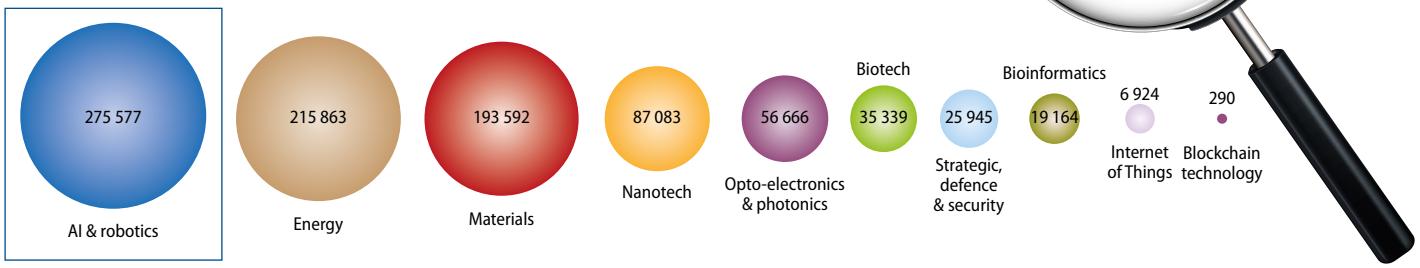
Policy briefs from the
UNESCO SCIENCE REPORT
The race against time for smarter development

Cross-cutting strategic technologies

Trends in artificial intelligence and robotics, 2011–2019

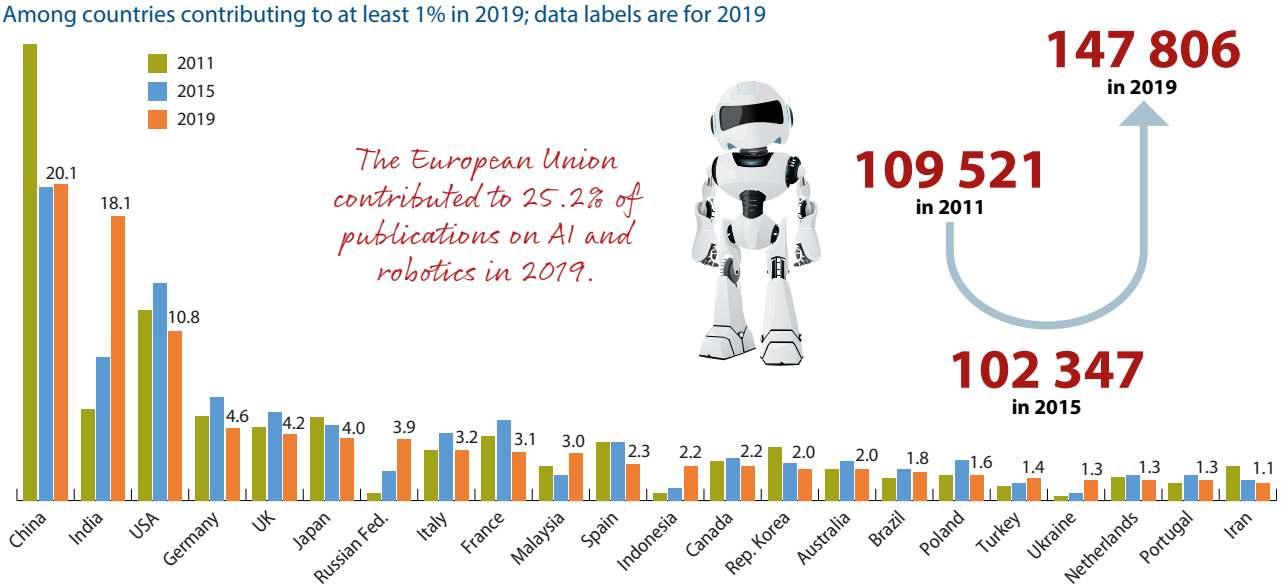
Scientific publications by cross-cutting strategic technology, 2018–2019



Trends in scientific publishing

- The field of artificial intelligence (AI) & robotics has dominated research output in cross-cutting strategic technologies[1] since 2011.
- Since 2015, there has been a resurgence of research interest in AI & robotics: 102 347 publications in 2015 and 147 806 in 2019 (+44%).
- Between 2015 and 2019, the shares of the EU and USA in AI & robotics receded as developing countries boosted their own output in this field (see figure below).
- In 2018, China, France, Japan, Singapore and the USA were home to the top 20 universities and public research organizations publishing on AI by volume. Half were located in China and six in the USA. Of the 30 leading patentholders, only five are US companies but these include those with the biggest AI portfolios, IBM and Microsoft (see figure on page 5).
- India's share of global publishing on AI & robotics tripled from 5.8% in 2011 to 18.1% in 2019, the fastest growth in world share of any country (see figure below and table on page 3).

Share of global publications on AI & robotics, 2011, 2015 and 2019 (%)
Among countries contributing to at least 1% in 2019; data labels are for 2019



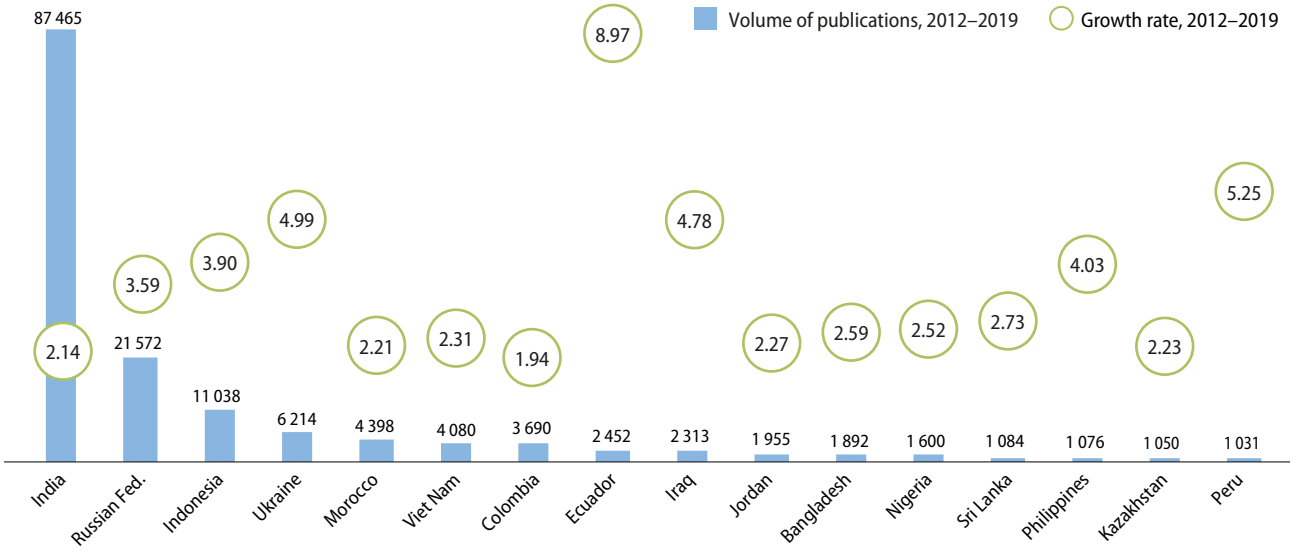
Source: UNESCO (2021) *UNESCO Science Report*, Figure 1.13

