The Future of Knowledge:
A Foresight Report 2019

Empowered lives.
Resilient nations.

مؤسسة محمد بن راشد آل مكتوم للمعرفة
MOHAMMED BIN RASHID AL MAKTOUM
KNOWLEDGE FOUNDATION

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FOREWORD
Mohammed Bin Rashid Al Maktoum Knowledge Foundation

To say 'Knowledge is Power' is an understatement. Knowledge truly is everything. Any society that longs for a better future, for a prosperous economy, for sustainable development, needs first to examine its situation, learn its strengths and weaknesses, and explore its options and opportunities. This is a fact, and a fact that makes knowledge essential – and even imperative – for communities to grow and move confidently into the future.

"A true leader does not derive power from his position, but from his ethics, from people's love for him, and from his knowledge," said His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE, Ruler of Dubai. Our leaders have always prioritised knowledge as a prerequisite for themselves before working to promote it amongst their people, and even establish it as a core national value and way of life.

As the foundation bearing H.H.'s name, and dedicated to the production, dissemination, and localisation of knowledge in the UAE, we, at the Mohammed bin Rashid Al Maktoum Knowledge Foundation, have followed in his footsteps and embraced the pursuit of knowledge as a primary objective and plan of action in everything we do.

The Mohammed bin Rashid Al Maktoum Knowledge Foundation has an arsenal of initiatives and programmes that we have developed over the years, in collaboration with many governmental and private-sector partners, to promote knowledge, and lay the foundations for empowered knowledge-centred societies in the UAE, the region, and the world. Amongst the most fruitful of these alliances has been our strong and enduring partnership with the United Nations Development Programme (UNDP), which has recently crossed its 10-year mark with many accomplishments to look back on and celebrate.

Our decade of collaboration with the UNDP on the Knowledge Project has given rise to a long list of landmark initiatives we take great pride in, chief amongst them is the ground-breaking Global Knowledge Index, launched in 2017 to measure the status of knowledge on the level of 136 countries around the world. The Index firmly positioned the Foundation as a leading global institution spreading knowledge and science to all corners of the globe.

We are delighted to be announcing the results of the Global Knowledge Index 2019. We are equally motivated to be launching the Future of Knowledge Foresight Report this year, to be an extension of the Index. The first of its kind in the world, the report establishes a connection between knowledge and future technologies. The Future of Knowledge Foresight Report 2019 surveys 40 countries, including the top five in the Global Knowledge Index, amongst others, analysing data from 150 million digital sources using 23 languages.

Teams of highly qualified experts and academics from around the world have been enlisted to work on both the Index and the Report. The two publications complement one another: the Global Knowledge Index seeks to present a qualitative diagnosis of the state of knowledge around the world, while the Report offers an analysis of the Future of Knowledge Foresight model, as well as recommendations for building knowledge economies.

We look forward, with anticipation and confidence, to launching the 2019 edition of the Report and revealing the findings of the Global Knowledge Index 2019. The Mohammed bin Rashid Al Maktoum Knowledge Foundation is honoured to be playing our part in promoting the UAE as a global centre for cultural dialogue, and a source of knowledge and ambitious strategies for building the advanced, knowledge-based societies of the future.

Sheikh Ahmed bin Mohammed bin Rashid Al Maktoum

Chairman of the Mohammed bin Rashid Al Maktoum Knowledge Foundation (MBRF)

FOREWORD
United Nations Development Programme

The release of this report coincides with the renewal of the longstanding partnership between the Mohammed bin Rashid Al Maktoum Knowledge Foundation (MBRF) and the United Nations Development Programme (UNDP). This successful partnership operates within the context of the "Knowledge Project," through which the parties aim to continue harnessing knowledge for sustainable development for a further decade to come.

Since 2008 the focus of the project has evolved from theoretical studies of the nature and status of knowledge; to quantitative monitoring and analysis of countries' knowledge profiles; and, ultimately, forecasting the future trajectory of knowledge acquisition, retention and application around the world. The project has supported various stakeholders in political, academic, research, industrial and economic circles to develop informed policies based on data and scientific evidence. It has also provided opportunities to monitor progress via the seven sectoral indices of the Global Knowledge Index, namely: pre-university education; technical and vocational education and training; higher education; research, development and innovation; information and communications technology; economy; and enabling environment.

