The Economist INTELLIGENCE UNIT

THE AUTOMATION READINESS INDEX

WHO IS READY FOR THE COMING WAVE OF AUTOMATION?

Supported by ABB

Contents

About the report

The Automation Readiness Index: Who is ready for the coming wave of automation? is an Economist Intelligence Unit report, commissioned by ABB. The analysis in the report is based on a new and original index, built by The Economist Intelligence Unit, as well as a series of in-depth interviews with subject matter experts from around the world.

The project has benefitted from counsel provided at various stages by a panel of experts consisting of prominent authorities on different facets of automation. These include the following:

- **Mercedes Crego,**
  head, Open Innovation EU, Philips Lighting
- **Dick Elsy,**
  chief executive officer, High Value Manufacturing Catapult
- **Elizabeth Fordham,**
  director of education and skills, OECD
- **Julie Huxley-Jones,**
  head of automation, GSK
- **Rose Luckin,**
  professor of learner centred design, University College London
- **Alan Manning,**
  professor of economics, London School of Economics
- **Francesc Pedro,**
  chief of section, Sector Policy Advice and ICT in Education, UNESCO
- **Geoff Pegman,**
  managing director, R U Robots
- **Saadia Zahidi,**
  head of education, gender and employment initiatives, World Economic Forum

Interviews were also conducted with:

- **Elena Alfaro Martinez,**
  chief executive officer, BBVA Data & Analytics
- **James Bessen,**
  professor of economics, Boston University
- **Dai Chia-peng,**
  general manager, automation technology, Foxconn
- **Lorenzo Fioramonti,**
  professor of political economy, University of Pretoria
- **Domonkos Gaspar,**
  head of global manufacturing digitisation, Autoneum
- **Neil Lawrence,**
  director of machine learning, Amazon; professor of machine learning, University of Sheffield
- **Sheri Ng,**
  managing director, NICE
- **Harry Patrinos,**
  practice manager for education, East Asia and Pacific, The World Bank
- **Milan Sheth,**
  partner - advisory services and technology, EY
- **Siim Sikkut,**
  chief information officer, Government of Estonia
- **Marco Henrique Terra,**
  director, Center for Robotics, Universidade de São Carlos

We would like to thank the panel and other experts for their time and insights.

Executive summary

There are few terms as emotive, and few subjects that elicit as much angst, within societies as that of automation. This might seem odd, given that automation technologies have long been present in our factories and offices. The advent, however, of highly intelligent technologies such as robotics and those based on the different forms of artificial intelligence (AI), which have the ability to perform more than just assembly-line types of tasks, has added a new dimension to discussions of future automation—namely the prospect that large numbers of roles performed today by humans, wearing white or blue collars, will be eliminated by machines.

Business leaders are not displaying much fear. Such anxieties as they have about these technologies are more about being caught out by market disruption. Thus many are speeding ahead to integrate AI or advanced robotics into their operations. That pace will accelerate in the next few years, and the actual impacts on economies and workforces will begin then to become clearer.

To avoid a vacuum, countries will need to put policies and plans in place to help individuals (and to some extent businesses) take maximum advantage of the opportunities that these technologies offer. Policies will also be needed to mitigate the negative impacts resulting from the displacement of some categories of workers from their familiar roles. In both cases it is a matter of policies and strategies that help workforces make the transition to a more automated economy.

The Automation Readiness Index compares countries on their preparedness for the age of intelligent automation. In assessing the existence of policy and strategy in the areas of innovation, education and the labour market, the study finds that little policy is in place today that specifically addresses the challenges of AI- and robotics-based automation. No country has yet to "take the bull by horns", in the view of several experts interviewed for the study. A small handful, however, including South Korea, Germany and Singapore—the overall index leaders—have undertaken individual initiatives in areas such as curriculum reform, lifelong learning, occupational training and workplace flexibility.

Other findings from the research include the following:

The challenges and opportunities of intelligent automation require a robust policy response informed by multi-stakeholder engagement but, so far, both are lacking. Although there is little agreement on the likely net impact of AI and robotics on employment, there is a consensus that governments will need to take action. Businesses, meanwhile, are forging ahead with adoption, meaning there is little time for dalliance. The lack of engagement between policymakers, industry, educational specialists and other stakeholders that must inform this action is therefore alarming. Unsurprisingly, the policy response to intelligent automation is nascent in even the top-ranked countries.

Middle-income countries will find adapting to automation tougher than others. With the exception of China, there is a large gap separating high-income countries from those in middle- and lower-income brackets. But lower-income countries with agriculture-based economies are less exposed than middle-income countries with large manufacturing bases. Shortcomings in basic skills education, among other weaknesses, will therefore severely hamper countries such as Malaysia and Indonesia—which are looking to use AI and robotics to emulate the East Asia "tigers"—as they attempt to capitalise on the opportunities offered by automation.

Index leaders earmark considerable funding and other support to AI and robotics research. Most types of support that governments provide for innovation and entrepreneurship are technology-agnostic. Fundamental research is different: the governments of Japan and South Korea, for example, channel hundreds of millions of dollars' worth of funds to public- and private-sector organisations that are conducting AI and robotics research. Germany, the US and Singapore do the same, although much of German funding is channeled to the manufacturing sector and supports research in other technologies such as the Internet of things (IoT) and data analytics.

Few countries have begun to address the impact of automation through educational policy. Intelligent automation is expected to boost the importance of both education related to STEM (science, technology, engineering and mathematics) and of so-called soft skills, which allow workers to trade on their uniquely human capabilities. However, in all but the highest-scoring countries, little has been done to prepare future workers through school curricula or, just as importantly, teacher training. At the same time, some experts warn that a focus on soft skills would be a distraction in countries where basic education is still not up to scratch.

Lifelong learning is becoming a rich area of experimentation. Several governments are looking for the right formula to encourage citizens to voluntarily undergo periodic skills upgrading. Singapore, for example, is experimenting with funding "individual learning accounts", which adults use to support training courses throughout their lives. Germany's Federal Ministry of Labour and Social Affairs is examining a similar scheme, as well as a modified form of "employment insurance" to fund skills upgrading throughout people's lives.

In most countries, vocational training is not up to the challenges posed by intelligent automation. Germany's system of vocational and technical education has long been held up as a model for other countries. Its system, along with those of South Korea and Singapore, help these three countries share leadership of the labour market policy category of the index. Experts interviewed for the study, however, warn that vocational training in most countries remains too focused on low-skilled occupations to be of use in preparing young people for the automated workplace.

Introduction: A need for policy

There are few areas of consensus among experts about how automation will affect economies and workforces. For example, some believe the gathering wave, based on the widescale diffusion of AI, machine learning and advanced robotics, will be no more disruptive than previous ones. This is the view of Alan Manning, a professor at the London School of Economics: "Every new wave of technology diffusion has impacts that are different, but I see no evidence that this is going to be radically different from what has come previously."

Others believe that what's coming will be different. "Traditionally technologies have automated a range of tasks that humans might not have wanted to do or might not have defined them as humans," says Elizabeth Fordham, director of education and skills at the OECD. "AI and robotics, however, are starting to automate higher order, non-routine tasks, some of which require critical thinking and creativity." For Julie Huxley-Jones, who is head of automation at GSK, a life sciences firm, it is the accelerated speed of change that most distinguishes the emerging wave of automation.

"The major difference with the past is that today's automation technologies are highly intelligent and able to learn."

Lorenzo Fioramonti, professor of political economy, University of Pretoria

The net impact on employment is another area of divergence. Estimates of potential job losses due to automation range from an oft-cited figure of 47% for the US[1] to more conservative estimates of around 9% for OECD countries.[2] Mr Manning believes the net impact of jobs of AI, robotics and other automation technologies will be zero, as new jobs will be created that offset the elimination of older ones.[3] James Bessen, a professor of economics at Boston University, believes that such automation may well create more jobs than it eliminates. "AI and robotics will likely lead to the creation of new demand for services that didn't exist before," he argues. "In this case job creation will benefit, possibly exceeding the labour saving that these technologies enable."

There are two areas of broad consensus. One is that automation technologies will replace certain tasks performed by workers as much, or more, than they replace entire jobs. Automation thus points toward the augmentation of work, potentially leading to greater job satisfaction, as well as to outright displacement. Humans will continue to play a role in designing or operating these systems, and it is expected that many activities will continue to require the distinct skills of humans. Work performed by people will be continuously redefined, requiring the constant updating of skills.

