The Global Innovation Index 2016: Winning with Global Innovation

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Since the release of the Global Innovation Index (GII) last year, the world economy has encountered a number of challenges that have led to further downgrades of global economic growth projections. In the context of such uncertainty, countries will seek ways to move the global economy out of its current holding pattern, thus avoiding a prolonged low-growth scenario. Innovation will be a critical ingredient to achieving this objective.

Overcoming the holding pattern and restoring the foundations for future growth

The global economy is not yet back on track towards a broadly shared and vigorous growth momentum. The world's leading economic institutions predict modest growth for 2016, no significant improvement from 2015, and a slight pick-up of growth in 2017.[1] Growth forecasts for 2015 and 2016 have been revised downwards for all world regions in recent months.

Economic recovery has indeed slowed in most high-income countries, including in the United States of America (USA), Japan, and some European countries. At the same time, low- and middle-income countries now face significantly lower growth perspectives than they did a few years ago.[2] Although economic activity is weakening, Asia as a whole continues to show robust growth despite the slowdown in China. In turn, growth in Africa, Latin America and the Caribbean, and other world regions has decreased considerably to modest levels. The fall in commodity prices has seriously weakened commodity-dependent economies such as Brazil, the Russian Federation (Russia), Nigeria, South Africa, and countries in the Middle East.

In parallel with the slowed recovery, concerns about disappointing future output growth are increasingly widespread. Today, lower capital and slower productivity growth—particularly as compared with the productivity boom of the late 1990s and early 2000s in high-income economies—are a global phenomenon, throwing into question future growth and improvements in living standards globally.[3] The term 'productivity crisis', used to characterize this situation, is now in wide circulation.

As a result, policy makers are urged to move beyond austerity policies, which shrink rather than expand longer-term investments. Stepped-up public investments in innovation would be good for short-term demand stimulus, and also good for raising long-term growth potential. Uncovering new sources of productivity and future growth are now the priority.[4] Fostering innovation-conducive business environments, investing in human capital, and taking advantage of the opportunities that global innovation and cooperation offer are critical in this regard.

Key findings in brief

The six key findings of GII Chapter 1 are:

1. Leveraging global innovation can help avoid a continued low-growth scenario
2. There is a need for a global innovation mindset and discussions on fresh governance frameworks
3. Innovation is becoming more global but divides remain
4. There is no mechanical recipe to create sound innovation systems; entrepreneurial incentives and "space for innovation" matter
5. Sub-Saharan Africa needs to preserve the innovation momentum in one of the most promising regions
6. Latin America is a region with untapped innovation potential with important risks to innovation efforts in the near-term

Leveraging global innovation to avoid a continued low-growth scenario

In the aftermath of the global financial crisis of 2009, this report and others have urged decision makers from the private and the public

Box 1: Moderate post-crisis R&D expenditure growth largely driven by the private sector

After the 2009 financial crisis, global R&D grew by 3.7% in 2010 and 5.3% in 2011 (see Figure 1). R&D expenditures slowed somewhat in 2012 to achieve 4.3% growth but, with a gain in confidence, rose to 5.2% in 2013. In high-income economies, R&D growth was mainly the result of increasingly confident business R&D. However, our estimates show a subdued scenario for 2014, with global R&D growing at 4.1% and business R&D a bit stronger, at 4.5%.[1]

This drop in momentum is driven in part by reduced R&D spending in China, which is experiencing its lowest total R&D growth rate since 1998, and an R&D slowdown in other emerging economies such as Brazil, Colombia, Mexico, and South Africa. In addition, the slowdown is a consequence of tighter government R&D budgets in high-income economies. Only few countries—such as Poland, New Zealand, Belgium, Israel, the Republic of Korea (Korea), and Spain (in order of the magnitude) were able to increase their government commitment to R&D in 2014.[2] This trend will likely continue in 2015, putting further downward pressure on global R&D.[3]

As illustrated in Tables 1.1 and 1.2, the relative growth of R&D spending after the crisis has varied across economies. Countries such as Egypt, China, Argentina, Poland, Turkey, Korea, and India, for example (in order of actual total R&D growth since 2008) have maintained robust spending in R&D. European countries such as the Czech Republic, the Netherlands, and others have seen a fall in R&D but a subsequent strong recovery. However, countries such as the United Kingdom (UK), Japan, the United States of America (USA), and also Singapore have seen a more challenging road to R&D recovery. Finally, some countries in Europe, such as Sweden, Greece, Spain, and others, as well as Canada and South Africa, are lagging.

Note

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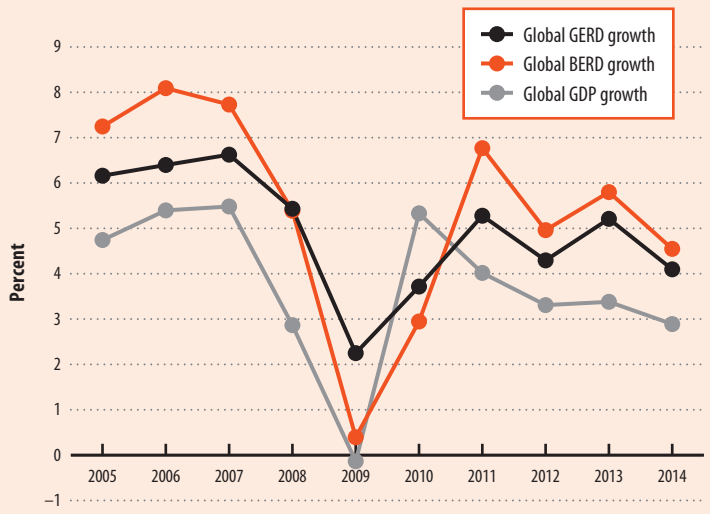
Notes for this box appear at the end of the chapter.

(Continued)

Figure 1: Global R&D expenditures: Losing momentum?



Source: Authors' estimate based on the UNESCO Institute for Statistics (UIS) database and the IMF World Economic Outlook database, April 2016.
Note: GERD = gross domestic expenditure on R&D; BERD = business enterprise expenditure on R&D.

sectors to avoid a cyclical reduction of innovation expenditures.[5] Now, about seven years after the crisis, the worst-case scenario of permanently reduced R&D growth seems to have been avoided, thanks largely to good government policies and the strong contribution of countries such as China, the Republic of Korea (Korea), and other emerging countries (see Box 1).[6]

This situation, however, is far from irreversible; more efforts are needed to return to pre-crisis R&D growth levels and to counteract the observed innovation expenditure slowdown. On par with the sluggish development of the world economy, our preliminary estimates show subdued global R&D growth for 2014 (see Figure 1). Slower R&D spending—particularly tighter government R&D budgets—in specific high-income economies such as the USA, Japan, and some European countries and slower R&D spending

Box 1: Moderate post-crisis R&D expenditure growth largely driven by the private sector *(cont'd.)*

Table 1.1: Gross domestic expenditure on R&D (GERD): Crisis and recovery compared

Countries with no fall in GERD during the crisis that have expanded since

	CRISIS		RECOVERY				
	2008	2009	2010	2011	2012	2013	2014
Egypt*	100	168	177	220	229	293	300
China	100	126	143	163	189	212	231
Argentina	100	115	128	145	165	171	n/a
Poland	100	113	127	138	166	166	185
Turkey	100	111	121	134	147	157	172
Korea, Rep.	100	106	119	133	147	155	166
India*	100	106	113	125	n/a	n/a	n/a
Mexico	100	102	113	110	116p	136p	150p
Hungary	100	108	110	116	121	136	138
Belgium	100	101	107	114	126	129	133
Colombia*	100	101	106	120	125	161	129
Russian Fed.	100	111	104	105	112	114	120
Ireland	100	110	110	107	110	109	114
France	100	104	105	108	110	111	112p
New Zealand†	100	107	n/a	109	n/a	108	n/a
Denmark	100	105	102	104	105	107	108p
Australia	100	n/a	102	102	n/a	107	n/a

Countries with fall in GERD during the crisis but above pre-crisis levels in 2014

	CRISIS		RECOVERY				
	2008	2009	2010	2011	2012	2013	2014
Slovakia	100	97	132	147	181	188	206
Czech Rep.	100	99	105	125	142	150	160p
Chile	100	93	92	104	114	127	125
Netherlands	100	99	102	115	116	116	118p
Austria	100	97	104	105	113	117	118p
Estonia	100	94	110	172	166	137	118p
Israel	100	96	97	104	110	113	116
Germany	100	99	103	110	113	112	114p
Norway	100	100	99	102	105	108	112p
United Kingdom	100	99	98	99	96	101	106p
Japan	100	91	93	96	97	102	105
Italy	100	99	101	100	103	104	102p
United States	100	99	99	101	101	104	n/a
Singapore	100	82	88	100	96	100	n/a

GERD below crisis levels in 2014

	CRISIS		RECOVERY				
	2008	2009	2010	2011	2012	2013	2014
Sweden	100	94	92	96	97	99	96p
Canada	100	100	99	100	101	97	95p
Greece	100	90	82	83	81	91	94p
Spain	100	99	99	96	91	88	86p
Luxembourg	100	98	93	93	80	84	84p
Finland	100	97	99	99	92	88	84
Portugal	100	106	105	98	89	85	83p
Iceland	100	100	n/a	92	n/a	73	75
Romania	100	77	74	82	82	68	69
South Africa	100	93	84	87	88	n/a	n/a

Source: OECD MSTI, February 2016; data used: Gross domestic expenditure on R&D (GERD) at constant 2010 PPP$, base year = 2008 (index 100).
* Country data source is the UNESCO UIS database; p = provisional data.
† Index year 2007; 2008 is missing.

Table 1.2: Business enterprise expenditure on R&D (BERD): Crisis and recovery compared

Countries with no fall in BERD during the crisis that have expanded since

	CRISIS		RECOVERY				
	2008	2009	2010	2011	2012	2013	2014
Poland	100	104	109	135	199	234	279
China	100	126	144	168	196	222	244
Turkey	100	101	116	131	150	168	193
Hungary	100	118	125	138	152	180	188
Korea, Rep.	100	105	118	135	152	162	172
India*	100	102	111	124	n/a	n/a	n/a
Ireland	100	116	116	116	121	124	129
Greece†	100	n/a	n/a	117	111	121	128p
Egypt*	100	105	110	112	115	117	120
New Zealand†	100	104	n/a	116	n/a	117	n/a
France	100	102	105	110	113	115	116p
Russian Fed.	100	110	100	102	104	110	114
Mexico	100	109	113	111	n/a	n/a	n/a

Countries with fall in BERD during the crisis but above pre-crisis levels in 2014

	CRISIS		RECOVERY				
	2008	2009	2010	2011	2012	2013	2014
Slovakia	100	93	130	127	174	203	177
Czech Rep.	100	96	103	118	130	139	153p
Belgium	100	98	105	115	131	134	139
Netherlands	100	93	98	130	131	129	133p
Argentina	100	93	108	130	129	129	n/a
Austria	100	96	103	104	115	119	121p
Israel	100	97	97	105	112	114	118
Estonia	100	98	127	252	221	151	118p
Norway	100	97	95	100	104	107	113p
Colombia*	100	73	82	96	116	113	112
Germany	100	97	99	107	111	108	112p
United Kingdom	100	96	96	102	99	104	111p
Italy	100	99	102	103	104	106	106p
Japan	100	88	90	94	94	99	104
Chile	100	68	68	88	97	110	104p
United States	100	96	94	97	98	103	n/a

BERD below crisis levels in 2014

	CRISIS		RECOVERY				
	2008	2009	2010	2011	2012	2013	2014
Denmark	100	105	98	99	99	98	99p
Australia	100	96	97	97	n/a	99	n/a
Singapore	100	70	75	86	81	83	n/a
Romania	100	103	95	99	107	69	95
Canada	100	98	95	98	95	90	88
Sweden	100	90	86	89	88	92	87p
Spain	100	93	93	91	87	85	82p
Iceland	100	92	87	90	n/a	76	78
Finland	100	93	93	94	85	81	77
Portugal	100	100	96	93	88	80	76
South Africa	100	84	71	70	67	n/a	n/a
Luxembourg	100	96	79	79	57	57	57p

Source: OECD MSTI, February 2016; data used: Business enterprise expenditure on R&D (BERD) at constant 2010 PPP$, base year = 2008 (index 100).
* Country data source is the UNESCO UIS database; p = provisional data.
† Index year 2007; 2008 is missing.

growth in emerging countries, in particular China, partly explain this slowdown.[7]

In terms of the global use of intellectual property (IP), the latest figures point to a 4.5% patent filing growth in 2014.[8] Although positive, this growth is lower than it has been in the previous four years.

Uncovering new sources of growth has shifted to become a priority for all stakeholders. Greater public investment in infrastructure and innovation would boost aggregate demand in the short term—which is needed in a world of chronic demand shortages—and it would raise long-term potential growth.

Our analysis of global R&D trends calls for a stronger role by the governments—one that goes beyond the stimulus packages concluded after the financial crisis—to support continued innovation expenditures and research. Historically, and still today, governments and public research actors have been central to driving critical innovations with important growth potential.[9] Even in high-income countries, the vast majority of basic R&D—which is critical to the progress of science, and hence to long-term growth—is financed and conducted by public actors.

Moreover, the growth of innovation expenditures in the developing world has largely been driven by only a few countries, most notably China. The question faced by the innovation community is how to more systematically spread R&D to other low- and middle-income economies, avoiding an overreliance on a handful of countries to drive global R&D growth. Also, even leading emerging countries, including China, still spend only a fraction of their research budget on basic R&D; instead they focus on applied R&D and development.[10]

Furthermore, as underlined in previous editions of the GII report, the focus cannot be on R&D expenditures alone. Rather, innovations—whether they are technological or non-technological, first-rate and new to the world or more incremental and new to the local market only—need to be efficiently deployed in the market place to have a true impact. The journey from a scientific invention or a creative business idea to a commercial, widely deployed successful product is as risky and challenging now as it has ever been.[11] A focus on large innovation inputs such as large R&D expenditures or a high number of scientific papers alone is not a recipe for sure success; promoting entrepreneurship and an innovation-conducive environment are vital.

One of the central views discussed in this year's GII is that a more globalized and diversified innovation system offers more promise today than ever before, both on the innovation supply side and, importantly, also the diffusion side. The potential gains of these promises remain under-assessed and probably underexploited.

Winning with global innovation

It is now common wisdom that science and innovation are more internationalized and collaborative than ever before. Moreover, thanks to facilitated cross-border flows of knowledge, a rising share of innovation is carried out through global innovation networks, leveraging talent worldwide.[12]

Understanding global innovation as a global win-win proposition

Arguably, all stand to gain from global innovation. There are reasons for significant optimism.

First, in terms of overall effort, more innovation investments are conducted today than ever before, including in sectors or industries that were previously considered medium- or low-technology. At the same time, information and communication technologies (ICTs) and the resulting data capabilities have driven down the costs of innovation (see also Lyons in Chapter 7).

Second, through increased international openness, the potential for global knowledge spillovers and technology transfer are on the rise by historical standards, via, for example, cross-border trade, foreign direct investment (FDI), the mobility of highly skilled people, and the international licensing of IP as measured by the GII framework.[13] Clearly, the importance of international R&D spillovers has long been recognized.[14] Inbound and outbound flows in innovation inputs and outputs drive productivity and economic growth. These internationalization efforts are no longer the affair only of large firms from rich countries. Building on research capacities at home, firms and entrepreneurs from developing countries are venturing abroad as they develop new products and services for global markets (see, for example, Kim et al. in Chapter 6).

Finally, diverse innovation actors in emerging countries now make meaningful contributions to the local and global innovation landscape. After significant catch-up in human capital and research capacities, a number of middle-income economies now play a prominent role in science and innovation, as documented extensively in a number of chapters of this year's GII (see Athreye and Cantwell in Chapter 2 and von Zedtwitz and Gassman in Chapter 9).[15] Indeed, the share of high-income countries in global

R&D expenditures and the production of global scientific publications and IP filings worldwide have decreased, though often as a result of the rise of China alone.[16]

As a consequence, the quest for innovative solutions becomes more wide-ranging and intense; affordable innovations—in areas as varied as health and the environment—are being sought more than ever. As original solutions are developed to suit local markets, innovative products and services are also becoming more useful for developing countries. With the right support, a South–South market in affordable technologies for lower-income consumers will develop (see last year's GII Chapter 1 and Chaminade and Gómez in Chapter 3 of the GII 2016).[17]

Yet, despite these promising prospects, innovation is sometimes not portrayed as a global win-win proposition. On the contrary, most metrics and innovation policies are designed for the national level. When actors of one country produce more science or engineering graduates or more patents, their abundance is perceived by other countries as a competitive threat rather than as a chance. When countries import technology or technology-intensive services from abroad this is regularly considered to be more a cost than a gain. Countries are rather perceived as 'contenders rather than collaborators' (see Chapter 2).

On balance, policy makers every so often worry that global innovation contributes to a 'hollowing out' of domestic national innovation systems. Their priority is to keep talent and investment at home. Worse, 'techno-nationalist policies', as noted in Chapter 2—the spurring of national technologies at the expense of others and the erection of barriers to different knowledge and technology flows—is a popular endeavour in many countries.[18]

What is needed to better communicate and amplify the benefits of global innovation and related cooperation?

First, measurable evidence regarding the organization and outcomes of the current global innovation model is missing. Although empirical economic work has gone a long way towards supporting international trade as a win-win strategy and in constructing appropriate indicators, the same is not true for global innovation. Additional analysis is required to understand the circumstances under which the globalization of innovation is positive and what obstacles need addressing.

Second, and building on the above, business strategies and public policies need to better approach innovation as a global positive—rather than as zero-sum proposition—and better complement the realm of national innovation systems.

Providing reliable evidence of the extent and impact of global innovation

Although the process of ever-more globalized innovation is not new, metrics and studies needed to study its extent, characteristics, and main impacts are missing.

Over the last few decades, significant progress has taken place to document the rising extent of the scientific and innovation capacity of particular nations; this is now measured in terms of R&D levels, researchers or graduates, publications or patents worldwide. A majority of countries now collect R&D, innovation, or IP data thanks both to the work of a number of international organizations devising survey manuals and questionnaires and to national statistical offices collecting data.[19] In contrast, measuring within-country innovation flows as well as measuring global innovation flows between countries—the topic of this GII—remains notoriously difficult.

It is still a challenge to capture cross-border knowledge flows and technology transfer, and to assess their impact and effectiveness. Clearly the levels of the main market-based channels of international technology transfer—classically trade, FDI, and technology payments for IP—are now better captured by official international data sources than they used to be. In the case of trade, disentangling high-tech from low-tech exports and establishing the knowledge-intensity of domestic value-added have become easier.[20] In the case of FDI, the overall volume of inbound and outbound investments is also available today.[21] Yet determining the exact industrial sector into which FDI flows, and how rich in R&D and technology these investments are, remains mostly infeasible on the basis of available data.

In the case of international licensing of IP and technologies, important data progress has been made to reflect cross-border payments for proprietary rights, such as patents or trade secrets.[22] Even so, these metrics are hardly available at the sectoral level, and for various methodological reasons these data are fraught with problems and hard to use as a comprehensive and reliable indicator of IP-based technology transfer.[23]

Worse, more directly innovation-related data—on indicators such as international R&D joint ventures and foreign R&D investments, including the setting up of R&D centres abroad—are available only in a patchy manner and often from non-official sources only. Indeed, firms are not asked to report on these critical activities when they

Box 2: Global Innovation and the UN 2030 Agenda for Sustainable Development

In July 2015, the Member States of the United Nations (UN) adopted the Addis Ababa Action Agenda on Financing for Development, focusing on the need to address the uneven distribution of innovative capacity.

In addition, in September 2015, the UN Member States adopted the 2030 Agenda for Sustainable Development, comprising 17 Sustainable Development Goals (SDGs) and 169 targets that will shape global development in the period 2015–30 (see Box 1 in Chapter 2 of the GII 2015). Most of the SDGs are directly or indirectly related to or influenced by technological upgrading, innovation, and related polices. Goal 9, for example—'Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation'—refers to several factors referenced in the GII: infrastructure, research, and technology.

In both UN processes, sound national innovation systems and effective global innovation flows are seen as key to promoting scientific, technological, and policy solutions.

In particular, the SDGs and their targets provide the framework for monitoring, reviewing, and ensuring the accountability of the 2030 Agenda at global, regional, and national levels. This process is based on statistical indicators established through an international consultative process. Disaggregated data—including better metrics of global innovation flows and technology transfers called for in earlier sections of this chapter—are important for monitoring SDG progress and making a clearer determination of the challenges and opportunities.

Although the GII is not part of the official list of indicators for implementation, it provides countries with an additional data-based tool for evidence-based policy making. On the basis of the GII, numerous workshops are taking place in different countries to bring innovation actors together to improve data availability, to boost the country's innovation performance, and to design fresh policy actions. Also collaborations are ongoing between the GII publishers and many UN organizations, in particular the United Nations Educational, Scientific and Cultural Organization (UNESCO), as well as private data providers, to optimize innovation metrics to monitor innovation performance. Countries are free to use these data to work towards the SDGs and to help foster global innovation flows.

follow standard reporting requirements. Yet, generally, understanding the role of multinational corporations in technology transfer and local spillovers in terms of scaling up domestic innovation capacity and skills is critical.[24] In sum, the internationalization of corporate R&D and its exact dynamics of technological upgrading as a result are insufficiently studied and understood.

Another type of 'embodied knowledge' flows is the migration of graduates, skilled scientists, and entrepreneurs. Vital work to better document the migration of highly skilled graduates or foreign-born inventors has taken place,[25] yet more needs to be done on this front.

Furthermore, a significant share of knowledge is accessible at no cost and diffuses freely, not through market-based mechanisms. Examples are the knowledge obtained through imitation and reverse engineering and knowledge obtained via distance learning courses, patent documents, or scientific publications. One can conjecture that the related benefits of these forms of knowledge transfer are large, if not huge. Yet neither the flows nor the gains can be suitably assessed.[26]

More importantly, assessing the quality and effectiveness of these market- and non-market based channels based on available data is mostly infeasible without further empirical validation.[27] Assessing the barriers to knowledge transfer and trade in ideas is also a relatively new area of research.[28] Issues to be addressed include what developing countries can do in terms of institutions, regulations, and their innovation systems to benefit more from R&D spillovers.

Finally, mostly available assessments of collaboration are still narrowly limited to assessing international co-ownership of patents or scientific papers by people in different countries. These data come with a number of methodological shortcomings.[29] More critically, they convey a merely one-dimensional, narrow view on international collaboration by documenting joint intermediate R&D-related outputs but not commercialized innovation or the benefits associated with this collaboration. As noted by Bound in Chapter 4, these popular collaboration data are also lagging and static indicators. International collaboration in science and innovation happen instead in fluid networks with their own internal dynamics, requiring the development of more networked-based metrics and approaches.

The same is true for efforts of governments or public research organizations to encourage international R&D collaboration. Although high-income countries pledge to collaborate more internationally, in particular on global challenges, the extent and impact of these collaborations are poorly documented.[30] In the same vein, exciting new efforts by public-private partnerships and

non-governmental organizations fostering global R&D and innovation collaboration are in progress. They bring together an array of innovation actors to solve global challenges—examples include joint research efforts on neglected diseases.[31] Yet it is hard to put an overall aggregate figure on their aggregate impact, particularly because these global efforts occur in a decentralized fashion. Although attempts are underway to document the overall impact of innovation, little evidence is available to document the benefits of international collaboration and the benefits of global R&D spillovers.

Finally, a lot has been written on the potential for South–South innovation flows or reverse innovations in which technology flows from developing to developed countries.[32] With some exceptions (see Chapter 3), most of the related evidence is based on anecdotes but certainly not robust data. Thus, in Chapter 4 Bound argues that the potential of these new innovation flows veers from 'wildly romanticized' to 'dangerously underestimated'.

This lack of transparency undermines the trust needed to build win-win alliances, as they typically involve local and global (external) innovators, as noted by von Zedtwitz and Gassman in Chapter 9. The lack of available data on global innovation flows and aggregate impacts is also crucially missing in debates around the UN Sustainable Development Goals (SDGs) (see Box 2) and in debates surrounding the topic of 'technology transfer'.

