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Preparing for disruption

Technological Readiness Ranking

A report by The Economist Intelligence Unit



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Executive summary

Over the long term, technological change is inescapable. Innovation is constantly pushing forward the limits of what is possible, while our increasingly globalised world makes the diffusion of new ideas much more effective. How prepared governments, businesses and individuals are for disruption—and in particular digital disruption—is increasingly important. As a result, the criteria that companies use to formulate their global business strategies are changing.

The Economist Intelligence Unit's Country Forecast service provides you with comprehensive medium and long-term forecasts for 82 of the world's largest economies. As part of this service, we provide access to a constantly updated set of political, economic and business climate forecasts, along with analysis written from the perspective of foreign investors. We also produce a ranking of these countries each quarter according to the quality and attractiveness of their business environments.

We have recently updated our Country Forecast service to include an assessment of how well prepared countries are for technological change, across three key categories. The first category is **access to the internet**, for which we look at internet usage and mobile phone subscriptions. The second category covers the **digital economy infrastructure**, looking at e-commerce, e-government and cyber-security. In our final category, **openness to innovation**, we explore international patents granted, research and development (R&D) spending, and the research infrastructure.

The highlights of our Technological Readiness Ranking are as follows:

- At the very top of our index for the historical period (2013-17) are Finland and Sweden, with the top ten also including a few west European countries, Australia and the advanced economies of Asia.
- In our forecast period (2018-22), which incorporates our analysts' forecasts for developments in the next five years, the US and France join the top ten, and Australia, Singapore and Sweden take over as the top-scoring locations.
- At the bottom of the index are Libya and Angola, where corruption and weak institutions have stymied investment in infrastructure. They are joined in the bottom ten by a number of developing countries in Latin America, Asia and elsewhere in Africa.
- In the forecast period we expect a modest improvement in score for all of the worst-performing countries except Venezuela, where a deepening economic crisis will forestall efforts to improve the digital economy. Peru will escape the bottom ten, being replaced by Kenya.
- We expect broad-based improvements in technological readiness in our forecast period as governments invest further in this area. Countries that will see particularly substantial improvements include Vietnam, Sri Lanka, Indonesia, Slovakia, Serbia and Jordan.

In this white paper we will examine each of the indicators that we have used in our Technological Readiness Ranking, exploring why they are important, how they are changing, and which countries are best exploiting the opportunities that they offer.

PREPARING FOR DISRUPTION

TECHNOLOGICAL READINESS RANKING

Technological Readiness Ranking

	2013-17			2018-22	
	Score	Ranking		Score	Ranking
Finland	9.71875	1	Australia	9.71875	=1
Sweden	9.4375	2	Singapore	9.71875	=1
Australia	9.15625	=3	Sweden	9.71875	=1
Austria	9.15625	=3	US	9.4375	=4
Germany	9.15625	=3	Finland	9.4375	=4
Netherlands	9.15625	=3	France	9.4375	=4
Singapore	9.15625	=3	Germany	9.4375	=4
Japan	8.875	=8	Japan	9.4375	=4
South Korea	8.875	=8	Netherlands	9.4375	=4
Taiwan	8.875	=8	Austria	9.15625	=10
US	8.59375	=11	Belgium	9.15625	=10
Canada	8.59375	=11	Hong Kong	9.15625	=10
Denmark	8.59375	=11	South Korea	9.15625	=10
France	8.59375	=11	Taiwan	9.15625	=10
Hong Kong	8.59375	=11	Canada	8.875	=15
Israel	8.59375	=11	Denmark	8.875	=15
New Zealand	8.59375	=11	Estonia	8.875	=15
UK	8.59375	=11	New Zealand	8.875	=15
Belgium	8.3125	=19	Switzerland	8.875	=15
Estonia	8.3125	=19	Israel	8.59375	=20
Norway	8.3125	=19	UK	8.59375	=20
Switzerland	8.3125	=19	Norway	8.3125	22
UAE	8.03125	23	Ireland	8.03125	=23
Qatar	7.46875	=24	Spain	8.03125	=23
Spain	7.46875	=24	UAE	8.03125	=23
Czech Republic	7.1875	=26	Lithuania	7.75	26
Ireland	7.1875	=26	Czech Republic	7.46875	=27
Italy	7.1875	=26	Italy	7.46875	=27
Lithuania	6.90625	=29	Malaysia	7.46875	=27
Malaysia	6.90625	=29	Poland	7.46875	=27
Poland	6.90625	=29	Qatar	7.46875	=27
Russia	6.90625	=29	Argentina	7.1875	=32
Chile	6.625	=33	China	7.1875	=32
Portugal	6.625	=33	Russia	7.1875	=32
Slovenia	6.625	=33	Slovenia	7.1875	=32
Argentina	6.34375	=36	Chile	6.90625	=36
China	6.34375	=36	Portugal	6.90625	=36
Brazil	6.0625	=38	Slovakia	6.90625	=36
Bulgaria	6.0625	=38	Bulgaria	6.625	=39
Hungary	6.0625	=38	Hungary	6.625	=39
Latvia	6.0625	=38	Ukraine	6.625	=39

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TECHNOLOGICAL READINESS RANKING

Technological Readiness Rankings (continued)