The other point of consensus is that seizing the opportunities and alleviating the strains that intelligent automation poses to economies require co-ordinated efforts by multiple stakeholders. Governments, businesses, educators, labour unions and civil society organisations all have roles to play in developing an understanding of what the impacts of automation are likely to be and to plan initiatives that will help their societies adapt. In many cases these will be policies developed and implemented by governments. "Governments need to have a strategy for automation," says Mr Manning. "I don't think you can just leave this to the market and believe it will deliver the right level of innovation."

To the starting blocks

Policies are required to help manage the transitions that businesses, schools and workforces will need to make in the areas of innovation, education and occupational skills development. To inform such policies, considerable dialogue should take place between governments and other stakeholders, most of whom, at least in developed countries, are studying the uses and implications of AI and robotics themselves.

Unfortunately, there is not yet much evidence of either policymaking or multi-stakeholder dialogue on this topic. "The vast majority of countries inside or outside the OECD are only starting to think about planning for the challenges of automation," says Ms Fordham. Ms Huxley-Jones rues a lack of dialogue between government and industry, as well as between different industries, on the challenges of automation. Other experts observe a similar dearth of dialogue between key stakeholders when it comes to adapting educational systems.

In this sense, no countries are genuinely ready for the age of intelligent automation. This is the case even for Germany, which has been a standard-bearer for the propagation of Industry 4.0 digital manufacturing strategies in which AI and robotics, along with the IoT, play a central role. The same may be said of East Asian countries, where governments are actively supporting the diffusion of these technologies in manufacturing and other sectors.

At this early stage, then, comparing nations' efforts to meet the challenges of automation is a case of examining the starting points for their policy responses. This is the purpose of the Automation Readiness Index—to determine which countries are better positioned to take up the policy challenges that automation poses. Its attention is focused on three areas: on innovation policies that directly or indirectly support research into and business adoption of AI, robotics and other advanced technologies; on education policies that aim to develop the human capital needed to take advantage of these technologies; and on labour market policies needed to manage the workforce's transition to a highly automated economy (For more detail, see chart "Index categories").

INDEX CATEGORIES

1. Innovation Environment

Sub-Categories	Indicator Themes
Research and Innovation	R&D on robotics, automation and AI
	Private investment on R&D
	Regulatory environment for adoption in existing industries
	Regulatory framework for innovation
	International partnerships and knowledge transfer schemes
	Technology adoption support (public and private sectors, SME's, individuals)
	Start-up support programmes
Infrastructure	Infrastructure/connectivity policies
	Cluster development programmes
Ethics and safety	Technology ethics and safety initiatives, data protection and cybersecurity
	Data literacy

2. Education Policies

Sub-Categories	Indicator Themes
Basic Education	Early education programmes
	21st century skills strategies
	Technology education programmes and data literacy
Post-compulsory education	Technology education programmes
	Access to education policies
Continuous education	Lifelong learning programmes
	Training and skills development in employment
	Career guidance programmes
Learning environments	Assessment reform (21st century skills)
	Teacher training reform
	Use of AI and data in education
	Innovation of school models (such as school autonomy and curricular deregulation)
	Social dialogue (with teachers and industry)

3. Labour Market Policies

Sub-Categories	Indicator Themes
Knowledge on automation	Government-led research on automation opportunities. Implementation of this knowledge, dissemination and public awareness
Workforce transition programmes	Programmes for the development of job-relevant skills
	Programmes for adoption of technology in the private sector and workplace innovation
	Collaboration between private and public sector (regarding education and labour market)

The Automation Readiness Index: Overview

The Automation Readiness Index measures countries' preparedness for the coming wave of intelligent automation. The index provides a snapshot across a set of 25 countries of current government-led efforts to anticipate the resulting changes and shape the outcomes of technological progress.

This study is concerned with changes over the next 20-30 years, in which augmentation and substitution of human activity are expected with the adoption of more autonomous technologies in all areas of the economy and society. It measures policies that promote technological progress, the creation of new businesses, the development of skills and policies that can help manage transitions in the labour market. Policies are grouped in three main categories: innovation environment, education policies and labour market policies.

This benchmarking model contains the results of the research based on 52 indicators (both qualitative and quantitative) that were determined through consultation with a panel of experts. The majority of the indicators have been scored by The Economist Intelligence Unit and are based on the examination of publicly available sources and expert interviews.

The country sample includes G20 countries and five additional nations representing diverse regions of the world.

Top ranking countries

High-income countries dominate each of the index categories, meaning their policy environment is deemed best suited to the challenges and opportunities of intelligent automation. South Korea tops the index rankings thanks to a strong score across all three categories.

Germany, Singapore and Japan—three countries that have demonstrated strong leadership on industry digitisation—take the next three spots in the ranking. Japan's performance is buoyed by a world-leading innovation environment, while Germany and Singapore take the top spot, joint with South Korea, for labour market policies.

Canada, the 5th-ranked country in the table, owes its standing at least partly to the initiatives that individual provinces such as Ontario are taking to adapt their educational systems and teaching approaches to the demands posed by advanced technologies (The federal government is more prominent in the support of technology innovation as well as strategy development to address the workforce effects of automation). This highlights the fact that in countries with relatively decentralised political structures, automation policy readiness often relies as much on the efforts of provincial or state governments as on the central government. This is particularly the case in education, where Bavaria in Germany and New South Wales in Australia are also demonstrating leadership.

Overall Index: ranks and scores

Average **62.1**

Mature	1	South Korea	91.3
Mature	2	Germany	89.6
Mature	3	Singapore	87.3
Mature	4	Japan	82.6
Mature	5	Canada	81.8
Developed	6	Estonia	79.5
Developed	7	France	78.9
Developed	8	UK	73.1
Developed	9	US	72.0
Developed	10	Australia	70.4
Developed	11	Italy	67.5
Developed	12	China	67.1
Developed	13	UAE	64.3
Emerging	14	Malaysia	57.7
Emerging	15	Turkey	53.7
Emerging	16	Russia	52.5
Emerging	17	Argentina	51.7
Emerging	18	India	47.2
Emerging	19	Brazil	46.4
Emerging	20	Colombia	44.7
Emerging	21	Saudi Arabia	42.0
Emerging	22	South Africa	41.0
Emerging	23	Mexico	40.7
Emerging	24	Vietnam	37.3
Emerging	25	Indonesia	33.1

Mature · Developed · Emerging

Can developing countries automate?

It is difficult to ignore the large gap in scores separating the top five or ten countries in the index from those in the lower tier. Most of the latter are middle-income countries, and some experts interviewed for this study hold fears for these nations' ability to capitalise on and meet the challenges of automation.

One is Harry Patrinos, practice manager for education, East Asia and Pacific with the World Bank. "Low-income, predominantly agricultural economies will be largely spared from the effects of automation for a while," he says. "The most affected will be the emerging, middle-income countries that are preparing for the East Asian miracle of open economies led by rapid industrialisation; this manufacturing model won't be available to them." China, he believes, is an exceptional case of a middle-income country with a strong manufacturing base and a government that is starting to address the automation-related changes needed in education and skills development. (China ranks 12th in the index, higher than some high-income countries such as the UAE.) Mr Patrinos is most worried about nations such as Malaysia and Indonesia (14th and 25th in the overall index), which do not have a strong education base at primary and secondary levels.

Other experts, although acknowledging such obstacles, believe many middle-income countries have the wherewithal to benefit from the diffusion of AI and robotics. Lorenzo Fioramonti, who is a professor of political economy at the University of Pretoria, envisages a "leapfrogging" scenario in which emerging countries prioritise supporting innovation among small businesses, as well as individual artisans and entrepreneurs. Robotics, he believes, can help small firms and micro-enterprises, including in Africa, to punch above their weight in competitive markets. "Because they are not locked into pre-existing technologies to the same extent as in the developed world, developing economies would not be at a large disadvantage should such development models take hold."

"In areas such as agriculture, automation is a great opportunity for emerging countries. Brazil is a good example; it will enable a productivity increase that is critical for [the] country's food sector to compete with developed countries. Energy production will also benefit with, for instance, the use of automation and robotics in offshore oil exploration."

Marco Henrique Terra, director, Center for Robotics, Universidade de São Carlos

This is of course a very big if, given the power of large technology and industrial companies, and developed-world governments, to fund research and development in robotics and AI. It is also clear from the index table that most middle- and lower-income countries have a relatively weak starting position in terms of policy development to tackle the challenge. A few, however, and not only China, are beginning to take steps in individual areas. Some examples will be highlighted in the discussion that follows.