Better business strategies and innovation policy approaches to maximize benefits

Better business strategies and policy approaches, along with fresh approaches to encourage global innovation cooperation and its governance, are required to maximize the benefits of global innovation.

When trying to identify how business strategies and public policies can be better attuned to reflect and leverage the advantages of global innovation, an array of 'horizontal challenges' presents itself:

First, as noted in this year's *Science and Engineering Indicators* report and the *UNESCO Science Report,* a multipolar world of research and innovation has emerged rather than one where the global innovation divide has been overcome (see also Box 3 on page 10).[33] Despite the increasingly global nature of research and innovation activities, the majority of activities are still concentrated in high-income economies and select middle-income economies such as Brazil, China, and India.

Second, as noted in Chapter 2, even most middle-income countries still depend on technology transfers from developed economies for solutions to mainly domestic problems (e.g., combatting diseases such as malaria or securing cheaper energy sources). Better technology diffusion to and within developing countries will help these countries to narrow the gap with advanced countries.[34] This must be a priority for all stakeholders in order to reap the fruits of innovation.

Third, appropriate research and innovation for and from lower- and lower-middle-income economies are desperately needed. Worryingly, some experts are raising concerns that global innovation might harm rather than and help this goal.[35] As increasing numbers of prominent scholars work together across borders, top innovators are drawn away from focusing on local needs. As a result, fewer global research results are being assimilated locally. As noted by Katragadda and Bharadwaj in Chapter 12 and Gokhberg and Roud in Chapter 13, developing countries need to clearly spell out their own innovation needs and strategically pursue them, rather than only feeding into globalized corporate innovation networks.

Fourth, although difficult to measure, there seems to be ample scope to expand global corporate and public R&D cooperation. In particular, much underused potential for innovation collaboration exists at the regional level—within Africa, within Asia, within Latin America and other regions.[36] The same is true for technology diffusion and cooperative research between rich and poorer countries.

Some of the resulting opportunities and challenges of global innovation can be outlined, both for firms and governments.

Firms: Embracing global corporate innovation networks and overcoming related complexities

For firms, perceiving global innovation as a win-win opportunity has been a long time in the making. Multinational corporations have started to move R&D resources across the world. They have located R&D resources in emerging countries for more than a decade, playing a critical role in bridging the technological gap between high- and middle-income countries and often leveraging the low-cost access to exceptional talent (see particularly Chapters 3, 7, 9, and 12 in this edition of the GII). Rather than only adapting products to local markets, more and more frequently research is conducted that helps to solve local problems in developed and developing countries alike.

Yet, despite a broadly positive trend, the extent of globalized R&D is still mostly incipient; untapped potential exists according to the

Box 3: The global innovation divide: China among top 25 and the narrowing gap between low- and middle-income countries

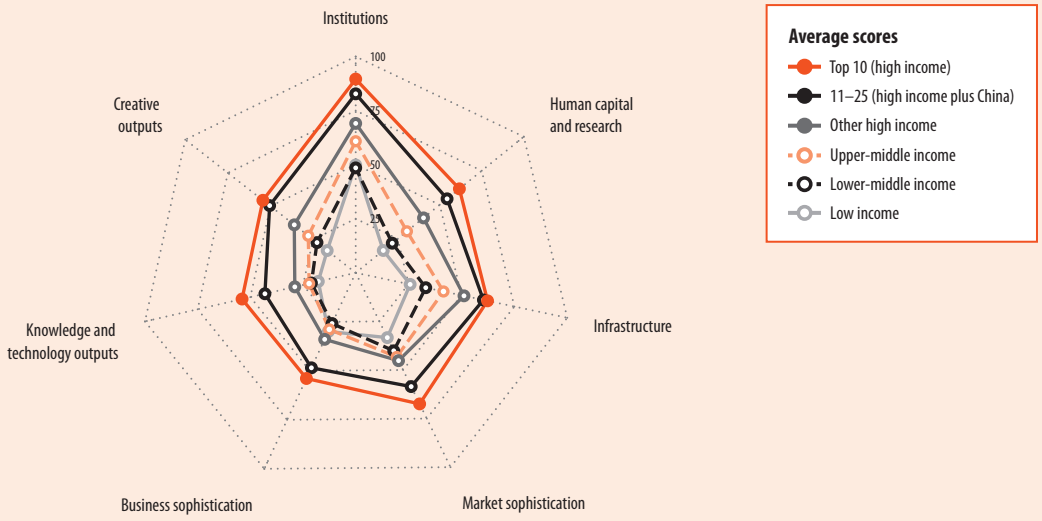
The top 25 GII slots are occupied by a stable set of high-income countries that consistently lead in innovation. In past years, hardly any country moved in or out of this group of top performers. This year some notable changes take place within the top 25, in part because of the inclusion of new indicators. Notably, for the first time a middle-income country—China—is among the top 25.

In the top 10, Switzerland remains at number 1 for the sixth consecutive year. Germany is in the top 10 in this year's GII, at 10th place, with Luxembourg (12th) exiting. Germany's entrance into the top 10 relies on its consistent performance in areas such as Research and development (sub-pillar 2.3) and Knowledge creation (sub-pillar 6.1), and it attains top indicator rankings in logistics performance (3.2.2), patent applications by origin (6.1.1), and country-code top-level domains (7.3.2). In addition, top scores in newly introduced indicators such as the average expenditure of top 3 global R&D companies (2.3.3) explain this rise.

The Czech Republic drops out of the top 25 this year. At the same time, China joins the top 25 group. This inclusion is driven not only by China's innovation performance but also by methodological considerations, such as the addition of four new indicators where China does particularly well. For example, the country has a particularly high number of R&D-intensive firms among the top global corporate R&D spenders (see Annex 2). China's innovation rankings this year also reflect high scores in both the Business sophistication and Knowledge and technology outputs pillars, in which it scores above the average of the overall ranked 11–25 group to which it now belongs. Top scores in indicators such as patent applications by origin (6.1.1), utility model applications by origin (6.1.3), high-tech exports (6.3.2), and creative goods exports (7.2.5), as well as in the new indicators, global R&D companies (2.3.3), domestic market scale (4.3.3), research talent in business enterprise (5.3.5), and industrial designs by origin (7.1.2) are all factors behind this high ranking.

The distance between the top 25 and the groups that follow is still evident. Figure 3.1 shows the average scores for six groups of economies: (1) the top 10, which are all high-income economies; (2) ranks 11–25, which are high-income plus China; (3) other high-income; (4) upper-middle-income (excluding China); (5) lower-middle-income; and (6) low-income economies.

Figure 3.1 Innovation divide bridged: China reaches the top 25



Note: Countries/economies are classified according to the World Bank Income Group Classification (July 2015).

Box 3: The global innovation divide *(cont'd.)*

Distinction between the top 10 innovation leaders and others in the top 25

The top 10 high-income economies perform above the 11–25 group in all pillars. This group's strengths are in Human capital and research (pillar 2), Market sophistication (pillar 4), and Knowledge and technology outputs (pillar 6). Past performance shows that the gap between both groups is currently larger in all the input-side pillars of the GII with the sole exception of Business sophistication (pillar 5). Conversely, this contrast also shows that variations in performance are now more narrow in Knowledge and technology outputs (pillar 6) and in Creative outputs (pillar 7), both of the pillars in the output-side of the GII.

That said, a number of high-income countries that rank in the 11–25 range—such as the Republic of Korea (11th), Canada (15th), Japan (16th), and Estonia (24th)—perform above the average of the top 10 in various pillars (i.e., Institutions, Infrastructure, and Creative outputs). China is not yet on par with any of the top 10 countries in any pillar. However, China scores higher in Business sophistication (pillar 5) and Knowledge and technology outputs (pillar 6) than its peers in the 11–25 group.

Middle-income economies: China closest to high-income countries, with Malaysia now at greater distance

Last year, China and Malaysia were the only two middle-income economies close to the top 25 group. Except for these two countries, the divide between the group of upper-middle-income economies and the group of other high-income 11–25 ranked economies was large, especially in the Institutions, Human capital and research, Infrastructure, and Creative outputs pillars.

On the variable level, and both in absolute and relative terms in relation to other countries, China has demonstrated the strongest improvement over the years in various key indicators, including gross expenditure in R&D (2.3.2), ICT services imports (5.3.3), the number of patent applications filed by residents (6.1.1), and citable documents H index (6.1.5) as well as other variables associated with the development and creation of human capital in innovation, such as tertiary enrolment (2.2.1), school life expectancy (2.1.3), tertiary inbound mobility (2.2.3), and the ranking average score of its top 3 universities (2.3.4).

With China part of the top 25, Malaysia (at 35th) is the closest middle-income economy to China in terms of its ranking, yet the distance between them has widened. Bulgaria, at 38th place, is the second middle-income economy in line. Indeed, Malaysia and Bulgaria show similar or higher pillar scores than those of the high-income economies group that are not in the top 25, especially in the Business sophistication and Knowledge and technology outputs pillars. A few middle-income countries—such as Turkey (42nd), Costa Rica (45th), the Republic of Moldova (46th), and Romania (48th)—are in the top 50.

On average, however, the divide between middle-income and high-income economies stays large, and continues to hold mostly in Institutions (pillar 1), Human capital and research (2), Infrastructure (3), and Creative outputs (7). Relative to last year, and possibly in part because of methodological considerations, the divide between these groups has also increased more notably in the Human capital and research and in Business sophistication and Knowledge and technology outputs pillars.

Low-income economies: Closing the gap with middle-income economies

Confirming a trend first spotted in the GII in 2014, on average, low-income economies successfully continue to close the innovation divide that separates them from middle-income economies. On average, and possibly related to the GII model changes, the gap is still significant especially in some pillars: Human capital and research, Infrastructure, Market sophistication, Knowledge and technology outputs, and Creative outputs. But the gap between the low- and lower-middle-income clusters in two pillars—Institutions and Business sophistication—has now disappeared. In fact, low-income economies now outperform even the upper-middle-income group on average in business sophistication. Efforts to bolster solid institutions and to enable businesses to thrive have seen considerable impact. Effectively this also means the old boundaries and innovation glass ceilings are further eroding. Countries such as Rwanda (83rd), Cambodia (95th), Malawi (98th), Uganda (99th), Benin (121st), and Burkina Faso (122nd) are a few of the low-income countries helping bridge the divide by shining above the average middle-income scores in more than one pillar.

Stability in regional innovation divides

The overall regional rankings based on the GII average scores show that the Northern America region is at the top (58.1), followed closely by Europe (46.9) and South East Asia, East Asia, and Oceania (44.6). Northern Africa and Western Asia (33.9) and Latin America and the Caribbean (30.3) are closing in on each other's scores, while this year the Central and Southern Asia average score (27.7) is marginally above that of Sub-Saharan Africa's average scores (25.6).[1]

Note

1 Regional groups are defined based on the United Nations classification, United Nations Statistics Division, revision of 13 October 2013.

chapters presented in this report. Most companies in high-income countries—particularly small- and medium-sized enterprises—and nearly all firms in emerging economies run all of their product development and innovation activities from their corporate centre (see Chapter 9). Other companies are on the verge of spanning more globalized networked innovation models, but still have the majority of their R&D centralized at home (Chapter 6).

In part this is because costs and benefits of geographic decentralization are still being explored. Many of the chapters in this year's GII illustrate the complexity of conducting globalized corporate innovation models, the difficulty of coordination between various departments and locations, and the centrality of improved governance and processes. As noted by von Zedtwitz and Gassman in Chapter 9, 'managing global R&D is more than just … coordinating foreign R&D teams—it is about managing the flow of innovation regardless of corporate allegiances and ownership, and appropriating the benefits irrespective of headquarter locations.' The greater division of work and increased specialization make the coordination of global innovation more demanding.

For most companies, building diverse local and international partnerships is challenging. As noted by Engel et al. in Chapter 8, the majority of firms have insufficient processes to identify, select, build and operate, and exit innovation partnerships globally. Yet organizations that systematically harness these relationships—including relationships with domestic start-ups, small- and medium-sized enterprises, and customers—will be best prepared to capture the next wave of growth. This nurturing of relationships requires experimentation with new customized partnership models and open innovation platforms, as illustrated by Poh in Chapter 10.

Moreover, as noted especially in Chapters 6, 7, 8, and 12, a new innovation culture is required to benefit from global innovation. This entails flatter hierarchies; increased cross-functional collaboration across R&D, supply chain management, and marketing; a diversified talent pool that brings in fresh perspectives and skills unencumbered by traditional approaches; an environment that encourages risk-taking and failure and learning from it; and cooperation with external players and customers to complement internal innovation.

Firms also need to walk a careful line between globalization and localization. As noted by Kim et al. in Chapter 6 and Katragadda and Bharadwaj in Chapter 12, firms need to simultaneously build global R&D capacity and develop localized solutions after having understood local customers' needs.

Finally, rolling out innovation globally is challenging. No matter how large or small a firm is, the execution of ideas and innovations in the global market place remains arduous and is largely guided by trial-and-error approaches. As noted in Chapter 9, this is particularly true when firms try to transfer innovative products from a developing country to an advanced one.

Governance and policy: Adjusting to the reality of global innovation

For governments and national policy making, facilitating increased international collaboration and complementing inward with more outward-looking approaches is now key to sustained success in innovation.

To be clear, there is no reason to believe that past national innovation approaches were misguided. On the contrary, throughout history nationally conducted innovation efforts and policies have largely been good for the world. This is partly because innovation is a global public good: regardless of who invests heavily in bringing about new scientific discoveries or innovations, they often diffuse beyond boarders to enrich other countries as well. In the same spirit, the national innovation policies of different countries—whose innovators and firms often compete against one another—have and will continue to create largely positive effects.

Rather the point is that the more globalized innovation processes offer new possibilities that countries are only learning to seize. In this context, Wagner et al. (2015) emphasize that

> The global network presents opportunities for … policy-makers to seek efficiencies that were not available when a few nations dominated science. With improved scanning of research and more effective communications, it may be possible to leverage foreign research, data, equipment, and know-how … . [Nations] must learn to manage and benefit from a network. Networks operate by reciprocity, exchange, incentives, trust, and openness, so explicit policies of support for complementary links [are desirable].[37]

In addition, an increasingly vast array of global challenges requires more internationally coordinated efforts to seek fitting and timely solutions.

For a start, policies need to further support openness, as suggested by Poh in Chapter 10. Identifying barriers to global cooperation and the flow of ideas should be a new global innovation policy priority. Removing barriers to mobility and fostering the cross-border flows of knowledge and people matters greatly in this context. Avoiding the

creation of new techno-nationalist barriers is also critically important.

In addition, national policies and related incentives should avoid focusing on domestic players alone to full reap the benefits of global innovation. Fiscal incentives, grants, and other national innovation policies could more explicitly favour international collaboration and the diffusion and integration of knowledge across borders. Calls for proposals could, more often, be jointly issued by multiple countries, particularly when convening large-scale, multi-disciplinary programmes. The programmes implemented at the European Union level have garnered experience and could serve as useful starting point.[38]

National and international science and innovation policies should also become more inclusive of developing countries. Fortunately, these countries have gained recent experience with programmes explicitly focused on research cooperation with developing counties—see, for example, the US Agency for International Development (USAID), the National Science Foundation (NSF), and the National Cancer Institute (NCI) joint research projects in the USA; in Switzerland, see the Commission for Research Partnerships with Developing Countries aimed at 'North-South' research.[39] Revamping official development assistance with the inclusion of R&D and innovation components is a welcome development. Guidance, too, is emerging on how to structure such cooperation between the developed and the developing world too.[40]

Edler in Chapter 5 and Finkel and Bell in Chapter 10 also emphasize the need to craft globally focused demand-side innovation policies. In their view, traditional supply-side innovation policies have failed to deliver progress for most developing countries. Demand-side policies and instruments need to be expanded and deployed broadly across the developing world to support the generation and diffusion of innovation for the benefit of local and global needs. Appropriate areas for such policies include government procurement, price-based measures, and demonstration projects.

There is a need for a global innovation mindset and discussions on fresh governance frameworks

Are new governance systems needed to improve global innovation cooperation? Are the current frameworks insufficient? These questions should be at the centre of future innovation policy debates.

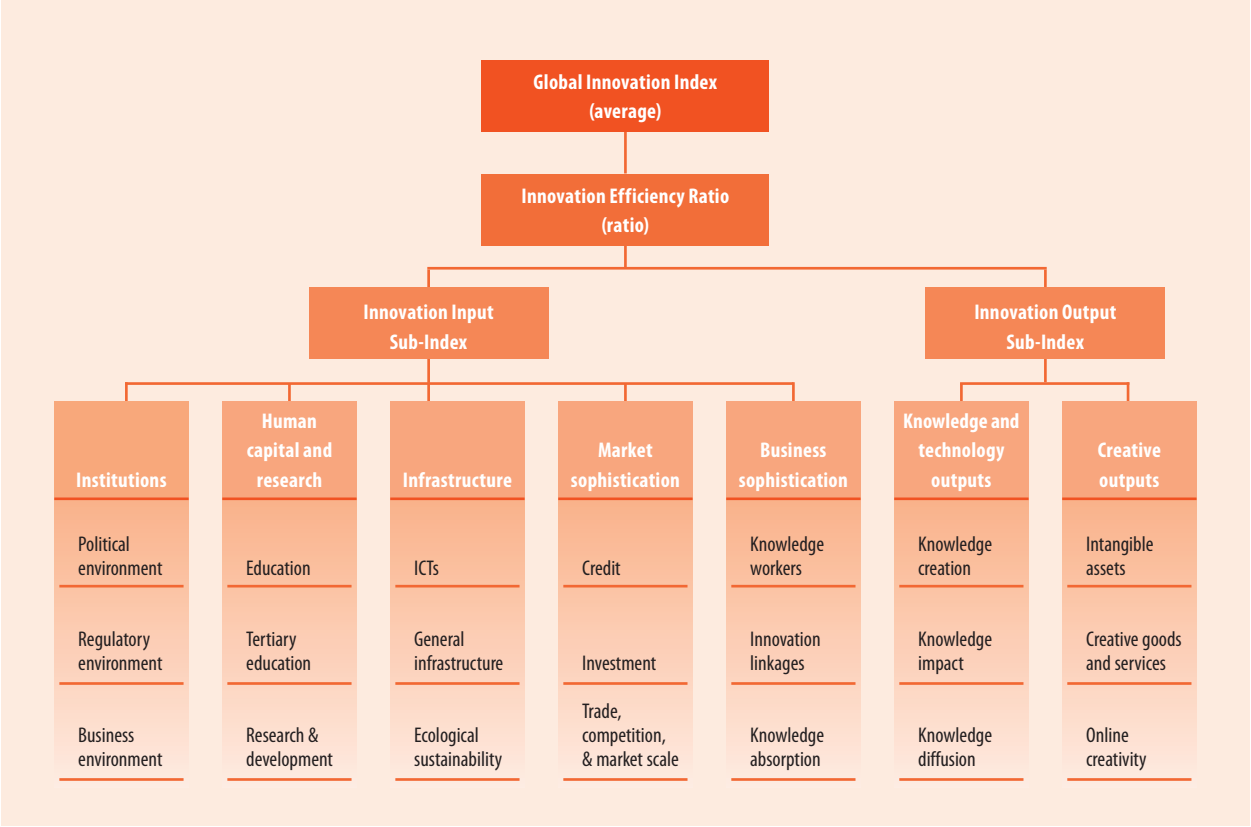
On the one hand, it can be argued that, for many innovation questions, there already is a global governance framework through organizations such as the International Telecommunication Union (ITU) for telecommunication issues, the International Organization for Standardization (ISO) for standardization issues, the World Intellectual Property Organization (WIPO) for IP matters, and the World Health Organization (WHO) for health-related matters, for example. There are also a number of ad-hoc or more specific regional and plurilateral initiatives such as CERN, the European Organization for Nuclear Research. Some fora, such as the Global Science Forum, are described in Chapter 11; similar initiatives for global science and R&D cooperation exist in the G7 process. As noted in Chapter 13 by Gokhberg and Roud, other opportunities arise through bilateral or plurilateral funding for R&D partnerships, policy dialogues such as the US-India Strategic and Commercial Dialogue,[41] and global coalitions such as the Mission Innovation as part of the United Nations Conference on Climate Change in Paris (COP21). Regional efforts such as China's Belt and Road Initiative also hold potential (see Box 7 on page 41).

On the other hand, scholars and institutions have called for complementary global governance mechanisms more focused on improving international science and R&D cooperation.[42] The argument is that innovation needs to be treated on par with trade, health, and immigration issues that have a dedicated international governance framework. Yet neither the exact scope of such international governance systems nor the proper institutional anchors have been fully elaborated. Importantly, such frameworks will need to be flexible and timely enough to accommodate the dynamic nature of innovation processes. Topics of coordination would include facilitating the mobility of scientists, establishing new funding or co-financing schemes for particular technologies, and designing programmes for improved international R&D collaboration.[43] Another important topic is the development of global research infrastructures and how to best design and implement their optimal prioritization and sharing modalities.[44]

In both cases, the challenge is to move towards increased global innovation cooperation via more inclusive governance mechanisms producing measurable outcomes that are evaluated and more clearly communicated over time. Better cooperation will help inform all stakeholders more broadly about the merits of global innovation, simultaneously pre-empting the formation of new barriers in this regard.

The next sections present the GII 2016 framework and results.

Figure 2: Framework of the Global Innovation Index 2016



The GII 2016 conceptual framework

The GII helps to create an environment in which innovation factors are continually evaluated. It provides a key tool of detailed metrics for 128 economies this year, representing 92.8% of the world's population and 97.9% of the world's GDP (in current US dollars).

Four measures are calculated: the overall GII, the Input and Output Sub-Indices, and the Innovation Efficiency Ratio (Figure 2).

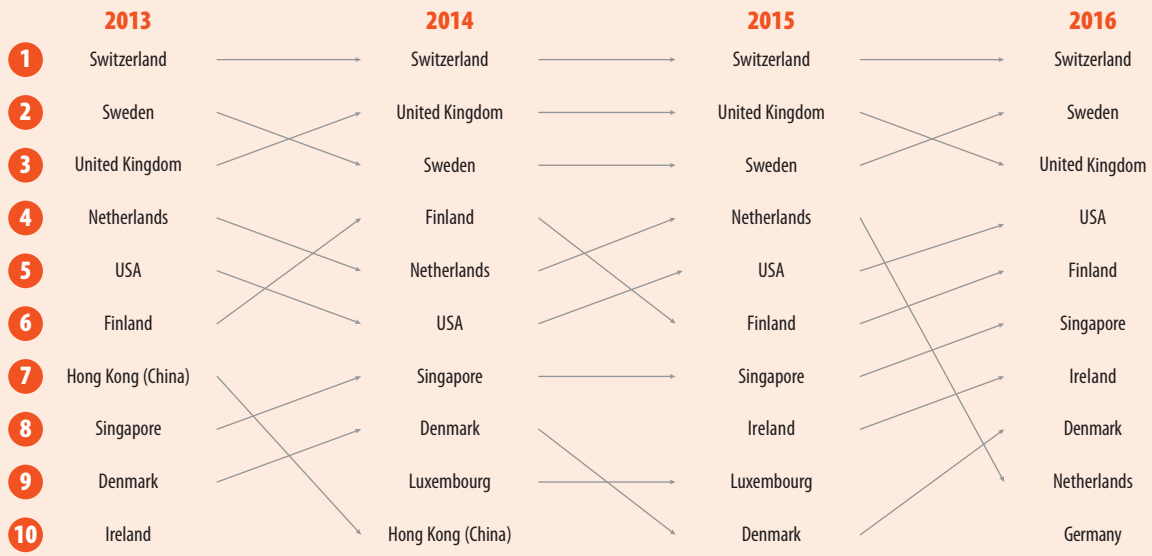
- **The overall GII score** is the simple average of the Input and Output Sub-Index scores.
- **The Innovation Input Sub-Index** is comprised of five input pillars that capture elements of the national economy that enable innovative activities: (1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication, and (5) Business sophistication.
- **The Innovation Output Sub-Index** provides information about outputs that are the results of innovative activities within the economy. There are two output pillars: (6) Knowledge and technology outputs and (7) Creative outputs.
- **The Innovation Efficiency Ratio** is the ratio of the Output Sub-Index score over the Input Sub-Index score. It shows how much innovation output a given country is getting for its inputs.