This year sees the release of the 2019 edition of the Global Knowledge Index (GKI). First produced in 2017, and covering 136 countries, the GKI is the only index to measure knowledge on a global level. It is accompanied by the second edition of the landmark study, The Future of Knowledge: A Foresight Report. This year, the report leverages the potential of big data byemploying a new purpose-built model to measure countries' readiness for further knowledge development in view of rapid technological developments and their impacts on key knowledge sectors.

The report identifies four technologies – artificial intelligence, cybersecurity, blockchain and biotechnology – as key focus areas for investment, given their potential to offer comprehensive and effective solutions to the world's most pressing environmental, economic and social challenges, thereby supporting the realisation of the 17 UN Sustainable Development Goals (SDGs).

Facilitating policymakers' access to, and use of, new knowledge is a UNDP priority; it is therefore highly encouraging to note that the momentum of the unique partnership between UNDP and MBRF has been maintained despite the challenges and turbulence experienced in the Arab States region in recent years. Through the Knowledge Project, we seek to shape a new and innovative vision for the realisation of the 2030 Agenda both within and outside Arab states.

We wish to express our appreciation to all those who have contributed to these achievements – and in particular the expert working teams, the Mohammed bin Rashid Al Maktoum Knowledge Foundation and its leaders, and the Knowledge Project team. Embracing the vision of His Highness Sheikh Mohammed Bin Rashid Al Maktoum – Vice President and Prime Minister of the United Arab Emirates and Ruler of the Emirate of Dubai that the future is made, not simply awaited, we look forward to publishing more insightful quantitative and qualitative data and analyses to enrich the global knowledge landscape in the years to come.

Mourad Wahba

UNDP Acting Associate Administrator and Regional Director for Arab States
United Nations Development Programme (UNDP)

Contributors

PwC Team
Laurent Probst, Virginie Lefebvre, Bertrand Pedersen, Iakov Frizis, Christine Lugrine, Alexandra Lange, Bruno A. Rodrigues Coelho, Sherif Labib, Miroslava Ivanova, Tara Sophia Mühlschlegel, Alexandra Ministrini, Zakaria El-Mokhtari, Tiffany Covolo, Priyakant Bhardwaj, Agnes Martinelle, Jill Wenger, Nuray Unlu-Bohn, Alex Teligadas

Knowledge Project Director (UNDP)
Hany Torky

Mohammed Bin Rashid Al Maktoum Knowledge Foundation
Jamal Bin Huwaireb (CEO), Saif Al-Mansoori (Corporate Affairs Advisor to the CEO)

United Nations Development Programme (UNDP)
Mourad Wahba (UNDP Acting Associate Administrator and Regional Director for Arab States),
Khaled Abdel Shafi (Regional Hub Director)

Research and Statistics, Knowledge Project (UNDP)
Anthony Fakhoury, Hany Torky, Stephanie Boustany

Communications and Web, Knowledge Project (UNDP)
Diana Assaf, Sirine Saghira

Digital Platform and Mobile Application
Dany Wazen (UNDP)
Integrated Digital Systems (IDS)

Operations and Administration
Programme Support Unit (PSU) and Management Support Unit (MSU),
Regional Hub for Arab States, UNDP