	2013-17			2018-22	
	Score	Ranking		Score	Ranking
Saudi Arabia	6.0625	=38	Costa Rica	6.34375	=42
South Africa	6.0625	=38	Cyprus	6.34375	=42
Ukraine	6.0625	=38	India	6.34375	=42
Costa Rica	5.78125	=45	Latvia	6.34375	=42
Kuwait	5.78125	=45	South Africa	6.34375	=42
Cyprus	5.5	=47	Brazil	6.0625	=47
India	5.5	=47	Saudi Arabia	6.0625	=47
Slovakia	5.5	=47	Croatia	5.78125	=49
Bahrain	5.21875	=50	Kuwait	5.78125	=49
Croatia	5.21875	=50	Mexico	5.78125	=49
Greece	5.21875	=50	Romania	5.78125	=49
Kazakhstan	5.21875	=50	Thailand	5.78125	=49
Thailand	5.21875	=50	Turkey	5.78125	=49
Turkey	5.21875	=50	Colombia	5.5	=55
Colombia	4.9375	=56	Jordan	5.5	=55
Mexico	4.9375	=56	Kazakhstan	5.5	=55
Romania	4.9375	=56	Philippines	5.5	=55
Tunisia	4.9375	=56	Serbia	5.5	=55
Morocco	4.65625	=60	Sri Lanka	5.5	=55
Philippines	4.65625	=60	Bahrain	5.21875	=61
Jordan	4.375	=62	Greece	5.21875	=61
Serbia	4.375	=62	Morocco	4.9375	=63
Azerbaijan	4.09375	=64	Tunisia	4.9375	=63
Iran	4.09375	=64	Azerbaijan	4.65625	=65
Sri Lanka	4.09375	=64	Vietnam	4.65625	=65
Kenya	3.53125	=67	Indonesia	4.375	=67
Vietnam	3.53125	=67	Iran	4.375	=67
Ecuador	3.25	=69	Ecuador	3.8125	=69
Egypt	3.25	=69	Peru	3.8125	=69
El Salvador	3.25	=69	Egypt	3.53125	=71
Indonesia	3.25	=69	El Salvador	3.53125	=71
Dominican Republic	2.96875	=73	Kenya	3.53125	=71
Peru	2.96875	=73	Algeria	3.25	=74
Venezuela	2.96875	=73	Cuba	3.25	=74
Algeria	2.6875	=76	Dominican Republic	2.96875	76
Cuba	2.6875	=76	Pakistan	2.6875	=77
Pakistan	2.40625	78	Venezuela	2.6875	=77
Bangladesh	2.125	=79	Bangladesh	2.40625	79
Nigeria	2.125	=79	Nigeria	2.125	80
Angola	1.28125	=81	Libya	1.84375	81
Libya	1.28125	=81	Angola	1.5625	82

Source: The Economist Intelligence Unit.

Access to the internet

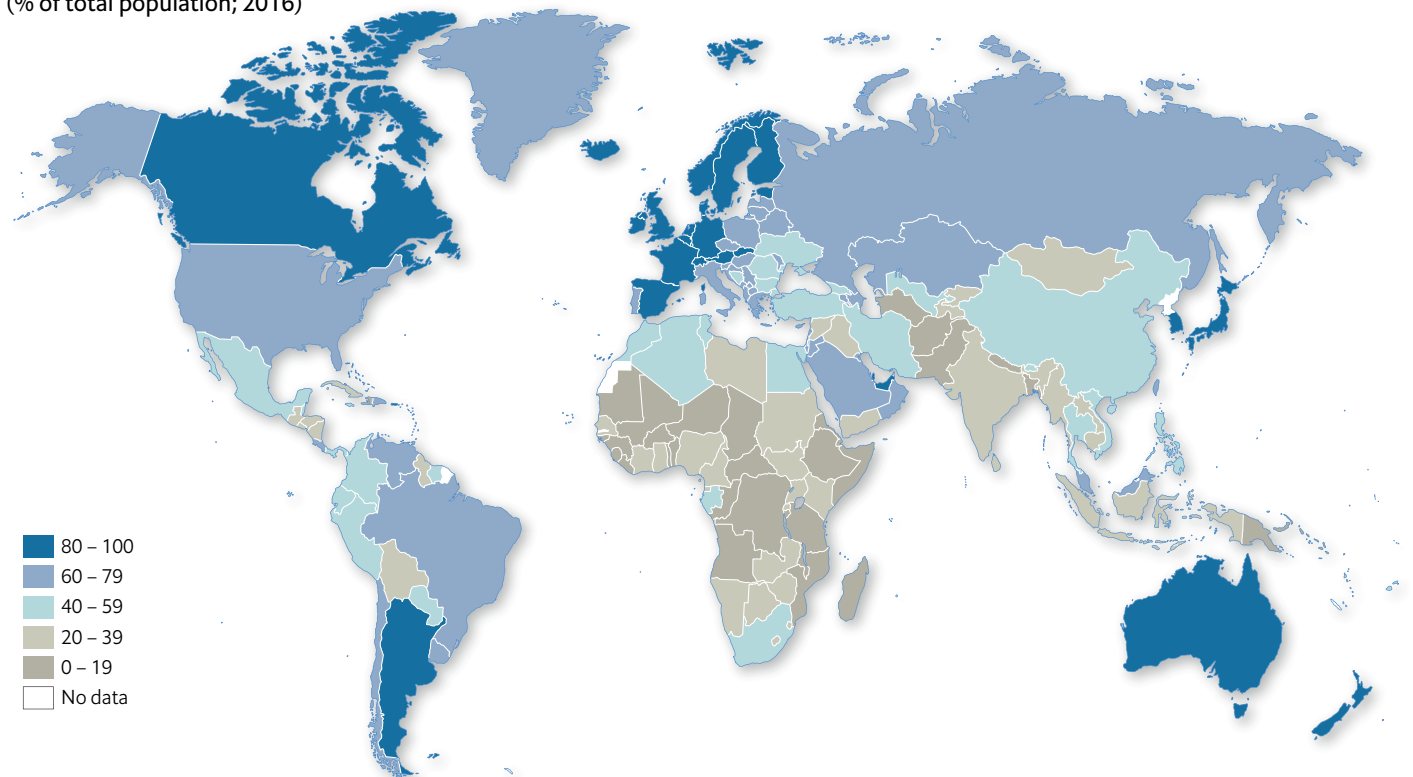
The most fundamental element of technological readiness is access to the internet. In much of the developed world, a fast and reliable internet connection is taken for granted; in those places where this is lacking, business opportunities are significantly constrained. This section of our ranking, which looks at the share of a country's population that has access to connectivity, underpins all of the others. Not only is access to the internet the *sine qua non* of technological readiness; it is also a critical component of a robust business environment.