1. Policy briefs are also available for: energy; materials science; nanoscience and nanotechnology; and biotechnology. See also the summary policy brief on global trends for all ten cross-cutting strategic technologies analysed in the *UNESCO Science Report* (2021).

- Over the dual periods 2012–2015 and 2016–2019, Ecuador's output on AI & robotics grew ninefold, one of the highest growth rates in the world (see figure below).
- **Big data analytics** have become vital to tech-based industries specializing in areas such as social media, aeronautics, automotive and drug design. AI is being used to determine the structure of atoms and molecules in computational drug design and computational materials science, for instance. More than one-quarter of basic research was financed by industry by 2017 in Switzerland (27%) and the USA (30%), countries which are leaders in innovation with large health sectors.
- Cameroon held the top position in sub-Saharan Africa for publication intensity in AI & robotics over 2016–2019, with 49.5 publications per million inhabitants (see chapter 19).
- Scientific output on AI & robotics has surged in countries of all income levels as they prioritize the transition to digital societies. For instance, Afghan scientists published one paper on AI in an international journal between 2012 and 2015 but 21 papers between 2016 and 2019.

Top 15 countries for growth rate in scientific publishing on AI and robotics, 2012–2019

Among countries with at least 500 publications, arranged by volume



Note: The growth rate is calculated as the number of publications from 2016–2019 divided by the number of publications form 2012–2015.

Source: UNESCO (2021) *UNESCO Science Report*, Figure 1.13

Strategies for artificial intelligence

Global trends in scientific publishing reflect the strategic importance of artificial intelligence, which is the object of a growing number of dedicated national, regional and global strategies.

Regional and supranational strategies for AI

- Announced in June 2020, the **Global Partnership on Artificial Intelligence** (GPAI) groups founding members Australia, Canada, France, Germany, India, Italy, Japan, Mexico, New Zealand, the Republic of Korea, Singapore, Slovenia, UK, USA and the European Union, as well as Brazil, the Netherlands, Poland and Spain. The GPAI seeks to ensure the development of AI in accordance with human rights and democratic values, to ensure public confidence and trust in the technology, as outlined in the *Principles on Artificial Intelligence* (2019) adopted by the member states of the Organisation for Economic Co-operation and Development.

- The **G7** science academies' declaration on artificial intelligence and society of March 2019 argued for a public policy debate on the destructive or military usage of AI.

- In 2018, the **European Commission** adopted its *Artificial Intelligence for Europe* strategy, followed by a co-ordinated implementation plan prepared with member states. The plan advocated closer co-operation between member states and with Norway, Switzerland and the Commission in four key areas: increasing investment in AI; making more data available; fostering talent; and ensuring trust by developing ethical, trustworthy AI (see chapter 9).

- The **East African Community** was planning to publish its own regional AI strategy in late 2022.

National strategies for AI

- **More than 30 countries** have defined a national strategy or policy for AI, including Canada, China, India, Japan, Mauritius, Norway, the Russian Federation, Saudi Arabia, the United Arab Emirates, USA and Viet Nam. Sixteen EU member states had published AI strategies by early 2020: Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Sweden and the United Kingdom. By the time of the *UNESCO Science Report's* release in mid-2021, Italy, Poland and Spain had released their own national AI strategies. Bangladesh has published a draft AI strategy (*see next entry*) and Algeria, Egypt, Malaysia and Tunisia all have plans to develop their own.

- Many developing countries are formulating their own national AI strategy with support from international partners. This is the case for **Bangladesh**, for instance, which has received support from USAID and the United Nations Environment Programme; the draft National Strategy for Artificial Intelligence identifies seven national priority sectors for artificial intelligence, namely: public service delivery; manufacturing; agriculture; smart mobility and transportation; skills and education; finance and trade; and health (see chapter 21).

- **Canada**, **China**, the **Russian Federation** and the **USA** are all seeking to lead in the field of AI.

  – **Canada** is striving to assume a leadership role in the international conversation on the potential social impact of AI. In 2017, the Université de Montréal launched the *Montreal Declaration for a Responsible Development of Artificial Intelligence*, in partnership with civil and academic partners. The International Development Research Centre is embarking on a programme to help developing countries build innovative AI for good and to regulate and govern AI technologies (see chapter 4).

  – The **US** federal government announced plans in 2020 to double government investment in quantum information science (QIS) and artificial intelligence by 2022 over the 2019 baseline. This increase will enable the National Science Foundation to create several national AI research institutes, in collaboration with the Departments of Agriculture, Homeland Security, Transportation and Veterans Affairs. These institutes will serve as focal points for multisector, multidisciplinary research involving academia, industry, federal agencies and non-profit organizations. QIS is seen as being of critical importance not only to economic competitiveness but

Top 10 countries for AI & robotics by total volume of scientific publications, 2011–2019

	Growth rate			
	2012–2019	2011–2019	2012–2015	2016–2019
China	1.19	231 963	91 520	108 636
USA	1.15	128 102	53 479	61 391
India	2.14	93 842	27 831	59 634
Germany	0.98	57 594	26 080	25 595
Japan	1.06	51 732	22 287	23 628
UK	1.09	51 152	21 978	24 044
France	0.93	43 467	20 243	18 739
Italy	1.07	37 206	16 284	17 409
Spain	0.91	33 601	15 520	14 076
Canada	1.06	26 199	11 399	12 037

