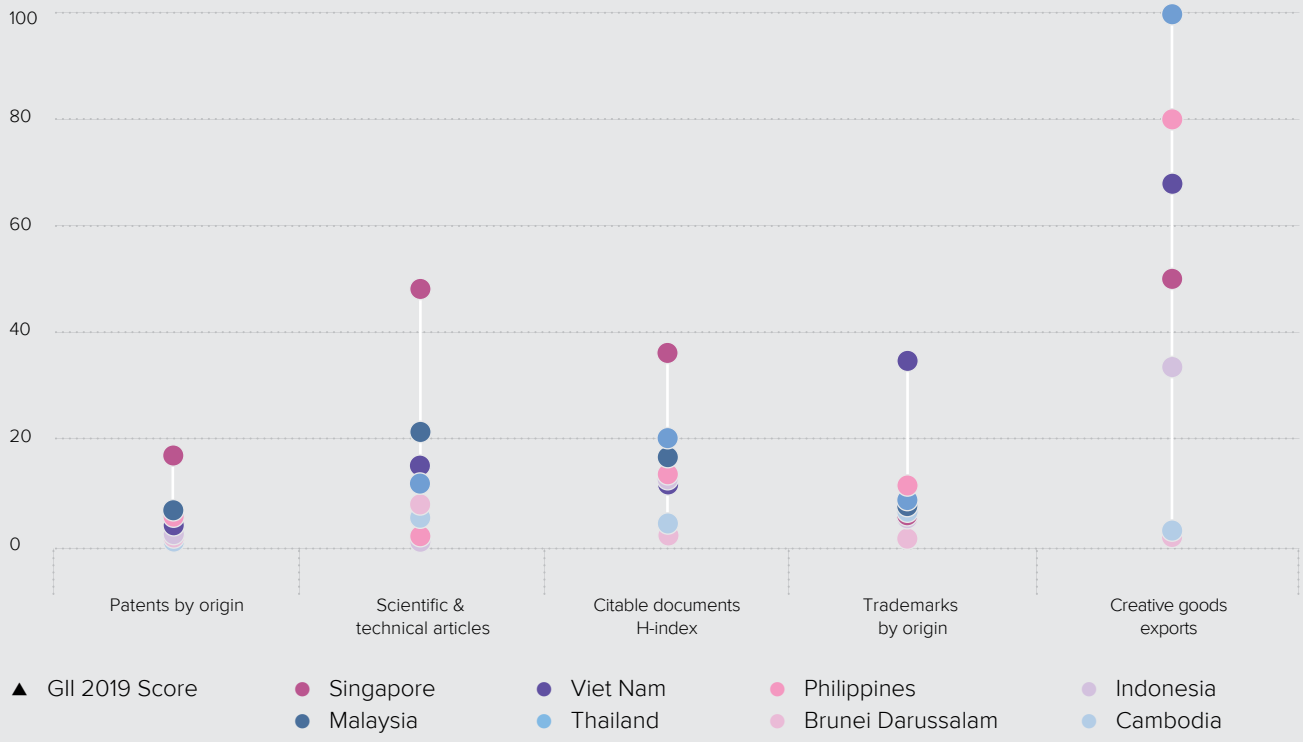
In input indicators, Viet Nam performs well in FDI net inflows but shows relatively low scores in Tertiary enrolment and Females employed with advanced degrees. It scores lowest in the group in Knowledge-intensive employment. In outputs, Viet Nam scores well in Scientific and technical publications, 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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