Each pillar is divided into three sub-pillars and each sub-pillar is composed of individual indicators, for a total of 82 indicators this year.

Further details on the GII framework and the indicators used are provided in Annex 1. It is important to note that each year the variables included in the GII computation are reviewed and updated to provide the best and most current assessment of global innovation. Other methodological issues—such as missing data, revised scaling factors, and new countries added to the sample—also impact year-on-year comparability of the rankings (details of these changes to the framework and factors impacting year-on-year comparability are provided in Annex 2).

Most notably, a more stringent criterion for the inclusion of countries in the GII was adopted this year, following the Joint Research Centre

Figure 3: Movement in the top 10 of the GII



Note: Year-on-year GII rank changes are influenced by performance and methodological considerations; see Annex 2.

(JRC) recommendation of past GII audits (see Annex 3 in this report and in previous years). Economies and countries were included in the GII 2016 only if 60% of data were available within each of the two sub-indices and if at least two of the three sub-pillars in each pillar could be computed. This more stringent criterion for inclusion in the GII ensures that country scores for the GII and for the two Input and Output Sub-Indices are not particularly sensitive to the missing values. As noted by the audit, this more stringent threshold has notably improved the confidence in the country ranks for the GII and the two sub-indices, and thus the reliability of the GII rankings (see Annex 3).

The Global Innovation Index 2016 results

The GII 2016 results have shown consistency in areas such as top rankings and the innovation divide. However, there also have been some new high-level developments as described below.

Stability at the top, led by Switzerland, Sweden, and the UK

In 2016, the GII remains relatively stable at the top. Switzerland leads the rankings for the sixth consecutive year, but for the first time Switzerland sees its distance from the second-best-scoring country narrowing, potentially reflecting a mix of methodological but also performance-related drivers. Sweden regains the 2nd place, last held in 2013, moving the United Kingdom (UK) down to 3rd. The USA and Finland each move up one spot to take the 4th and 5th spots, respectively. Singapore, Ireland, and Denmark also improved upon their 2015 rankings and remain in the top 10, while the Netherlands falls five ranks to 9th place, mostly driven by an FDI-related variable and missing data points. Germany enters the top 10 this year as Luxembourg moves out, making it the only new entrant among the top 10 this year.

Figure 3 shows movement in the top 10 ranked economies over the last four years:

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

Furthermore, stability remains across the top 25 economies with one exception: the Czech Republic drops from 25th to 27th in 2016 as China becomes the first middle-income economy to enter the top 25 (see Box 3 on page 10). Within

the top 25 group, several other economies move up by two or more spots, including the Republic of Korea (11th), Japan (16th), France (18th), and Belgium (23rd).

Innovation is becoming more global but divides remain

The GII rankings have shown a remarkable level of global diversity among innovation leaders over the years. Among the top-ranked 25 innovative nations this year are not only economies from Northern America (such as Canada and the USA) and Europe (such as Germany, Switzerland, and the UK) but also from South East Asia, East Asia, and Oceania (such as Australia, Japan, Korea, and Singapore) and Northern Africa and Western Asia (Israel).

Economies that perform at least 10 percent higher than their peers for their level of GDP are labelled 'innovation achievers'; they include many economies from Sub-Saharan Africa, such as Kenya, Madagascar, Malawi, Rwanda, and Uganda; one from Northern Africa and Western Asia (Armenia); one from South East Asia, East Asia, and Oceania (Viet Nam); and several from Central and Southern Asia (such as India and Tajikistan). A wide variety of countries outperform their income group in at least four of the seven GII pillars; these include countries such as Bhutan, Brazil, Cambodia, Costa Rica, Georgia, Indonesia, Mexico, Morocco, the Philippines, South Africa, and others.

Yet, rather than levelling the playing field, a multipolar world of research and innovation has emerged. The majority of activities are still concentrated in high-income economies and select middle-income economies such as Brazil, China, India, and South Africa. Only China has seen its R&D expenditures or other innovation input and output metrics move closer to rich countries such as the USA. Other middle-income economies remain distant; Malaysia slipped further away this year. The divide between the group of upper-middle-income economies and the group of high-income economies is large, especially in the Institutions, Human capital and research, Infrastructure, and Creative outputs pillars.

Innovation divides remain according to the GII 2016 (see Box 3 on page 10). The distance between the performance of the top 10 ranked innovation nations and all others is still wide. However, this year a mix of innovation performance and methodological considerations allows China, a middle-income economy, to join the 11–25 ranked group, traditionally composed of high-income countries.

However, other middle-income economies that were identified in the past as being on the heels of the richer countries in the top rankings either remain far from these groups or are moving away from them. Malaysia (35th) and Bulgaria (38th) are the only two remaining middle-income economies (other than China) still close to top high-income groups.[45] Both of these economies, however, show a ranking that is similar or higher than those of the high-income economies that are not in the top 25. This is especially evident in the Business sophistication and Knowledge and technology outputs pillars. Although for some economies this divide seems to be reducing, on average, the high-income economies rank above middle-income in Institutions (pillar 1), Human capital and research (2), Infrastructure (3), and Creative outputs (7).

At lower levels of income, the innovation divide between middle- and low-income economies continues to close (see Box 3 on page 10), partly driven by potential methodological but also partly driven by performance-related factors. This year, on average, lower-income economies are more similar to lower-middle-income economies in Institutions and Business sophistication. Yet in some pillars low-income economies still lag behind; this is especially the case in the Human capital and research, Infrastructure, Market sophistication, Knowledge and technology outputs, and Creative outputs pillars.

High-quality innovation continues to matter and China is catching up

As noted over the past four years, quality is as important an element of innovation as quantity (see Box 4 on page 18). Since the 2013 edition of the GII, quality has been measured by (1) quality of local universities (2.3.4, QS university rankings average score of top 3 universities); (2) internationalization of local inventions (5.2.5, patent families filed in three offices, changed to patent families filed in two offices in the GII 2016); and (3) the number of citations that local research documents receive abroad (6.1.5, citable documents H index). This year Japan, the USA, the UK, and Germany remain at the top of the composite indicator that combines these three indicators among the high-income economies. Japan takes over the top position, boosted by high scores in the new measurement of patent families; both the USA and the UK take the top two spots, respectively, in the quality of local universities while sharing top place in the number of citations (see Box 4). China is both top in the group of middle-income economies and has scores in the quality of local universities and the number of citations that are above the high-income

group average and on par or above those of some economies in the top 10 quality of innovation for that income group. In patents filed, however, China remains below this average. Yet the innovation quality scores for China are the only ones among its group that display a balance similar to that of high-income economies.

When not considering China, other top-scoring middle-income economies are also helping close the gap between these two income groups. India, Brazil, and South Africa this year have scores in the quality of universities and number of citations that are close to those of China, and similar to or above the high-income group averages. Although India and Brazil still rank below China on the patent family metric, their scores are beginning to approach those of China and thus helping reduce this income group divide. This year South Africa's scores in all three indicators are higher, especially in the revised patent files, giving it a higher overall position in quality of innovation, just below Brazil. Russia, now a high-income economy, has an overall score for this composite indicator that places this country between the quality of innovation rankings of India and Brazil. This fact puts four out of five BRICS economies in similar overall rankings in this composite indicator.

This year Seychelles, Argentina, and Hungary are no longer part of the top 10 group of middle-income economies in innovation quality because of low data coverage in the case of Seychelles (see Annex 2), and because of changes in income group classification in the case of Argentina and Hungary. These changes lead Mexico, Malaysia, and Turkey—all three economies among the top 10 middle-income economies since this innovation quality metric was introduced—to move ahead in the rankings. Furthermore, these shifts also give Thailand, Colombia, and Ukraine the opportunity to enter the top 10 ranking of middle-income economies this year.

These results lead us directly into the main GII rankings.

2016 results: The world's top innovators

The following section describes and analyses the prominent features of the GII 2016 results for the global leaders in each index and the best performers in light of their income level.[46] A short discussion of the rankings at the regional level follows.[47]

Tables 1 through 3 on pages 20–25 present the rankings of all economies included in the GII 2016 for the GII and the Input and Output Sub-Indices.

The top 10 in the Global Innovation Index

Switzerland has earned the number 1 position in the GII for the sixth consecutive year. It has maintained this top spot in the GII since 2011, as well as its number 1 position in the Innovation Output Sub-Index and in the Knowledge and technology outputs pillar since 2012. It ranks among the top 25 in all pillars and sub-pillars with only three exceptions on the sub-pillar side: Business environment (31st), Education (32nd), and Information and communication technologies (39th).

Switzerland, a knowledge-based economy of 8.3 million people with one of the highest GDP per capita in the world (PPP$58,551), ranks in the top 10 for all pillars with the exception of Infrastructure (15th). Its high Innovation Efficiency Ratio (5th among all economies included in the GII 2016, and 1st among the GII 2016 top 10) allows Switzerland to benefit from its solid innovation capabilities and help transform its resources into high-level innovation outputs.

Sweden regains the second highest position in the GII, a rank it held from 2011 to 2013. Sweden remains the top Nordic economy, showing improvements in both the Input (5th) and Output (2nd) Sub-Indices of the GII. This higher ranking is led by gains in Investment (7th) and Creative goods and services (14th). With improved rankings in 11 of the 21 sub-pillars this year, Sweden continues to rank among the top 25 economies in all sub-pillars. Overall, Sweden shows top 10 rankings in all pillars with the exception of Institutions (11th).

Ranking 3rd in the GII this year, the **United Kingdom** (UK) maintains its position among the top 3 ranks, after a rise from 11th in 2011 to 2nd in both 2014 and 2015. The UK ranks 7th overall in the Innovation Input Sub-Index and 4th overall in the Innovation Output Sub-Index, up one spot from 2015. It ranks in the top 10 economies on all pillars with two exceptions: Institutions and Business sophistication. On the sub-pillar side, the UK ranks in the top 25 economies across the Input and Output Sub-Indices with only four exceptions: Education (28th), General infrastructure (34th), Knowledge absorption (33rd), and Knowledge diffusion (34th). Although the UK is still distant to the performance of the top 25 in sub-pillar 3.2 (General infrastructure), the rank increase of the UK on general infrastructure was its largest rank increase on the input side, up by 14 positions since 2015.

The United States of America (USA) reaches the 4th position. It increases its rank in both the Input Innovation Sub-Index (3rd) and the Output Innovation Sub-Index (7th).

Box 4: Innovation quality: Japan, the USA, and the UK at the top

Measuring the quality of innovation-related input and output indicators as well as their quantity is critical for an accurate assessment. Indeed, some economies have managed to ramp up the quantity of specific indicators—such as education expenditures, patents, and publications—without making much impact. To address this issue, and to better measure the quality of innovation, three indicators were introduced into the GII in 2013: first, the quality of local universities (determined through indicator 2.3.4, QS university rankings average score of top 3 universities); second, the internationalization of local inventions (indicator 5.2.5, patent families filed in three offices; this indicator was changed to patent families filed in two or more offices in the 2016 GII); and third, the number of citations that local research documents receive abroad (indicator 6.1.5, citable documents H index). Figure 4.1 shows the sum of the scores of these three indicators and captures the top 10 highest-performing high- and middle-income economies for this combined indicator.

Top 10 high-income economies: Japan, the USA, the UK, and Germany continue to lead

Among the high-income group, four economies—Japan, the United States of America (USA), the United Kingdom (UK), and Germany—have stood at the top positions in this innovation quality metric since its introduction. This year Japan is number 1 in this ranking. Its scores for the quality of universities and citable documents remain almost unchanged for the past two years. Japan achieves this position mainly as a result of its high score in the modified patent family indicator. The USA and the UK share the top positions in the quality of papers and universities for the fourth consecutive year. In 2016, however, the USA takes the top spot from the UK in the quality of universities.

Like Japan, the Republic of Korea (Korea) and Sweden are high-income economies that have improved their ranking on this combined innovation quality indicator. Korea moves up two spots to replace Canada at the 6th position, above France in the 7th. This upward movement is explained mostly by Korea's better scores in patent families and by Canada's lower scores in university quality and patent families. France scores better this year in citable documents and keeps its 7th position in the innovation quality indicator. Although Sweden shows marginally lower scores in the quality of universities than last year, a stronger score in patent families drives its upward movement. Along with Canada, the Netherlands falls in this quality ranking by one position to 10th. Although the Netherlands this year ranks among the high-income economies with 11th place in university rankings and 12th in patent families, its lower score on the latter indicator is the main culprit for this drop.

Top 10 middle-income economies: China leads and India overtakes Brazil

Overall, the gap between high- and middle-income economies is still considerable. When excluding China, the gap in average scores between these two groups in both the quality of universities (33.1 points) and in citable documents (26.6 points) is expanding, while it is slightly narrower in patent families (28.8 points).

China moves to 17th place in innovation quality this year, allowing it to retain its position at the top of the middle-income economies and further narrowing the distance between these and the high-income group. This upward movement can be attributed to China's higher overall scores in university rankings (7th) and citable documents (16th).

China is now the only middle-income economy with innovation quality scores that display a balance similar to that of high-income economies. The rest of the middle-income economies still depend on their top university rankings to improve their combined quality scores.

India (ranked 66th overall in the GII) swaps the 3rd for the 2nd position with Brazil (ranked 69th in the GII) this year. India's positive move is the result of its performance in university rankings, where it comes in 2nd among middle-income economies and 20th overall; and in patent families, where—also because of methodological changes—it now ranks 3rd among middle-income economies and 37th overall for this indicator. Brazil's performance, on the other hand, shows a slightly better score in citable documents but is affected by lower scores in the quality of universities and in the new patent family indicator.

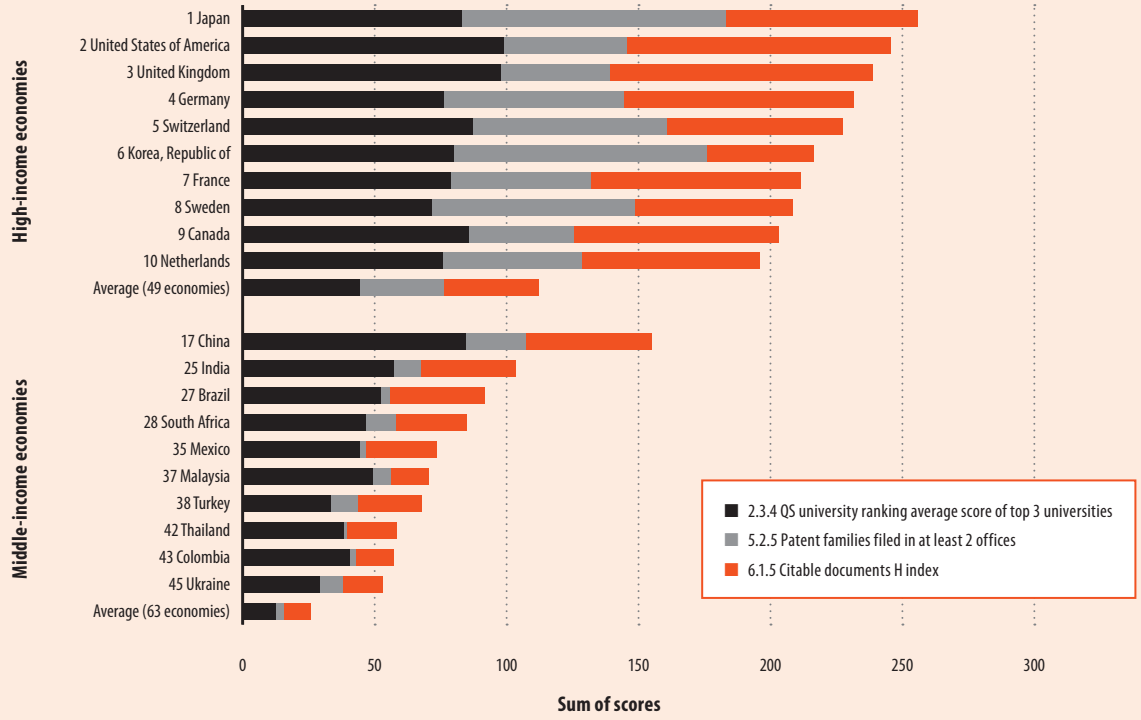
Although most economies at this level of development still display a weak relative performance in patent families, India and Brazil are now beginning to approach the performance shown by China.

South Africa, another large middle-income country, also moves upwards in both the GII and in the overall quality of innovation this year. This progress is the result of higher scores in all three quality-measuring indicators, but is mostly a consequence of a better score in patent families. This advance places South Africa at 35th in that indicator and in 28th position overall in innovation quality. Although no longer part of the middle-income bracket since 2014,

(Continued)

Box 4: Innovation quality: Japan, the USA, and the UK at the top *(continued)*

Figure 4.1: Metrics for quality of innovation: Top 10 high- and top 10 middle-income economies



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 2014). Upper- and lower-middle income categories are grouped together as middle-income economies.

the Russian Federation, now a high-income economy, improves in both the GII overall and in the quality of innovation rankings this year. The Russian Federation's overall score for this composite indicator places this country in the 26th spot among all other economies, just between the rankings of India and Brazil.

This year Seychelles, Argentina, and Hungary are no longer part of the top 10 group of middle-income economies in innovation quality. Seychelles is not included in the GII 2016 as a result of insufficient data coverage, and Argentina and Hungary are now being classified as high-income economies.[1] These shifts lead Mexico, Malaysia, and Turkey—three economies that have been in the middle-income top 10 since this innovation quality metric was introduced—to move ahead in the rankings. In particular, their rise can be credited to higher scores in the quality of universities for Mexico; a constant performance in all three innovation quality indicators for Malaysia; and an improved score in patent families for Turkey. These shifts also allow Thailand, Colombia, and Ukraine to enter the top 10 rankings of middle-income economies this year.

Note

1 This classification is according to the World Bank's estimates of gross national income (GNI) per capita for the previous year.

Table 1: Global Innovation Index rankings

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Efficiency Ratio	Rank	Median: 0.65
Switzerland	66.28	1	HI	1	EUR	1	0.94	5	
Sweden	63.57	2	HI	2	EUR	2	0.86	10	
United Kingdom	61.93	3	HI	3	EUR	3	0.83	14	
United States of America	61.40	4	HI	4	NAC	1	0.79	25	
Finland	59.90	5	HI	5	EUR	4	0.75	32	
Singapore	59.16	6	HI	6	SEAO	1	0.62	78	
Ireland	59.03	7	HI	7	EUR	5	0.89	8	
Denmark	58.45	8	HI	8	EUR	6	0.74	34	
Netherlands	58.29	9	HI	9	EUR	7	0.82	20	
Germany	57.94	10	HI	10	EUR	8	0.87	9	
Korea, Rep.	57.15	11	HI	11	SEAO	2	0.80	24	
Luxembourg	57.11	12	HI	12	EUR	9	1.02	1	
Iceland	55.99	13	HI	13	EUR	10	0.98	3	
Hong Kong (China)	55.69	14	HI	14	SEAO	3	0.61	83	
Canada	54.71	15	HI	15	NAC	2	0.67	57	
Japan	54.52	16	HI	16	SEAO	4	0.65	65	
New Zealand	54.23	17	HI	17	SEAO	5	0.73	40	
France	54.04	18	HI	18	EUR	11	0.73	44	
Australia	53.07	19	HI	19	SEAO	6	0.64	73	
Austria	52.65	20	HI	20	EUR	12	0.73	43	
Israel	52.28	21	HI	21	NAWA	1	0.81	23	
Norway	52.01	22	HI	22	EUR	13	0.68	55	
Belgium	51.97	23	HI	23	EUR	14	0.78	27	
Estonia	51.73	24	HI	24	EUR	15	0.91	6	
China	50.57	25	UM	1	SEAO	7	0.90	7	
Malta	50.44	26	HI	25	EUR	16	0.98	2	
Czech Republic	49.40	27	HI	26	EUR	17	0.82	21	
Spain	49.19	28	HI	27	EUR	18	0.72	48	
Italy	47.17	29	HI	28	EUR	19	0.74	33	
Portugal	46.45	30	HI	29	EUR	20	0.75	31	
Cyprus	46.34	31	HI	30	NAWA	2	0.79	26	
Slovenia	45.97	32	HI	31	EUR	21	0.74	39	
Hungary	44.71	33	HI	32	EUR	22	0.83	17	
Latvia	44.33	34	HI	33	EUR	23	0.78	28	
Malaysia	43.36	35	UM	2	SEAO	8	0.67	59	
Lithuania	41.76	36	HI	34	EUR	24	0.63	75	
Slovakia	41.70	37	HI	35	EUR	25	0.74	36	
Bulgaria	41.42	38	UM	3	EUR	26	0.83	16	
Poland	40.22	39	HI	36	EUR	27	0.65	66	
Greece	39.75	40	HI	37	EUR	28	0.61	84	
United Arab Emirates	39.35	41	HI	38	NAWA	3	0.44	117	
Turkey	39.03	42	UM	4	NAWA	4	0.84	13	
Russian Federation	38.50	43	HI	39	EUR	29	0.65	69	
Chile	38.41	44	HI	40	LCN	1	0.59	91	
Costa Rica	38.40	45	UM	5	LCN	2	0.71	50	
Moldova, Rep.	38.39	46	LM	1	EUR	30	0.94	4	
Croatia	38.29	47	HI	41	EUR	31	0.65	68	
Romania	37.90	48	UM	6	EUR	32	0.72	46	
Saudi Arabia	37.75	49	HI	42	NAWA	5	0.61	85	
Qatar	37.47	50	HI	43	NAWA	6	0.56	97	
Montenegro	37.36	51	UM	7	EUR	33	0.62	80	
Thailand	36.51	52	UM	8	SEAO	9	0.70	53	
Mauritius	35.86	53	UM	9	SSF	1	0.57	95	
South Africa	35.85	54	UM	10	SSF	2	0.55	99	
Mongolia	35.74	55	UM	11	SEAO	10	0.72	47	
Ukraine	35.72	56	LM	2	EUR	34	0.84	12	
Bahrain	35.48	57	HI	44	NAWA	7	0.58	92	
TFYR of Macedonia	35.40	58	UM	12	EUR	35	0.67	56	
Viet Nam	35.37	59	LM	3	SEAO	11	0.84	11	
Armenia	35.14	60	LM	4	NAWA	8	0.83	15	
Mexico	34.56	61	UM	13	LCN	3	0.63	76	
Uruguay	34.28	62	HI	45	LCN	4	0.62	81	
Colombia	34.16	63	UM	14	LCN	5	0.56	96	
Georgia	33.86	64	LM	5	NAWA	9	0.65	67	