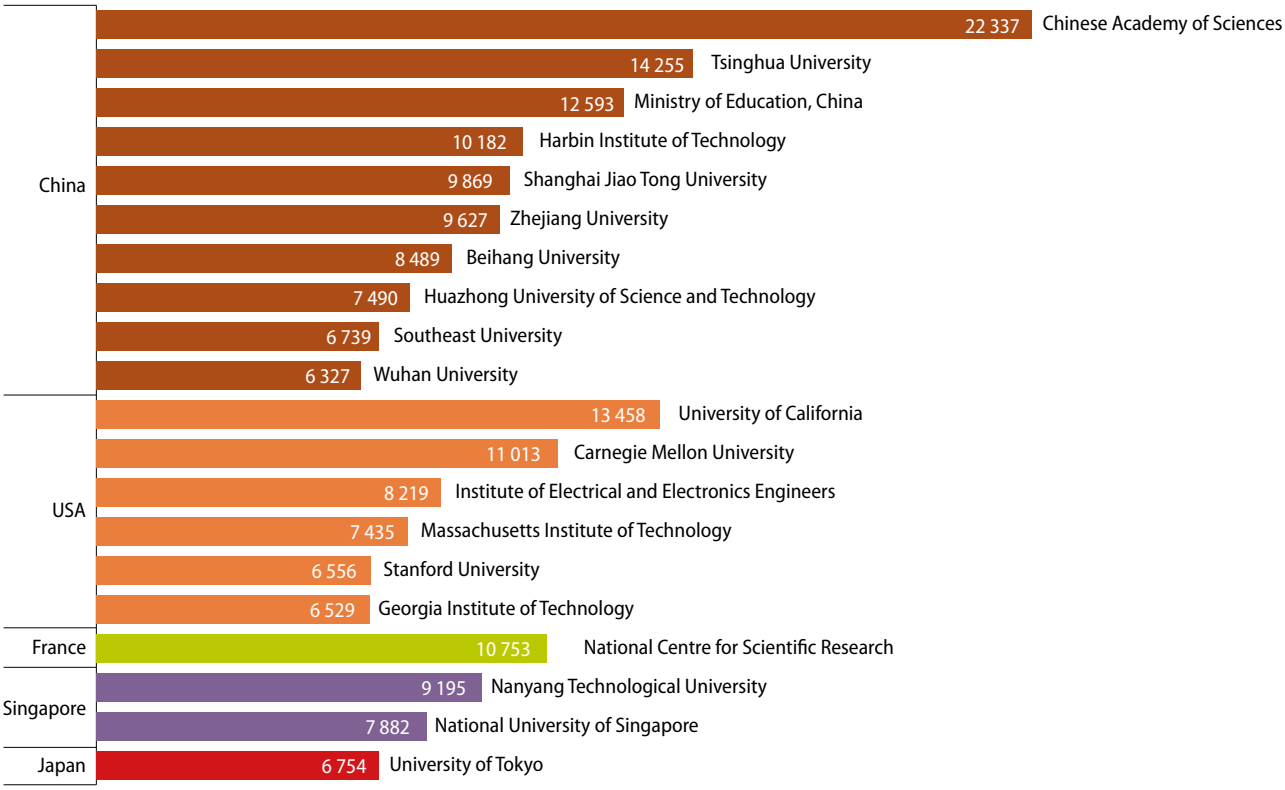
Source: UNESCO (2021) *UNESCO Science Report*, table designed for the present policy brief

also to cybersecurity. '*Foreign deployment of a large-scale quantum computer, even ten or more years in the future, would put sensitive information encrypted with today's most widely used algorithms at a greatly increased risk of decryption,*' according to the US intelligence community's *Worldwide Threat Assessment* (see chapter 5).

– The **Russian Federation's** *National Artificial Intelligence Development Strategy for 2020–2030* seeks to create new high-performance jobs, competitive renumeration and favourable working conditions for AI professionals (see chapter 13).

– **China** aims to be 'the world's primary centre for innovation in AI,' by 2030, according to its New *Generation Artificial Intelligence Development Plan*. The government has launched megaprogrammes in science and engineering to 2030 that include quantum computing, AI and brain science and brain-inspired intelligence (see chapter 23).

Top 20 universities and public research organizations publishing on artificial intelligence, by number of publications, 2018



Source: UNESCO (2021) *UNESCO Science Report*, Figure 5.6

Applying artificial intelligence

- Many countries are introducing e-governance, examples being **Djibouti, India, Morocco, Uganda and the United Arab Emirates**. Digital technologies such as AI, big data and blockchain can be used in e-governance to improve the delivery of public services such as passport renewal or registration of a new business. By eliminating cash payments, digital payment systems can facilitate online marketplaces, reduce the informal economy, combat corruption and improve tax collection.

- In 2018, all but four of the top 30 applicants for AI patents were companies, as opposed to public research institutions. Of these, five are US companies, including the two with the biggest AI portfolios, IBM and Microsoft. The other leading companies are: Toshiba, Samsung, NEC, Fujitsu, Hitachi, Panasonic, Canon, Alphabet (parent company for Google), Siemens, Sony and Toyota (see Figure 5.6 in the report).

- Based on the data from the top five patent offices (USA, European Union, Japan, Republic of Korea and China) for patents in AI owned by the world's top 2 000 R&D companies and filed over 2012–2014, this sector was dominated at the time by companies headquartered in **Japan, Republic of Korea, USA, the Taiwan Province of China and China** (see Figure 24.5 in the report).

- **China, the USA, UK, India and Canada** together account for 62% of AI applications developed in response to the Covid-19 pandemic, according to a June 2020 report from UK thinktank Nesta (see chapter 4).

- In **Brazil**, digital technologies are being introduced into a wide range of sectors that include health, agriculture and banking (see chapter 8).