Editor
Francis Field

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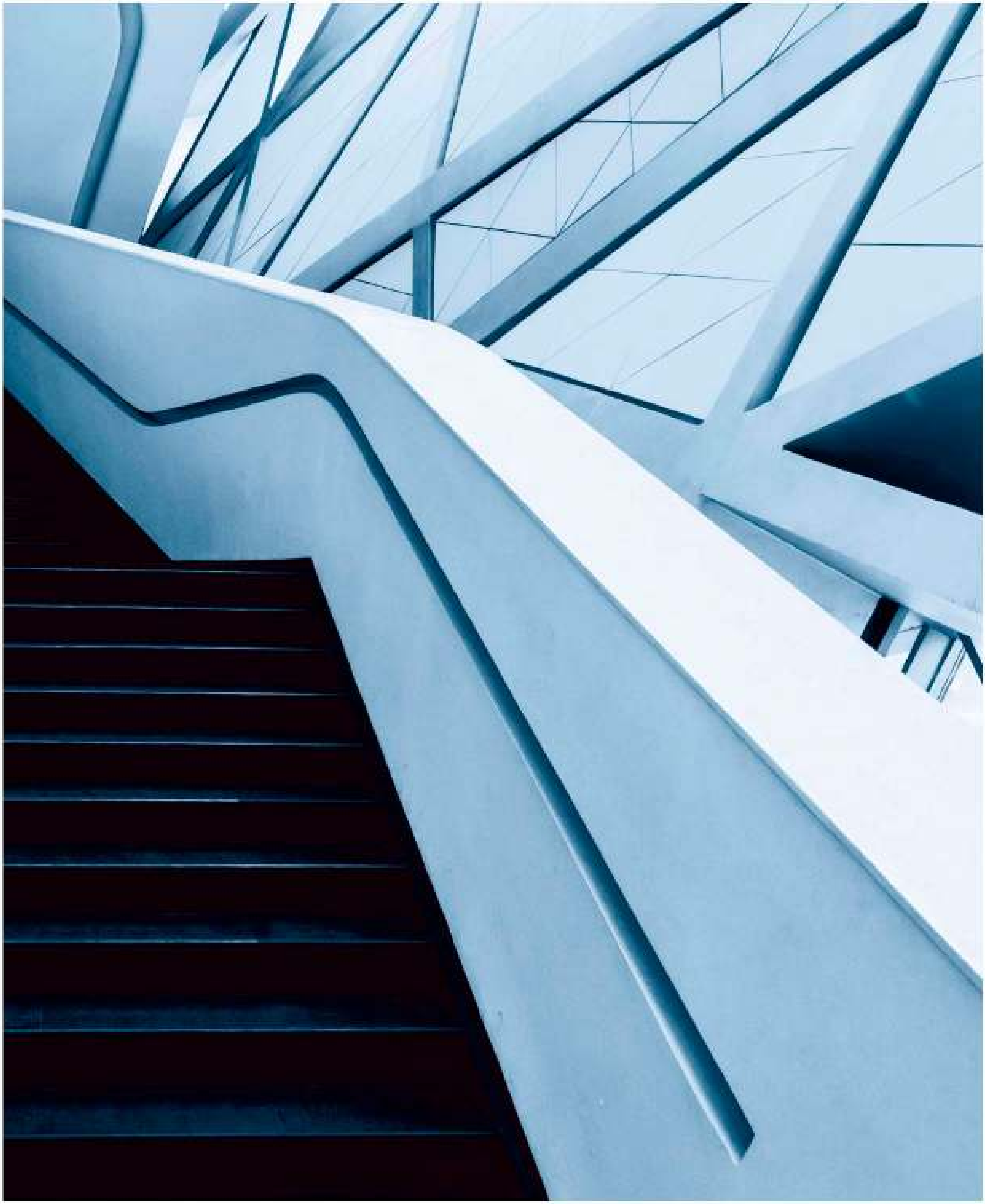


INTRODUCTION

The world is changing rapidly before our eyes. In the midst of the Fourth Industrial Revolution, new technologies are emerging and disrupting our lives at an unprecedented rate; we now live in a 'global' era, characterized by rapid advancements in technology and connectivity. Blockchain, biotechnology, cybersecurity and artificial intelligence (AI) are significantly changing the way we live, work and interact within society. These developments create unparalleled opportunities and challenges for businesses, communities and individuals alike.