We have approached the question of internet access in two ways: the level of internet usage; and the number of mobile-phone subscriptions per head.

Internet usage

Internet users

(% of total population; 2016)



Source: ITU.

We estimate that about half of the global population had access to the internet in 2017; by 2022 this will have risen to three-quarters. With broadband penetration already high in the West, most of this growth will come from Latin America and the Middle East, both of which are attracting significant amounts of broadband investment from the private sector. Africa will also spur growth, as a host of

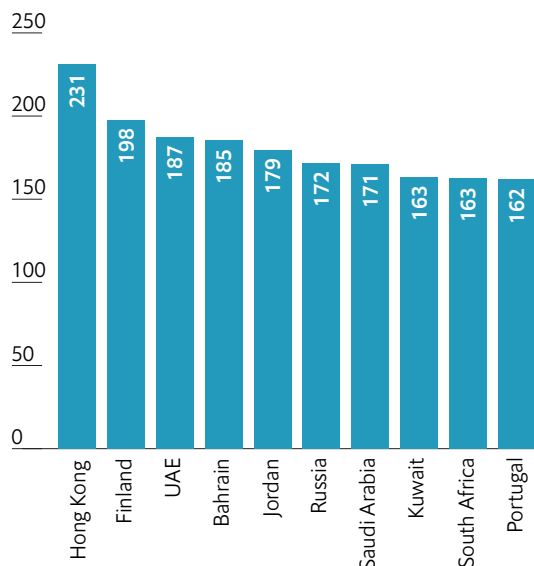
countries continue to develop and implement broadband infrastructure strategies. In some markets, the growing availability of competitive mobile broadband packages will result in consumers becoming increasingly reliant on mobile phones for internet access. In India, for example, around 80% of internet usage now takes place via mobile phones.

In line with this strong growth outlook, we expect over half of the 82 countries in our ranking to register improvements in their scores for internet usage between our historical period (2013-17) and our forecast period (2018-22). We expect particularly strong jumps in access in India, the Philippines, Ecuador and Malaysia. Only one country is likely to see a decline in internet access in this period: Venezuela, which is currently enduring a debt and hyperinflation crisis that we expect to turn into an outright economic collapse.

On the whole, there is a strong correlation between the level of internet usage and a country's overall technological readiness score. However, there are a few exceptions, with Bahrain, Kuwait and Azerbaijan having high levels of internet usage but scoring poorly in the other categories of our ranking. In the case of Azerbaijan, where this contrast is most striking, internet usage—at 78% of the population—is above that in Russia and much of central and eastern Europe, but investment in broadband provision and other elements of digital infrastructure has failed to keep pace with demand.

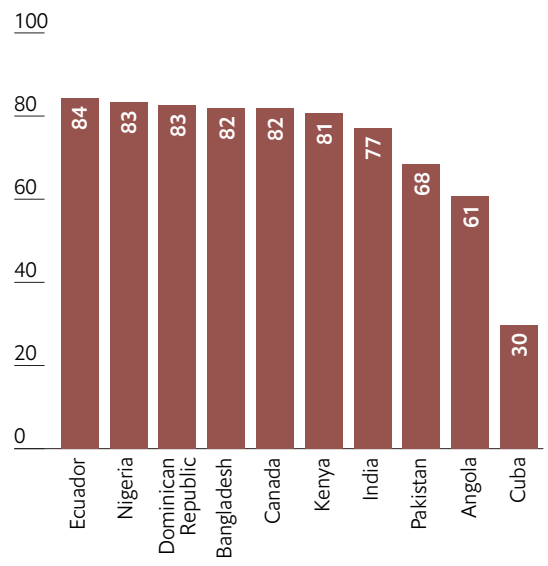
Mobile phone subscriptions

Mobile phone subscriptions: Top 10
(per 100 people; 2015)



Source: ITU.

Mobile phone subscriptions: Bottom 10
(per 100 people; 2015)



A complementary indicator to internet access, the number of mobile phone subscriptions per head helps to build up the picture of how easy it is for individuals from all segments of society to access the internet. It also suggests how much household demand there is for connectivity, and indicates a country's capacity to adopt and embed new technologies.

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The average number of mobile phone subscriptions per head has soared over the past decade, and in our highest-ranking country—Hong Kong—there are now a staggering 2.3 subscriptions per person. Finland, the UAE and Bahrain also have highly saturated markets. Only in 13 of the countries in our index is there less than one mobile phone subscription per person. Perhaps the most surprising inclusion in this group is Canada, which reflects the high cost of phone subscriptions in this country. Cuba's position at the very bottom of our ranking reflects the policies of the communist government: Cubans were not allowed to buy mobile phones until 2008, and internet access remains severely restricted.