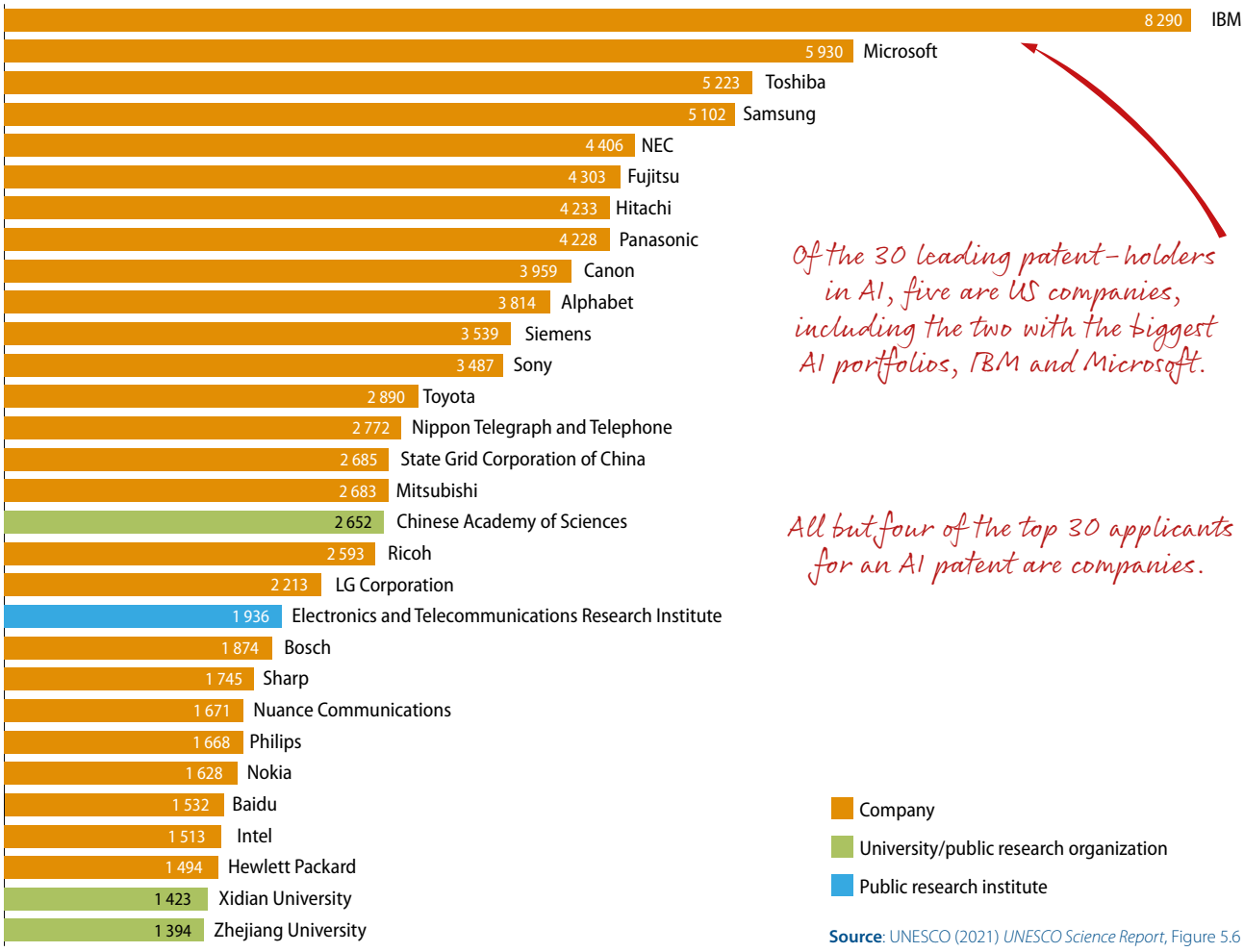
  – Under Brazil's *E-Health Strategy* (2017), the adoption of information technology is being encouraged to improve the Unified Health System (SUS). Medical big data and artificial intelligence are being used to develop prediction models and new drugs, as well as protocols for diagnosis and treatment. Virtual reality and remotely controlled robots are being used to train surgeons.

  – In agriculture, one of the main uses of digital technology is to connect and integrate equipment used to labour the fields, such as tractors.Agriculture is a vital economic sector for Brazil, the third-biggest producer (after China and the USA) and second-biggest exporter (after the USA) of agricultural products.

  – Since 2018, Brazil has passed legislation to establish norms for data-sharing and consumer rights, clarify rules for fintech companies and pave the way for the free national Instantaneous Payment System and Instantaneous Payment Account (PIX). The Central Bank opened PIX for registration on 5 October 2020. Within five days, almost 25 million registrations had been filed. Banco Bradesco, one of Brazil's two largest private banks, was the first Brazilian bank to have an AI interface. Developed by IBM and launched in 2016, this chatbot can recognize spoken Brazilian Portuguese, thanks to Banco Bradesco's expertise in this area.

- In the **Russian Foundation**, the Skolkovo Foundation has been actively supporting Covid-19 start-ups developing new technologies to battle the virus, including antiviral drugs, biobanks and clinical decision support systems supported by artificial intelligence to speed up interpretation of X-ray images of patients with suspected pneumonia (see chapter 13).

Top 30 applicants for patents in artificial intelligence, 2018
By number of patent families within their portfolio



Source: UNESCO (2021) *UNESCO Science Report*, Figure 5.6

ROBEAR has been developed by RIKEN as an experimental project to see if robots can be used to help people with restricted mobility move between their wheelchair and other furniture. It is capable of carrying a reclining adult in its arms and can travel in different directions. © RIKEN

- According to the **Israel** Start-up Nation central database, more than 150 Israeli companies were developing technologies as of May 2020. Solutions included telemedicine technology, such as remote monitoring and the analysis of patients' vital signs using radar, artificial intelligence and advanced optical sensor technology (see chapter 16).

- After the **Lebanese** National Council for Scientific Research (CNRS-L) issued a Flash Call for Covid-19 Management in March 2020, 29 research projects were selected, including the use of artificial intelligence (AI) to support early diagnosis of Covid-19 and measure its impact on the mental health of frontline workers.

- In October 2020, the World Health Organization reported that **Africa** accounted for 12.8% of new or modified existing technologies developed to support the Covid-19 response. Most African inventions involved digital technologies (57.8%). About 25% made use of three-dimensional printing and 11% of robotics. Africa accounts for about 17% of the global population.