The labour market has been significantly altered by technological change, with structural unemployment looming owing to the mismatch between labour demand and supply. As such, policymakers are facing a growing skills gap that affects the ability of businesses, governments and citizens to fully exploit the opportunities advanced technologies create. Repetitive tasks and manual jobs are disappearing as process automation and digital tools render them obsolete. Large sections of the workforce lack the competencies required to engage in this new working environment; they show limited awareness of the technologies and skills of the future and often lack access to lifelong learning and training opportunities. The labour market therefore faces an alarming skills gap, given the increasing demand for high-skilled labour and the absence of qualified individuals, resulting in an extensive range of vacancies that remain open for months on end.

This study aims to caution policymakers that, in the absence of comprehensive re/upskilling and training opportunities, economies will risk stagnation and potential decline in the near future. For example, the Netherlands recently revised their economic growth predictions due to the negative impacts of a growing skills gap on their economy.[1] Governments therefore must urgently reimagine their national skills ecosystems to accommodate the needs of current and future workforces in these changing times and equip them with the skills necessary to thrive in an era driven by advanced technologies.

Investments in technology alone are not sufficient to strengthen the competitiveness and sustainability of a given economy. Without the talent necessary to employ these technologies and drive innovation, nations will risk undermining the competitiveness of their industries and reduce their attractiveness to investors and businesses. Policymakers must develop and implement sustainable skills strategies, in line with the Sustainable Development Goals (SDGs), to strengthen the competitiveness of their nations and position them as drivers of innovation.

1.1 Technology and the evolving knowledge landscape

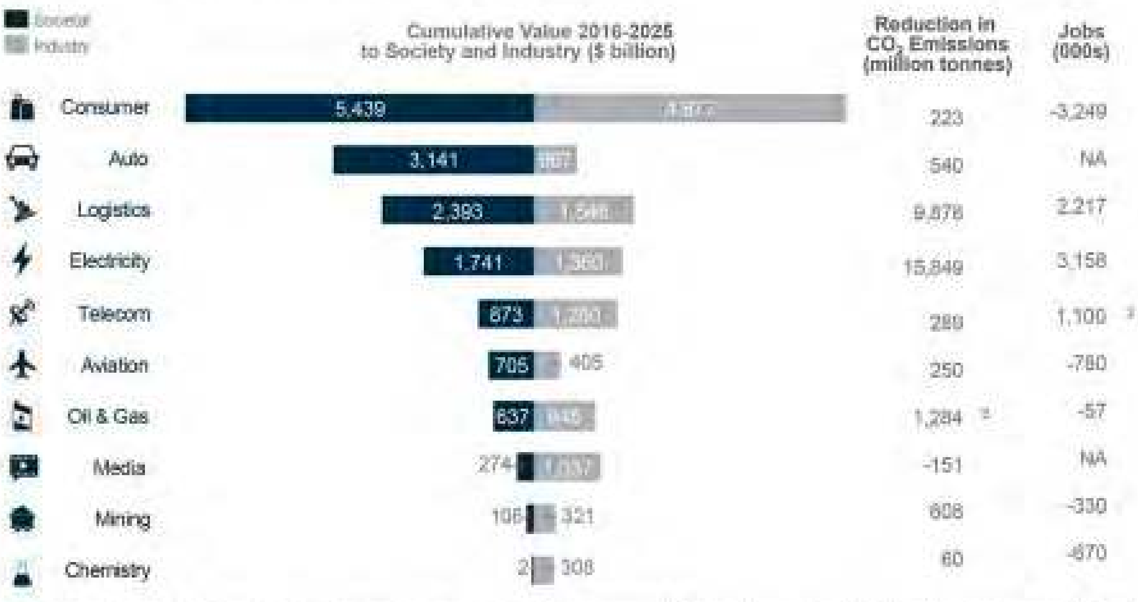
+70% added value created in the economy by **digitally enabled** platforms in the **next decade.**[2]

Used to their full potential, advanced technologies will allow decision makers to accompany their citizens into a new era of opportunity. The World Economic Forum (WEF) estimates that the value, both for society and industry, of the ongoing global digital transformation will reach US$100 trillion by 2025 if exploited to its full potential.[3] Businesses will need to transform into digital companies to fully benefit from this value creation and remain competitive; an estimated 70 percent of new value created in the economy over the next decade will be based on digitally enabled platforms.[4] AI alone could contribute $15.7 trillion to global GDP by 2030.[5] The Gulf states, in particular, has recognized this potential, with the region's governments increasing investments in AI development and education. For example, the United Arab Emirates has appointed a Minister of State for AI to drive its ambitious AI 2031 strategy.