We expect mobile subscriptions to continue to grow strongly over the forecast period, with operators in many markets struggling to roll out infrastructure fast enough to keep pace with consumer demand—particularly for mobile broadband data. Telecommunications operators are working to invest in spectrum bands to boost network capacity and so cater to this growing demand. In developing countries the main focus is on fourth-generation (4G) technology, but in advanced economies the discussion is already moving on to what 5G capabilities might involve.

More broadly speaking, mobile technology is an increasingly powerful tool. Mobile payment systems are growing in sophistication and functionality, opening up commercial opportunities even in countries where broadband subscriptions remain low. Meanwhile, mobile applications, for instance in the fields of healthcare and education, are increasingly becoming tools to support human capital development in emerging markets.

Digital economy infrastructure

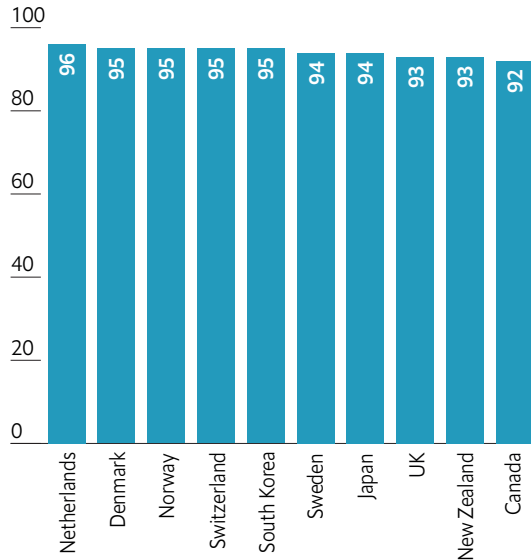
The growth of the digital economy has revolutionised how we work, shop, communicate, read the news and pay our taxes. In the course of this, we have seen radical improvements in efficiency, for instance through the time-saving effects of e-commerce and e-government. We have also seen a rise in cyber threats, as more and more data is shared and as services and networks are increasingly shifted online.

The infrastructure that a country has in place to support the digital economy, for instance to ensure that online transactions can be conducted smoothly and safely, is thus becoming an increasingly important aspect of the business environment.

We include three indicators to explore this in our ranking: the e-commerce business environment, the scope of e-government services and cyber-security preparedness.

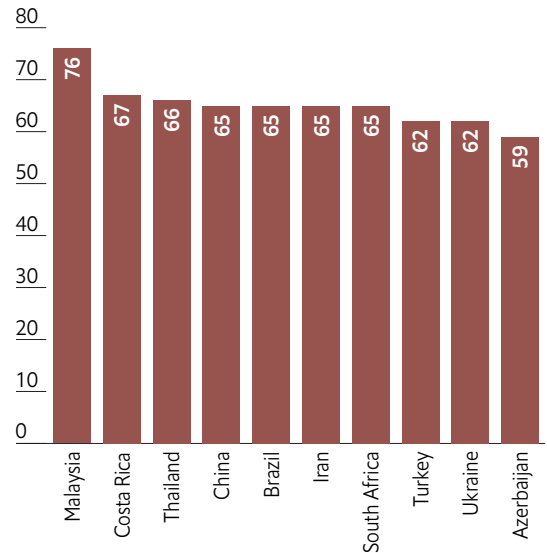
E-commerce

Top ten e-commerce business environments
(e-commerce index, out of 100; 2015)



Source: UNCTAD.

Top ten among developing countries
(e-commerce index, out of 100; 2015)



As mobile and broadband functionality improves around the world, business transactions are increasingly moving online. For vendors, e-commerce offers an opportunity to reach a truly global audience and deliver goods and services at considerably lower cost. For consumers, benefits include greater choice, improved price visibility and easier access to niche products. Countries with a strong e-commerce offering are increasingly finding themselves well placed to attract investment.

However, in many countries poor internet connectivity and inadequate regulation hamper online sales, while small and medium-sized enterprises struggle with inadequate resources or poor

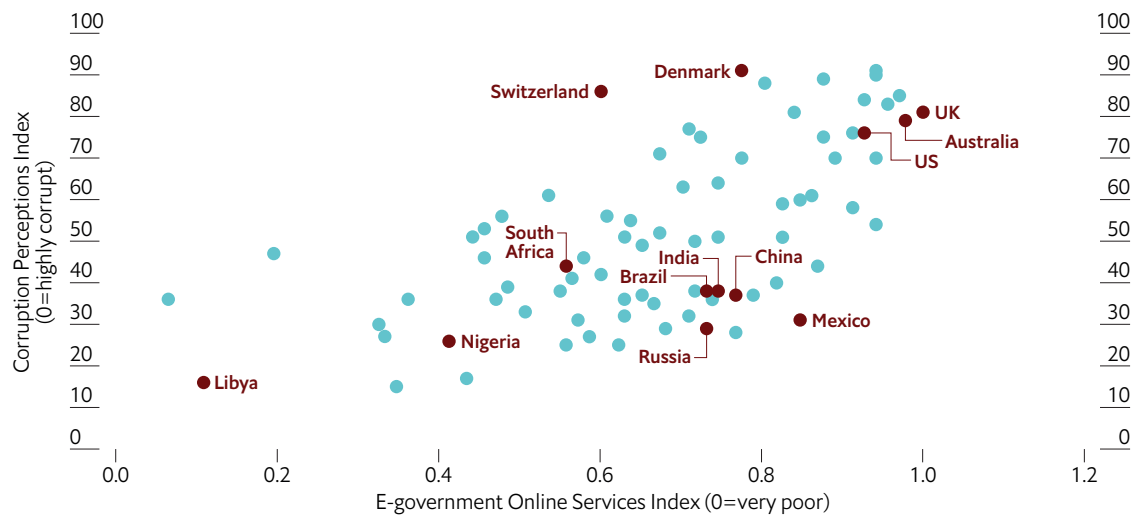
information technology literacy. Cultural factors also play a part: in countries where trust in online transactions is low, and in those where purchasing habits revolve around bricks-and-mortar retail stores and informal market trading, take-up of e-commerce has been slow.