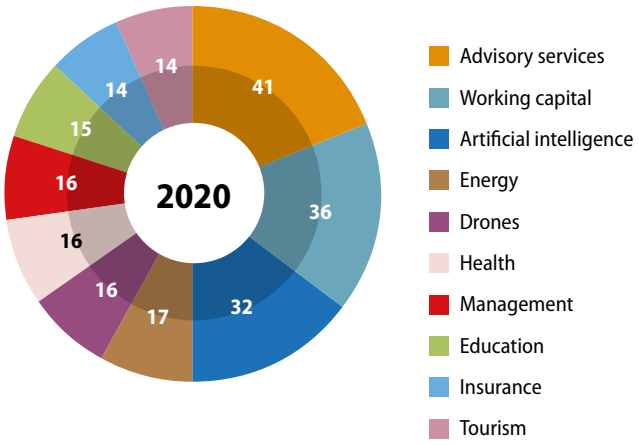
- AI is ranked third in the list of top ten product categories developed at **African tech hubs** in 2020, according to Briter Intelligence (see Figure 20.6 in the report).

- **IBM** established a research laboratory in **South Africa** in 2016, with a focus on the host country's priorities in the areas of health care, education, agriculture and financial services. The first industrial research facility on the African continent, IBM Research Africa is also present in Kenya. IBM has a research lab and innovation hub in South Africa. IBM has also set up an academic programme offering internships and scholarships to Africa students and an enterprise development programme that provides young inventors with mentorship. Start-ups can also access information and a 16-qubit quantum computer via the cloud. IBM also offers a certificate in AI and other fields via its Digital Nation Africa platform.

- **Google** set up Africa's first centre for AI in April 2019 in Accra, **Ghana.** The centre employs software engineers and research scientists hailing from Ghana, Lesotho, Nigeria, Senegal and Uganda, as well as Canada, Ireland, Israel, the UK, USA and elsewhere. The centre is collaborating with local universities to roll out African solutions to prevailing problems. It intends to provide research grants and PhD scholarships to drive research in AI (see chapter 18).

- In **South Africa,** the start-up Jumo has launched an AI-powered platform to assess lending risk and tailor financial products to those living in developing countries where credit information is scarce. It has received an investment of US$52 million from several investors, including Goldman Sachs (see Box 20.4 in the report).

Number of products developed by African tech hubs in top ten product categories, 2020



Source: UNESCO (2021) *UNESCO Science Report*, Figure 20.2

- GiftedMom Co., a start-up created by young **Cameroonians** in 2016, has developed a smartphone application for Android users that can be downloaded from the Google Play store. An automated SMS and voice application sends notifications to pregnant women and nursing mothers reminding them when to go for their next antenatal care session or take their baby for vaccination (see Box 19.5 in the report). The development of a digital economy is a priority for the Government of Cameroon, which has organized a biennial forum since 2018 to identify and support the most promising ideas for the creation of start-ups for the digital economy.

- In **Zimbabwe**, the Sis Joy chatbot powered by AI offers health advice to those with limited access to health care. A Covid-19 module has been integrated into Sis Joy to advise app users on when to see a doctor or self-quarantine. Users can also make appointments through volunteer doctors and nurses.

- In **Morocco**, the start-up Atlan Space, founded in 2016, uses AI and drones to monitor the environment. It received the Bank of Africa's African Entrepreneurship Award in 2019 (see Chapter 17).

- In **India**, the *National Strategy for Artificial Intelligence* (2018) seeks to leverage AI technologies to improve health care, education and agricultural yields and to enable smart cities infrastructure, smart mobility and smart transportation. In 2015, the government selected about 100 cities grouping a population of 99.63 million for the Smart Cities mission; however, it is the Internet of Things rather than AI that is being used most. By 2019, just ten cities accounted for 48% of the completed projects. The *National Electric Mobility Mission Plan 2020* (2013) has, meanwhile, sought to populate India with a fleet of 6–7 million electric and hybrid vehicles by 2020, manufactured in India. According to the national Society of Manufacturers of Electric Vehicles, 2.18 million such vehicles were sold in 2018, 1% of total vehicle sales. At present, there are more than 400 000 electric two-wheelers and a few thousand electric cars on Indian roads; diffusion is being hampered by the sales price and the relative scarcity of both lithium-ion batteries and charging stations spaced at reasonable intervals.

- In **Bhutan**, the Beehive Monitoring Assistant app has been developed which uses AI to inspect the health of beehives and provide updates continually throughout the day. The project was supported by the FabLab Bhutan initiative (see Box 21.3 in the report).

- **Japan** is using AI for disaster response and prevention. Chubu University is leading the development of an AI system capable of calculating the extent of a disaster in real time from satellite data. The goal is to compress a job that took people five days in 2018 into a five-minute calculation. This system should be operational by 2023 (see Box 24.3 in the report).