Chapter 1: Innovation for automation

Discussions of AI- and robotics-driven automation can elicit fear, even among business managers. Some may be concerned about the potential for disruption in their markets or among their workforce, but many more are pushing ahead to implement such technologies or to map out their future implementation in their enterprises. An Economist Intelligence Unit study published in early 2017 found, for example, that 3% of businesses globally are deploying AI in their internal processes or products now, and 75% expect to be "actively implementing" it within three years.[4] Many companies feel they have no choice, lest they be outpaced by rivals that master such techniques. Others clearly see AI and robotics as an opportunity, not to be missed, to gain an edge through innovation.

This is certainly the case for GSK. According to Ms Huxley, "we've been using automation for the last few years to free the hands of our scientists so that they can focus on using their minds. We can produce, through automation, significantly more experimental data output using machines and using techniques that we wouldn't have been able to do manually. Automation is augmenting the work of scientists, and the latter are moving from being purely data generators to being data analysers and decision-makers."

"We are using AI today to automate many of our internal processes, including risk management, fraud detection, document classification and compliance, and also customer-facing processes in contact centres, online and in our branches."

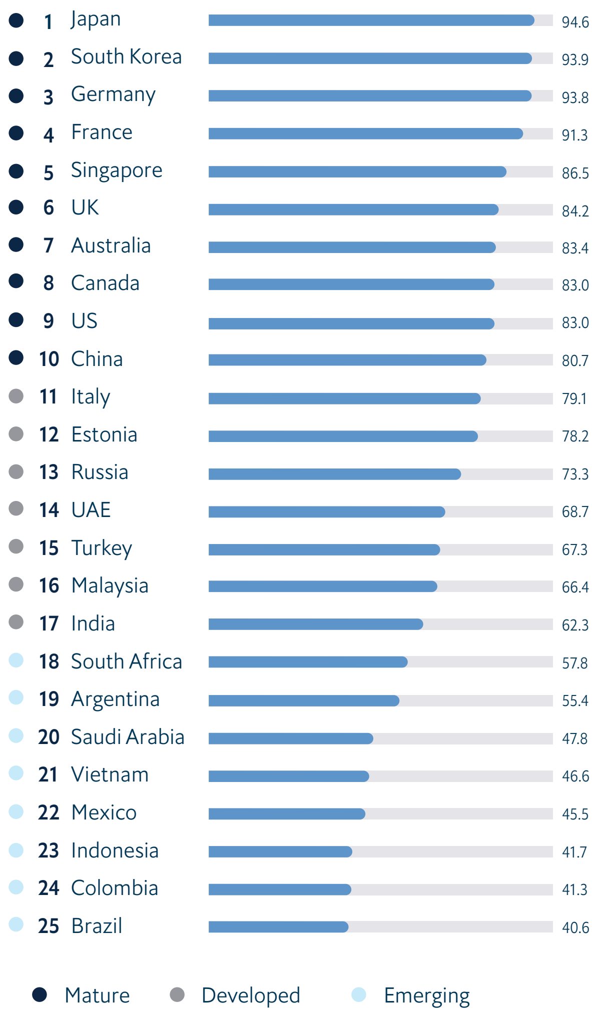
Elena Alfaro Martinez, chief executive officer, BBVA Data & Analytics

As in many fields of advanced technology, governments have an important role to play in facilitating the diffusion of AI and robotics throughout the economy. In some countries it is partly a matter of building awareness.

This is the case in Estonia, which in many ways is still transitioning from a Soviet-era economic structure to a market-driven one. According to Siim Sikkut, the government's CIO, many of the country's enterprises can still get by using relatively inexpensive labour, so incentives for the deployment of advanced technology are not strong.

Innovation Environment: ranks and scores

Average **69.9**



"Automation technologies are not on their radar," he says. "So we're pursuing initiatives (such as technology demos) to build awareness among businesses about the opportunities and challenges. We're also providing credit lines and grants to companies to help them test and trial these technologies, as well as funding to provide retraining of their employees."

In many developed countries, governments play a major role in technology diffusion in supporting the basic research that will eventually be applied and commercialised by businesses, whether through direct funding or the provision of financial incentives. The leaders in the innovation environment category of the index earmark some of this funding for AI and robotics. This is the case in Japan, the category leader, where the Strategic Council for AI Technology, a government body established in 2016, co-ordinates the AI-related work of three national research and development (R&D) centres, as well as those of several ministries.[5] The same is true of South Korea, where the Ministry of Science and ICT has set aside close to US$150m in 2017 for funding AI-related R&D conducted by public- and private-sector organisations.[7] Germany's federal government, through its funding and other forms of direct support of Industry 4.0 initiatives, is doing much to advance research and innovation in robotics.

Regulating innovation

Governments, of course, can stifle technological progress as well as facilitate it. Restrictive visa regimes that prevent domestic businesses from hiring the best technology talent available are one example. Several governments have programmes that actively seek to encourage the migration of skilled professionals in STEM disciplines. A relatively new addition to that list is France (ranked 4th in the innovation environment category), the government of which launched the French Tech Visa in January 2017, a fast-track procedure targeted at technology entrepreneurs and professionals.[8] The UK, however, might have placed higher than 6th if it had a specific programme to attract technology professionals. As it is, there are concerns that the visa regime overall will become tighter once the country exits the EU.

In middle- and lower-income markets, excessive red tape involved in starting a business still holds back technology entrepreneurs in otherwise major technology powers such as China and India. But when it comes to providing support to tech start-ups, governments of several such countries are leaving few stones unturned to try and unleash entrepreneurial spirits. Malaysia is one example, ranking 16th in the category but on a par with most high-income countries in the group of indicators relating to start-up support. These include government programmes to fund technology accelerators and incubators and provide seed financing to start-ups. India, too, fares well in this aspect of innovation support, partly thanks to the national government's ambitious Startup India programme, launched in 2016.

No time to waste

As instrumental as government support is for the development and adoption of automation technologies, businesses are not necessarily predicating their plans on it. Domonkos Gaspar, head of global manufacturing digitisation at Autoneum, a European automotive component supplier, says his company is not waiting around for government leadership. "We know what we need to do," he says. Elena Alfaro Martinez of BBVA says the same: "Co-ordinating multi-stakeholder activity in this field is enormously complex". She notes that "we have to move fast and cannot afford to wait for governments or other institutions to take the initiative."

Leading by example

When it comes to building a strong innovation environment, Estonia (ranked 12th out of 25 for this category) labours under a number of disadvantages in comparison with the index leaders in this category. For one thing, it does not have vast budgetary resources at its disposal to fund basic research in AI or robotics. And despite Estonia's reputation as a digital pioneer—the small country has played an important role in the gestation of firms including Skype and Transferwise—its larger companies lack technology ambition, according to Mr Sikkut.

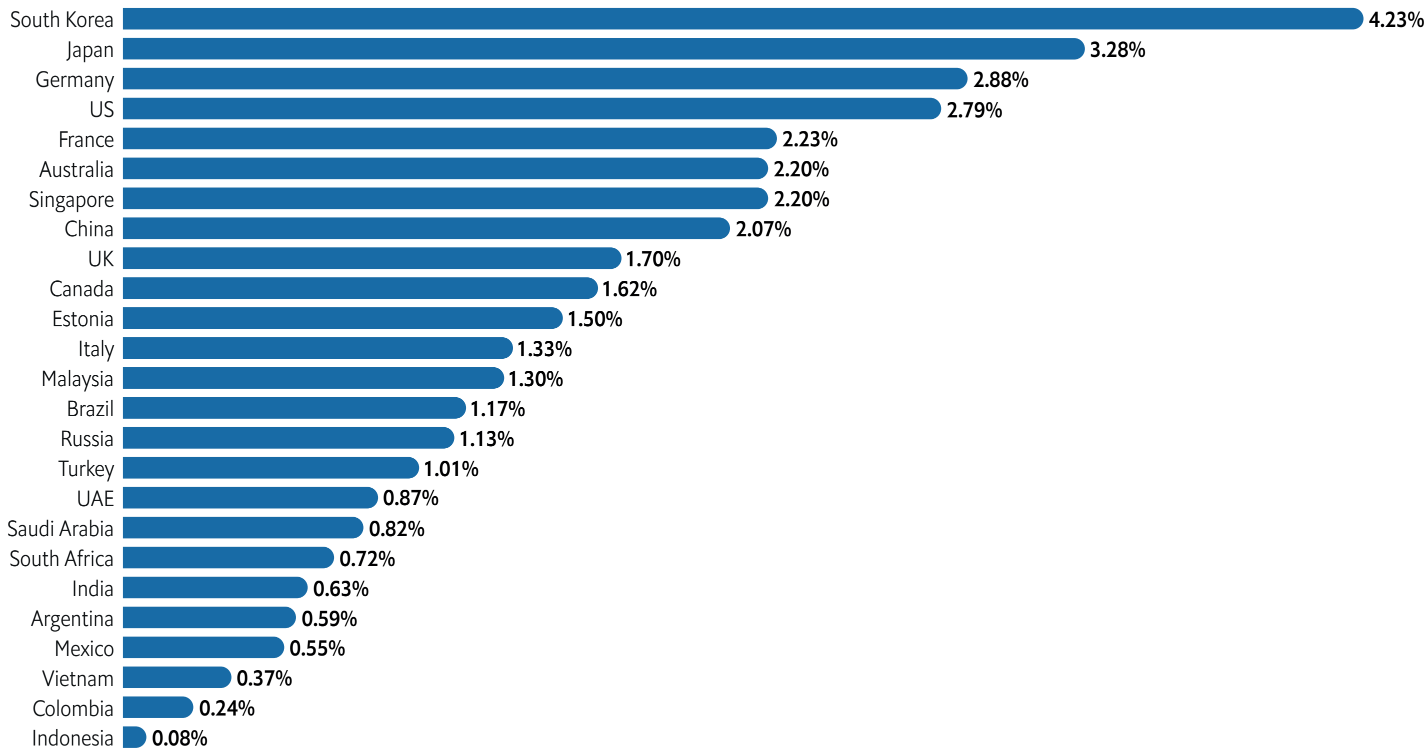
The government is trying to compensate for these handicaps partly through the development of industrial policy, he says, but also by taking a direct role itself in the development of advanced technology platforms that its businesses can use.