The UN Conference on Trade and Development (UNCTAD) publishes a business-to-consumer e-commerce index, and we have drawn on its findings in making our country-level assessments. This index explores access to the internet, the availability of secure servers, the ease and security of online payments, and the reliability of the postal system—essential to deliver purchases to customers. The countries that score most highly on this category of our ranking are the Netherlands, Denmark, Norway, Switzerland and South Korea. Among developing countries the leaders are Malaysia, Costa Rica, Thailand, China and Brazil.

We expect the less developed countries in our ranking to struggle in our forecast period to improve the quality of their e-commerce business environments—and indeed their technological readiness overall, since these measures are strongly correlated. African countries in particular still have a lot to do to improve penetration rates and infrastructure, to develop trust in online payments and to increase public access to banking services. Purchases on mobile devices (m-commerce) already account for the bulk of online sales in this region, and future developments are likely to focus further on m-commerce opportunities.

E-government

E-government services and corruption

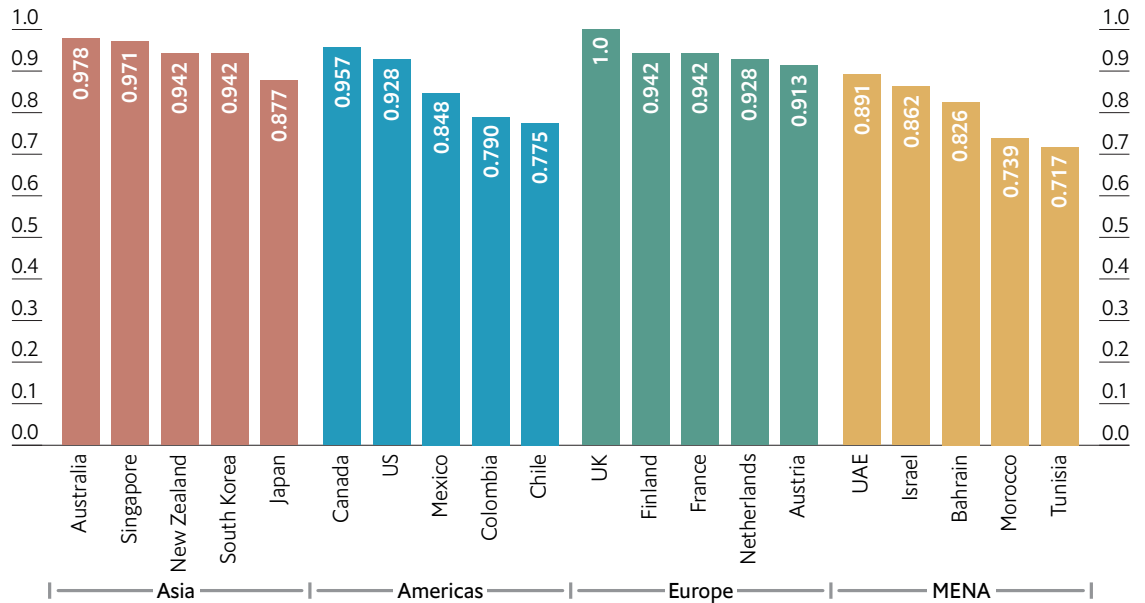


Note: 2016 data for e-government; 2015 data for corruption perceptions.
 Sources: UN E-Government Development Index; Transparency International Corruption Perceptions Index.

Offering government services online has a number of benefits both for governments and for citizens. From the governmental perspective, it is more cost-effective and reduces opportunities for corruption. For citizens, e-government is often more convenient and can make it easier to engage with the democratic process. In theory at least, e-government can increase transparency, and so also trust.

Top scorers in the Online Service Index

(by region; 2016)



Source: UN E-Government Development Index.

In practice, however, e-government services vary greatly from country to country. Our ranking of e-government offerings rests in part on the findings of the UN's E-Government Development Index, and in particular a subcomponent of this called the Online Service Index. This was put together following a major study to assess the useability of e-service and e-participation websites run by governments around the world.