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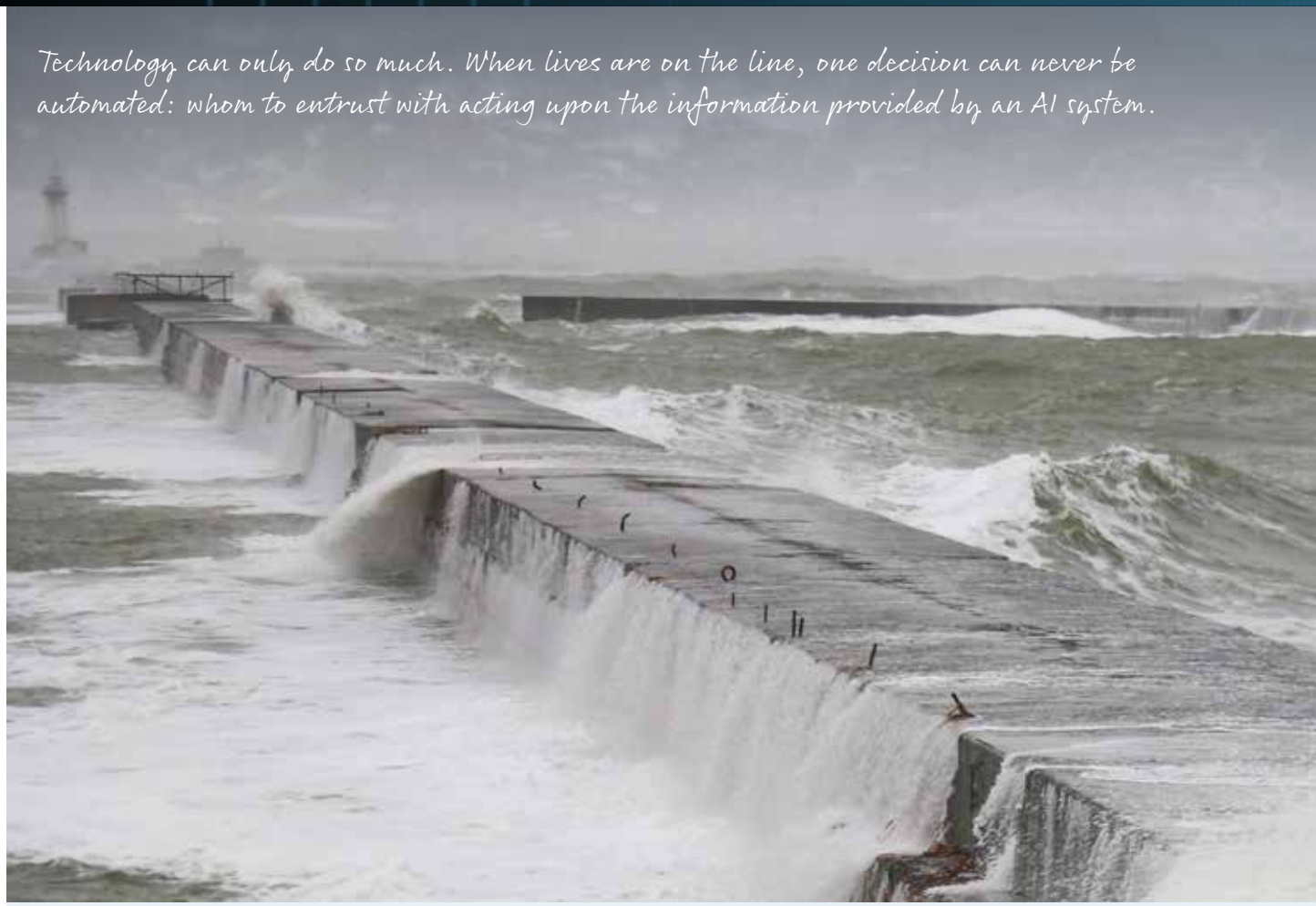
Feeding artificial intelligence with big data need not be a costly exercise

Artificial intelligence relies on big data, which needs to be collected: the more data, the better the algorithm. This process can be costly but it does not have to be. The Internet of Things is a low-cost, low-power technology that can be deployed in most remote areas to collect data, such as environmental data.

The Internet of Things can be combined with machine learning and blockchain technology to facilitate environmental management, such as by creating smart water systems for urban areas.

Although data extraction is energy-intensive, advances in AI can save energy, as in the case of Japan's AI-facilitated disaster response.

Source: Box 24.3 in the *UNESCO Science Report* (2021)



Using artificial intelligence to improve Japan's disaster readiness and response

A central goal of Japan's *Artificial Intelligence Technology Strategy* (2017) is to 'carry out resilience-oriented urban development utilizing AI' to provide advance warning of an impending disaster and streamline the disaster response.

The Cross-ministerial Strategic Innovation Promotion Programme has been working with public and private partners to implement this strategy.

For instance, the National Research Institute for Earth Science and Disaster Resilience has developed a Shared Platform for Disaster Management which pools information collected by ministries.

Chubu University is leading the development of an AI system capable of calculating the extent of a disaster in real time from satellite data. The goal is to compress a job that took people five days in 2018 into a five-minute calculation. This system should be operational by 2023.

Kyushu University, meanwhile, is developing an AI system capable of guiding evacuation efforts for deployment nationwide by 2027.

For its part, the Japanese firm Weathernews Inc. is designing a chatbot for smartphones to inform citizens during a disaster about evacuation procedures and where to find relief supplies, for instance. The system is capable of collecting and analysing audiovisual information, including photos provided by users. Japan plans to deploy this chatbot nationwide in 2022.

More emphasis on AI for disaster prevention

The *Basic Disaster Management Plan* was revised in May 2019 by the Central Disaster Management Council to make it obligatory 'to use ICTs such as AI, the Internet of Things, cloud computing technology and social networking services for disaster prevention'.

This focus on using AI for disaster prevention is fairly new. Up until now, more emphasis has been laid on the response and rescue phase. For example, Sendai City has tested a prototype with private companies for a tsunami alert using AI and blockchain technology, whereby the AI system automatically launched a drone, sending an alert through mobile phones and radios and using facial recognition software to identify victims *in situ*.

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No AI without the right kind of data

AI systems can be used to track storms and monitor flood conditions, making it possible to ready the population for these impending disasters hours or even days in advance.

This possibility does not extend to earthquakes, however. The most that ground sensors can do is to provide about ten seconds' advance warning of an impending earthquake. A panel set up by the Japanese government in 2017 concluded that 'no methods have been established, so far, to predict earthquakes using artificial intelligence'.

This is because the field of seismology has not yet determined which type of data can best follow the processes signaling a build-up to an earthquake. Without the right kind of data, machine-learning algorithms will be unable to develop an appropriate model for predicting earthquakes.

Specialized agencies in Japan are in the process of harmonizing their disaster response for both geological and climate-change related hazards, in order to create sufficiently large datasets.

Source: Box 24.3 in the *UNESCO Science Report* (2021)

Republic of Korea embracing autonomous ships

The Republic of Korea's Master *Plan for Cultivating Marine Science and Technology* (2018–2022) focuses on strategic industries where private sector engagement will be essential. Alongside smart shipping and ports, the Republic of Korea plans to foster autonomous ships to nurture new growth engines and create jobs.

Autonomous ships will create new jobs

Although it may seem counterintuitive, reducing the human presence in navigation will create new jobs in the maritime industry, such as for port-side management, technicians and engineers. A 2018 report suggests that career prospects for sailors remain positive over the next decade, which may help to alleviate seafarers' anxieties about job security. Pilotless vehicles will not be fully automated. Most ships will be semi-autonomous and still need sailors. Some aspects of maritime navigation have been automated for years, helping sailors and port authorities to reduce the margin for error and simplify the manoeuvres of massive ships and movement of cargo.