"All the infrastructure platforms we're building are meant to be used by the entire country, including businesses, and not just government," explains Mr Sikkut. An example is X-Road, a secure data exchange platform it built over a decade ago to facilitate interoperability between public-sector agencies. (Since June 2017 it is also used for cross-border data transfer between the Estonian and Finnish governments.) Since the platform's inception, it has been used widely by citizens.[7] The platform is now available for commercial firms to use, for data transfer with the government and for B2B data exchange between commercial enterprises.

The government also has plans, according to Mr Sikkut, to develop platforms that both utilise AI techniques and that help to facilitate AI R&D. "Once we build a framework for those," he says, "it will be there for businesses as well as universities, other not-for-profit institutions and of course citizens to use."

Chart 1

Gross expenditure on R&D as % of GDP, 2016



Source: UNESCO Institute for Statistics.

Getting research to the market

In November 2017 it was announced that the UK government's Industrial Strategy Challenge Fund, which was formed in April of the same year, had awarded £68m in funding to four research and innovation projects in robotics and AI systems, mainly involving offshore energy development.[9] Several universities are among the recipients. In the UK and elsewhere, universities are indeed a major source of fundamental research in these and other advanced technologies, but restrictive intellectual property (IP) practices have often prevented much of the research from finding its way to market.

To facilitate the commercialisation of their inventions, three UK institutions—Glasgow University, King's College London and Bristol University—launched the Easy Access IP initiative in 2010. This commits the institutions to license many of their innovations to businesses at no cost. Since its launch, eight other UK universities have signed on to the scheme, as well as seven in Australia, two in Canada, two in Sweden, one in each of China and Germany, and a handful of others.

The scheme is a particular boon to technology start-ups and other small businesses that have been scared away from commercialising ideas born in universities due to a combination of high cost, complex legal agreements and lengthy application times.[10] Licensing agreements used by the participating universities are one page in length and involve no application or licensing fees. (The only costs that firms have to bear are for patent approvals.) Many of the institutions post the inventions they make available on a website, and businesses similarly apply for a licence online. The licensee's commitments are: to acknowledge the university as the source of the IP and do its utmost to commercialise a product or service based on the IP within three years.

Chapter 2: Skills for an automated economy

If countries need a long-term strategy to deal with the challenges of automation, education must be at the centre of it. In a world where routine tasks are automated, schools will need to teach students skills that software or machines cannot yet easily replicate. At the same time, they must provide students with a grounding in certain technical skills, for example coding, which are likely to be required in most future roles. Many such roles will also require an understanding of AI techniques and robotics themselves. As these technologies evolve, so will the roles of humans that work with them.

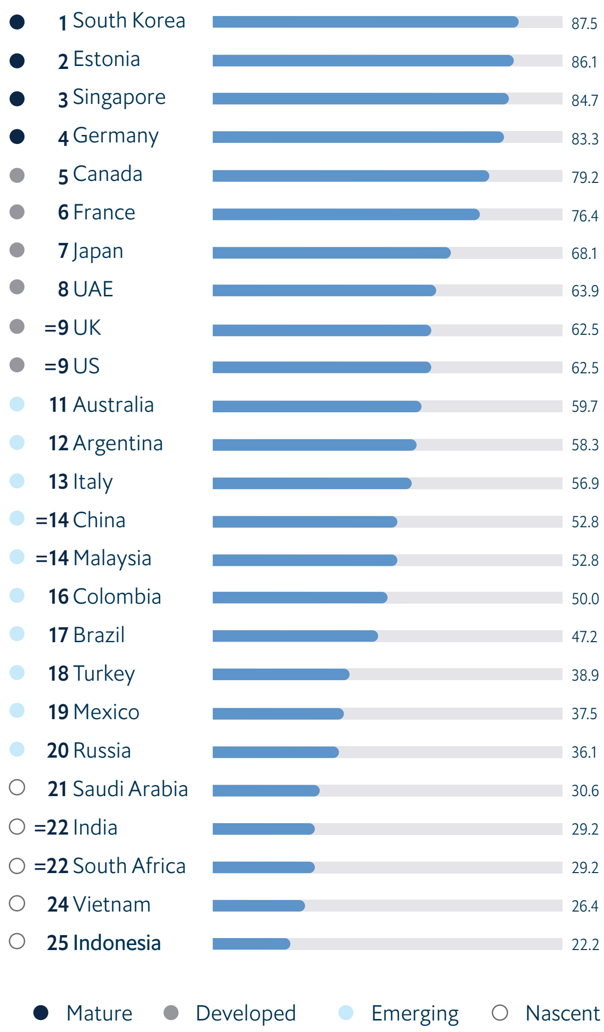
This continuous transformation will demand a high degree of adaptability on the part of individuals to continue learning throughout their working lives; educational and training systems must cater effectively to this demand. Teacher training and assessment, and career guidance are other facets of human capital development that must be adapted to 21st century needs. Opportunities must also not be missed to improve the quality of learning itself through the use of AI and other advanced technologies.

This is a monumental challenge for even the most developed of countries, requiring big picture thinking among government, educators and businesses. According to the experts interviewed for this report, there is plenty of thinking but very little planning or action on this front anywhere in the world today. "No one has gotten to the point of strategic planning for educational change in this context, and there is a dire need for it," says Rose Luckin, professor of learner-centred design at University College London.

The leading performers in educational policy readiness are not vastly different from those in the other two categories, mainly involving the swapping of a few places. This is not a surprise to Saadia Zahidi, who is head of education, gender and employment initiatives at the World Economic Forum: "Very few countries are taking the bull by the horns when it comes to adapting education systems for the age of automation. Those that are have long had a clear focus on human capital development. These are countries in northern Europe and the Nordic region, as well as Singapore, which are probably running some of the most useful experiments for the future world of work." South Korea is the category leader, partly on the strength of its efforts to reform teacher training and assessment and to update school curricula, with a particular emphasis on integrating soft skills into classwork.

Education Policies: ranks and scores

Average **55.3**



Hard skills, soft skills or both?

Curriculum reform is one facet of education policy that has received considerable attention in most of the countries in the index, both at compulsory and post-compulsory levels. Years of discussion about the need for basic digital skills, for example, has led many systems to introduce coding into primary and secondary school curricula, as well as STEM coursework in secondary and vocational training programmes. More recent discourse about the value that "soft", human-centred skills are likely to have in the automated workplace has resulted in efforts to ensure that these too are emphasised in early and later stage learning. Many of these efforts are led by regional or national governments. In Estonia, for example (2nd in the education category) Mr Sikkut relates that his office is assisting universities and schools in their design of future curriculum needs.

"Programming requires a way of thinking that is helpful to develop even if you don't programme computers for a living. I used to teach programming to biologists; they learn far more than how to make a computer work."