Table 1: Global Innovation Index rankings *(continued)*

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Efficiency Ratio	Rank	Median: 0.65
Serbia	33.75	65	UM	15	EUR	36	0.65	70	
India	33.61	66	LM	6	CSA	1	0.66	63	
Kuwait	33.61	67	HI	46	NAWA	10	0.73	42	
Panama	33.49	68	UM	16	LCN	6	0.66	61	
Brazil	33.19	69	UM	17	LCN	7	0.55	100	
Lebanon	32.70	70	UM	18	NAWA	11	0.73	41	
Peru	32.51	71	UM	19	LCN	8	0.51	109	
Morocco	32.26	72	LM	7	NAWA	12	0.66	64	
Oman	32.21	73	HI	47	NAWA	13	0.53	103	
Philippines	31.83	74	LM	8	SEAO	12	0.71	49	
Kazakhstan	31.51	75	UM	20	CSA	2	0.51	108	
Dominican Republic	30.55	76	UM	21	LCN	9	0.62	82	
Tunisia	30.55	77	UM	22	NAWA	14	0.60	86	
Iran, Islamic Rep.	30.52	78	UM	23	CSA	3	0.71	51	
Belarus	30.39	79	UM	24	EUR	37	0.45	116	
Kenya	30.36	80	LM	9	SSF	3	0.76	30	
Argentina	30.24	81	HI	48	LCN	10	0.56	98	
Jordan	30.04	82	UM	25	NAWA	15	0.67	58	
Rwanda	29.96	83	LI	1	SSF	4	0.38	123	
Mozambique	29.84	84	LI	2	SSF	5	0.73	45	
Azerbaijan	29.64	85	UM	26	NAWA	16	0.54	101	
Tajikistan	29.62	86	LM	10	CSA	4	0.77	29	
Bosnia and Herzegovina	29.62	87	UM	27	EUR	38	0.46	115	
Indonesia	29.07	88	LM	11	SEAO	13	0.71	52	
Jamaica	28.97	89	UM	28	LCN	11	0.53	104	
Botswana	28.96	90	UM	29	SSF	6	0.42	119	
Sri Lanka	28.92	91	LM	12	CSA	5	0.70	54	
Albania	28.38	92	UM	30	EUR	39	0.40	121	
Namibia	28.24	93	UM	31	SSF	7	0.54	102	
Paraguay	28.20	94	UM	32	LCN	12	0.62	77	
Cambodia	27.94	95	LI	3	SEAO	14	0.59	90	
Bhutan	27.88	96	LM	13	CSA	6	0.28	128	
Guatemala	27.30	97	LM	14	LCN	13	0.62	79	
Malawi	27.26	98	LI	4	SSF	8	0.74	38	
Uganda	27.14	99	LI	5	SSF	9	0.52	106	
Ecuador	27.11	100	UM	33	LCN	14	0.60	87	
Honduras	26.94	101	LM	15	LCN	15	0.53	105	
Ghana	26.66	102	LM	16	SSF	10	0.60	88	
Kyrgyzstan	26.62	103	LM	17	CSA	7	0.50	110	
El Salvador	26.56	104	LM	18	LCN	16	0.48	113	
Tanzania, United Rep.	26.35	105	LI	6	SSF	11	0.81	22	
Senegal	26.14	106	LM	19	SSF	12	0.66	62	
Egypt	25.96	107	LM	20	NAWA	17	0.63	74	
Côte d'Ivoire	25.80	108	LM	21	SSF	13	0.82	19	
Bolivia, Plurinational St.	25.24	109	LM	22	LCN	17	0.59	89	
Ethiopia	24.83	110	LI	7	SSF	14	0.83	18	
Madagascar	24.79	111	LI	8	SSF	15	0.74	35	
Mali	24.77	112	LI	9	SSF	16	0.74	37	
Algeria	24.46	113	UM	34	NAWA	18	0.49	111	
Nigeria	23.15	114	LM	23	SSF	17	0.67	60	
Nepal	23.13	115	LI	10	CSA	8	0.58	94	
Nicaragua	23.06	116	LM	24	LCN	18	0.41	120	
Bangladesh	22.86	117	LM	25	CSA	9	0.52	107	
Cameroon	22.82	118	LM	26	SSF	18	0.58	93	
Pakistan	22.63	119	LM	27	CSA	10	0.64	71	
Venezuela, Bolivarian Rep.	22.32	120	HI	49	LCN	19	0.46	114	
Benin	22.25	121	LI	11	SSF	19	0.43	118	
Burkina Faso	21.05	122	LI	12	SSF	20	0.28	127	
Burundi	20.93	123	LI	13	SSF	21	0.39	122	
Niger	20.44	124	LI	14	SSF	22	0.36	125	
Zambia	19.92	125	LM	28	SSF	23	0.64	72	
Togo	18.42	126	LI	15	SSF	24	0.36	124	
Guinea	17.24	127	LI	16	SSF	25	0.49	112	
Yemen	14.55	128	LM	29	NAWA	19	0.34	126	

Note: World Bank Income Group Classification (July 2015): LI = low income; LM = lower-middle income; UM = upper-middle income; and HI = high income. Regions are based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

Table 2: Innovation Input Sub-Index rankings

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median: 41.87
Singapore	72.94	**1**	HI	**1**	SEAO	**1**	
Hong Kong (China)	69.15	2	HI	2	SEAO	2	
United States of America	68.71	3	HI	3	NAC	**1**	
Finland	68.49	4	HI	4	EUR	**1**	
Sweden	68.48	5	HI	5	EUR	2	
Switzerland	68.38	6	HI	6	EUR	3	
United Kingdom	67.50	7	HI	7	EUR	4	
Denmark	67.06	8	HI	8	EUR	5	
Japan	66.00	9	HI	9	SEAO	3	
Canada	65.41	10	HI	10	NAC	2	
Australia	64.85	11	HI	11	SEAO	4	
Netherlands	64.03	12	HI	12	EUR	6	
Korea, Rep.	63.54	13	HI	13	SEAO	5	
New Zealand	62.64	14	HI	14	SEAO	6	
France	62.56	15	HI	15	EUR	7	
Ireland	62.44	16	HI	16	EUR	8	
Norway	61.98	17	HI	17	EUR	9	
Germany	61.91	18	HI	18	EUR	10	
Austria	60.86	19	HI	19	EUR	11	
Belgium	58.23	20	HI	20	EUR	12	
Israel	57.78	21	HI	21	NAWA	**1**	
Spain	57.26	22	HI	22	EUR	13	
Luxembourg	56.64	23	HI	23	EUR	14	
Iceland	56.64	24	HI	24	EUR	15	
United Arab Emirates	54.53	25	HI	25	NAWA	2	
Czech Republic	54.28	26	HI	26	EUR	16	
Estonia	54.15	27	HI	27	EUR	17	
Italy	54.07	28	HI	28	EUR	18	
China	53.12	29	UM	**1**	SEAO	7	
Portugal	53.05	30	HI	29	EUR	19	
Slovenia	52.99	31	HI	30	EUR	20	
Malaysia	52.05	32	UM	2	SEAO	8	
Cyprus	51.88	33	HI	31	NAWA	3	
Lithuania	51.18	34	HI	32	EUR	21	
Malta	51.01	35	HI	33	EUR	22	
Latvia	49.73	36	HI	34	EUR	23	
Greece	49.42	37	HI	35	EUR	24	
Hungary	48.94	38	HI	36	EUR	25	
Poland	48.71	39	HI	37	EUR	26	
Chile	48.25	40	HI	38	LCN	**1**	
Qatar	48.05	41	HI	39	NAWA	4	
Slovakia	47.96	42	HI	40	EUR	27	
Saudi Arabia	46.99	43	HI	41	NAWA	5	
Russian Federation	46.69	44	HI	42	EUR	28	
Croatia	46.38	45	HI	43	EUR	29	
Montenegro	46.13	46	UM	3	EUR	30	
South Africa	46.12	47	UM	4	SSF	**1**	
Mauritius	45.75	48	UM	5	SSF	2	
Bulgaria	45.30	49	UM	6	EUR	31	
Costa Rica	44.94	50	UM	7	LCN	2	
Bahrain	44.79	51	HI	44	NAWA	6	
Romania	43.99	52	UM	8	EUR	32	
Colombia	43.78	53	UM	9	LCN	3	
Bhutan	43.46	54	LM	**1**	CSA	**1**	
Rwanda	43.40	55	LI	**1**	SSF	3	
Peru	43.18	56	UM	10	LCN	4	
Thailand	42.98	57	UM	11	SEAO	9	
Brazil	42.73	58	UM	12	LCN	5	
Turkey	42.54	59	UM	13	NAWA	7	
Mexico	42.52	60	UM	14	LCN	6	
Uruguay	42.33	61	HI	45	LCN	7	
TFYR of Macedonia	42.31	62	UM	15	EUR	33	
Oman	42.10	63	HI	46	NAWA	8	
Belarus	41.99	64	UM	16	EUR	34	

Table 2: Innovation Input Sub-Index rankings *(continued)*

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median: 41.87
Kazakhstan	41.75	65	UM	17	CSA	2	
Mongolia	41.56	66	UM	18	SEAO	10	
Georgia	41.02	67	LM	2	NAWA	9	
Serbia	40.94	68	UM	19	EUR	35	
Botswana	40.93	69	UM	20	SSF	4	
Bosnia and Herzegovina	40.54	70	UM	21	EUR	36	
Albania	40.53	71	UM	22	EUR	37	
India	40.49	72	LM	3	CSA	3	
Panama	40.31	73	UM	23	LCN	8	
Moldova, Rep.	39.57	74	LM	4	EUR	38	
Morocco	38.93	75	LM	5	NAWA	10	
Ukraine	38.91	76	LM	6	EUR	39	
Argentina	38.86	77	HI	47	LCN	9	
Kuwait	38.84	78	HI	48	NAWA	11	
Viet Nam	38.45	79	LM	7	SEAO	11	
Armenia	38.40	80	LM	8	NAWA	12	
Azerbaijan	38.39	81	UM	24	NAWA	13	
Tunisia	38.10	82	UM	25	NAWA	14	
Jamaica	37.96	83	UM	26	LCN	10	
Dominican Republic	37.80	84	UM	27	LCN	11	
Lebanon	37.78	85	UM	28	NAWA	15	
Philippines	37.23	86	LM	9	SEAO	12	
Namibia	36.66	87	UM	29	SSF	5	
Jordan	36.01	88	UM	30	NAWA	16	
El Salvador	35.92	89	LM	10	LCN	12	
Iran, Islamic Rep.	35.72	90	UM	31	CSA	4	
Uganda	35.63	91	LI	2	SSF	6	
Kyrgyzstan	35.61	92	LM	11	CSA	5	
Honduras	35.33	93	LM	12	LCN	13	
Cambodia	35.06	94	LI	3	SEAO	13	
Paraguay	34.75	95	UM	32	LCN	14	
Mozambique	34.55	96	LI	4	SSF	7	
Kenya	34.44	97	LM	13	SSF	8	
Sri Lanka	34.08	98	LM	14	CSA	6	
Indonesia	34.04	99	LM	15	SEAO	14	
Ecuador	33.92	100	UM	33	LCN	15	
Guatemala	33.69	101	LM	16	LCN	16	
Tajikistan	33.51	102	LM	17	CSA	7	
Ghana	33.37	103	LM	18	SSF	9	
Algeria	32.80	104	UM	34	NAWA	17	
Burkina Faso	32.78	105	LI	5	SSF	10	
Nicaragua	32.78	106	LM	19	LCN	17	
Egypt	31.76	107	LM	20	NAWA	18	
Bolivia, Plurinational St.	31.66	108	LM	21	LCN	18	
Senegal	31.47	109	LM	22	SSF	11	
Malawi	31.41	110	LI	6	SSF	12	
Benin	31.16	111	LI	7	SSF	13	
Venezuela, Bolivarian Rep.	30.52	112	HI	49	LCN	19	
Niger	30.08	113	LI	8	SSF	14	
Burundi	30.04	114	LI	9	SSF	15	
Bangladesh	30.02	115	LM	23	CSA	8	
Nepal	29.31	116	LI	10	CSA	9	
Tanzania, United Rep.	29.05	117	LI	11	SSF	16	
Cameroon	28.88	118	LM	24	SSF	17	
Mali	28.53	119	LI	12	SSF	18	
Madagascar	28.45	120	LI	13	SSF	19	
Côte d'Ivoire	28.29	121	LM	25	SSF	20	
Nigeria	27.80	122	LM	26	SSF	21	
Pakistan	27.51	123	LM	27	CSA	10	
Ethiopia	27.19	124	LI	14	SSF	22	
Togo	27.11	125	LI	15	SSF	23	
Zambia	24.25	126	LM	28	SSF	24	
Guinea	23.18	127	LI	16	SSF	25	
Yemen	21.67	128	LM	29	NAWA	19	

Note: World Bank Income Group Classification (July 2015): LI = low income; LM = lower-middle income; UM = upper-middle income; and HI = high income. Regions are based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

Table 3: Innovation Output Sub-Index rankings

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median: 26.35
Switzerland	64.19	**1**	HI	**1**	EUR	**1**	
Sweden	58.66	2	HI	2	EUR	2	
Luxembourg	57.57	3	HI	3	EUR	3	
United Kingdom	56.35	4	HI	4	EUR	4	
Ireland	55.63	5	HI	5	EUR	5	
Iceland	55.35	6	HI	6	EUR	6	
United States of America	54.08	7	HI	7	NAC	**1**	
Germany	53.97	8	HI	8	EUR	7	
Netherlands	52.54	9	HI	9	EUR	8	
Finland	51.32	10	HI	10	EUR	9	
Korea, Rep.	50.75	11	HI	11	SEAO	**1**	
Malta	49.86	12	HI	12	EUR	10	
Denmark	49.84	13	HI	13	EUR	11	
Estonia	49.31	14	HI	14	EUR	12	
China	48.02	15	UM	**1**	SEAO	2	
Israel	46.77	16	HI	15	NAWA	**1**	
New Zealand	45.82	17	HI	16	SEAO	3	
Belgium	45.71	18	HI	17	EUR	13	
France	45.51	19	HI	18	EUR	14	
Singapore	45.38	20	HI	19	SEAO	4	
Czech Republic	44.53	21	HI	20	EUR	15	
Austria	44.44	22	HI	21	EUR	16	
Canada	44.00	23	HI	22	NAC	2	
Japan	43.04	24	HI	23	SEAO	5	
Hong Kong (China)	42.22	25	HI	24	SEAO	6	
Norway	42.04	26	HI	25	EUR	17	
Australia	41.28	27	HI	26	SEAO	7	
Spain	41.11	28	HI	27	EUR	18	
Cyprus	40.80	29	HI	28	NAWA	2	
Hungary	40.47	30	HI	29	EUR	19	
Italy	40.28	31	HI	30	EUR	20	
Portugal	39.85	32	HI	31	EUR	21	
Slovenia	38.95	33	HI	32	EUR	22	
Latvia	38.92	34	HI	33	EUR	23	
Bulgaria	37.53	35	UM	2	EUR	24	
Moldova, Rep.	37.21	36	LM	**1**	EUR	25	
Turkey	35.52	37	UM	3	NAWA	3	
Slovakia	35.43	38	HI	34	EUR	26	
Malaysia	34.66	39	UM	4	SEAO	8	
Ukraine	32.53	40	LM	2	EUR	27	
Lithuania	32.34	41	HI	35	EUR	28	
Viet Nam	32.29	42	LM	3	SEAO	9	
Armenia	31.89	43	LM	4	NAWA	4	
Costa Rica	31.87	44	UM	5	LCN	**1**	
Romania	31.81	45	UM	6	EUR	29	
Poland	31.73	46	HI	36	EUR	30	
Russian Federation	30.31	47	HI	37	EUR	31	
Croatia	30.19	48	HI	38	EUR	32	
Greece	30.09	49	HI	39	EUR	33	
Thailand	30.04	50	UM	7	SEAO	10	
Mongolia	29.93	51	UM	8	SEAO	11	
Montenegro	28.59	52	UM	9	EUR	34	
Chile	28.57	53	HI	40	LCN	2	
Saudi Arabia	28.51	54	HI	41	NAWA	5	
TFYR of Macedonia	28.49	55	UM	10	EUR	35	
Kuwait	28.37	56	HI	42	NAWA	6	
Lebanon	27.62	57	UM	11	NAWA	7	
Qatar	26.88	58	HI	43	NAWA	8	
India	26.73	59	LM	5	CSA	**1**	
Georgia	26.71	60	LM	6	NAWA	9	
Panama	26.67	61	UM	12	LCN	3	
Mexico	26.60	62	UM	13	LCN	4	
Serbia	26.57	63	UM	14	EUR	36	
Philippines	26.43	64	LM	7	SEAO	12	

Table 3: Innovation Output Sub-Index rankings *(continued)*

Country/Economy	Score (0–100)	Rank	Income	Rank	Region	Rank	Median: 26.35
Kenya	26.28	65	LM	8	SSF	1	
Uruguay	26.22	66	HI	44	LCN	5	
Bahrain	26.17	67	HI	45	NAWA	10	
Mauritius	25.97	68	UM	15	SSF	2	
Tajikistan	25.74	69	LM	9	CSA	2	
Morocco	25.58	70	LM	10	NAWA	11	
South Africa	25.58	71	UM	16	SSF	3	
Iran, Islamic Rep.	25.33	72	UM	17	CSA	3	
Mozambique	25.13	73	LI	1	SSF	4	
Colombia	24.55	74	UM	18	LCN	6	
United Arab Emirates	24.18	75	HI	46	NAWA	12	
Indonesia	24.10	76	LM	11	SEAO	13	
Jordan	24.06	77	UM	19	NAWA	13	
Sri Lanka	23.77	78	LM	12	CSA	4	
Brazil	23.65	79	UM	20	LCN	7	
Tanzania, United Rep.	23.65	80	LI	2	SSF	5	
Côte d'Ivoire	23.31	81	LM	13	SSF	6	
Dominican Republic	23.31	82	UM	21	LCN	8	
Malawi	23.11	83	LI	3	SSF	7	
Tunisia	23.00	84	UM	22	NAWA	14	
Ethiopia	22.48	85	LI	4	SSF	8	
Oman	22.32	86	HI	47	NAWA	15	
Peru	21.84	87	UM	23	LCN	9	
Paraguay	21.64	88	UM	24	LCN	10	
Argentina	21.62	89	HI	48	LCN	11	
Kazakhstan	21.27	90	UM	25	CSA	5	
Madagascar	21.13	91	LI	5	SSF	9	
Mali	21.02	92	LI	6	SSF	10	
Guatemala	20.91	93	LM	14	LCN	12	
Azerbaijan	20.88	94	UM	26	NAWA	16	
Cambodia	20.82	95	LI	7	SEAO	14	
Senegal	20.81	96	LM	15	SSF	11	
Ecuador	20.30	97	UM	27	LCN	13	
Egypt	20.16	98	LM	16	NAWA	17	
Jamaica	19.98	99	UM	28	LCN	14	
Ghana	19.94	100	LM	17	SSF	12	
Namibia	19.83	101	UM	29	SSF	13	
Bolivia, Plurinational St.	18.83	102	LM	18	LCN	15	
Belarus	18.79	103	UM	30	EUR	37	
Bosnia and Herzegovina	18.70	104	UM	31	EUR	38	
Uganda	18.65	105	LI	8	SSF	14	
Honduras	18.56	106	LM	19	LCN	16	
Nigeria	18.50	107	LM	20	SSF	15	
Pakistan	17.75	108	LM	21	CSA	6	
Kyrgyzstan	17.63	109	LM	22	CSA	7	
El Salvador	17.19	110	LM	23	LCN	17	
Botswana	16.99	111	UM	32	SSF	16	
Nepal	16.94	112	LI	9	CSA	8	
Cameroon	16.76	113	LM	24	SSF	17	
Rwanda	16.53	114	LI	10	SSF	18	
Albania	16.24	115	UM	33	EUR	39	
Algeria	16.13	116	UM	34	NAWA	18	
Bangladesh	15.71	117	LM	25	CSA	9	
Zambia	15.58	118	LM	26	SSF	19	
Venezuela, Bolivarian Rep.	14.12	119	HI	49	LCN	18	
Nicaragua	13.35	120	LM	27	LCN	19	
Benin	13.33	121	LI	11	SSF	20	
Bhutan	12.30	122	LM	28	CSA	10	
Burundi	11.82	123	LI	12	SSF	21	
Guinea	11.30	124	LI	13	SSF	22	
Niger	10.80	125	LI	14	SSF	23	
Togo	9.73	126	LI	15	SSF	24	
Burkina Faso	9.31	127	LI	16	SSF	25	
Yemen	7.43	128	LM	29	NAWA	19	

Note: World Bank Income Group Classification (July 2015): LI = low income; LM = lower-middle income; UM = upper-middle income; and HI = high income. Regions are based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

The introduction of more accurate innovation indicators this year helps the USA's upward momentum. The USA keeps its top ranking in pillar 4, Market sophistication, and also this year in each of its three sub-pillars. In all other sub-pillars, the USA ranks in the top 25 with just four exceptions: Education (39th), Tertiary education (50th), Ecological sustainability (60th), and Intangible assets (45th). At the indicator level, the USA takes the top spot in 10 different indicators, including QS university rankings, venture capital deals, computer software spending, and cultural and creative services exports. In two new indicators—global R&D companies and domestic market scale—it ranks 2nd. This year the country also ranks 2nd in the quality of innovation composite indicator for the first time since its introduction in 2013, although this is largely the result of methodological considerations (see Box 4 on page 18). Box 5 on page 36 dives deeper into opportunities for the USA.

Finland re-enters the top 5 in the GII this year at 5th place. Its ranking of 4th in the Innovation Input Sub-Index can be partially attributed to Finland's place within the top 5 for three of its pillars: Institutions (2nd), Human capital and research (1st), and Business sophistication (4th). Nine of Finland's 16 relative strengths across pillars, sub-pillars, and indicators lie within Institutions and Human capital and research. The country takes the top spot in two indicators here: rule of law and ease of resolving insolvency. Finland's performance as part of the top 10 group relies on 16 of the 21 sub-pillars ranking in the top 10, including Business environment (1st), Knowledge workers (4th), Investment (8th), Innovation linkages (7th), Knowledge creation (8th), Knowledge diffusion (10th), and Knowledge absorption (10th). Improvement opportunities for Finland are seen in Trade, competition, and market scale (48th), Knowledge impact (41st), Ecological sustainability (31st), and Creative goods and services (30th).

Singapore moves up one position to 6th in this year's GII, earning the top rank in the South East Asia, East Asia, and Oceania region. It also earns the top spot in the Innovation Input Sub-Index, led by its ranking in the top 5 for all Input pillars and 1st place in three input pillars: Institutions, Infrastructure, and Business sophistication. Singapore maintains its rank of 20th in the Innovation Output Sub-Index, moving up two spots in the Knowledge and technology pillar to reach the top 10. In addition to ranking 1st in three pillars, Singapore also takes the top spot in three sub-pillars: Political environment, Regulatory environment, and Knowledge absorption. At the indicator level, Singapore sees relative stability across pillars, with the most significant improvements since 2015 in five indicators: expenditure on education (up 9 spots), ICT services imports (up by 47 spots), intellectual property receipts (up by 6 spots), ICT services exports (up by 11 spots), and trademarks by origin (up by 11 spots).

Ireland is ranked 7th this year after entering the top 20 in 2010 and the top 10 in 2012. Ireland's rank rose this year in overall Innovation Outputs (5th) and is perceived as a more efficient economy in terms of innovation, as captured by an improved Innovation Efficiency Ratio (8th). Ireland ranks in the top 20 across all pillars, with the greatest improvement in Infrastructure (19th). This is the result of a better performance in gross capital formation, although this indicator remains a relative weakness for the economy. Conversely, Ireland sees its largest drop in Market sophistication (19th); this shift can be attributed to two variables moving out of the top 25 in that sub-pillar: ease of getting credit and domestic credit to private sector, ranking now at 27th and 35th, respectively.

Denmark ranks 8th in this year's GII, a spot it also held in 2014. Denmark's improved positioning comes as it ranks in the top 25 economies across all pillars. At the sub-pillar level, Denmark improves in Tertiary education (17th), Investment (5th), Knowledge absorption (32nd), and Intangible assets (29th). It has also achieved a spot in the top 25 economies in 15 of the 21 sub-pillars. Although the country has a number of strengths in both the input and output sides of the GII, Denmark's most notable areas of opportunity are also in both sub-indices: Trade, competition, and market scale (36th), Knowledge absorption (32nd), and Knowledge impact (32nd).

The Netherlands has been ranked in the top 10 economies of the GII since 2008, and the country remains there in 2016 at 9th position. However, in part because of methodological considerations (see below), this year its ranking is affected by its lower ranks on both the Innovation Input Sub-Index (12th) and the Innovation Output Sub-Index (9th). The Netherlands achieves a top 25 ranking among all economies for all pillars of the GII, with a better ranking this year in Infrastructure (12th) and Business sophistication (9th). Conversely, the Netherlands' performance falls at the pillar level in Knowledge and technology outputs, where it ranks 16th overall. This change is mainly a consequence of lower rankings in the Knowledge diffusion sub-pillar (114th) and the indicator FDI net outflows (118th).

The latter indicator, identified as highly volatile in previous GII editions, partly drives the fall in the ranking of the Netherlands. Also, for some new variables—namely, IP receipts and ICT services exports—the Netherlands lacks data.

Germany rounds out the top 10 economies of the GII, moving into this group for the first time since 2009. Germany's ranking increases are notable across five pillars: Institutions (18th), Market sophistication (16th), Business sophistication (15th), Knowledge and technology outputs (8th), and Creative outputs (7th). Germany shows stability in its ranks in both the Innovation Input Sub-Index (18th) and the Innovation Output Sub-Index (8th), and improves in its Innovation Efficiency Ratio (9th). Ranking in the top 25 economies across all pillars, and in the top 10 economies for both output pillars, Germany shows improvements on the output side in Knowledge impact (26th), Intangible assets (8th), and Creative goods and services (29th). In addition, specific strengths at the indicator level on the output side are behind the upward drive that now has Germany among the top 10. These include patents by origin (1st), Citable documents H index (3rd), industrial designs by origin (5th), and country-code top-level domains (1st).