66% of CEOs in the Middle East have **introduced AI to their business or plan** to start in the next three years.[6]

The penetration of ICT across all sectors and industries has facilitated knowledge sharing and creation as temporal and spatial barriers disappear. New technologies such as big data, machine learning and cloud computing enable organizations to collect and process huge amounts of data. The data collected offers vast amounts of knowledge on processes in place, as well as on consumer behaviour. The key to success for many organizations lies in the speed with which they can integrate such knowledge into their existing business models/processes or share it with the broader market.

Figure 1.1: The potential impact of digital initiatives by industry



(1) Total societal value at stake includes impact on customers, society and the environment; the impact on external industries has not been considered; (2) Excludes the Extending Connectivity digital initiative; (3) Reduction in emissions for Oil and Gas refers to reduction in CO_2 emissions

Source: World Economic Forum, 2017.

The introduction of new technologies also inevitably changes the nature of work. Both government and business leaders will need to collaborate closely to ensure all of society is able to access and contribute to this new world of opportunities.

Research suggests that technology contributes to labour market polarization. This, in turn, causes a similarly polarized and increasingly unequal distribution of wages: employment in high- and low-skilled positions has grown substantially, while the number of middle-skilled jobs has dropped dramatically.[7] These findings are supported by a study conducted by the WEF, which estimates that "75 million jobs may be displaced by a shift in the division of labour between humans and machines, while 133 million new roles may emerge that are more adapted to the new division of labour between humans, machines and algorithms."[8] Thus, jobs are still being created at a faster pace than they are disappearing and massive technologically-driven unemployment seems unlikely.

However, most organizations struggle to recruit and retain talent as a new skills and knowledge paradigm emerges. The continuous introduction of new technologies leads to productivity improvements; yet it also challenges individuals, governments and corporations to master an ever-growing number of applications and to adapt to regular technological updates.[9] Disruptive technological changes accelerate the obsolescence of workers' skills, with 14 percent of jobs now at high risk of automation.[10] As a result, corporations, governments and educational institutions are struggling to predict the set of jobs and skills that will be required in 30 years' time.

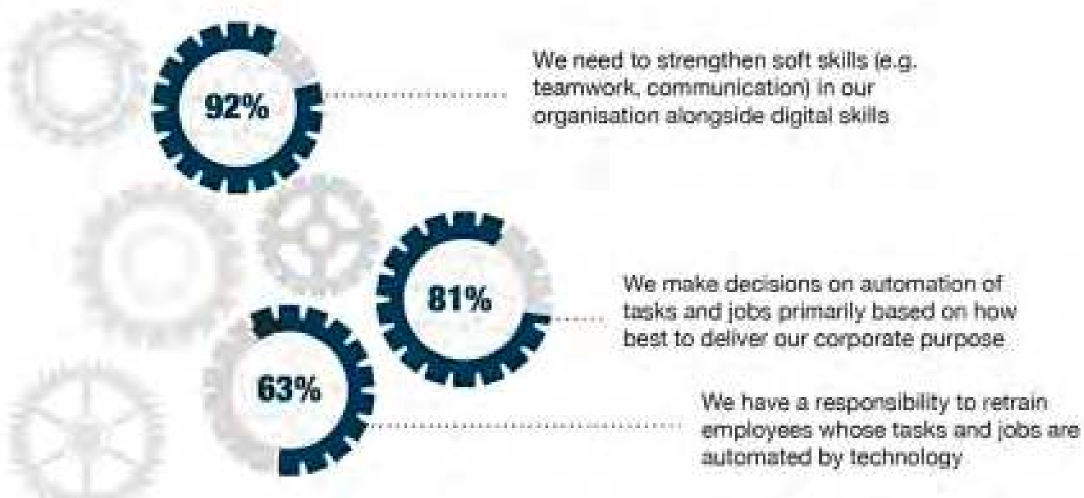
Seventy nine percent of CEOs are concerned about the availability of key skills and identify this point as one of the top three threats to the continued growth of their businesses.[11] In the Middle East, 92 percent of CEOs believe they need to strengthen their firm's soft skills – alongside digital communication skills – compared to 91 percent globally.[12] Overall, the skills gap that exists within their workforces represents a particular source of concern, given that it impedes innovation and prompts higher staffing costs. Organizations are being forced to invest greater sums in their recruitment and training processes or face mass layoffs due to the misalignment of their workforces with changing organizational needs.