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Autonomous ships should be safer

The Republic of Korea conducted a technology assessment on maritime autonomous surface ships under its Marine Science and Technology Cultivation Act (2017). Its efforts are in line with one of the International Maritime Organization's (IMO) seven strategic directions for 2018–2023, that of integrating new and advanced technologies in the regulatory framework. In June 2018, IMO launched a Regulatory Scoping Exercise to determine the extent of adoption of autonomous surface ships.

Autonomous ships should ensure greater safety at sea for seafarers and reduce risks to the environment from spills, collisions and other disasters. This will be vital to cleaning up the shipping industry, which moves 90% of global trade and accounts for 3% of global CO2 emissions. The industry's emissions are even projected to more than double by 2050, according to the IMO.

Source: Box 25.1 in the *UNESCO Science Report* (2021)

Implications of artificial intelligence for the job market

- So far, AI does not seem to have led to widespread job losses.
- In **Latin America**, fintech and growing automation are beginning to steer investment towards products, processes and services that rely on innovation but the impact on employment has yet to be felt. If we take the example of Mexico, it counted 5 700 industrial robots in 2018, ranking ninth worldwide for automation. About half of these robots were installed in the automotive sector. Many industrial robots in Mexico have been imported from the USA, Europe and Asia by automobile manufacturers with local assembly plants (see chapter 7).
- As in Latin America, the manufacturing sector accounts for the greatest share of imported robots in **India**. Although their number increased by an average of 64% per year from 2000 to 2016, these do not account for more than 10% of total employment in manufacturing. However, with related technologies developing quickly, many tasks may become automated in the near future. This could radically alter the employment landscape in India and beyond (see chapter 22).
- The decline of traditional manufacturing has become a sensitive issue in the **USA**. Manufacturing output in 2017 was at least 5% greater than in 2000 but the sector has become more capital-intensive and less labour intensive, owing to the widespread introduction of automation.
  - Some 5.5 million manufacturing jobs in the USA were lost between 2000 and 2017. This drop can also be attributed to a skills mismatch in the USA for today's more sophisticated manufacturing sector. Individuals with a high-school degree or less who are performing standardized tasks are more than four times more likely to hold highly automatable jobs than those with bachelor's degrees. Twelve million such workers of Hispanic and Afro-American heritage have already been displaced by automation. In the coming decades, it is estimated that about 25% of US jobs (36 million in 2016) will face high exposure to automation (see chapter 5).
  - A relatively new phenomenon in the USA is that AI is threatening better-paid professional jobs in high-tech fields and metropolitan areas. This trend will require considerable restructuring of career pathways and training programmes (see chapter 5).

Training in artificial intelligence and related fields

- The **US** National Quantum Initiative Act (2018) formalized a multi-agency effort to develop research and a skilled workforce in quantum information science. Additionally, the legislation requires that the National Science Foundation and the Department of Energy each establish between two and five 'multidisciplinary centers for quantum research and education,' with each receiving approximately US$ 10 million in funding (see chapter 5).
- **Morocco's** Euromed University in Fes opened a School of Digital Engineering and Artificial Intelligence in September 2019, in partnership with the Polytechnic School in France. The initial intake comprised about 100 students at the bachelor level (see chapter 17).
- Masdar City in the **United Arab Emirates** hosts the Mohamed bin Zayed University of Artificial Intelligence, inaugurated in October 2019, which is among the world's first to specialize in AI. The university offers master's and PhD programmes in machine learning, computer vision and natural language processing (see chapter 17).
- According to the *National Strategy for Data & AI* launched in October 2020 by **Saudi Arabia's** National Authority for Data and Artificial Intelligence, 40% of the local workforce should have acquired basic skills in data and AI and there should be 15 000 local specialists in these fields by 2030 (see chapter 17).
- **Kenya's** first graduate school in information technology, the Kenya Advanced Institute of Science and Technology, has been modelled on the Korean institute of the same name.
- The Government of the **Republic of Korea** is expected to contribute KES 10 billion (*ca* US$90 million) towards establishing a graduate school which is set to admit its first intake of master's and PhD students in 2021. They will be enrolled in three faculties: Mechanical, Electrical and ICT Engineering; Chemical, Civil and Agricultural Engineering and Biotechnology; and Basic Science. The graduate school is accommodated by Konza Technology City.
- In 2018, **Pakistan's** Higher Education Commission established four national centres to build research capacity in areas critical to the Fourth Industrial Revolution, namely: the National Centres for Artificial Intelligence; Robotics and Automation; Big Data and Cloud Computing; and Cybersecurity. For the first time in recent history, these centres were established through a highly competitive multi-stage process, during which critical clusters of expertise across the country were identified. Each of these

four national centres is a consortium of 10–12 laboratories spread across the country, co-ordinated by the national hub. Over 300 postdoctoral researchers work across these 46 laboratories, along with hundreds of PhD and master's students, research associates and assistants (see chapter 21).

- Two centres of excellence focused on the Internet of Things and on data science were established in **Rwanda** in 2017 at the University of Rwanda with support from the World Bank (see Table 19.4 in the report). A subregional centre of excellence in theoretical physics was also established in 2018 at the University of Rwanda, with support from UNESCO's Abdus Salam International Centre for Theoretical Physics. It is called the East African Centre for Fundamental Research and includes teaching and research programmes in machine learning (see Box 19.9 in the report). Rwanda has also hosted one of the African Institutes for Mathematical Sciences since 2016.
- The Government of **Cameroon** founded the National School of Posts, Telecommunications and Information and Communication Technologies in 2016. It has also set up a high-tech centre specializing in robotics, digital manufacturing and computer-aided vision, as well as a three-dimensional (3D) printing centre that is unique in sub-Saharan Africa. A training centre for various computer-aided design and drawing tools has also been operational since 2017 (see chapter 19).

Source: UNESCO (2021) *UNESCO Science Report: the Race Against Time for Smarter Development.* S. Schneegans, T. Straza and J. Lewis (eds), UNESCO Publishing, Paris

Publication data: Scopus (Elsevier), including Arts, Humanities & Social sciences; data treatment by Science-Metrix

Workshop in robotics and coding at RobotsMali. Inaugurated in March 2018, this educational centre for children, teenagers and university students also runs courses on artificial intelligence, electronics and the Internet of Things. Classes are also offered in entrepreneurship, marketing, design and project management.
© UNESCO Bamako/Oumou Dicko

Ties to other UNESCO programmes

UNESCO has a wide range of programmes in artificial intelligence (AI). The following are some examples.