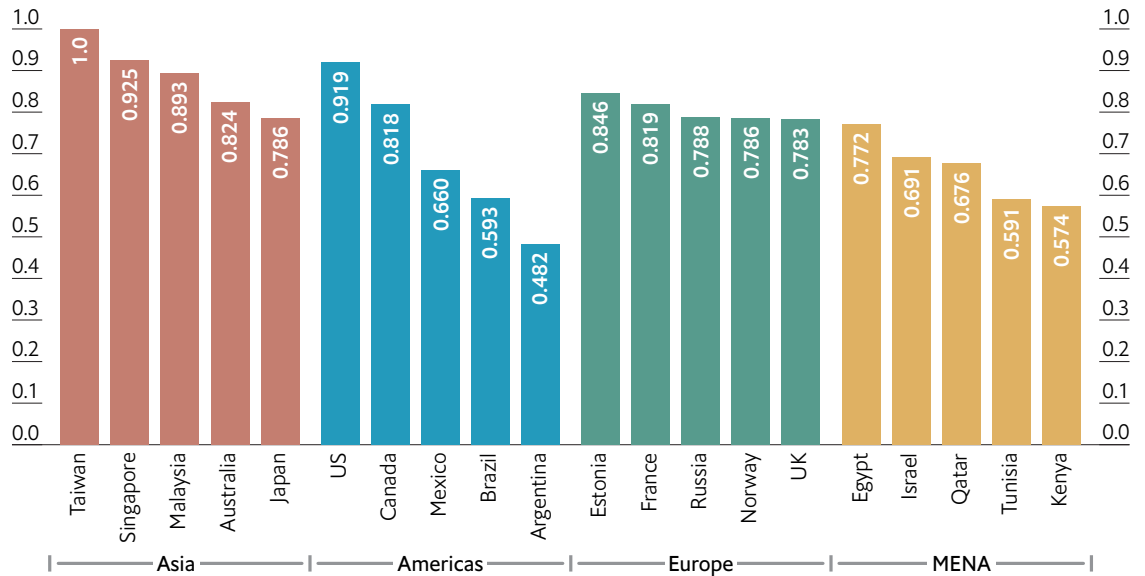
The top-scoring countries in the Online Service Index are the UK, Australia, Singapore and Canada, closely followed by Finland, France, New Zealand and South Korea. Bringing up the rear are Algeria, Libya and Cuba, where the authorities have not prioritised the development of e-government. Russia also scores comparatively poorly. Various countries are currently investing in e-government, and we expect them to see an improvement in our forecast period; these include Malaysia, Sri Lanka, Ireland, Belgium and Argentina.

One of the main drivers of e-government strategies, for instance in the Asia-Pacific region, is the desire to reduce corruption. By reducing the number of interactions with officials and speeding up the decision-making process, online services can help to cut down on corrupt practices, and this has been shown to be particularly effective in developing countries. However, it is not a silver bullet: accurate record-keeping and a robust legal system are needed too.

Cyber-security preparedness

Top scorers in the Global Cybersecurity Index

(by region; 2017)



Source: ITU.

In 2017 there was a spate of highly disruptive cyber attacks, including the so-called WannaCry and Petya ransomware attacks. In early 2018 Germany suffered a sustained attack on its government networks and the US blamed Russia for an attack on its energy grid. Revelations of data breaches at social media networks, and the use of personal data for propaganda purposes, have proliferated in recent years.

Consequently, ensuring that sufficient cyber-security measures are in place has become a priority for governments and a matter of concern for the corporate world. We have included a measure of these efforts in our ranking, drawing on the findings of the Global Cyber-Security Index published by the International Telecommunication Union (ITU), a UN agency. This consists of an assessment of a country's legal, technical and organisational capacities, along with measures of public awareness and intra-state co-operation.

The top-scoring countries on this metric include the US, Canada, Australia and Singapore. Estonia has long been the digital leader in Europe, and it is also the leader for cyber-security. The country's capital, Tallinn, has hosted NATO's cyber-security centre since 2008. We expect Estonia's score to improve further in 2018-22 compared with 2013-17. However, we expect deteriorations in scores for some other countries, such as Finland and Argentina, where growth in the frequency and severity of cyber attacks is likely to outpace efforts to upgrade security.

The effectiveness of programmes to improve cyber-security preparedness will become increasingly important to follow in our forecast period, as cyber warfare—by both state-sponsored actors and criminal networks—becomes more sophisticated and widespread. Our concerns about this centre not just on the threat to consumer faith in the security of the internet, but also on the risk that cyber attacks could be used to damage physical infrastructure (such as energy grids), constrain government activities or influence democratic processes.

Openness to innovation

How easy it is to develop and implement new ideas varies from country to country. If there is funding available to help researchers to explore innovations, and if infrastructure is in place to help firms to adopt new technologies, then the business environment will appear more attractive to forward-looking companies. In turn, too, openness to innovation can influence consumers' expectations and boost productivity—a key driver of long-term economic growth.

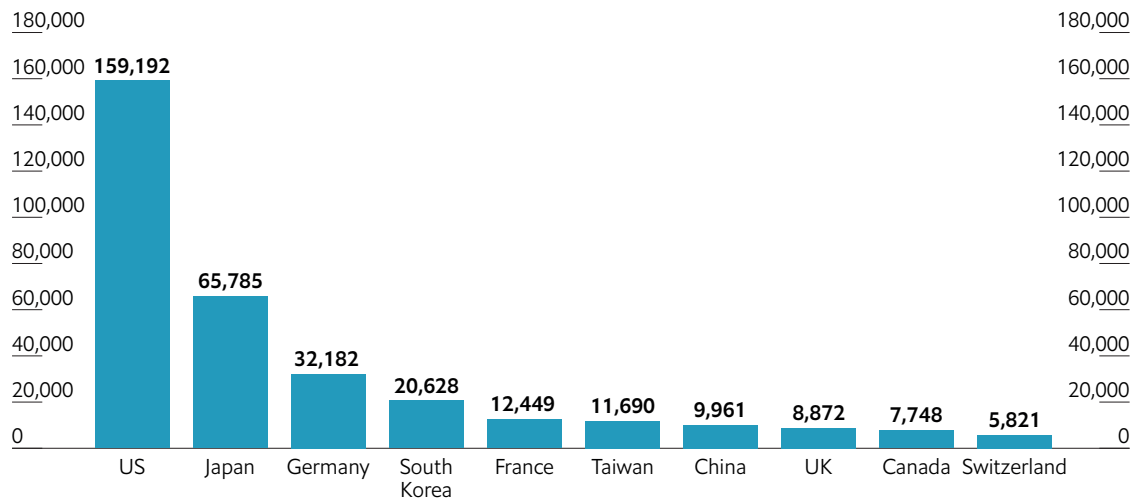
This feature of the business environment is not static. New government initiatives, foreign direct investment (FDI) trends and the snowball effect of successful industry clusters can all have an impact. Over time, these changes alter the relative strengths of different countries as investment locations.