Neil Lawrence, director of machine learning, Amazon

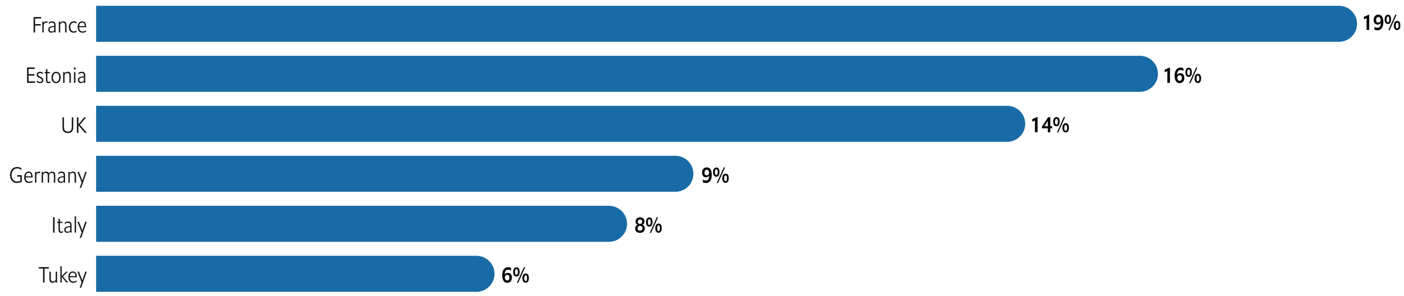
China's national government has been one of the more proactive in this regard. "There are impressive things happening in China," says Mr Patrinos. "The government is making a concerted effort to rethink school curricula at different levels with a new emphasis on creativity, and they are considering relaxing exam pressure in order to facilitate it. And in China, once something becomes policy, it gets rolled out pretty rapidly."

In all educational systems, changing curricula is only part of the battle of ensuring that students graduate from institutions with the desired skills. The other, arguably tougher part of it is training teachers to be able to impart "21st century skills". This, says Ms Luckin, is where the lack of strategic planning in education poses particularly high risks: "Huge expectations are being placed on educators that somehow they'll be able to change what they teach. But who's going to get them ready to do that?"

All five of the top-scoring countries in the education category have at least begun to adapt teacher training. Such efforts take the form of designing comprehensive programmes made available nationally or selected regions—for example, Ontario in Canada and Bavaria in Germany—for training teachers in how to impart "21st century competencies". (The Ontario government defines these as critical thinking, communication, collaboration and creativity.[11])

Chart 2

Population aged 25 to 64 participating in education and training, selected European countries, 2016



Source: Eurostat.

In most cases this includes training in using advanced technologies to enhance teaching and learning. Ms Luckin believes the application of AI techniques themselves will prove beneficial to educators as, along with their schools, they gain a much deeper understanding of how their students actually learn. She points to the New South Wales educational authorities in Australia as especially proactive today in studying and experimenting with AI applications in the learning process.

First, the basics

For all the attention soft and hard skills receive in the context of the automation challenge, there is a risk in some middle- and low-income countries that the educational authorities will lose sight of need to ensure that foundational skills are being learned. Mr Patrinos has particular worries for countries such as Malaysia, Indonesia and Thailand where, he says, there are too many students at primary and secondary levels without basic reading and other skills.

Francesc Pedro, UNESCO's chief of section, Sector Policy Advice and ICT in Education, warns that the discussion about the importance of soft skills often has the effect of distracting stakeholders from the importance of foundational skills. "There is no point in claiming that your system will now foster creativity and problem-solving when children still struggle with basic literacy and numeracy, and where digital skills are limited to the elite," he says. Mr Patrinos makes a broader point: "You're much less prone to the negative effects of automation if you've been to school and are achieving higher levels of learning."

Credit for lifelong learning

In an age when technology often changes how individuals work, sometimes fundamentally, how do working people adapt? Lifelong learning is an important part of the answer, affording people the opportunity to voluntarily undertake training throughout their careers in order to acquire new skills.

Creating an institutional framework to support lifelong learning is one challenge, and several countries have made a good start in tackling it. Index high scorers in this area include Singapore and the UAE, OECD members such as Estonia, the US and Canada, as well as middle-income countries Argentina and Brazil.

A trickier challenge is convincing people to participate in lifelong learning.

An experiment under way in Singapore seeks to meet this challenge by providing citizens credits with which to finance study during the course of their lives. Under the programme, launched in January 2016 as part of the government's SkillsFuture initiative, every citizen 25 years of age and over is eligible to receive a credit of S$500 (US$370) to establish an "individual learning account". These funds can be used to pay for courses at any of 500 government-sponsored training providers.

Ms Zahidi calls this a "very useful experiment" in giving people the wherewithal to decide on their own what new skills they want to acquire during their lives and how to acquire them. She adds, however, that the jury is out on how many citizens will take up the offer. And a clear picture of the programme's actual utility to people is unlikely to emerge for several years, given the nature of lifelong learning.

Sheri Ng, the Singapore-based managing director Asia Pacific of NICE, a software provider, is also praiseworthy of the initiative but worries about the content of the courses on offer: "It's not clear that the training being provided is adequate to the demands of the future workplace."

Chapter 3: Managing workplace transitions

Despite fears of widespread job losses resulting from intelligence automation, in businesses where robotics and AI are being actively deployed now labour scarcity appears to be a bigger problem. Ms Ng states that her company cannot find enough people in the region's labour markets to carry out its automation-related work. Ms Huxley-Jones reports similar hiring challenges in her part of GSK. In both cases it is highly skilled technical specialists (in IT, or chemistry and biology) that are in demand. Mr Gaspar points out, however, that alongside highly skilled robotics specialists, Autoneum's plants around the world are also in great need of lower- and middle-skilled operators. The latter category will be needed in large numbers for at least the next five years, he says, to "help convert our physical assets and standardise our operational data" for the needs of digital manufacturing.

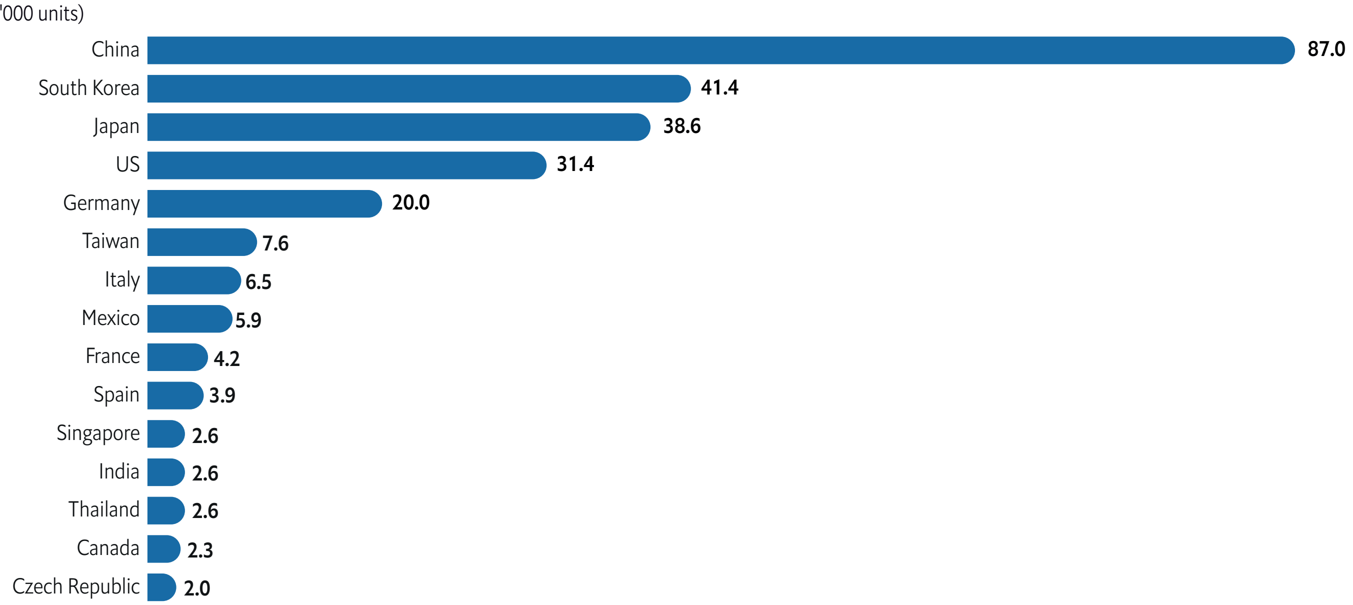
Labour scarcity is even a challenge at Foxconn, a Taiwanese electronics manufacturer that has deployed over 40,000 robots at its mainland China factories. Dai Chia-peng, the company's general manager of automation technology, reports difficulty recruiting in many roles: "The majority of our production lines employ a mix of automated stations and manual operations for the various process steps, and we expect this to remain the case for the foreseeable future. We need system programmers, automation engineers and maintenance technicians working on automated production lines to ensure smooth operations."