The top 10 in the Innovation Input Sub-Index

The Innovation Input Sub-Index considers the elements of an economy that enable innovative activity through five pillars. The top 10 economies in the Innovation Input Sub-Index are Singapore, Hong Kong (China), the USA, Finland, Sweden, Switzerland, the UK, Denmark, Japan, and Canada. Hong Kong (China), Japan, and Canada are the only economies in this group that are not also in the GII top 10.

Hong Kong (China) is ranked 14th in the GII overall, down from 11th in 2015. It ranks in the top 25 economies for all pillars except for Knowledge and technology outputs (30th). With particularly high rankings in Institutions (4th), Infrastructure (2nd), and Market sophistication (2nd), Hong Kong (China) has the second spot in the Innovation Input Sub-Index. In 9 of the 15 Input sub-pillars, Hong Kong (China) ranks in the top 10, with either stable or improved rankings from 2015 in 14 of these sub-pillars. In addition to improvements in the Institutions pillar, its top performance in Market sophistication can be noted. This is where most of the economy's individual strengths are identified—ease of protecting minority investors, market capitalization, total value of stocks traded, and applied weighted tariff are all ranked 1st. Conversely, despite improving in rank in two indicators in the Education sub-pillar, expenditure on education (89th) and government expenditure on education per pupil (60th) are both relative areas of opportunity for improvement. The introduction of new indicators is also a factor to consider when assessing Hong Kong (China)'s drop from the top 10 this year (see Annex 2).

Japan moves up three spots in the Innovation Input Sub-Index to 9th and up three spots in its overall GII ranking to 16th. Ranking in the top 15 economies for all five input pillars, Japan improved most in Market sophistication (8th) and Business sophistication (10th). Within Market sophistication, Japan shows progress in market capitalization (13th) and total value of stocks traded (4th). Within Business sophistication, Japan improves in ICT services imports (49th) and in overall Knowledge absorption (11th). Other areas of strength for Japan on the input side include Research and development (2nd), ICTs (4th), and Trade, competition, and market scale (2nd).

Canada remains in the top 10 in the Innovation Input Sub-Index, ranking 10th in the sub-index and 15th overall, up one position from 2015 (see Box 5 on page 36 for more details on Canada). Canada's strengths on the input side come from having top 25 rankings in each of its pillars. Canada shows particular strengths in Institutions (6th) and Market sophistication (3rd). At the sub-pillar level, Canada performs at relative levels of strength and within the top 10 overall economy rankings in Political environment (8th), Business environment (2nd), General infrastructure (4th), Credit (8th), and Investment (4th).

The top 10 in the Innovation Output Sub-Index

The Innovation Output Sub-Index variables provide information on elements that are the result of innovation within an economy. Although scores on the Input and Output Sub-Indices might differ substantially, leading to important shifts in rankings from one sub-index to the other for particular countries, the data confirm that efforts made to improve enabling environments are rewarded with better innovation outputs. The top 10 economies in the Innovation Output Sub-Index this year are Switzerland, Sweden, Luxembourg, the UK, Ireland, Iceland, the USA, Germany, the Netherlands, and Finland.

The 10 economies leading the Innovation Output Sub-Index remain consistent with their ranking in 2015, with several shifts: four economies move upward in ranking

within the top 10 (Sweden, the UK, Ireland, and the USA), while two economies move downward in ranking within the top 10 (Luxembourg, the Netherlands). Eight of these economies are already in the GII top 10; the profiles of the other two economies are discussed below.

Luxembourg ranks 3rd in the Innovation Output Sub-Index in 2016 and 12th in the overall GII. On the output side, Luxembourg comes in 11th in Knowledge and technology outputs and 2nd in Creative outputs, improving and maintaining its position from 2015, respectively. Luxembourg ranks among the top five economies in four of the six output sub-pillars: Knowledge diffusion (5th), Intangible assets (1st), Creative goods and services (10th), and Online creativity (3rd); it ranks 1st in five indicators: PCT patent applications, FDI net outflows, cultural and creative services exports, national feature films, and generic top-level domains (TLDs). Luxembourg also achieves the top position in the Innovation Efficiency Ratio rankings while maintaining the second-highest GDP per capita (PPP$ GDP) of all GII 2016 economies (after Qatar).

Iceland ranks 6th in the Innovation Output-Sub Index in 2016 and 13th in the GII overall, maintaining its GII 2015 positioning in both. Although Iceland ranks 24th in the Innovation Input Sub-Index, down one spot from 2015, on the output side this year it shows its strength in its 1st place in Creative outputs, the same rank it held last year. Within this pillar, Iceland holds the top spot in two of its sub-pillars: Creative goods and services and Online creativity, while ranking 1st in four of its indicators: national feature films, printing and publishing manufactures, generic top-level domains (TLDs), and Wikipedia edits. Within the Knowledge and technology outputs pillar (22nd), Iceland ranks 1st in scientific and technical articles, while exhibiting opportunities for growth in its lower rankings in growth rate of GDP per worker (84th) and high- and medium-high-tech manufactures (85th).

Top performers by income group

Viewing economies among their income-group peers can illustrate important relative competitive advantages and help decision makers glean important lessons for improved performance that are applicable on the ground. The GII also assesses results relative to the development stages of countries.

Table 4 shows the 10 best-ranked economies in each index by income group. The top 24 positions in the GII are taken by high-income economies, a shift from 2015 as China (now in the upper-middle-income group) moves into the top 25 group in the GII (see Box 3 on page 10).

Switzerland, Sweden, and the UK are among the high-income top 10 on the three main indices, while Switzerland and Sweden are also in the top 10 in the Innovation Efficiency Ratio. Hungary, now in the high-income group, shows rank improvements across all three main indices, as well as in the Innovation Efficiency Ratio, where it is now among the top 10 ranked economies.

Among the 10 highest-ranked upper-middle-income economies, eight remain from 2015: China (25th this year), Malaysia (35th), Bulgaria (38th), Costa Rica (45th), Romania (48th), Montenegro (51st), Thailand (52nd), and Mauritius (53rd). Newcomers to this group of the 10 best upper-middle-income performers include Turkey (42nd) and South Africa (54th), which displace Belarus (79th) and TFYR of Macedonia (58th).

China, Malaysia, Bulgaria, Costa Rica, Romania, and Montenegro are among the 10 best-ranked upper-middle-income economies across all three main indices; of these, all except Malaysia and Montenegro also make it to the upper-middle-income top 10 in the Innovation Efficiency Ratio.

The same analysis for lower-middle-income countries shows that eight of the top 10 countries from 2015 remain in the top 10 this year. These include the Republic of Moldova (46th), Ukraine (56th), Viet Nam (59th), Armenia (60th), Georgia (64th), India (66th), Morocco (72nd), and the Philippines (74th). New this year to the top 10 lower-middle-income countries are Kenya (80th) and Tajikistan (86th), which displace Sri Lanka (91st) and Senegal (106th). All of the top 10 lower-middle-income countries have rankings in the top 10 for each of the three indices with the exceptions of Kenya and Tajikistan; the Republic of Moldova, Viet Nam, Ukraine, Armenia, and the Philippines also make it to the lower-middle-income top 10 in the Innovation Efficiency Ratio.

There has also been a strong consistency among low-income countries, with nine out of 10 economies remaining in the top 10. Rwanda is the top-ranked low-income country (83rd), having moved up 11 spots in the overall GII since 2015, and with ranking improvements in the Innovation Input-Sub-Index (55th), Innovation Output Sub-Index (114th), and Innovation Efficiency Ratio (123rd). This last ranking, however, is still identified as a weakness for that country. Following in the ranking of low-income countries are Mozambique (84th), Cambodia (95th), Malawi (98th), Uganda

Table 4: Ten best-ranked economies by income group (rank)

	Global Innovation Index	Innovation Input Sub-Index	Innovation Output Sub-Index	Innovation Efficiency Ratio
High-income economies (49 in total)				
1	**Switzerland (1)**	Singapore (1)	**Switzerland (1)**	Luxembourg (1)
2	**Sweden (2)**	Hong Kong (China) (2)	**Sweden (2)**	Malta (2)
3	**United Kingdom (3)**	United States of America (3)	Luxembourg (3)	Iceland (3)
4	United States of America (4)	Finland (4)	**United Kingdom (4)**	**Switzerland (5)**
5	Finland (5)	**Sweden (5)**	Ireland (5)	Estonia (6)
6	Singapore (6)	**Switzerland (6)**	Iceland (6)	Ireland (8)
7	Ireland (7)	**United Kingdom (7)**	United States of America (7)	Germany (9)
8	Denmark (8)	Denmark (8)	Germany (8)	**Sweden (10)**
9	Netherlands (9)	Japan (9)	Netherlands (9)	**United Kingdom (14)**
10	Germany (10)	Canada (10)	Finland (10)	Hungary (17)
Upper-middle-income economies (34 in total)				
1	**China (25)**	**China (29)**	**China (15)**	**China (7)**
2	Malaysia (35)	Malaysia (32)	**Bulgaria (35)**	Turkey (13)
3	**Bulgaria (38)**	Montenegro (46)	Turkey (37)	**Bulgaria (16)**
4	Turkey (42)	South Africa (47)	Malaysia (39)	Lebanon (41)
5	**Costa Rica (45)**	Mauritius (48)	**Costa Rica (44)**	**Romania (46)**
6	**Romania (48)**	**Bulgaria (49)**	**Romania (45)**	Mongolia (47)
7	Montenegro (51)	**Costa Rica (50)**	Thailand (50)	**Costa Rica (50)**
8	Thailand (52)	**Romania (52)**	Mongolia (51)	Iran, Islamic Rep. (51)
9	Mauritius (53)	Colombia (53)	Montenegro (52)	Thailand (53)
10	South Africa (54)	Peru (56)	TFYR of Macedonia (55)	TFYR of Macedonia (56)
Lower-middle-income economies (29 in total)				
1	**Moldova, Rep. (46)**	Bhutan (54)	**Moldova, Rep. (36)**	**Moldova, Rep. (4)**
2	**Ukraine (56)**	Georgia (67)	**Ukraine (40)**	**Viet Nam (11)**
3	**Viet Nam (59)**	India (72)	**Viet Nam (42)**	**Ukraine (12)**
4	**Armenia (60)**	**Moldova, Rep. (74)**	**Armenia (43)**	**Armenia (15)**
5	Georgia (64)	Morocco (75)	India (59)	Côte d'Ivoire (19)
6	India (66)	**Ukraine (76)**	Georgia (60)	Tajikistan (29)
7	Morocco (72)	**Viet Nam (79)**	**Philippines (64)**	Kenya (30)
8	**Philippines (74)**	**Armenia (80)**	Kenya (65)	**Philippines (49)**
9	Kenya (80)	**Philippines (86)**	Tajikistan (69)	Indonesia (52)
10	Tajikistan (86)	El Salvador (89)	Morocco (70)	Sri Lanka (54)
Low-income economies (16 in total)				
1	Rwanda (83)	Rwanda (55)	**Mozambique (73)**	Ethiopia (18)
2	**Mozambique (84)**	**Uganda (91)**	Tanzania, United Rep. (80)	Tanzania, United Rep. (22)
3	**Cambodia (95)**	**Cambodia (94)**	**Malawi (83)**	Madagascar (35)
4	**Malawi (98)**	**Mozambique (96)**	Ethiopia (85)	Mali (37)
5	**Uganda (99)**	Burkina Faso (105)	Madagascar (91)	**Malawi (38)**
6	Tanzania, United Rep. (105)	**Malawi (110)**	Mali (92)	**Mozambique (45)**
7	Ethiopia (110)	Benin (111)	**Cambodia (95)**	**Cambodia (90)**
8	Madagascar (111)	Niger (113)	**Uganda (105)**	**Nepal (94)**
9	Mali (112)	Burundi (114)	**Nepal (112)**	**Uganda (106)**
10	**Nepal (115)**	**Nepal (116)**	Rwanda (114)	Guinea (112)

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

Table 5: Innovation achievers and their income groups and regions

Economy	Income group	Region
Moldova, Rep.	Lower-middle	EUR
Mozambique	Low income	SSF
Rwanda	Low income	SSF
Viet Nam	Lower-middle	SEAO
Malawi	Low income	SSF
Tajikistan	Lower-middle	CSA
Kenya	Lower-middle	SSF
Ukraine	Lower-middle	EUR
India	Lower-middle	CSA
Uganda	Low income	SSF
Czech Republic	High income	EUR
Armenia	Lower-middle	NAWA
Malta	High income	EUR
Madagascar	Low income	SSF
Portugal	High income	EUR

Note: These countries appear 10% or more above the trend line and are listed here in order of distance.
Regions are based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

(99th), the United Republic of Tanzania (105th), Ethiopia (110th), Madagascar (111th), Mali (112th), and Nepal (115th), which displaces Burkina Faso (122nd). Ranking well across all main indices of the GII, Rwanda, Mozambique, Cambodia, Malawi, Uganda, and Nepal are among the top 10 low-income countries. Of these, all except Rwanda are in the low-income top 10 in the Innovation Efficiency Ratio.

Maximizing innovation resources and synergies: The Innovation Efficiency Ratio

The Innovation Efficiency Ratio is calculated as the ratio of the Output Sub-Index score over the Input Sub-Index score. It assesses the effectiveness of innovation systems and policies. It must be noted, however, that economies might also reach a relatively high Innovation Efficiency Ratio as a result of particularly low input scores. Because of this, efficiency ratios must be analysed jointly with GII, Input, and Output scores, and with the development stages of the economies in mind.

The 10 countries with the highest Innovation Efficiency Ratios are countries that combine certain levels of innovation inputs with more robust output results (see Table 1 on page 20): Luxembourg, Malta, Iceland, the Republic of Moldova, Switzerland, Estonia, China, Ireland, Germany, and Sweden. Eight of the top 10 most efficient economies are high-income economies.

As in 2015, economies from Europe, South East Asia, East Asia, and Oceania, Northern Africa and Western Asia, and Sub-Saharan Africa take up the first 20 positions in this ratio ranking.

Among upper-middle-income economies, only China is in the top 10 in terms of efficiency; China also ranks in the top 15 in the Innovation Output Sub-Index, surmounting its relatively lower ranking in the Innovation Input Sub-Index. Within the upper-middle-income group, 47.1% of economies rank higher in outputs than they do in inputs.

Among lower-middle-income economies, only the Republic of Moldova is in the top 10 in terms of efficiency; the Republic of Moldova also ranks at the top of lower-middle-income economies in the Innovation Output Sub-Index (36th). Additionally, Viet Nam, Ukraine, Armenia, and Côte d'Ivoire rank in the group of the top 20 economies globally in terms of innovation efficiency. Within the lower-middle-income group, 75.9% of economies rank higher in outputs than they do in inputs. No low-income economies are in the top 10 this year in innovation efficiency rankings.

Clustering leaders, innovation achievers, and underperformers: The GII bubble chart

The GII helps also identify economies that over- or underperform on innovation relative to their level of development. Figure 4 on page 32 illustrates the findings by presenting the GII scores plotted against GDP per capita in PPP$ (in natural logs). The economies that appear close to the trend line show results that are in accordance with what is expected based on their level of development. The further up and above the trend line an economy appears, the better its innovation performance is when compared with that of its peers at the same stage of development. Light-coloured bubbles in the figure correspond to the efficient innovators (a majority of them are situated above the trend line), while the dark-coloured bubbles represent those countries in the lower half of the Innovation Efficiency Ratio.

Among the innovation leaders we find the top 25 countries that, with two exceptions—China is now in and the Czech Republic is out—are the same economies as in 2015. A majority of economies in this category are in the high-income group and located in Europe or South East Asia, East Asia, and Oceania. All of these economies also have a GII score above 50.[48] These all show solid innovation systems where investments in human capital prosper in stable innovation infrastructures to create the highest levels of innovation outputs globally.

Economies that perform at least 10 percent higher than their peers for their level of GDP are called 'innovation achievers'. These economies are shown in Table 5. Innovation achievers demonstrate better results in innovation because they continuously make improvements to their institutional framework, have a set of highly skilled workers who operate

Table 6: Heatmap for GII top 10 economies and regional and income group averages (1–100)

Country/Economy	GII	Institutions	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Input	Knowledge and technology outputs	Creative outputs	Output	Efficiency
Switzerland	66.28	90.25	63.32	60.97	69.76	57.57	68.38	66.99	61.38	64.19	0.94
Sweden	63.57	88.32	64.82	66.33	66.17	56.78	68.48	63.92	53.40	58.66	0.86
United Kingdom	61.93	87.65	62.61	66.39	71.63	49.24	67.50	50.17	62.53	56.35	0.83
United States of America	61.40	85.74	57.03	61.73	86.63	52.45	68.71	56.54	51.62	54.08	0.79
Finland	59.90	94.31	68.11	59.99	62.72	57.34	68.49	52.07	50.56	51.32	0.75
Singapore	59.16	94.85	67.08	69.11	71.52	62.14	72.94	49.63	41.14	45.38	0.62
Ireland	59.03	88.15	54.00	59.39	56.94	53.76	62.44	57.89	53.36	55.63	0.89
Denmark	58.45	91.56	65.77	58.77	71.33	47.86	67.06	46.36	53.33	49.84	0.74
Netherlands	58.29	90.98	55.30	62.07	58.05	53.75	64.03	44.08	61.01	52.54	0.82
Germany	57.94	84.11	58.93	58.51	59.70	48.29	61.91	51.64	56.29	53.97	0.87
Average	**36.73**	63.10	**33.91**	**43.36**	**45.37**	**33.58**	**43.86**	**27.58**	**31.62**	**29.60**	**0.66**
Region											
Northern America	58.05	88.70	54.99	62.04	80.12	49.47	67.06	48.73	49.36	49.04	0.73
Europe	46.85	76.00	46.73	52.61	49.81	40.39	53.11	37.57	43.61	40.59	0.75
South East Asia, East Asia, and Oceania	44.59	69.70	42.99	50.88	56.93	41.50	52.40	36.06	37.48	36.77	0.71
Northern Africa and Western Asia	33.83	60.45	32.02	44.40	42.12	26.91	41.18	24.22	28.72	26.47	0.63
Latin America and the Caribbean	30.29	52.93	26.29	40.14	42.30	30.77	38.49	18.09	26.09	22.09	0.57
Central and Southern Asia	27.73	49.47	24.83	35.02	40.63	25.78	35.15	19.92	20.71	20.32	0.59
Sub-Saharan Africa	25.56	52.42	17.98	28.21	35.92	27.56	32.42	18.41	19.00	18.70	0.58
Income level											
High income	48.33	77.74	48.84	56.26	53.59	42.07	55.70	37.85	44.09	40.97	0.73
Upper-middle income	33.50	60.67	30.99	41.80	43.68	29.61	41.35	23.03	28.26	25.65	0.62
Lower-middle income	27.87	48.52	21.75	33.12	40.13	25.88	33.88	21.01	22.71	21.86	0.64
Low income	24.15	49.86	16.40	25.74	33.34	29.95	31.06	17.74	16.73	17.23	0.56

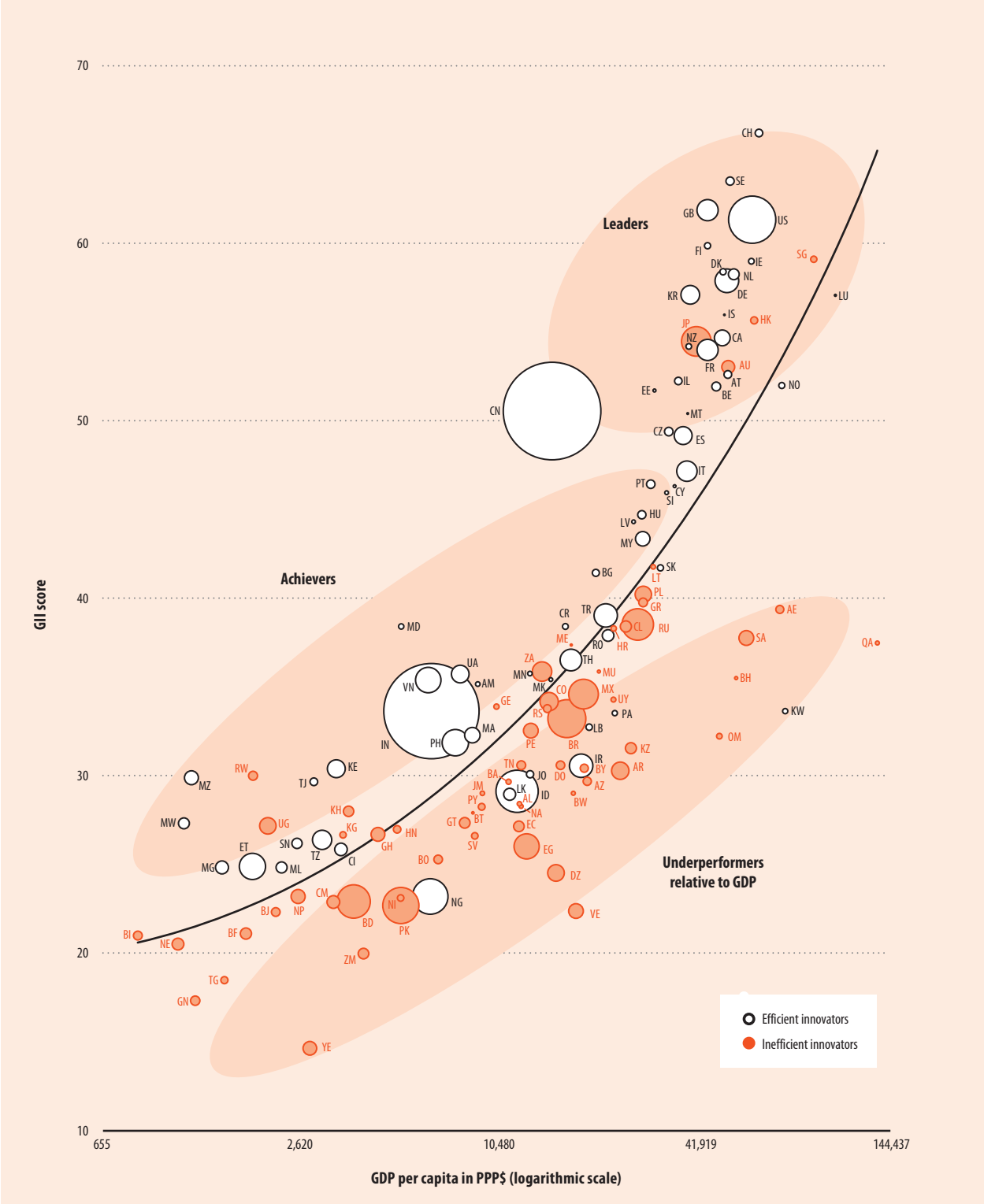
Worst — Average — Best

Note: Darker shadings indicate better performances. Countries/economies are classified according to the World Bank Income Group and the United Nations Regional Classifications (July 2015 and October 2013, respectively).

in more stable innovation systems, show a better integration with international markets, and display more solid channels of knowledge absorption. These traits result in higher economic growth rates per worker and in more sophisticated local business communities that are attractive for foreign investment. Yet progress on these dimensions is still not uniform across their economies.[49] The number of innovation achiever countries—a total of 15—is smaller this year than it was in previous editions. This is the result of having fewer countries covered by the GII this year, resulting from stricter minimum data requirement.[50] If the less strict data coverage rule from last year were applied this year, the total number of innovation achievers would increase to 24 and include the following economies (listed in order of distance to the trend): Mongolia, Georgia, Bulgaria, the Philippines, the United Republic of Tanzania, Latvia, Hungary, Morocco, Cambodia, and Malaysia.

In either case, the majority of countries in this category would still

Figure 4: GII scores and GDP per capita in PPP$ (bubbles sized by population)



Note: 'Efficient innovators' are countries/economies with Innovation Efficiency ratios ≥ 0.66; 'Inefficient innovators' have ratios < 0.66; the trend line is a polynomial of degree three with intercept ($R^2 = 0.661$).