In our ranking, we explore openness to innovation through three indicators: internationally granted patents, R&D spending and research infrastructure.

International patents granted

International patents

(total granted by the European Patent Office and US Patent and Trademark Office, 2015)



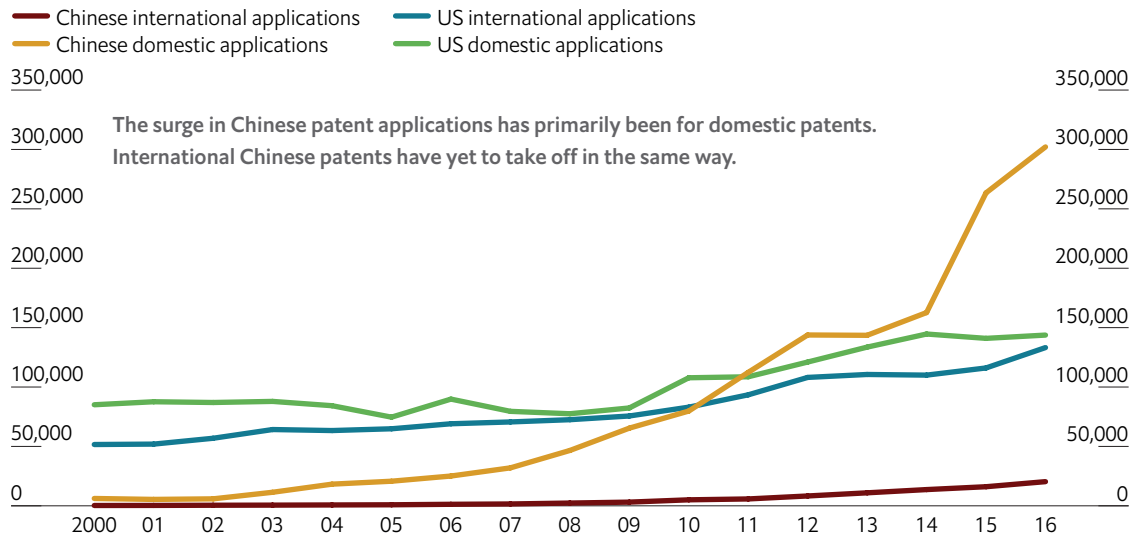
Sources: European Patent Office; US Patent and Trademark Office.

Patent activity is a good measure of innovation in that it is objective, quantifiable and internationally comparable. It does have drawbacks, though: not all patents are high-quality ideas with practical applications. In some countries, firms require their employees to apply for patents, resulting in a proliferation of low-level inventions. In others, firms apply for patents that are highly derivative—so-called copycat patents.

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TECHNOLOGICAL READINESS RANKING

Trends in Chinese patent applications



Source: World Intellectual Property Organisation.

To filter out these low-quality patents, we have looked only at the patents granted by the European Patent Office and the US Patent and Trademark Office. These international patents are expensive to apply for and are rigorously examined. As a consequence, they tend to be pursued only for inventions that have a wide range of potential uses and that might also find applications abroad.

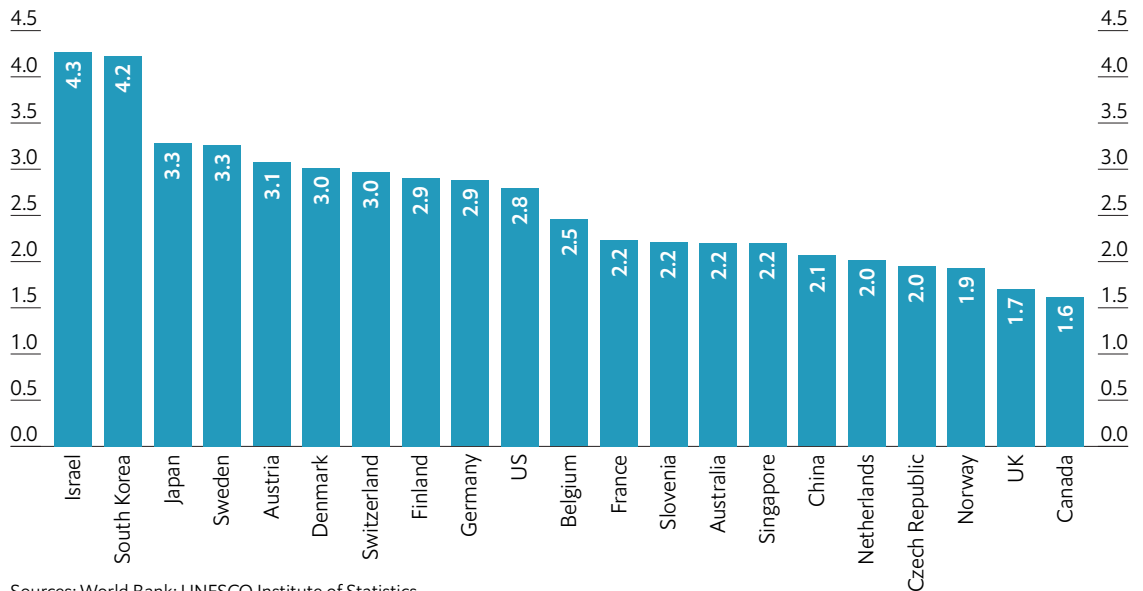
On this metric the US, Japan, Germany and South Korea are—unsurprisingly—the top performers. China comes in seventh place, after achieving rapid growth in recent years. Strong growth has also been seen in lower-ranking countries such as Mexico and Slovakia, and we expect this to continue in our forecast period. In the case of Mexico, this reflects a new government-led innovation strategy focused on supporting regional-level capabilities. In Slovakia’s case it reflects the impact of substantial and ongoing FDI inflows.