In the longer term, however, the widespread adoption of intelligent automation technologies is likely to have a profound effect on labour markets. Even those optimistic about the nature of the post-industrial economy acknowledge that there will be losers as well as winners. One is Alan Manning: "At most risk are workers with a skill that was previously scarce, and they earned decent money from using it. If new technologies can perform the given tasks better and more cheaply, they can no longer get a return on the skill. Those are the obvious losers from advanced technology."

Chart 3

Estimated worldwide annual supply of industrial robots, 10 largest markets, 2016

('000 units)



Source: International Federation of Robotics, *World Robotics 2017 Industrial Robots.*

> **"Educational institutions in Asia are far behind business when it comes to training. They're still training electrical and mechanical engineers. Businesses like ours are having to devise and conduct training of staff ourselves in order to meet the demands we already have."**
>
> *Sheri Ng, NICE*

In this context, the challenge for government and industry, with the help of educational institutions, is to ensure that such groups are provided ample opportunity to gain the skills needed to operate effectively in the future workplace and take advantage of opportunities brought about by automation. Labour market policies to enable greater worker mobility and flexibility—for example, through relaxed licencing requirements for certain occupations or more portable workplace benefits[12]—can help countries to meet this challenge. Just as important are programmes, supported by governments and implemented in the workplace or in training institutions, to help employees gain the new skills they will need.

The countries where such policies and programmes are closest to being in place are the same that are the most supportive of AI and robotics innovation and are beginning to address the associated educational challenges. Germany, Singapore and South Korea all share the top position in this index category, followed closely by Japan. The top three earn high scores in nearly every labour market policy indicator, including in government support and encouragement of workplace retraining, as well as approaches to vocational training. A 2017 report published by PwC, a consultancy, extols Germany's dual apprenticeship and vocational training system (as well as those of Switzerland and Austria) as a model for preparing young people for the age of automation. Japan and Canada are also among the top performers in both The Economist Intelligence Unit and PwC rankings.[13]

Ms Fordham of the OECD agrees that there are pockets of vocational training success in Germany and other European countries, but observes a "long tail" of vocational schools that are training large numbers of low-skilled people to work in low-skill jobs. "Vocational training in most countries," she says, "is currently far from being able to address the challenges of automation."

Labour Market Policies: ranks and scores

Average **60.4**

=1	Germany	93.8	Mature
=1	Singapore	93.8	Mature
=1	South Korea	93.8	Mature
4	Japan	87.5	Mature
5	Canada	84.4	Mature
6	UK	71.9	Developed
=7	China	68.8	Developed
=7	Estonia	68.8	Developed
=7	US	68.8	Developed
=10	Australia	65.6	Developed
=10	Italy	65.6	Developed
12	France	59.4	Emerging
=13	Brazil	56.3	Emerging
=13	Turkey	56.3	Emerging
=13	UAE	53.1	Emerging
=16	India	53.1	Emerging
=16	Saudi Arabia	50.0	Emerging
18	Malaysia	43.8	Emerging
19	Russia	40.6	Emerging
=20	Colombia	40.6	Emerging
=20	Vietnam	37.5	Emerging
=22	Indonesia	37.5	Emerging
=22	Mexico	37.5	Emerging
=24	Argentina	31.3	Emerging
=24	South Africa	31.3	Emerging

● Mature ● Developed ● Emerging

> **"Vocational education and training is weak in most developing countries. Their challenge is to enable workers at a later stage in life to continue their education. They need to establish incentives and channels for younger and older workers to do that."**
>
> *Francesc Pedro, UNESCO*

Training robots with iPads

Children today can create toy robots, drones and other gadgets in the home, and can programme them with the help of an iPad. Apple, the US consumer electronics firm that created the ubiquitous tablet, introduced the Swift Playgrounds app in 2016 to guide children, as well as adult hobbyists, through the process of writing code for operating a variety of different devices, including dancing robots.

Geoff Pegman, managing director of R U Robots, a robotics design consultancy based in Manchester (the UK) asks himself: if children can programme a robot using an iPad, why can't any worker in a factory do the same? His firm has created a similarly intuitive interface for use by workers at some of its food industry clients. "It a relatively simple way of programming a production floor robot," he says. Much like an iPad, the individual drags and drop things into place to create the code that operates the robot.

"I've never met anyone that can't use an iPad," says Mr Pegman. After programming the robot, the workers use innate skills to monitor the production process, which may be as simple as determining whether what they see "looks like a good sandwich". It may also include designing sandwiches, pizzas and other meals. "This is very hard for machines to do," he says. The use of such intuitive approaches helps to make the technology much more accessible to lower-skilled people, maintains Mr Pegman. "It reduces the costs of entry for them. You don't need lots of training if the systems are designed properly."

People who had been doing boring jobs, says Mr Pegman, such as placing ingredients on pieces of bread to create a sandwich, are now programming robots to do this and are looking after them. This, he believes, has left them in qualitatively higher order roles than the ones they performed before.

Work 4.0

Given the long and colourful history of its influential trade unions, it should perhaps be no surprise that the German government is deeply engaged in comprehensive study and multi-stakeholder dialogue on the future shape of work and how labour market policy can be adapted to accommodate it. In April 2015 the German labour ministry embarked on a series of discussions with businesses, academic experts, trade unions, educational institutions and other organisations on precisely this topic. The exercise, dubbed ***Arbeiten 4.0*** (Work 4.0)—a title chosen to complement the ***Industrie 4.0*** strategy discussions—culminated in the publication of a labour ministry white paper in November 2016.[14] It advances a series of proposals to address the inevitable impact that automation will have on the workplace, including the following:

Personal activity accounts. The ministry argues for the establishment of accounts that new entrants set up when they embark on their working life. Launched with initial capital, the account would receive credits and individual contributions over time and be used by the individual to fund continuing education or retraining, or even to start a business.

Employment insurance. The country's existing unemployment insurance scheme should, the ministry suggests, be transformed into a "preventive" form of insurance, which would fund periodic vocational training for individuals during their employment, and not only after they have lost their jobs.

Work time flexibility. An eight-hour workday regime prevails across much of the German economy, in most cases governed by collective agreements between unions and employers. The ministry proposes to allow individual workers and their employers to agree on the individual's work schedule and work location.

These proposals, particularly on work time, might seem non-controversial but, if acted on, would mark a significant change in the life of German workers, as well as their employers.

Conclusion: Trial and error

The dearth of policy development thus far to address intelligent automation does not result from government laziness or inattention. It has more to do, according to Ms Fordham, with the enormous number of unknowns about precisely how automation technologies will affect the workforce and what types of responses will be effective. "I don't think anybody confidently predicts what the implications are for the labour market in terms of the jobs that will be available," she says, "still less in terms of the types of knowledge, skills and attitudes that will be important in it."

The sheer extent of unknowns is due partly to the unique properties of the technologies in question. AI, machine learning, advanced robotics and even predictive analytics have intelligent, potentially cognitive capabilities that begin to approach those of humans. In this respect, previous waves of technology change, such as the diffusion of PCs and worldwide adoption of mobile phones, hold only limited lessons for the future.

"We're in a stage of experimentation, and I think it's going to take us a couple of decades to figure out which policies and approaches work and which don't."
James Bessen, Boston University

Societies are therefore in for a long period of trial and error before something approaching "best practice" begins to emerge from country experiments. Some experts, such as Ms Fordham, believe that many lessons need to be learned and shared before strategic plans to address automation are set in stone. Such experiments are under way in a handful of countries but are yet to yield clear results. For example, the Singapore government's effort to nudge its citizens toward voluntary, lifelong skills development is attracting international attention, but experts warn that it may not generate the desired results. Even if it does, the lessons may not be applicable elsewhere.

More study, multi-stakeholder dialogue and international knowledge sharing appear, then, to be the order of the day for governments. In some areas, such as encouraging AI- and robotics-led innovation by companies, the policy contours are probably already clear. Supporting basic research, clearing the way for start-ups and ensuring competitive markets are likely to be as helpful to AI and robotics innovation as they have been for past technology advances. Policy directions for education systems and labour markets are less clear for the moment, as the affects of intelligent automation have yet to be widely felt. Policy should not wait for too long, however, because the business world is moving ahead with automation at speed.

Notes

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[4] EIU, *Artificial intelligence in the real world: The business case takes shape*, 2017.

[5] Strategic Council for AI Technology (Japan), “Artificial Intelligence Technology Strategy”, March 31st 2017.

[6] “South Korea to fund IoT, AI R&D, startups in 2017”, *Telecompaper*, January 7th 2017.

[7] It is claimed that X-road saves the government “more than 2.8m hours of labour every year”. See “Estonia’s data exchange lets you pay your taxes in five minutes”, *Apolitical* (a website), August 10th 2017.