Figure 4: GII scores and GDP per capita in PPP$ (bubbles sized by population): ISO-2 Country Codes

Code	Country
AL	Albania
DZ	Algeria
AR	Argentina
AM	Armenia
AU	Australia
AT	Austria
AZ	Azerbaijan
BH	Bahrain
BD	Bangladesh
BY	Belarus
BE	Belgium
BJ	Benin
BT	Bhutan
BO	Bolivia, Plurinational St.
BA	Bosnia and Herzegovina
BW	Botswana
BR	Brazil
BG	Bulgaria
BF	Burkina Faso
BI	Burundi
KH	Cambodia
CM	Cameroon
CA	Canada
CL	Chile
CN	China
CO	Colombia
CR	Costa Rica
CI	Côte d'Ivoire
HR	Croatia
CY	Cyprus
CZ	Czech Republic
DK	Denmark
DO	Dominican Republic
EC	Ecuador
EG	Egypt
SV	El Salvador
EE	Estonia
ET	Ethiopia
FI	Finland
FR	France
GE	Georgia
DE	Germany
GH	Ghana
GR	Greece
GT	Guatemala
GN	Guinea
HN	Honduras
HK	Hong Kong (China)
HU	Hungary
IS	Iceland
IN	India
ID	Indonesia
IR	Iran, Islamic Rep.
IE	Ireland
IL	Israel
IT	Italy
JM	Jamaica
JP	Japan
JO	Jordan
KZ	Kazakhstan
KE	Kenya
KR	Korea, Rep.
KW	Kuwait
KG	Kyrgyzstan
LV	Latvia
LB	Lebanon
LT	Lithuania
LU	Luxembourg
MG	Madagascar
MW	Malawi
MY	Malaysia
ML	Mali
MT	Malta
MU	Mauritius
MX	Mexico
MD	Moldova, Rep.
MN	Mongolia
ME	Montenegro
MA	Morocco
MZ	Mozambique
NA	Namibia
NP	Nepal
NL	Netherlands
NZ	New Zealand
NI	Nicaragua
NE	Niger
NG	Nigeria
NO	Norway
OM	Oman
PK	Pakistan
PA	Panama
PY	Paraguay
PE	Peru
PH	Philippines
PL	Poland
PT	Portugal
QA	Qatar
RO	Romania
RU	Russian Federation
RW	Rwanda
SA	Saudi Arabia
SN	Senegal
RS	Serbia
SG	Singapore
SK	Slovakia
SI	Slovenia
ZA	South Africa
ES	Spain
LK	Sri Lanka
SE	Sweden
CH	Switzerland
TJ	Tajikistan
TZ	Tanzania, United Rep.
TH	Thailand
MK	TFYR of Macedonia
TG	Togo
TN	Tunisia
TR	Turkey
UG	Uganda
UA	Ukraine
AE	United Arab Emirates
GB	United Kingdom
US	United States of America
UY	Uruguay
VE	Venezuela, Bolivarian Rep.
VN	Viet Nam
YE	Yemen
ZM	Zambia

consist of middle- and low-income economies and would still mostly be situated in Sub-Saharan Africa and the eastern region of Europe.

There is also a group of economies that perform at least 10 percent below their peers for their level of GDP. This cluster includes 36 countries from different regions and income groups. Nine of these are from the high-income group (7 high-income economies are from the Middle East), 13 are from the upper-middle income group, 12 are lower-middle economies, and 2 are low-income economies.

Regional rankings

This section discusses regional and sub-regional trends, with snapshots for some of the economies leading in the rankings. This year various notable changes occur in these regional GII rankings, in part as a result of changed performance or methodological considerations (see Annex 2).

Table 6 on page 31 presents a heatmap with the scores for the top 10, along with average scores by income and regional group. To put the discussion of rankings further into perspective, Figure 5 on page 35 presents, for each region, bars representing the median pillar scores (second quartile) as well as the range of scores determined by the first and third quartile; regions are presented in decreasing order of their average GII rankings (except for the EU, which is placed at the end).

Northern America (2 economies)

Northern America, the UN-defined region that includes both the USA and Canada, holds two of the top 15 rankings in this year's GII. Both the USA and Canada are high-income economies and rank in the top 10 economies in terms of GDP. The USA ranks 4th overall this year, up one position from 2015, and is in the top 10 economies in both the Innovation Input Sub-Index (3rd) and the Innovation Output Sub-Index (7th). Canada is 15th overall, having also moved up one spot from 2015, and is in the top 25 economies in the Innovation Input Sub-Index (10th) and the Innovation Output Sub-Index (23rd).

For more details on the innovation environment of the USA and Canada, see Box 5 on page 36.

Sub-Saharan Africa: Preserving the innovation momentum in one of the most promising regions (25 economies)

For several editions, the GII has noted that the Sub-Saharan Africa region performs well on the innovation front. Since 2012, Sub-Saharan Africa has had more countries among the group of innovation achievers than any other region. As economic slowdown occurs, it will be important for Africa to preserve its current innovation momentum (see Box 6 on page 38).

Similar to 2015, there are nine economies that rank in this year's top 100 economies in the GII: Mauritius takes the top spot among all economies in the region (53rd), followed by South Africa (54th), Kenya (80th), Rwanda (83rd), Mozambique (84th), Botswana (90th), Namibia (93rd), Malawi (98th), and Uganda (99th). All of these economies remained either at stable or improved GII rankings in relation to their 2015 rankings, with the exception of Mauritius, which drops four spots this year.

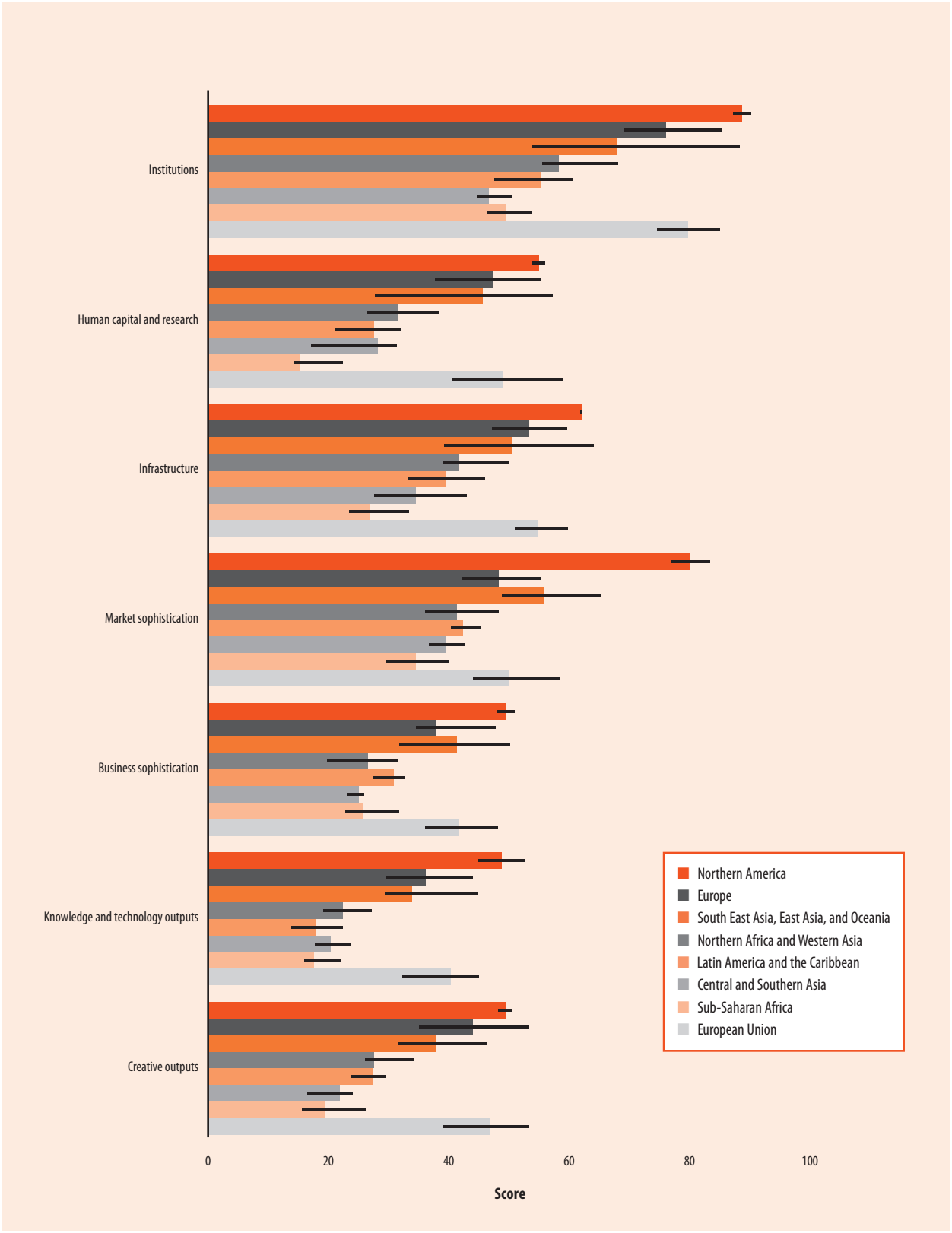
The remaining 16 economies in this region can be found at the bottom of the rankings (100 or lower). Eleven of them have improved since 2015: Ghana (102nd), the United Republic of Tanzania (105th), Côte d'Ivoire (108th), Ethiopia (110th), Madagascar (111th), Nigeria (114th), Benin (unranked in 2015, this year 121st), Burundi (123rd), Niger (124th), Togo (126th), and Guinea (127th). See Box 6 on page 38 for more details.

Latin America and the Caribbean: A region with untapped innovation potential but important risks in the near-term (19 economies)

In the last few GII editions, Latin America was labelled as a region with important untapped innovation potential. Although significant potential exists, the GII rankings of local countries, relative to other regions, have not steadily improved. Furthermore, none of the economies in the region has recently been an innovation achiever, with performance higher than expected by its GDP. Still, a few economies—such as Chile, Colombia, and Mexico—stood out among their peers; the important role of Brazil and the emergent role of Peru and Uruguay were noted in past GII editions. And, this year, Chile, Colombia, Costa Rica, Mexico, and Uruguay achieve the best regional GII ranks.

Clearly, most if not all countries in Latin America and the Caribbean, particularly their local governments, firms, and other actors, continue to have the innovation agenda firmly on their radar. This is unlikely to come to a sudden halt anytime soon. Yet, as Latin America and the Caribbean, especially Brazil, has entered into a zone of considerable economic turbulence, it will be important to overcome short-term political and economic constraints and to cling to longer-term innovation commitments and results. Greater regional R&D and innovation cooperation in Latin America and the Caribbean might indeed help in this process, as underlined in this year's GII theme.

Figure 5: Median scores by regional group and by pillar



Note: The bars show median scores (second quartiles); the lines show the range of scores between the first and third quartiles.

Box 5: Northern America: The USA and Canada on different innovation pathways?

Northern America is home to two large high-income economies, the United States of America (USA) and Canada. Although both economies have achieved top scores this year, these two countries have been experiencing different innovation dynamics over recent years.

Ranked 4th in the GII overall rankings and number 2 on innovation quality,[1] the USA continues to be one of the leading innovation nations. It has prominent positions among the top 25 countries in all GII pillars and 17 of the 21 sub-pillars. It comes in 1st on the Credit, Investment, and Trade, competition, and market scale sub-pillars and scores among the top 10 on six of the other sub-pillars.[2] The USA also continues to be the highest performer of R&D worldwide, accounting for close to 27% of the world total in 2014 according to our estimates.[3] US total R&D spending is projected to increase by 4.2 percent in 2017.[4] Although US businesses are responsible for 70% of R&D spending, its government continues to play a substantial role in performing and financing R&D, driving one of the highest levels of basic R&D globally.[5] The quality of its innovation system is frequently demonstrated by its top scores in the quality of its universities and the quality of its scientific publications (see Box 4). It also boasts a high degree of market sophistication and its innovation clusters, in particular those on the East and West Coasts of the country, continue to be a magnet for top talent and a critical source of technological and non-technological innovation.

Still, the USA's lead in innovation is narrowing in terms of the absolute levels of key innovation input and output metrics alone. With fast growth in its R&D expenditure, China accounted for about 21% of global R&D spending in 2014, second only to the USA. Studies note that China is also catching up rapidly in the number of researchers and the absolute number of scientific publications.[6] The same is true for output indicators such as patents by origin, where the USA's lead is tightening.

Of course absolute spending or absolute figures on publications do not guarantee a successful innovation system, which remains unparalleled in the USA, thanks to its thriving market sophistication and business sector and its solid ties between research and firms. Other countries will continue to benchmark their innovation systems against the USA's system, with its success stories, for years to come.

Nonetheless, the USA also exhibits some structural weaknesses; education (it ranks 39th, far below its overall rank of 4th on the GII) and tertiary education (ranks 50th) continue to be relatively weaker spots. On tertiary education, the number of graduates in science and engineering, (ranked 85th) is low; this has been a source of concern for some time. The USA's performance on the PISA assessment (ranked 25th) is less alarming but also lower than the average of top 10 innovating economies (see Figure 5.1). More broadly, the USA faces a productivity and investment weakness, reflected in its low score in gross fixed capital formation and labor productivity (see Figure 5.1).

Canada also continues to be among the top 25 innovation leaders. Now standing at rank 15 with top 25 scores in all leading pillars and 13 of the 21 sub-pillars, it has a clear lead in having one of the most conducive business and investment climates worldwide and ranks in the top 10 in seven sub-pillars.[7] It ranks favourably in terms of innovation quality, boasting a world-class university network and top-quality scientific publications.

On average, however, Canada's GII rankings have declined in recent years. Partly as a result of methodological changes to the GII model and partly because of its relatively weak performance, Canada dropped out of the top 10 in 2011; the country also shows weaknesses in its education indicators. Looking at human capital and research, Canadian R&D expenditures have been on a different trajectory than those of the USA. Specifically, the growth of its R&D expenditures has been on a downward trend since 2001.[8] Where business R&D in the USA is increasing at a much faster pace than government R&D, dynamics in Canada are the reverse (see Figure 5.2). So far, earlier government attempts to revive R&D by providing tax support have not translated into more business R&D.[9] In terms of the government's education expenditure per pupil, Canada ranks 64th; the average rank of top 10 innovating economies (excluding the USA) is 33 in this indicator. Other weaknesses include new businesses creation, ICT services imports, and gross capital formation.

Figure 5.1 compares the 2016 GII scores of the USA, Canada, and the average scores of top 10 GII innovating economies (without the USA) on key innovation input and output indicators. Although the USA and Canada each lead in some areas, in several variables they perform worse than the top 10 average. Some of these variables are government expenditure/pupil, secondary; knowledge-intensive employment; and high-tech and medium-high tech output.

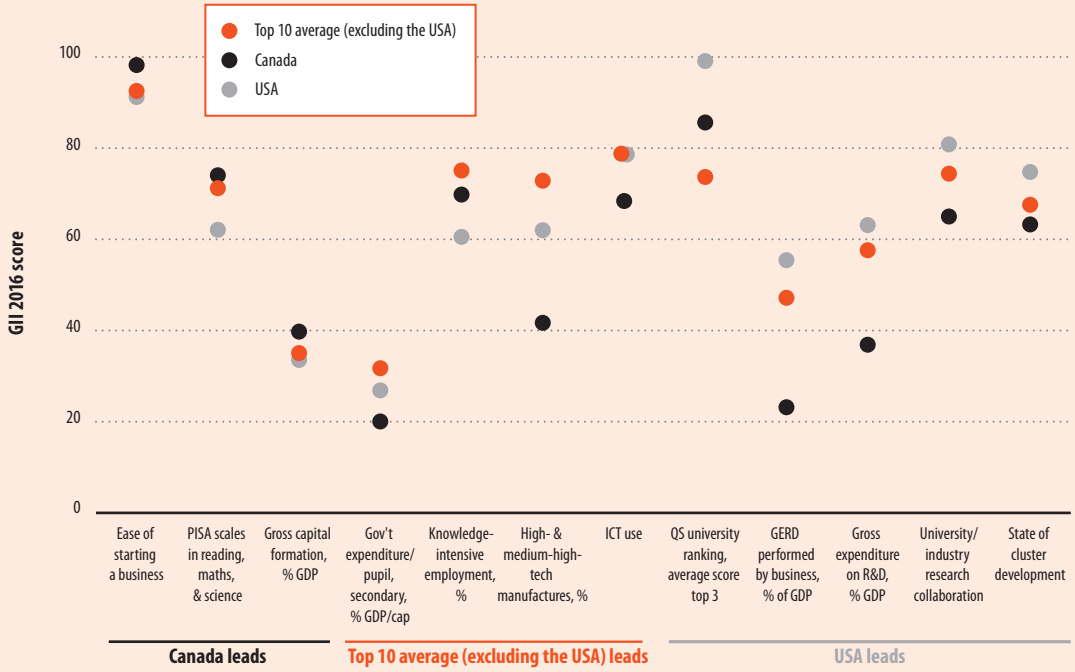
For both the USA and Canada to grow as innovation leaders they need not only to overcome their weaknesses but also to reinforce their education and research base. Canada, for instance, plans to counteract its relative decline and increase its investments in infrastructure, extend its research capacity, provide a stimulating environment for creative and entrepreneurial firms, and invest in its universities and research hospitals. It proposes, over next four years, to provide support for innovation clusters and networks across the country.[10] As global innovation leaders, the direction of innovation policies that governments adopt will determine the synergies that these two economies can harness to maintain Northern America as a key global innovation hub.

Notes

Notes for this box appear at the end of the chapter.

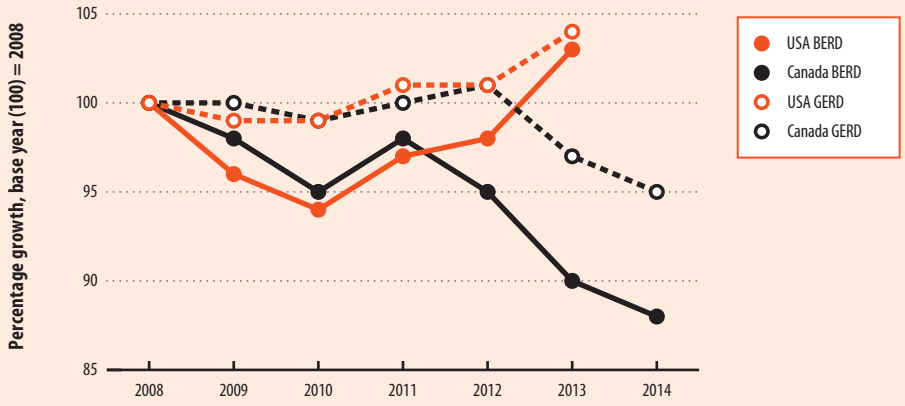
Box 5: Northern America: The USA and Canada on different innovation pathways? *(continued)*

Figure 5.1: The United States of America, Canada, and top 10 average (excluding the USA) scores



Source: GII 2016 data.

Figure 5.2: The United States of America and Canada: Public and private R&D spending, 2008–14



Source: GII based on UIS data.
Note: BERD = Business enterprise expenditure on R&D; GERD = Gross domestic expenditures on R&D.

Box 6: Sub-Saharan Africa: Preserving the innovation momentum in one of the most promising regions

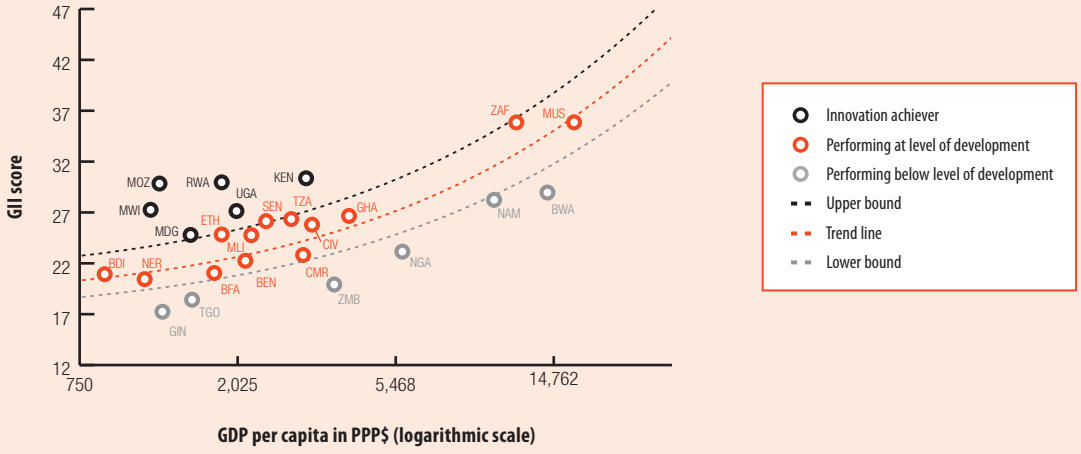
For several editions, the GII has noted that the Sub-Saharan Africa region performs well on the innovation front. Since 2012, Sub-Saharan Africa has had more countries among the group of innovation achievers than any other region.[1] Noted improvements in the Institutions, Business sophistication, and Knowledge and technology output pillars have allowed the region as a whole to catch up to Central and Southern Asia in these factors, and even to overtake Northern Africa and Western Asia in Business sophistication. The drivers of growth that have been at play in the region have come mostly from an improved institutions, a better business environment, and explicit efforts on the part of science and innovation policy.

Assisted by economies such as Mauritius, South Africa, Rwanda, and Botswana, Sub-Saharan Africa this year has its highest scores in the Institutions and Market sophistication pillars. These countries perform on par or above their peers in South East Asia, East Asia, and Oceania and Europe in some of these pillars. In addition to developments in Business sophistication, efforts to improve infrastructure have translated into a higher regional score in this pillar. Larger economies, such as Botswana and Namibia, are helping promote this expansion through stronger performances in general infrastructure and ecological sustainability. These, among other positive efforts, can be highlighted as factors that are helping to keep the region's overall innovation momentum alive, albeit with economic and GDP growth slowing in the region over the last year.

This box benchmarks the regional innovation performance of Sub-Saharan Africa countries by taking into account both the overall GII scores and those of the seven individual GII pillars. Countries are termed 'innovation achievers' and said to outperform their peers if their GII scores are higher than expected based on their level of economic development (as measured by GDP per capita).[2] Countries also have the opportunity to be 'pillar outperformers' if they outperform their peers on four or more of the seven GII pillars. Countries that meet both of these benchmarks are referred to as 'innovation outperformers'.

Although the number of countries considered in the GII decreased in 2016, affecting the total of those identified as innovation achievers, the Sub-Saharan Africa region continues to lead in this metric. Figure 6.1 shows the performance of all 25 economies in the Sub-Saharan Africa region included in the GII 2016. This year, a total of six economies from this region—Mozambique, Rwanda, Malawi, Kenya, Uganda, and Madagascar, representing 40% of all innovation achievers—perform better than their level of development would predict (see Figure 6.1 for details). The innovation achiever economies, shown in black, are located above the upper bound and farthest from the trend line. A total of 13 economies are identified as performing at their level of development, while the last 6 are performing below development.[3]

Figure 6.1: Innovation achievers in Sub-Saharan Africa



Note: BDI = Burundi; BEN = Benin; BFA = Burkina Faso; BWA = Botswana; CIV = Côte d'Ivoire; CMR = Cameroon; ETH = Ethiopia; GHA = Ghana; GIN = Guinea; KEN = Kenya; MDG = Madagascar; MLI = Mali; MOZ = Mozambique; MUS = Mauritius; MWI = Malawi; NAM = Namibia; NER = Niger; NGA = Nigeria; RWA = Rwanda; SEN = Senegal; TGO = Togo; TZA = Tanzania, United Republic of; UGA = Uganda; ZAF = South Africa; ZMB = Zambia.

Box 6: Sub-Saharan Africa: Preserving the innovation momentum in one of the most promising regions *(continued)*

Importantly, Kenya, Mozambique, Malawi, Rwanda, and Uganda stand out for being innovation achievers at least four times in the past five years. Kenya, the chief innovation achiever in the region, has been credited as such every year since 2011, including in 2016. Likewise, these five economies, along with South Africa, Niger, and Mauritius, outperform their peers in more than half of the seven GII pillars in 2016. Most of these economies are more likely to outperform in Business sophistication and less likely to do so in either Human capital and research or Infrastructure. Uganda outperforms in all seven pillars, followed by Rwanda and Mozambique, which do so in six. South Africa and Kenya outperform in five, while Mauritius, Malawi, and Niger outperform in only four.