Of course, patented inventions on their own are not enough to boost the productive capacity of an economy or to foster an innovative business culture. The impact that they have depends on whether they are put to use effectively. In some economies that have benefited heavily from FDI, such as Poland, we see islands of foreign-owned innovation that generate only limited spillover effects for the broader economy. In contrast, innovation clusters such as Singapore that have closely linked businesses, suppliers, financing and research institutions all in one place punch far above their weight.

R&D spending

R&D spending

(% of GDP; top 20 countries; 2015)



Sources: World Bank; UNESCO Institute of Statistics.

A proxy for how well innovation is funded, R&D spending (as a share of GDP) has been shown to be correlated with higher productivity and longer-term growth. For emerging markets it is a way to move closer to the technology frontier, while for developed markets it can help to maintain competitiveness.

Israel and South Korea are the biggest spenders on this metric, with R&D spending in both countries exceeding 4% of GDP. The EU, where R&D spending amounts to just 2% of GDP on average, has long looked with envy at Japan (3.3% of GDP) and the US (2.8% of GDP), and catching up with these countries is one of the aims of its Europe 2020 strategy. In the meantime, however, R&D spending in China, at 2.1% of GDP, has overtaken that in the EU.

There are significant variations in where this funding comes from. Business enterprise funding is by far the largest source for Japan, China and South Korea, accounting for over three-quarters of total R&D spending. Russia has an unusually large share of government funding, at around two-thirds of the total, reflecting the heavy involvement of the state in the economy—and especially in the oil and gas sector, where this spending is concentrated. In central and eastern Europe, where EU structural and cohesion funds are important sources of investment financing, around a third of R&D spending is financed from abroad.

A high rate of spending on innovation is not guaranteed to be productive. Its impact can be reduced by ineffective allocation, for instance to meet targets rather than achieve results. Moreover, without a broader ecosystem to support innovation it is unlikely to make a big difference. Hence the importance of the final indicator in our ranking, the research infrastructure.

Research infrastructure

Top 10 clusters of inventive activity

(ranked by international patent filings)

City or city cluster	Country	Largest inventor	Main technological field	Main co-inventing cluster	Ranking
Tokyo-Yokohama	Japan	Mitsubishi Electric	Electric machinery	Osaka-Kobe-Kyoto	1
Shenzen-Hong Kong	China-Hong Kong	ZTE Corporation	Digital communication	Beijing	2
San Jose-San Francisco, CA	US	Google	Computer technology	Portland, OR	3
Seoul	South Korea	LG Electronics	Digital communication	Daejeon	4
Osaka-Kobe-Kyoto	Japan	Murata Manufacturing	Electric machinery	Tokyo-Yokohama	5
San Diego, CA	US	Qualcomm	Digital communication	San Jose-San Francisco, CA	6
Beijing	China	BOE Technology Group	Digital communication	San Jose-San Francisco, CA	7
Boston-Cambridge, MA	US	MIT	Pharmaceuticals	San Jose-San Francisco, CA	8
Nagoya	Japan	Toyota	Transport	Tokyo-Yokohama	9
Paris	France	L'Oréal	Transport	Lyon	10

Note: 2011-15 data for patent filings through the Patent Co-operation Treaty (PCT) system. Main co-inventing cluster is defined as the cluster accounting for the largest share of external co-inventors within the top 100 clusters.

Source: World Intellectual Property Organisation.

For this final category in our ranking, we score the 82 countries based not on a single data series but on a qualitative and survey-based assessment of a number of indicators. These include the quality of the country's research institutions, the strength of university-industry links and how supportive the government's policy mix is for innovative firms.

The OECD countries dominate the top positions in this category, owing to the advantages of having long-established networks of universities and industrial firms, and because of their high income levels, which attract skilled researchers and scientists from elsewhere. However, a number of emerging economies are catching up. A 2017 study of the world's most dynamic clusters of inventive activity included Shenzhen-Hong Kong and Beijing (China) in the top ten and Bengaluru, Mumbai and Pune (India) in the top 100. We also expect improvements in the coming years in Indonesia, Argentina and Jordan, among others.

Innovation clusters are one example of an effective research infrastructure. The combination of skilled people, venture capital and start-up incubators, a supportive policy framework, existing business activity, universities and an attractive lifestyle can turbocharge innovation. The hope of building the next Silicon Valley is seeing an increasing amount of government interest in promoting such clusters. Of course, to be successful they need to play to existing strengths—such as the automotive industry in Nagoya, Japan, or pharmaceuticals in Boston, Massachusetts—and must have robust institutions and a good business environment more broadly as well.

Sources

- International Telecommunication Union (ITU), the UN agency specialising in information and communication technologies, for data on internet usage, mobile phone subscriptions and the Global Cyber-Security Index
- UN Conference on Trade and Development (UNCTAD) B2C E-Commerce Index and UN E-government Development Survey
- European Patent Office and US Patent and Trademark Office
- “Identifying and ranking the world’s largest clusters of inventive activity”, Economic research working paper by Kyle Bergquist, Carsten Fink and Julio Raffo for the World Intellectual Property Organisation (WIPO)
- World Bank and UN Educational, Scientific and Cultural Organisation (UNESCO) Institute for Statistics, for R&D spending data
- World Economic Forum (WEF) Global Competitiveness Index

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