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[9] “Break-through robotics and AI projects funded through Industrial Strategy Challenge Fund”, November 8th 2017 press release of the Engineering and Physical Sciences Research Council (EPSRC).

[10] A 2015 assessment of the programme’s five-year results in the UK found that most licences had been granted to small businesses located near each university. National Centre for Universities and Businesses, *Easy Access IP: A Preliminary Assessment of the Initiative*, March 2015.

[11] “*21st Century Competencies: Foundation Document for Discussion*, 2016.

[12] These and other policy measures to relax workplace rigidities with a view toward the automation future are advocated by Andrew McAfee and Erik Brynjolfsson in “Human Work in the Robotic Future: Policy for the Age of Automation”, *Foreign Affairs*, July-August 2016.

[13] *The $1.2 trillion prize from empowering young workers to succeed in an age of automation: PwC Young Workers Index,* October 2017. (Neither South Korea nor Singapore are included in the study.)

[14] *Weissbuch: Arbeiten 4.0*, November 2016.

Appendix: Framework and methodology

Index framework

The Economist Intelligence Unit (EIU), working with an expert panel, developed a framework for answering the central question of the study:

Which countries are best prepared for the coming wave of automation?

The resulting framework combines 52 indicators, the majority of which (45) are qualitative and were designed specifically for this study. These are grouped into three categories:

- **Innovation environment**
  Entrepreneurship and innovation policies are crucial for promoting a culture that encourages the development and uptake of new technologies and rewards businesses and individuals. Enabling regulations and a competitive environment will support a dynamic economy and the creation of new occupations and even industries. At the same time, governments should develop regulatory frameworks that guarantee that the new technology is broadly diffused, but used safely and responsibly.
- **Education policies**
  As automation develops, workers will need new skills to complement technologies. Moreover, new jobs and sub-sectors will be created by automation, requiring new and upgraded skills in the current and future workforce. An evolving labour market requires continuous learning. This category covers a range of policies to develop the human capital needed to provide these skills, including improvements in the quality of education and how it is accessed by disadvantaged groups.
- **Labour market policies**
  This category considers policies that facilitate mobility of the workforce across sectors, the transition from training to employment, as well as the creation of new forms of employment. Furthermore, it covers policies that promote the inclusion of disadvantaged groups or those that have been displaced by automation, with the aim of maintaining productivity and providing opportunities for meaningful employment.

Methodology development

Literature review: The initial step in the development of the methodology was a literature review carried out by researchers at the EIU, across policy documents, academic literature, and other studies on automation and artificial intelligence (AI), aimed at identifying existing frameworks, indicators and data sources on the impact of and policies addressing automation, which could be used in the development of this new measurement approach. The search covered more than 50 publications from the past five years, which were then prioritised according to relevance and grouped into thematic areas.

Preliminary framework development: An initial framework was then developed on the basis of the literature review and consultations with internal experts. The EIU then convened a panel of international experts from the private and public sectors, academia, and international institutions to discuss and validate the preliminary approach during a one-day session in London. Over the course of this session, the most relevant indicators of readiness for automation were determined for each study category.

Further to expert recommendations, the EIU performed additional rounds of verifications to establish the best possible metrics, such as data audits, literature searches and data analysis.

Country selection

The largest economies of the world were selected (G20), comprising a majority of high-income countries (ten), upper-middle-income countries (seven), and two lower-middle-income countries (India and Indonesia). We have focused on large and advanced economies because they are more exposed to the changes brought about by automation and, consequently, are more likely to be developing innovative policies and best practices.

Additional countries were selected in consultation with the expert panel on the basis of relevance and geographic representation. Estonia and Singapore were selected on the basis of their advances in digitalisation and being potential sources of best practices. Furthermore, the UAE, Colombia, Malaysia and Vietnam were selected for representation of key emerging economies from Latin America, South-east Asia, and the Middle East.

Argentina	Colombia	Indonesia	Russia	Turkey
Australia	Estonia	Italy	Saudi Arabia	UAE
Brazil	France	Japan	Singapore	UK
Canada	Germany	Malaysia	South Africa	US
China	India	Mexico	South Korea	Vietnam

Construction of the scores

This study is structured as a composite index, and overall scores for each country are produced through weighting and combining scores of the three categories and their indicators. In turn, indicator scores are calculated as the weighted average of individual sub-indicator scores.

All scores are presented on a normalised scale of 0 to 100 (where 100 is best), displaying the relative performance of each country within the selection of 25. Normalisation is based on the formula:

$x = (x - Min(x)) / (Max(x) - Min(x))*100$ where $Min(x)$ and $Max(x)$ are, respectively, the lowest and highest values in the 25 countries for any given indicator.

Category weightings: Overall, weightings are intended to reflect the importance attached to each conceptual dimension of the index. For instance, a higher weight was attached to the Innovation environment (40%) and Education policies (40%) than the Labour market policies (20%), reflecting a focus on long-term competitiveness of the economy.

Indicator weights: Within the Innovation environment and Education policies categories, some of the indicators and sub-indicators are given greater weight. This decision was based on how meaningful these indicators were for the ultimate assessment of the index, and for some quantitative indicators based on the robustness of the data. This is the case for the Investment in research and development (R&D) (UNESCO), E-Government Development Index (UN) and Quality of universities (Global Innovation Index) sub-indicators in the Innovation environment category, and for the 21st-century skills and knowledge, STEM (science, technology, engineering and maths) post-compulsory education, Continuous education, Assessment reform, Teacher training and Curricular innovation indicators in the Education policies category (EIU ratings).

Quantitative and qualitative indicators

A total of **45 qualitative indicators** were designed by the EIU for this study that analyse topics for which little or no cross-country data were previously available for the countries covered by the study. These indicators were based on standardised assessments of country performance using detailed scoring guidelines, and are displayed as scores on a numeric scale (0 to 2, where 2 is best). Assessment of policies and initiatives in each country included in the study was based on official and publicly available sources and corroborated by over 80 expert interviews with local academics, think-tanks, policymakers, consultants and entrepreneurs.

The **seven quantitative indicators** in the index draw on numeric raw data from key global organisations including the World Bank, UNESCO, UN, Global Entrepreneurship Monitor, International Telecommunication Union and Global Innovation Index.

Limitations

- Qualitative indicators developed by the EIU on the policies for automation readiness were based on the assessment of policies and programmes pursued by national governments. Where authority for the given sector is heavily devolved to the sub-national level, such as public education in federal countries, we considered the situation that applies in that country's most affluent city/metropolitan area in order to capture and compare countries' most advanced practices. The limitation of this approach is that the results of these indicators may not always reflect the situation across the country as a whole.
- Qualitative indicators based on the examination of national policies and plans should be interpreted as an action from the government in a particular direction, and cannot be interpreted as a measure of effectiveness or of quality of implementation of particular programmes or objectives.
- Research for this study was carried out in the second half of 2017, looking at the most recent evidence of governments' policies, programmes, and initiatives across the three categories. This is a landscape that is undergoing continuous change.
- The study offers a simplified view of the complex landscape of the impact of automation on economies and society, based on indicators deemed the most representative across selected topics. Selection was informed by an examination of the literature and consultations with experts. This means that not all critical areas relevant to automation have been addressed.
- For quantitative indicators, the index relies on the latest available data. Databases are not updated with the same frequency, and therefore there may be lags in how the situation on the ground is depicted by certain indicators.

Indicator framework detail

Indicator	Unit	Source	Weights	Definition
1) INNOVATION ENVIRONMENT			40%	
1.1) Research and innovation environment—Financing			10%	
1.1.1) Public funds for R&D on robotics, automation and AI	0-2	EIU rating	25%	Existence of public funds dedicated to R&D focusing specifically on AI and automation and robotics.
1.1.2) R&D spending (as % of GDP)	% of GDP	UNESCO	50%	Gross expenditure on R&D as % of GDP.
1.1.3) Government incentives for private investment in R&D	0-2	EIU rating	25%	Existence of policies incentivising private investment in R&D.
1.2) Research and innovation environment—Policies and regulations			10%	
1.2.1) Entrepreneurship promotion campaigns	0-2	EIU rating	25%	Existence of nationwide initiatives encouraging positive attitudes towards entrepreneurship.
1.2.2) Time to start a business	# Days	World Bank	25%	The number of days required to start a business.
1.2.3) Strength of insolvency framework	0-16	World Bank	25%	Quality of insolvency laws that govern relations between debtors, creditors and the court.
1.2.4) Cultural and social norms for entrepreneurship	1-5	Global Entrepreneurship Monitor	25%	The extent to which social and cultural norms encourage or allow actions leading to new business methods or activities that can potentially increase personal wealth and income.
1.3) Research and innovation environment—Knowledge transfer			10%	
1.3.1) International partnerships for innovation	0-2	EIU rating	50%	International research and innovation platforms.
1.3.2) Visa schemes for attracting high-skill individuals in STEM	0-2	EIU rating	50%	Existence of national schemes dedicated to attracting STEM expertise from abroad.
1.4) Research and innovation environment—Technology adoption			10%	
1.4.1) Policies supporting technology adoption in the private sector, ie small and medium-sized enterprises (SMEs)	0-2	EIU rating	25%	Existence of a national programme supporting technology adoption by SMEs.
1.4.2) Policies supporting technology adoption in the public sector	0-2	EIU rating	25%	Existence of a national programme supporting technology adoption by the government.
1.4.3) E-Government Development Index	0-1	UN	50%	E-government effectiveness in the delivery of economic and social services in education, health, labour and employment, finance, and social welfare.
1.5) Research and innovation environment—Start-up support			10%	
1.5.1) Start-up ecosystem support programmes	0-2	EIU rating	50%	Existence of national start-up support programmes.