This year the five innovation achievers mentioned above, plus Burkina Faso, are labeled as innovation outperformers within the Sub-Saharan Africa region. Table 6.1 shows the full list of achievers and outperformers in this region.

Yet the relatively strong performance in innovation in the region is neither uniform across all economies nor is future success guaranteed. Economic forecasts, such as that of the International Monetary Fund, suggest that, after a prolonged period of strong economic growth, Sub-Saharan Africa will face an economic slowdown, partly as a result of a sharp decline in commodity prices.[4] It is notable that in some oil-importing African nations—particularly some in East Africa, such as Kenya and Rwanda—stand out as innovation achievers. As these and other innovation achievers noted above get caught up in a greater economic slowdown, it will be important for them to preserve their current innovation momentum.

Other countries in Sub-Saharan Africa have to redouble their innovation efforts in order to grow and move away from relying on oil and commodity revenues alone.

Notes

1 In 2011, most innovation achievers were located in the South East Asia, East Asia, and Oceania region. In 2012 and 2013, Europe and Sub-Saharan Africa shared the same number of innovation achievers, six and four, respectively.

2 For a country to be labeled an 'innovation outperformer' it has to be identified as an 'innovation achiever' and it must also score above its income group average in four or more GII pillars for two or more years, including the two most recent—2014 and 2015. In 2016, 15 economies were identified as innovation outperformers. See Chapter 2 in GII 2015 on the theme 'Effective Innovation Policies for Development' for more details.

3 The general trend line is defined by the scores and economic development level of all countries considered in the GII. The threshold bounds are defined as 10% above and 10% below the scores defined by trend line (see Box 2 in Chapter 2 of the GII 2015 for more details).

4 IMF, 2016c.

Source

IMF, 2016c.

Table 6.1: Sub-Saharan Africa: Innovation achievers, pillar outperformers, and innovation outperformers, 2011–16

Economy	Income group	Years as an innovation achiever	Years as a pillar outperformer	Innovation outperformer
Kenya	Lower-middle income	2016, 2015, 2014, 2013, 2012, 2011 (6)	2016, 2015, 2014, 2013, 2012, 2011 (6)	Yes
Rwanda	Low income	2016, 2015, 2014, 2012 (4)	2016, 2015, 2014, 2012 (4)	Yes
Mozambique	Low income	2016, 2015, 2014, 2012 (4)	2016, 2015, 2014, 2012 (4)	Yes
Malawi	Low income	2016, 2015, 2014, 2012 (4)	2016, 2015, 2014, 2012 (4)	Yes
Uganda	Low income	2016, 2015, 2014, 2013 (4)	2016, 2015, 2014, 2013 (4)	Yes
Madagascar	Low income	2016 (1)	—	No
Senegal	Lower-middle income	2015, 2014, 2013, 2012 (4)	2015 (1)	No
Mali	Low income	2015, 2013 (2)	2013 (1)	No
Burkina Faso	Low income	2015, 2014 (2)	2015, 2014 (1)	Yes
Gambia	Low income	2014 (1)	2014 (1)	No
Zimbabwe	Low income	2012 (1)	2012 (1)	No
Ghana	Lower-middle income	2011 (1)	2011 (1)	No

Note: The table includes GII 2016. Economies identified as innovation achievers and pillar outperformers for two or more consecutive years, including 2014 and 2015, are also identified as innovation outperformers.

Latin America and the Caribbean includes only upper- and lower-middle-income economies, with four exceptions: Chile, Uruguay, Argentina, and the Bolivarian Republic of Venezuela, which are all high-income economies. Ranking 1st in the region this year is Chile (44th overall), followed closely by Costa Rica (45th), which gains six spots in the rankings from 2015.

As previously mentioned, the minimum data coverage threshold rule was adjusted this year to retain only those economies with sufficient data coverage in the GII. As a result, Barbados and Guyana drop from the GII this year (see Annex 2). Trinidad and Tobago, the other country from that region that drops, although having sufficient coverage in both the Input and Output Sub-Indices, it is not considered in the GII this year because it does not have scores for at least two sub-pillars in pillar 2: Human capital and research.

Following Chile and Costa Rica within the region, and ranking in the top half of the GII this year, are Mexico (61st), Uruguay (62nd), and Colombia (63rd). The top 100 economies overall include Panama (68th), Brazil (69th), Peru (71st), Dominican Republic (76th), Argentina (81st), Jamaica (89th), Paraguay (94th), and Guatemala (97th). The remaining economies in the region rank at 100 or below in the GII this year: Ecuador (100th), Honduras (101st), El Salvador (104th), the Plurinational State of Bolivia (109th), Nicaragua (116th), and the Bolivarian Republic of Venezuela (120th).

Although important regional potential exists, the GII rankings of local countries relative to other regions have not steadily improved. In recent years and in 2016, no economies from this region are identified as innovation achievers. Only Brazil, Costa Rica, El Salvador, Mexico, and Panama are identified as pillar outperformers.

Chile is ranked 44th in the GII this year, at the top spot in the region. It is ranked 40th and 53rd in the Innovation Input Sub-Index and Innovation Output Sub-Index, respectively, with a place in the top 50 economies across four pillars: Institutions (36th), Infrastructure (38th), Market sophistication (47th), and Business sophistication (41st). Its improvements in 2016 are mainly in Market sophistication and Business sophistication, with better rankings in ease of protecting investors and applied tariff rate. The largest loss of momentum comes from Creative outputs, where Chile ranks 93rd in the new indicator industrial designs, a relative overall weakness for the economy. Chile also shows areas of weakness in pillar 2, Human capital and research (62nd), in a total of five indicators including government expenditure in education (84th), PISA scales in reading, maths, and science (45th), pupil-teacher ratio (86th), tertiary inbound mobility (95th), and the newly introduced indicator measuring average expenditure of the top 3 global companies by R&D (45th).

Mexico is ranked 61st in 2016, down from 57th in 2015, coming in at 60th and 62nd overall in the Innovation Input Sub-Index and Innovation Output Sub-Index, respectively. The country ranks the highest among pillars in Market sophistication (51st), where it ranks among the top 25 economies in Trade, competition, and market scale (24th). Mexico also sees improvements in 7 of the 10 indicators within this pillar, including a strong improvement in microfinance gross loan portfolios (45th). Conversely, Mexico's ranking on the output side falls to 62nd. This is the result of lower rankings for intellectual property receipts (77th) and FDI net outflows (64th). For Mexico, Business sophistication (pillar 5 at 77th) still harbours most of the country's weaknesses: females employed with advanced degrees (69th), GERD financed by abroad (94th), and the number of joint venture–strategic alliance deals (60th). Venture capital deals (69th), computer software spending (67th), cultural and creative services exports (66th), and printing and publishing manufactures (85th) are also areas of potential improvement for Mexico.

Brazil is ranked 69th this year in the GII, gaining one position since 2015. Brazil's strongest pillar ranking is in Business sophistication (39th), where it sees one of its highest rankings in IP payments (8th). Brazil's improvement on the input side, up seven spots from 2015 to 58th, is caused by specific gains across several other indicators, including political stability and safety (68th), ease of paying taxes (121st), ICT use (46th), gross capital formation (98th), environmental performance (45th), microfinance gross loans (59th), and intensity of local competition (40th). Brazil also benefits from high rankings in two new indicators: domestic market scale (7th) and average expenditure of the top 3 global companies by R&D (17th). Brazil sees its largest drop in Creative outputs (90th), where one of its relative weaknesses is printing and publishing output manufactures (74th). While for Brazil the General infrastructure (91st) sub-pillar is no longer identified as a weakness, both Business environment (123rd) and Tertiary education (111th) still have room for improvement. Brazil has made gains in areas such as joint venture and strategic alliance deals (66th) and printing and publishing manufactures (74th), yet in these

areas further improvements can be made.

Central and Southern Asia (10 economies)

Economies of the Central and Southern Asia region have seen an improvement in ranking since 2015: after only three of these economies ranked in the top 100 overall in the GII last year, six of the 10 economies in the region rank in the top 100 in 2016.

India maintains its top place in the region, moving up 15 spots from 81st last year to 66th overall; Kazakhstan also maintains its position as second in the region, moving up seven spots, from 82nd to 75th overall. The remaining economies rank in order within the region as follows: the Islamic Republic of Iran shows an improvement in its ranking (at 78th) this year; this is followed by Tajikistan (86th), Sri Lanka (91st), Bhutan (96th), Kyrgyzstan (103rd), Nepal (115th), Bangladesh (117th), and Pakistan (119th). There has also been an improvement in data coverage for economies in Central and Southern Asia. In 2016, economies in the region averaged 83.4% coverage of data in the GII, up from 80.3% in 2015. Only three economies in the region are highlighted as missing 20 or more values (see Annex 2).

India ranks 1st in the region, as it did in 2015, and improves its ranking among lower-middle-income economies to 6th (up two places from 8th in 2015). Ranking 66th overall this year, India advances 15 spots overall to reach the same position it had in the GII 2013. India ranks among the top 50 economies overall in two pillars: Market sophistication (33rd) and Knowledge and technology outputs (43rd). The country maintains stable or improved rankings across all pillars, with the most significant improvements in Human capital and research (up 40 spots) and Business

Box 7: China's Belt and Road Initiative: Towards More Regional Cooperation

China's Belt and Road Initiative (BRI) initiative (the Initiative on Building Silk Road Economic Belt and 21st-Century Maritime Silk Road), also referred to as 'One Belt One Road', was first introduced in 2013 by President Xi Jinping and more formally announced in 2015. It aims to promote economic integration among Asian, European, and African economies that lie on the path of the ancient Silk Road.[1] From around 200 BC into approximately the 15th century, the ancient Silk Road connected the East to the West, linking China to Europe through Central Asia.[2] Historians consider the road an important factor in the growth of civilizations of China, India, parts of Persia, Europe, and Arabia.[3] The road was a central transport hub, used primarily for shipping silk, gold, spices, glass, textiles, and livestock.

The idea of the BRI initiative is to revive the Silk Road spirit to help regional integration and economic development. Although the exact list of countries that will be part of the BRI is still open, the current list comprises over 60 countries, mostly middle-income economies but also select high- and low-income economies.[4] The current plan has two dimensions: (1) a series of highways, economic corridors, and rail networks between countries on the former land route of the Silk Road; and (2) a network of sea routes between the costal ports of the economies in question, hence a maritime Silk Road.[5]

The initiative aims to not only support infrastructure and trade, but also to bring about greater cooperation in promoting education, for example via the New Silk Road University Association; and in boosting research cooperation and innovation. With respect to economic conditions and innovation, the countries in question vary significantly in their level of economic development and the sophistication of their national innovation systems.

The GII rankings of countries along the principal original land route between China and Greece, and largely crossing Central Asia, vary from China (ranked 25th) and Turkey (42nd) at the top to Armenia (60th), Georgia (64th), and Kazakhstan (75th) in the middle and to Tajikistan (86th) and Kyrgyzstan (103rd). These countries are equally diverse in their performance on the various GII innovation input and output pillars. In the area of Human capital and research, GII ranks range from China (29th) to Armenia (104th); in the area of Infrastructure, ranks range from China (36th place) to Tajikistan (123rd); and in Knowledge and technology outputs, from China (6th) to Kyrgyzstan (96th). This diversity continues when comparing these countries based on critical innovation inputs such as Gross expenditure on R&D as a share of GDP, which ranges from 2.1% of GDP in China (with $313 billion in 2014) to 0.1% of GDP in Tajikistan ($21 million).[6] This diversity holds also for innovation output factors such as patents filed by origin—where China comes in at 1st place and Tajikistan at 112th—as well as many other variables, such as High-tech production and exports.

This diversity across the BRI countries, though challenging, is also a source of the appeal of this initiative: if the comparative advantages of diverse countries can be leveraged, the potential for robust progress is high. Deeper economic integration, better infrastructure, and cooperation in fields such as education, research, and innovation have the potential to lead to convergence at higher levels and increased economic development.

Notes

1 The State Council, People's Republic of China, 2015.

2 Elisseeff, 2000; Hansen, 2012; Xinru, 2011.

3 Bentley, 1993.

4 The State Council, People's Republic of China, 2015.

5 The State Council, People's Republic of China, 2015.

6 UNESCO-UIS Science & Technology Data Center, update from April 2016. Data used: GERD, performed by Business enterprise (in '000 PPP$, constant prices, 2005). Data for Kyrgyzstan corresponds to 2013. For the others it corresponds to 2014.

sophistication (up 59 spots). Within Human capital and research, India data coverage increased, specifically in graduates in sciences and engineering (ranked 8th overall in 2016, while this was a missing value in 2015), affecting the jump in its ranking. India's ranking in the Business sophistication pillar is affected most by a substantial improvement in Knowledge workers (up 46 spots) and Knowledge absorption (up 33 spots); India improves in the ranking of firms offering formal training by 56 spots to reach 42nd place. Furthermore, India improves across all indicators within the Knowledge absorption sub-pillar, and it turns in a solid performance in the GII model's newly incorporated research talent in business enterprise, where it ranks 31st. Conversely, India shows weakness in two sub-pillars: Business environment (117th) and Education (118th). In the former pillar, ease of starting a business (114th), and in the latter, the pupil-teacher ratio (103rd) and tertiary inbound mobility (99th) are three areas where India can seek improvement. Progress is also needed in environmental performance (110th) on the input side; on the output side, indicators measuring new businesses (101st), global entertainment and media market (59th), and printing and publishing manufactures (84th) all show room for improvement.

Sri Lanka ranks 91st overall in the GII this year, and, along with India and the Islamic Republic of Iran, the country ranks among the top 100 economies in all three main indices as well as in the Innovation Efficiency Ratio. Sri Lanka sees the greatest improvement in pillars in Institutions (up twelve spots) and Creative outputs (up eight spots). Sri Lanka exhibits relative strengths in Infrastructure in particular, ranking 58th overall and ranking in the top 40 economies for four of its 10 indicators. The country ranks 78th overall in the Innovation Output Sub-Index (up one spot from 2015), where it exhibits the greatest improvements in rankings in scientific and technical publications (110th, up six spots), FDI net outflows (81st, up ten spots), ICTs and business model creations (52nd, up nine spots), generic top-level domains (TLDs) (100th, up six spots), and country-code TLDs (102nd, up eight spots). Weaknesses for Sri Lanka are, at the pillar level, in Institutions (116th); the country also exhibits weaknesses in Regulatory environment (125th), Education (111th), and Credit (110th) sub-pillars. At the indicator level, most of Sri Lanka's weaknesses are located in the Education sub-pillar, where expenditure on education (117th), government expenditure per pupil (105th), tertiary inbound mobility (94th), and gross expenditure on R&D (102nd), among others, are all areas where its performance could see improvement.

Box 7 on page 41 elaborates on the significant heterogeneity of innovation rankings in parts of this region, and describes efforts for increased international cooperation along the ancient Silk Road.

Northern Africa and Western Asia (19 economies)

Israel (21st) and Cyprus (31st) achieve the top two spots in the region for the fourth consecutive year, improving by one and three positions, respectively. Also among the top 5 in the region are two of the six economies in the Gulf Cooperation Council (GCC): the United Arab Emirates (41st) and Saudi Arabia (49th).

Despite these top ranks, and compared to their level of development, resource-rich countries in the region could rank higher (see Figure 4 on page 32). These countries exhibit relative shortcomings in important areas, such as Institutions, Market sophistication, and Business sophistication. This phenomenon—reminiscent of what has been called the 'resource curse' or the 'paradox of plenty'—has been discussed in the GII before (see the GII 2013, 2014, and 2015 reports). These GCC countries, however, are uniquely positioned to do better in the years to come. Many of them have been diversifying towards innovation-rich sectors already; such diversification offers the GCC countries the potential to do better in the years to come.

Sixteen of the 19 economies in the Northern Africa and Western Asia region are in the top 100, including Qatar (50th), Bahrain (57th), Armenia (60th), Georgia (64th), Kuwait (67th), Lebanon (70th), Morocco (72nd), Oman (73rd), Tunisia (77th), Jordan (82nd), and Azerbaijan (85th). Of all the economies in the region, Turkey (42nd), Kuwait, and Algeria (113th) see the most improvement in their GII ranking, having moved up 16 spots, 10 spots, and 13 spots, respectively.

Israel moves up one place, from 22nd to 21st, in 2016, while remaining number 1 in the Northern Africa and Western Asia region. Israel is ranked in the top 25 economies for five of the seven pillars and is the only economy in the region to rank in the top 10 for any pillar (6th, Business sophistication). The country ranks 21st and 16th in the Innovation Input Sub-Index and Innovation Output Sub-Index, respectively, seeing the most gains in Education (45th, up 6 spots), Trade, competition, and market scale (49th, up 26 spots), Knowledge absorption (16th, up 40 spots), and Intangible assets (34th, up 52 spots). Israel's biggest drop at the pillar level is Knowledge and technology outputs, where it moves down three spots; this has affected

its lower ranking in innovation efficiency 23rd (down three spots from 20th last year). At the indicator level, Israel ranks in the top 3 economies in six different areas: researchers (1st), gross expenditure on R&D (2nd), venture capital deals (1st), GERD performed by business (1st), females employed with advanced degrees (3rd), and research talent in business enterprise (1st)—the last a newly introduced indictor to reflect the linkages in the innovation ecosystem. Weaknesses for Israel are found in the input side of the GII and are more prominent in political stability and safety (114th), the cost of redundancy dismissal (110th), and the intensity of local competition (109th). On the output side, two areas show possibilities for improvement: the growth rate of GDP per worker (93rd) and trademarks by origin (90th).

Turkey ranks 4th in the region in 2016, improving across all three main indices and the Innovation Efficiency Ratio and ranking 42nd overall (up from 58th in 2015). Its ranking in the Innovation Efficiency Ratio (13th) is 1st in the Northern Africa and Western Asia region, with improvements in the Output Innovation Sub-Index of 15 places in Knowledge and technology outputs and 6 in Creative outputs. Turkey ranks in the top 50 economies in five different sub-pillars: Tertiary education (49th), Research and development (38th), Trade, competition, and market scale (12th), Knowledge creation (35th), and Intangible assets (5th). On the other hand, weaknesses in areas closely associated with R&D—such as expenditure on education (103rd), females employed with advanced degrees (72nd), and GERD financed by abroad (87th)—are identified for Turkey. Other areas where improvement can be achieved by Turkey are ICT services imports (118th) and exports (116th), and cultural and creative services exports (72nd).

South East Asia, East Asia, and Oceania (14 economies)

Unlike 2015, this year all economies within the South East Asia, East Asia, and Oceania region are ranked within the top 100 in the GII. All economies in the region also rank within the top 100 in the Innovation Input Sub-Index, the Innovation Output Sub-Index, and the Innovation Efficiency Ratio.

The top five economies in the region rank in the top 25 overall for the GII, the Innovation Input Sub-Index, and the Innovation Output Sub-Index: Singapore (6th), Korea (11th), Hong Kong (China) (14th), Japan (16th), and New Zealand (17th). Australia ranks next (19th), coming in 11th on the input side; China follows (at 25th), ranking 7th in efficiency. Among upper-middle-income economies, three economies (China, Thailand, and Mongolia) improved from 2015; Malaysia moved down three spots to 35th overall. Malaysia's move is affected by its drop of five spots on the output side, though it shows improvement in rankings across the Human capital and research, Infrastructure, and Market sophistication pillars.

Viet Nam (59th) maintains its top place among lower-middle-income economies; following Viet Nam, in the same order as in 2015, are the Philippines (74th, up nine spots) and Indonesia (88th, up nine spots). Low-income economy Cambodia maintains its ranking in the top 100 economies overall (95th).

The Republic of Korea (Korea) is the only economy in the region to rank among the top 25 economies across all main indices as well as the Innovation Efficiency Ratio. Korea ranks 11th overall, up three spots from last year, and ranks 13th and 11th in the Innovation Input Sub-Index and Innovation Output Sub-Index, respectively. Korea is among the top 10 economies in three pillars: Human capital and research (3rd), Infrastructure (9th), and Knowledge and technology outputs (5th). It improves in all other pillars, particularly in Business sophistication (13th, up 17 spots) and Creative outputs (21st, up 7 spots). In addition to ranking 1st overall in four existing indicators (gross expenditure on R&D, E-participation, patents by origin, and PCT patent applications), Korea also ranks 1st in one of this year's three new indicators: industrial designs by origin. The Institutions pillar, where Korea ranks 31st, provides the economy's greatest opportunities for improvement. Within this pillar, the cost of redundancy dismissal rank (107th) is Korea's lowest ranked indicator and weakness.

Japan has risen in the GII rankings each year for the last four years, moving up to 16th in 2016. Japan ranks 9th overall in the Innovation Input Sub-Index, led by top 10 rankings among all economies in Infrastructure (7th), Market sophistication (8th), and Business sophistication (10th); the country also ranks 24th overall in the Innovation Output Sub-Index. Japan ranks in the top 5 economies for three sub-pillars, all on the input side: Research and development (2nd), Information and communication technologies (4th), and Trade, competition, and market scale (2nd). The only pillar in which Japan saw downward movement in was Infrastructure (down two spots to 7th place this year), despite the lack of any relative indicator weaknesses. Outside of this pillar, however, Japan shows the highest number of relative weaknesses in Knowledge and technology outputs, ranking 97th

or lower in growth rate of GDP per worker, new businesses, and ICT services exports.

Europe (39 economies)

In this year's edition of the GII, 15 of the top 25 economies come from Europe. This region is home to the top 3 economies of the GII 2016: Switzerland (1st), Sweden (2nd), and the United Kingdom (3rd). Following these regional leaders among this group of top 25 are Finland (5th), Ireland (7th), Denmark (8th), the Netherlands (9th), Germany (10th), Luxembourg (12th), Iceland (13th), France (18th), Austria (20th), Norway (22nd), 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 (see Annex 2). 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, Italy, Portugal, Hungary, Poland, and the Russian Federation.

Seventeen economies follow among the top 50 and maintain relatively stable rankings since 2014: Malta (26th), the Czech Republic (27th), Spain (28th), Italy (29th), Portugal (30th), Slovenia (32nd), Hungary (33rd), Latvia (34th), Lithuania (36th), Slovakia (37th), Bulgaria (38th), Poland (the largest mover in this group, improving by seven spots to 39th), Greece (40th), the Russian Federation (43rd), the Republic of Moldova (46th), Croatia (47th), and Romania (48th).

The remaining European economies remain among the top 100 economies overall. Ukraine is the only economy in the group to improve since 2015, up eight spots. The region's rankings continue as follows: Montenegro (51st), Ukraine (56th), the Former Yugoslav Republic of Macedonia (58th), Serbia (65th), Belarus (79th), Bosnia and Herzegovina (87th), and Albania (92nd).

France moves up three spots in 2016 from 21st to 18th overall. France ranks 15th in the Innovation Input Sub-Index and 19th in the Innovation Output Sub-Index, improvements of two spots and four spots, respectively. It ranks in the top 25 economies and improves in all pillars with one exception (Institutions, where it moves down five spots to 26th). France's two most improved pillars on the input side, Infrastructure (8th) and Market sophistication (15th), gained four spots and ten spots, respectively, as the economy has earned top 5 overall rankings in three areas: government's online service (1st), E-participation (4th), and venture capital deals (1st). France also sees a drop in Political environment (29th) and Regulatory environment (21st). France's greatest relative weaknesses outside of the top 100 overall rankings are FDI net inflows (118th) and growth rate of GDP per worker (90th).

Ukraine moves up from 64th to 56th in 2016. This is the highest ranking of the GII the Ukraine has attained, led by an improvement of eight places in the Innovation Input Sub-Index (76th) and an improvement of seven places in the Innovation Output Sub-Index (40th). Ukraine's ranking in the Innovation Efficiency Ratio also improves by three spots to 12th overall (and 10th in the region), one of the economy's relative strengths in 2016. Ukraine ranks among the top 100 economies for all pillars with one exception (Institutions, 101st); it also improved in rankings across all pillars with two exceptions (Institutions and Human capital and research). Ukraine's higher overall ranking is in part the result of improvements of 10 or more spots across seven sub-pillars: Business environment (79th), General infrastructure (110th), Ecological sustainability (100th), Investment (113th), Trade, competition, and market scale (46th), Innovation linkages (88th), and Intangible assets (42nd). The only pillar where Ukraine ranks below the top 100 economies is Institutions (101st), where it also has the highest number of weaknesses: political stability and safety (125th), ease of resolving insolvency (113th), and, at the sub-pillar level, Political environment (123rd).