An ethical framework for AI

Artificial intelligence (AI) has great potential but also could also undermine human rights and human dignity, if misused. That is why UNESCO collaborated with its 193 member states to create a global standard-setting instrument to provide AI with a strong ethical basis. After several rounds of consultations, the draft Recommendation on the Ethics of Artificial Intelligence was adopted by all of UNESCO's member states in November 2021.

Dialogue on AI policy design

UNESCO has been facilitating an international dialogue on how to harness the potential of AI and open data to spur progress towards the Sustainable Development Goals and has been assisting countries in designing their own national AI policy. For instance, UNESCO's regional bureau for science in Latin America is working with the Massachusetts Institute of Technology and the InterAmerican Development Bank to provide countries with information on related policy design as follow-up to the Latin America SumMIT on Artificial Intelligence in January 2020.

In December 2018, UNESCO organized the first AI Forum for Africa in Benguérir, Morocco. This is to be followed by subregional fora across Africa. The first of these was to be held in Kenya in 2020 but has been delayed on account of the Covid-19 pandemic.

UNESCO organized a second regional forum on AI in December 2019 for Latin America and the Caribbean which was hosted by Brazil.

AI for emergency planning

AI is being used to inform emergency planning and management of natural hazards and disasters. To this end, UNESCO's International Hydrological Programme (IHP) began developing an application of AI back in 2005 with a focus on hydrological risks such as floods, droughts and storms, in partnership with a team at the University of California, Irvine (USA). The UNESCO G-WADI Geoserver application uses an artificial neural network algorithm to estimate real time precipitation worldwide. It tracked the Haiyan Super Typhoon as it approached the Philippines in 2013, for example. The Namibian Drought Hydrological Services use this geoserver to prepare daily bulletins with up-to-date information on flood and drought conditions for local communities. Another example concerns the Landslide – Environmental Virtual Observatories (Landslide EVO) being implemented by UNESCO and its partners.

AI to protect nature and learn from it

UNESCO has a World Network of Biosphere Reserves that encompassed 738 sites in 134 countries in 2022. Managed by local communities, these biosphere reserves cover about 5% of the planet's surface area on land. The communities living in these sites commit to experimenting with innovative ways of promoting sustainable development. For example, biosphere reserves have been using drones to monitor land-use changes, changes in vegetation and biodiversity in the Wudalianchi Biosphere Reserve in China. In Mont Nimba Biosphere Reserve in Guinea, drones are helping to improve the conservation of chimpanzees.

UNESCO's Abdus Salam International Centre for Theoretical Physics (ICTP) in Italy is a centre of excellence proposing both teaching and research. It brings hundreds of scientists from the developing world to Italy each year for advanced studies. The ICTP has helped the Government of Rwanda to establish the East African Centre for Fundamental Research at the University of Rwanda, which proposes teaching and research programmes in physics and machine learning. It opened in 2018.

One research project undertaken by ICTP scientist Antonio Celani and his colleagues from the University of California San Diego and the Salk Institute for Biological Studies has served to improve our understanding of how migrating birds extend their flying range and conserve energy. Soaring birds exploit warm, rising air currents — or 'thermals' — to fly and gain height without needing to flap their wings. Mechanical gliders could learn to soar like birds with the help of machine

Migrating birds like this egret conserve energy over hundreds or even thousands of kilometres by using warm, rising air currents to fly and gain height without needing to flap their wings. Scientists at UNESCO's Abdus Salam International Centre for Theoretical Physics have used machine learning to identify navigation strategies that could exploit fluctuations in these air currents and, thereby, contribute to the development of energy-efficient, long-distance autonomous gliders.

Presentation of Rocknet targeting potential donors © UNESCO

learning – but it is not yet understood exactly how birds find and navigate thermals. This makes it hard to teach autonomous gliders to mimic these birds. Dr Celani's research was published in *Nature* in 2018.

AI for education: meet Rocknet

UNESCO's International Geoscience and Geoparks Programme is developing Rocknet, an AI-driven application for a mobile phone which will enable users to identify different types of rock simply by taking a photograph. The application will also explain how each rock is used, such as in construction or to power electronic devices. Inspired by PlantNet, RockNet is being developed by UNESCO in partnership with IFPEN, a French institute specializing in petroleum and renewable energy. The non-profit application should be ready for release by late 2023, as long as complementary funding can be identified.

Big data, cloud computing and AI in geosciences

The Council of UNESCO's International Geosciences Programme identified Big data, Cloud Computing and Artificial Intelligence in Geosciences as one of nine priority topics for its 2019 call for project proposals from geologists around the world. This type of research would involve close collaboration between research institutions and the private sector.

Skills to integrate AI into university teaching curriculum

In August 2020, UNESCO teamed up with the Huawei ICT Academy (Kenya) to produce a week-long training programme for early-career university faculty members from Comoros, Ethiopia, Kenya, Madagascar, Mauritius, Rwanda, the Seychelles and Uganda who were keen to integrate AI into their regular teaching curriculum. The programme taught transdisciplinary skills and creative thinking. Successful trainees were awarded Huawei certification as certified professionals in AI. It was planned to organize more courses in 2021 (see chapter 18).

Fostering gender equality in AI

Each year, the L'Oréal-UNESCO Programme for Women in Science offers 15 fellowships to young women scientists from the around the world who are considered International Rising Talents, including scientists specializing in AI and related fields. For instance, in 2020, young Lebanese neuroscientist Laura-Joy Boulos was awarded a fellowship for her project to use AI to study the effect of prolonged post-war situations on mental health and decision-making. See here (in French: here).

In 2019, the publication of *I'd Blush if I Could: Closing Gender Divides in Digital Skills through Education* (2019) by UNESCO and the Equal Skills Coalition highlighted the case of Siri, a servile, female-gendered voice assistant used by hundreds of millions of internauts who had been trained to respond to insults by saying 'I'd blush if I could'. This case study sparked a global conversation about the potential ramifications for gender equality of the use of voice assistant technologies. UNESCO subsequently interviewed 12 leaders in AI, digital technologies and gender equality from academia, civil society and the private sector. These interviews and additional research were synthesised in a report published in August 2020.