Indicator	Unit	Source	Weights	Definition
1.5.2) Public funds for start-up financing	0-2	EIU rating	50%	Existence of public funds dedicated to financing start-ups.
1.6) Infrastructure—Broadband			10%	
1.6.1) Existence of national broadband strategy	0-2	EIU rating	33.3%	Existence of national strategies that promote widespread use of the internet.
1.6.2) Internet usage (five-year change)	0-100	ITU	33.3%	Effectiveness in enhancing internet access.
1.6.3) Programmes to increase internet speed	0-2	EIU rating	33.3%	Strategy to develop a fast broadband network across the country.
1.7) Infrastructure—Clusters			10%	
1.7.1) Cluster development programmes	0-2	EIU rating	33.3%	Existence of cluster development programmes.
1.7.2) Quality of universities	0-100	Global Innovation Index	66.7%	Average score of the top three universities at the QS World University Ranking.
1.8) Ethics and safety—Ethics boards			10%	
1.8.1) Technology ethics and safety institutions	0-2	EIU rating	50%	Existence of an ethics board focusing on the ethical implications of technology, and particularly AI and automation.
1.8.2) Cybersecurity strategy	0-2	EIU rating	50%	Existence of public efforts to address cybersecurity.
1.9) Ethics and safety—Data protection			10%	
1.9.1) Data protection laws	0-2	EIU rating	50%	Existence of data protection legislation and regulations.
1.9.2) Data protection enforcement institution	0-2	EIU rating	50%	Enforcement of data protection legislation
1.10) Ethics and safety—Citizens use			10%	
1.10.1) Data safety awareness campaigns	0-2	EIU rating	100%	Existence of nationwide campaigns to promote the safe use of data, the internet, robotics, and AI.
2) EDUCATION POLICIES			40%	
2.1) Early childhood policies			5.6%	
2.1.1) Strategy for early childhood development	0-2	EIU rating	100%	Existence of a national early childhood education and development strategy.
2.2) Compulsory education—21st-century skills and knowledge			11.1%	
2.2.1) Strategy addressing 21st-century skills and knowledge	0-2	EIU rating	50%	Existence of a government-led strategy that focuses on cultivating 21st-century skills and knowledge (eg interpersonal and problem-solving skills) in compulsory education.
2.2.2) Integration of 21st-century skills and knowledge in curricula	0-2	EIU rating	50%	Integration of 21st-century skills and knowledge in relevant curriculum guidelines.
2.3) Compulsory education—Technical skills and knowledge			5.6%	

Indicator	Unit	Source	Weights	Definition
2.3.1) Strategy addressing technical skills and knowledge	0-2	EIU rating	50%	Existence of a government-led strategy that focuses on cultivating technical skills and knowledge (eg digital skills) in compulsory education.
2.3.2) Integration of technical skills and knowledge in curricula	0-2	EIU rating	50%	Integration of technical skills and knowledge in relevant curriculum guidelines.
2.4) Compulsory education—Career guidance			5.6%	
2.4.1) Career guidance programmes (secondary education)	0-2	EIU rating	100%	Availability of career counselling services in secondary education.
2.5) Post-compulsory education—STEM			11.1%	
2.5.1) Programmes to increase enrolment in STEM (tertiary education)	0-2	EIU rating	100%	STEM in higher education.
2.6) Post-compulsory education—Access			5.6%	
2.6.1) Policies for increased access to tertiary education	0-2	EIU rating	100%	Policies supporting increased participation in tertiary education, targeted at traditionally excluded groups.
2.7) Continuous education			11.1%	
2.7.1) National lifelong learning strategy	0-2	EIU rating	50%	Existence of national lifelong learning programmes.
2.7.2) Financial support for lifelong learning activities	0-2	EIU rating	50%	Financial support for lifelong learning.
2.8) Learning environment—Assessment reform			11.1%	
2.8.1) Assessment of 21st-century skills and knowledge in compulsory education	0-2	EIU rating	100%	Systematic assessment of 21st-century skills and knowledge in compulsory education.
2.9) Learning environment—Teacher training			11.1%	
2.9.1) Technical and 21st-century skills and knowledge training for teachers (compulsory education)	0-2	EIU rating	100%	The extent to which teachers are trained to deliver education for skills of the future in compulsory education.
2.10) Learning environment—Use of technology and data			5.6%	
2.10.1) Use of technology in education delivery (compulsory education)	0-2	EIU rating	50%	Using technology in the classroom to improve education outcomes and increase student interaction with technology in compulsory education.
2.10.2) Use of technology and data in education analytics (compulsory education)	0-2	EIU rating	50%	Using data and analytics to drive innovative learning and assessment processes in compulsory education.
2.11) Learning environment—Curricular innovation			11.1%	
2.11.1) School autonomy for curriculum design (compulsory education)	0-2	EIU rating	100%	Curriculum deregulation in compulsory education.
2.12) Learning environment—Social dialogue			5.6%	
2.12.1) Social dialogue in the education sector (compulsory education)	0-2	EIU rating	100%	Existence of a dialogue between different stakeholders of the public and private sectors to shape the education system.

Indicator	Unit	Source	Weights	Definition
3) LABOUR MARKET POLICIES			20%	
3.1) Research and policymaking			12.5%	
3.1.1) Government-led research on the impact of automation, AI and robotics	0-2	EIU rating	50%	Existence of a national review/strategy examining the automation of the economy.
3.1.2) Social dialogue on the future of work	0-2	EIU rating	50%	Existence of an open body/platform for discussion or dissemination between the government and key stakeholders, including the business community on the impact of automation, AI and robotics on society and the economy.
3.2) Workforce transition programmes—Vocational training			12.5%	
3.2.1) Dual Vocational Education and Training (VET) systems	0-2	EIU rating	50%	Existence of a national dual VET system.
3.2.2) Institution driving improvement of VET	0-2	EIU rating	50%	Existence of a body devoted to the research and development of the national VET system.
3.3) Workforce transition programmes—Transition from university			12.5%	
3.3.1) Programmes for work experience, apprenticeships, internships	0-2	EIU rating	100%	Existence of national programmes supporting traineeships or internships targeted at those transitioning from university to the workforce.
3.4) Workforce transition programmes—Targeted retraining			12.5%	
3.4.1) Targeted retraining programmes for the labour force	0-2	EIU rating	100%	Existence of retraining programmes for displaced workers focusing on transition to high-demand sectors.
3.5) Workforce transition programmes—Workplace transitions			12.5%	
3.5.1) Support programmes for human capital development (SMEs)	0-2	EIU rating	100%	Existence of programmes supporting training, personnel development or reallocation in the private sector, especially in SMEs.
3.6) Workforce transition programmes—Public Employment Services (PES)			12.5%	
3.6.1) Existence of PES institutions	0-2	EIU rating	50%	Existence of a comprehensive PES institution.
3.6.2) PES information tool	0-2	EIU rating	50%	Existence of a PES tool providing the public with information about trends in occupations and potential demand across the country.
3.7) Workforce transition programmes—Sector linkages			12.5%	
3.7.1) Platforms for industry-labour market dialogue	0-2	EIU rating	50%	Co-operation of PES institutions with industry.
3.7.2) Platforms for university-labour market dialogue	0-2	EIU rating	50%	University-industry collaboration platform.
3.8) Workforce transition programmes—Regulations			12.5%	
3.8.1) Review of regulations for new forms of employment	0-2	EIU rating	100%	Existence of a national review of new forms of employment/future of work.

External data sources

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