Conclusions

The theme for this year's GII is 'Winning with Global Innovation'. This chapter has provided a current assessment of worldwide innovation expenditures, making calls for a renewed and sustained innovation effort. Following this year's theme, it has analysed the opportunities and challenges of designing innovation policies for a new global innovation context that aims for a global win-win proposition. The chapter has also presented the main GII 2016 results, distilling main messages and noting some important evolutions that have taken place since last year. The remaining chapters provide more details on this year's theme from academic, business, and particular country perspectives from leading experts and decision makers.

There is no automatism or mechanical recipe for creating sound innovation systems. Absolute spending on R&D or absolute figures on the number of domestic researchers, on the number of science and engineering graduates, or on scientific publications do not guarantee

a successful innovation system. In fact, all too often a higher share of science and engineering graduates, for example, is pursued as a panacea for creating sound innovation systems. Clearly policy makers have to start somewhere, and this factor is easily measurable. Yet the creation of sound innovation systems—with solid innovation inputs, sophisticated markets, a thriving business sector, and sturdy linkages among innovation actors—and assessing their performance is more complex than aiming at increasing one innovation input variable, as evidenced in the GII model.

One approach to overcoming a purely quantitative approach is to look at the quality of innovation, as the GII does, assessing the worth of universities, scientific output, and patents. Good quality remains a distinct characteristic of leaders such as Germany, Japan, the UK, and the USA. China is the only middle-income country showing a comparable innovation quality. India comes in second among middle-income economies.

Yet there is more to the story. High-quality innovation inputs and outputs are often the reflection of other factors that make an innovation ecosystem healthy, vibrant, and productive. Ideally, these systems become self-perpetuating, bottom-up, and without a recurrent need for policy or government to drive innovation. How best to create such an organic innovation system poses an interesting dilemma for governments and their role in future innovation policy models. On the one hand, it is now accepted that governments continue to play an important role in generating innovation. The boundaries between industrial and innovation policy are slim or non-existent; both play an important role. In particular, in the last few decades, Asian economies have benefited from a strong and strategic coordination role of governments in innovation. The role of governments in spurring innovation in high-income countries in Northern America and Europe has also been strong throughout history.

It can be argued that the role of governments, and also of public and coordinated private investments, might be even more significant today than it has been in the past. Driving future innovation in the fields such as travel, health, and communications is becoming more complex and costly.

On the other hand, if governments overreach, if they select technologies, they might quickly end up diluting the possibility of self-sustaining organic innovation ecosystems. Providing enough space for entrepreneurship and innovation; the right incentives and encouragement to bottom-up forces such as individuals, students, small firms, and others; and a certain 'freedom to operate' that often challenges the status quo is part of the equation. Surely developing countries are well-advised to avoid over relying on government forces as the sole driver to orchestrating a sound innovation system.

For governments, finding the right balance between intervention and laissez-faire has never been as challenging.

Over the last years, the GII has established itself as a leading reference on innovation. The GII is meant to be a 'tool for action' for decision makers with the goal of improving countries' innovation performances. Upon the release of the GII, numerous workshops in different countries bring innovation actors together around the GII results with the aim of improving data availability, boosting a region's or a country's innovation performance, and designing policies for effective impact. These exchanges on the ground also generate feedback that, in turn, improves the GII and assists the journey towards improved innovation measurement and policy. This valuable feedback will continue to be integrated into future iterations of the GII in the years to come.

Notes for Box 1

1 These estimates are based on preliminary calculations using GERD and BERD figures at constant $PPP-2005 prices from the UNESCO-UIS Science & Technology Data Center, updated February 2015, with imputed value for the USA in 2014. Economies included: Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Bhutan, Bolivia (Plurinational State of), Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Côte d'Ivoire, Democratic Republic of the Congo, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong (China), Hungary, Iceland, India, Indonesia, Iran (Islamic Republic of), Iraq, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Macao (China), Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Mongolia, Montenegro, Morocco, Mozambique, Namibia, Nepal, the Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Puerto Rico, Qatar, Republic of Korea, the Republic of Moldova, Romania, Russian Federation, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Taiwan (China), Tajikistan, Thailand, the Former Yugoslav Republic of Macedonia, Timor-Leste, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, the United Arab Emirates, the United Kingdom, the United Republic of Tanzania, the United States of America, Uruguay, Uzbekistan, Venezuela (Bolivarian Republic of), Viet Nam, Yemen, Zambia, and Zimbabwe.

2 Data are based on the OECD Main Science and Technology Indicators (MSTI), updated January 2016.

3 OECD data on government appropriations to R&D (GBAORD) (accessed 2 May 2016) via OECD MSTI.

Notes for Box 5

1 Innovation quality is measured as an average of three GII variables: QS university ranking average score of top 3 universities, patent families filed in at least two offices, and the citable documents H index.

2 These six sub-pillars are Research and development (R&D), Information and communication technologies (ICTs), Knowledge workers, Knowledge creation, Knowledge impact, and Creative goods and services.

3 NSF, 2016. The estimates are based on preliminary calculations using GERD and BERD figures at constant $PPP 2005 prices from the UNESCO-UIS database with imputed value for the USA in 2014.

4 Government of the United States of America, 2016. Available at https://www.whitehouse.gov/administration/eop/ostp/rdbudgets.

5 OECD MSTI, updated 9 February 2016. Data used: Gross domestic expenditure on R&D (GERD) at constant 2010 PPP$; UNESCO-UIS Science & Technology Data Center; and OECD Main Science and Technology Indicators (MSTI), update from April 2016. Data used: GERD, performed by Business enterprise (in '000 PPP$, constant prices, 2005).

6 NSF, 2016.

7 These seven sub-pillars are Political environment; Business environment; General infrastructure; Credit; Investment; Trade, competition & market scale; and Online creativity.

8 See Box 1 on R&D expenditures; OECD, 2015a; OECD, 2013.

9 OECD, 2015b; OECD, 2013.

10 Government of Canada, 2016. Available at http://www.budget.gc.ca/2016/docs/plan/ch2-en.html.

Notes for Chapter 1

1 Conference Board, 2016; IMF, 2016a; IMF, 2016b; OECD, 2016; World Bank, 2016.

2 IMF, 2016a; IMF, 2016b; OECD, 2016; World Bank, 2016.

3 Conference Board, 2015.

4 IMF, 2015; IMF, 2016b; OECD, 2016; WIPO, 2015b.

5 OECD, 2009; WIPO, 2010; Dutta et al., 2013.

6 Dutta et al., 2014, and Dutta et al., 2015, based on UNESCO Institute for Statistics R&D data and OECD Main Science and Technology Indicators. See also Soete et al., 2015. Largely as a result of slower GDP growth, global R&D intensity—computed as global R&D expenditures over global GDP—remained relatively stable at about 1.7% in 2014, compared with about 1.6% in 2008, with the Republic of Korea overtaking Israel in 2013 to become the most R&D-intensive country.

7 These estimates are based on preliminary calculations using GERD and BERD figures at constant $PPP- 2005 prices from UNESCO-UIS database with imputed value for the USA in 2014.

8 WIPO, 2015b. At the same time patent applications under WIPO's Patent Cooperation Treaty (PCT) saw a 1.7% increase in 2015; a significant fall in growth compared with previous years (WIPO, 2016).

9 WIPO, 2015b.

10 UIS, 2015; Soete et al., 2015.

11 WIPO, 2015b.

12 Wagner et al., 2015.

13 Cincera and Pottelsberghe, 2001; Griliches, 1992.

14 Coe and Helpman, 1995; Coe et al., 2009; Griliches, 1992.

15 See also Soete et al., 2015; WIPO, 2015b.

16 Avenyo et al., 2015; WIPO, 2015b.

17 Dutta et al., 2015.

18 Ezell et al., 2013; Ezell et al., 2015.

19 Examples are efforts of the New Partnership for Africa's Development (NEPAD), OECD, UNESCO, and WIPO.

20 See indicators on high-tech goods and services trade in the GII.

21 See FDI flow data in the GII. Sources are the UNCTAD FDI Statistics Database at http://unctad.org/en/Pages/DIAE/FDI%20Statistics/FDI-Statistics.aspx and OECD FDI statistics database at http://www.oecd.org/daf/inv/OECD-BMD4-FDI-statistics-database-predefined-queries.pdf.

22 See the IP payment data in the GII. For background see IMF, 2009; UN et al., 2011. For shortcomings see Box 1.11 in Chapter 1 in WIPO, 2013.

23 See Box 1.11 in WIPO, 2013.

24 Alkemade et al., 2015; Dunning and Lundan, 2009.

25 Fink and Miguelez, forthcoming; ; INSEAD, 2015; Miguelez and Fink, 2013; OECD, 2015b; Scellato et al., 2014.

26 Keller, 2004.

27 Cincera and Van Pottelsberghe, 2001.

28 Keller, 2004.

29 See Box 1.3 in WIPO, 2011; Bergek and Bruzelius, 2010.

30 For a notable exception see OECD, 2014, on the economic value of The European Organization for Nuclear Research (CERN).

31 See also the WHO Global Observatory on Health R&D and the development of R&D blueprints that help prioritize and direct R&D on infectious diseases, available at http://apps.who.int/gb/ebwha/pdf_files/WHA69/A69_29-en.pdf.

32 WIPO, 2011.

33 NSF, 2016; UNESCO, 2015.

34 OECD, 2015c; WIPO, 2015a; World Bank, 2008; World Bank, 2016.

35 Wagner et al., 2015.

36 Brunner, 2016.

37 Wagner et al., 2015.

38 The 'forced cooperation rules' of EUREKA are an example in this regard, at http://www.eurekanetwork.org/.

39 See http://www.naturalsciences.ch/organisations/kfpe.

40 OECD, 2011.

41 U.S.-India Commercial, Trade, and Economic Cooperation, Washington, DC, September 22, 2015; http://www.state.gov/r/pa/prs/ps/2015/09/247174.htm.

42 See Soete et al., 2015, on this point.

43 See the 'Daejeon Ministerial Declaration on Science, Technology, and Innovation Policies for the Global and Digital', available at http://www.oecd.org/sti/daejeon-declaration-2015.htm, which also suggests the need to update the 'Recommendation of the Council Concerning a General Framework of Principles for International Co-operation in Science and Technology,' C(88)60/FINAL, which dates from 1988.

44 For related efforts, see BMBF, 2015.

45 Hungary (33rd), another middle-income economy identified as being on the heels of the high-income top performers in the GII 2015, changes its income group from upper-middle to high income this year.

46 Economies are grouped according to the World Bank classification (July 2015) gross national income (GNI) per capita, calculated using the World Bank Atlas method. The groups are: low income, US$1,045 or less; lower-middle income, US$1,046 to US$4,125; upper-middle income, US$4,126 to US$12,735; and high income, US$12,736 or more.

47 Since 2012, the regional groups have been based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; and SSF = Sub-Saharan Africa.

48 Although Malta (GII rank 26) has a score above 50, it is not considered among the leaders because its ranking is below the top 25.

49 Innovation achievers share the most strengths in the Innovation Efficiency Ratio, Knowledge absorption (5.3), government expenditure on education per pupil, secondary (2.1.2), growth rate of GDP per person engaged (6.2.1), microfinance institutions' gross loan portfolio (4.1.3), GERD financed by abroad (5.2.3), foreign direct investment net inflows (5.3.4), ICT services exports (6.3.3), and trademark application class count by origin (7.1.1). They also share the most weaknesses in tertiary enrolment (2.2.1), global R&D companies, average expenditure top 3 (2.3.3), QS university ranking average score top 3 universities (2.3.4), ICT access (3.1.1), GDP per unit of energy use (3.3.1), ISO 14001 environmental certificates (3.3.3), total value of stocks traded (4.2.3), and employment in knowledge-intensive services (5.1.1).

50 This year the rule to determine what countries become part of the GII rankings shifts from one that requires a minimum overall data coverage of 60% of all indicators to one where this same percentage is applied individually to each input and output side of the index (see Annex 2 for further details).

References and sources

Alkemade, F., G. Heimeriks, A. Schoen, L. Villard, and P. Laurens, 2015. 'Tracking the Internationalization of Multinational Corporate Inventive Activity: National and Sectoral Characteristics'. *Research Policy* 44 (9): 1763–72.

Avenyo, E. K., C. Chien, H. Hollanders, L. Marins, M. Schaaper, and B. Verspagen. 2015. 'Tracking Trends in Innovation and Mobility'. In *UNESCO Science Report 2015.* Paris: UNESCO. Chapter 2.

Bentley, J. 1993. *Old World Encounters: Cross-Cultural Contacts and Exchanges in Pre-Modern Times.* New York: Oxford University Press.

Bergek, A. and M. Bruzelius. 2010. 'Are Patents with Multiple Inventors from Different Countries a Good Indicator of International R&D Collaboration? The Case of ABB'. *Research Policy* 39 (10): 1321–34.

BMBF (Federal Ministry of Education and Research, Germany). 2015. 'Group of Senior Officials on Global Research Infrastructures Progress Report 2015'. Meeting of the G7 Science Ministers 8–9 October 2015. Available at https://www.bmbf.de/files/151109_G7_Broschere.pdf.

Brunner, H.-P. 2016. *The Impact of Regional Cooperation and Integration Drivers on Economic Productivity and welfare, with Particular Attention to Southeast Asia Innovation Networks and the New Asian Regionalism: A Knowledge Platform on Economic Productivity.* Cheltenham, UK: Edward Elgar Publishing.

Cincera, M. and B. Van Pottelsberghe. 2001. 'International R&D Spillovers: A Survey'. *Brussels Economic Review* 169 (1): 3–31.

Coe, D. and E. Helpman. 1995. 'International R&D Spillovers'. *European Economic Review* 39: 859–87.

Coe, D. T., E. Helpman, and A. W. Hoffmaister. 2009. 'International R&D Spillovers and Institutions'. *European Economic Review* 53 (7): 723–41.

Conference Board. 2015. *Productivity Brief 2015: Global Productivity Growth Stuck in the Slow Lane with No Signs of Recovery in Sight,* authors B. van Ark and A. Erumban, May. New York: The Conference Board.

———. 2016. *Global Economic Outlook 2016: The Global Economy in a Holding Pattern,* November. New York: The Conference Board.

Cornell University, INSEAD, and WIPO. 2013. *The Global Innovation Index 2013: The Local Dynamics of Innovation,* eds. S. Dutta and B. Lanvin. Ithaca, Fontainebleau, and Geneva: Cornell, INSEAD, and WIPO.

———. 2014. *The Global Innovation Index 2014: The Human Factor in Innovation,* eds. S. Dutta, B. Lanvin, and S. Wunsch-Vincent. Ithaca, Fontainebleau, and Geneva: Cornell, INSEAD, and WIPO.

———. 2015. *The Global Innovation Index 2015: Effective Innovation Policies for Development,* eds. S. Dutta, B. Lanvin, and S. Wunsch-Vincent. Ithaca, Fontainebleau, and Geneva: Cornell, INSEAD, and WIPO.

Dunning, J. H. and S. M. Lundan. 2009. 'The Internationalization of Corporate R&D: A Review of the Evidence and Some Policy Implications for Home Countries'. *Review of Policy Research* 26 (1–2): 13–33.

Dutta, S., R. Escalona Reynoso, A. Bernard, B. Lanvin, and S. Wunsch-Vincent. 2014. 'The Global Innovation Index 2014: The Human Factor in Innovation'. In *The Global Innovation Index 2014: The Human Factor in Innovation,* eds. S. Dutta, B. Lanvin, and S. Wunch-Vincent. Ithaca, Fontainebleau, and Geneva: Cornell, INSEAD, and WIPO. 3–68.

Dutta, S., R. Escalona Reynoso, A. Bernard, B. Lanvin, and S. Wunsch-Vincent. 2015. 'The Global Innovation Index 2015: Effective Innovation Policies for Development'. In *The Global Innovation Index 2015: Effective Innovation Policies for Development,* eds. S. Dutta, B. Lanvin, and S. Wunsch-Vincent. Geneva, Ithaca, and Fontainebleau: Cornell, INSEAD, and WIPO. 3–63.

Eichengreen, B., Park, D, and K. Shin. 2015. 'The Global Productivity Slump: Common and Country-Specific Factors'. *NBER Working Paper* No. 21556, September.

Elisseeff, V. 2000. *The Silk Roads: Highways of Culture and Commerce.* New York: UNESCO Publishing/Berghahn Books.

European Commission. 2015. 'The 2015 EU Industrial R&D Investment Scoreboard'. Authors Héctor Hernández, Alexander Tübke, Fernando Hervás, Antonio Vezzani, Mafini Dosso, Sara Amoroso, and Nicola Grassano. Seville, Spain: European Commission, Joint Research Centre.

Ezell, S., Atkinson R. D., and M. A. Wein. 2013. *Localization Barriers to Trade: Threat to the Global Innovation Economy.* Washington, DC: ITIF.

Ezell, S., A. Nager, and R. D. Atkinson. 2015. *Contributors and Detractors: Ranking Countries' Impact on Global Innovation.* Washington, DC: ITIF.

Fink, C. and E. Miguelez. Forthcoming. *The International Mobility of Talent and Innovation - New Evidence and Policy Implications.* Series on Innovation, Intellectual Property and Economic Development. Cambridge and Geneva: Cambridge University Press and World Intellectual Property Organization.

Government of Canada. 2016. 'Chapter 2: Growth for the Middle Class'. Government of Canada, 2016. Available at http://www.budget.gc.ca/2016/docs/plan/ch2-en.html.

Government of the United States of America. 2016. 'R&D Budgets', Office of Science and Technology Policy, The Administration, whitehouse.gov. Available at https://www.whitehouse.gov/administration/eop/ostp/rdbudgets.

Griliches, Z. 1992. 'The Search for R&D Spillovers'. *Scandinavian Journal of Economics* 94 (Supplement): 29–47.

Hansen, V. 2012. *The Silk Road: A New History.* New York: Oxford University Press.

IMF (International Monetary Fund) 2009. *Balance of Payments and International Investment Position Manual Sixth Edition (BPM6).* Washington, DC: IMF.

———. 2015. 'Where Are We Headed? Perspectives on Potential Output'. *World Economic Outlook (WEO): Uneven Growth: Short- and Long-Term Factors.* April 2015. Washington, DC: IMF.

———. 2016a. 'Update: World Economic Outlook 2016: An Update of the Key WEO Projections'. January 2016. Washington, DC: IMF.

———. 2016b. 'Recent Developments and Prospects'. *World Economic Outlook (WEO): Too Slow for Too Long.* April 2016. Washington, DC: IMF.

———. 2016c. *Regional Economic Outlook: Sub-Saharan Africa: Time for a Policy Reset.* April 2016. Washington, DC: IMF.

INSEAD. 2015. *The Global Talent Competitiveness Index 2015–2016: Talent Attraction and International Mobility,* eds. B. Lanvin and P. Evans. Fontainebleau, France: INSEAD.

Keller, W. 2004. 'International Technology Diffusion'. *Journal of Economic Literature* 42 (3): 752–82.

Leigh, N. and E. Blakely. 2013. *Planning Local Economic Development: Theory and Practice,* fifth edition. Los Angeles: SAGE Publications.

Miguelez, E. and C. Fink. 2013. 'Measuring the International Mobility of Inventors: A New Database'. *WIPO Economics Working Paper* No. 8. Geneva: WIPO.

NSF (National Science Foundation). 2016. 'Science and Engineering Indicators 2016', National Science Board, National Science Foundation, (NSB-2016-1), January. Arlington, VA: NSF.

OECD (Organisation for Economic Co-operation and Development). 2009. *Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth,* eds. D. Guellec and S. Wunsch-Vincent. Paris: OECD Publishing.

———. 2011. *Global Science Forum: Report on Opportunities, Challenges and Good Practices in International Research Cooperation between Developed and Developing Countries.* April. Available at https://www.oecd.org/sti/sci-tech/47737209.pdf.

———. 2013. 'Science, Technology and Industry Scoreboard'. Country Profile: Canada. Paris: OECD Publishing.

———. 2014. *The Impacts of Large Research Infrastructures on Economic Innovation and on Society: Case Studies at CERN.* Paris: OECD Publishing. Available at http://www.oecd.org/sti/sci-tech/CERN-case-studies.pdf.

———. 2015a. Main Science and Technology Indicators (MSTI). Last update: MSTI 9 February 2016. Available at: http://www.oecd.org/science/inno/msti.htm.

———. 2015b. *Science, Technology and Industry Scoreboard: Innovation for Growth and Society.* Paris: OECD Publishing.

———. 2015c. *The Future of Productivity.* Paris: OECD Publishing.

———. 2015d. Daejeon Declaration on Science, Technology, and Innovation Policies for the Global and Digital Age. Available at http://www.oecd.org/sti/daejeon-declaration-2015.htm.

———. 2016. *OECD Interim Economic Outlook.* February 2016. Paris: OECD Publishing.

NSF (National Science Foundation), 2016. *Science and Engineering Indicators 2016.* National Science Board, Arlington, VA: National Science Foundation.

PricewaterhouseCoopers and Strategy&. 2014. 'Global Innovation 1000: Proven Paths to Innovation Success: Ten Years of Research Reveal the Best R&D Strategies for the Decade Ahead'. *strategy+business magazine* 77 (Winter 2014), 28 October.

Scellato, G. and Franzoni, C. and P. E. Stephan. 2014. 'Migrant Scientists and International Networks'. *Andrew Young School of Policy Studies Research Paper Series* No. 14-07.

Soete, L., S. Schneegans, D. Eröcal, B. Angathevar, and R. Rasiah. 2015. 'A World in Search of an Effective Growth Strategy'. *UNESCO Science Report: Towards 2030.* Paris: UNESCO. 21–56.

The State Council, People's Republic of China. 2015. Full Text: Action Plan on the Belt and Road Initiative. Available at http://english.gov.cn/archive/publications/2015/03/30/content_281475080249035.htm.

UIS (UNESCO Institute for Statistics). 2015. Science, Technology and Innovation Indicators. Last update: November 2015. Available at: http://data.uis.unesco.org/.

UN, IMF, OECD, Eurostat, UNCTAD, UNWTO, and WTO. 2011. *Manual on Statistics of International Trade in Services 2010.* New York: United Nations.

UNESCO (United Nations Educational, Scientific and Cultural Organization). 2015. *UNESCO Science Report: Towards 2030.* Montreal: UNESCO.

Wagner C. S., H. W. Park, and L. Leydesdorff. 2015. 'The Continuing Growth of Global Cooperation Networks in Research: A Conundrum for National Governments'. *PLoS ONE* 10 (7): e0131816. doi:10.1371/journal.pone.0131816.

WIPO (World Intellectual Property Organization). 2010. 'The Impact of the Economic Crisis and Recovery on Innovation'. *World Intellectual Property Indicators 2010.* Economics and Statistics Division. Geneva: WIPO.

———. 2011. 'The Changing Nature of Innovation and Intellectual Property'. In *World IP Report 2011: The Changing Face of Innovation.* Geneva: WIPO. Chapter 1.

———. 2013. 'Branding in the Global Economy'. In *World IP Report 2013: Brands – Reputation and Image in the Global Marketplace.* Geneva: WIPO. Chapter 1.

———. 2015a. 'A Look Inside the Economic Growth Engine'. In *World Intellectual Property Report 2015: Breakthrough Innovation and Economic Growth.* Geneva: WIPO. Chapter 1.

———. 2015b. *World Intellectual Property Indicators 2015.* Geneva: WIPO.

———. 2016. 'U.S. Extends Lead in International Patent and Trademark Filings.' World Intellectual Property Organization Press Release. PR/2016/788. April 2016. Geneva: WIPO.

World Bank. 2008. 'Technology Diffusion in the Developing World'. In *Global Economic Prospects.* Washington, DC: World Bank Group. Chapter 2.

———. 2016. 'Global Outlook: Disappointments, Risks and Spillovers'. In *Global Economic Prospects.* Washington, DC: World Bank Group. Chapter 1.

Xinru, L. 2010. *The Silk Road in World History.* New York: Oxford University Press.