Figure 1.2: CEOs in the Middle East adapt their people strategies to the digital age

Thinking about your people strategy for the digital age, how strongly do you agree or disagree with the following statements?

Respondents who stated 'Strongly Agree' or 'Agree'

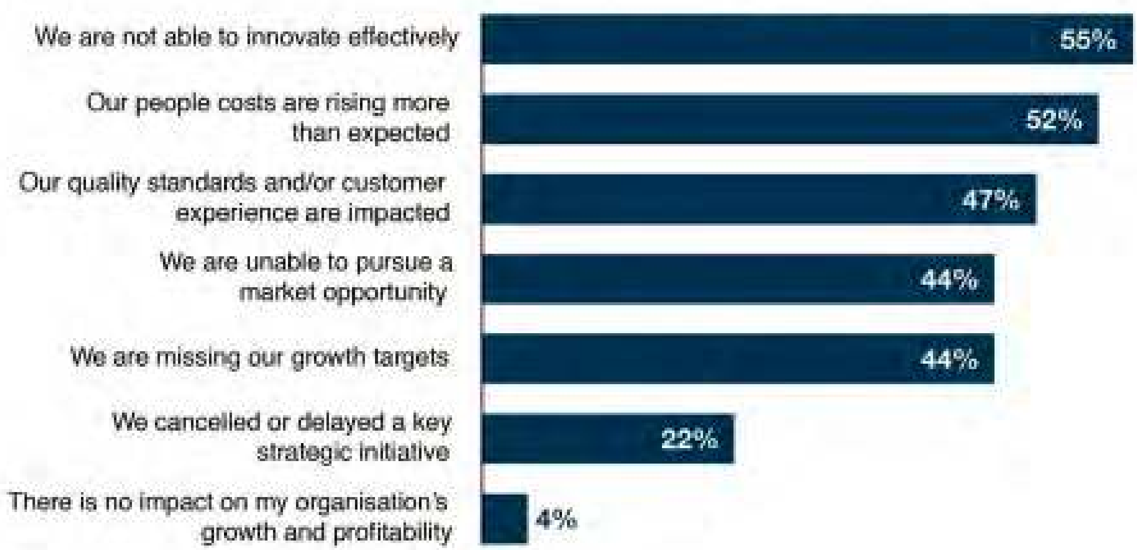
Middle East



Source: PricewaterhouseCoopers, 2018a.

This trend also greatly concerns national decision makers. The availability of talent and a skilled workforce is crucial in driving innovation and ensuring the competitiveness of the businesses and industries present in a given region or country. Organizations will seek to relocate their activities if they do not find the right talent that will enable them to continue to grow and succeed. This leads to rising unemployment as local workforces fail to meet the skills requirements of employers.

Figure 1.3: What impact is 'availability of key skills' having on your organization's growth prospects?



Source: PricewaterhouseCoopers, 2019a.

The growing misalignment between the skills available and those required to drive future innovation creates demand for new upskilling and reskilling solutions. Increasing collaboration and coordination between governments, industrial actors, labour unions and academic institutions (including training providers) will be necessary to develop and implement solutions that bridge skills gaps and mismatches. Even though some countries have developed national skills strategies, they do not actively collaborate with industry partners, labour unions and academic institutions. These efforts will need to increase significantly to ensure the continued competitiveness of local industries and economies.

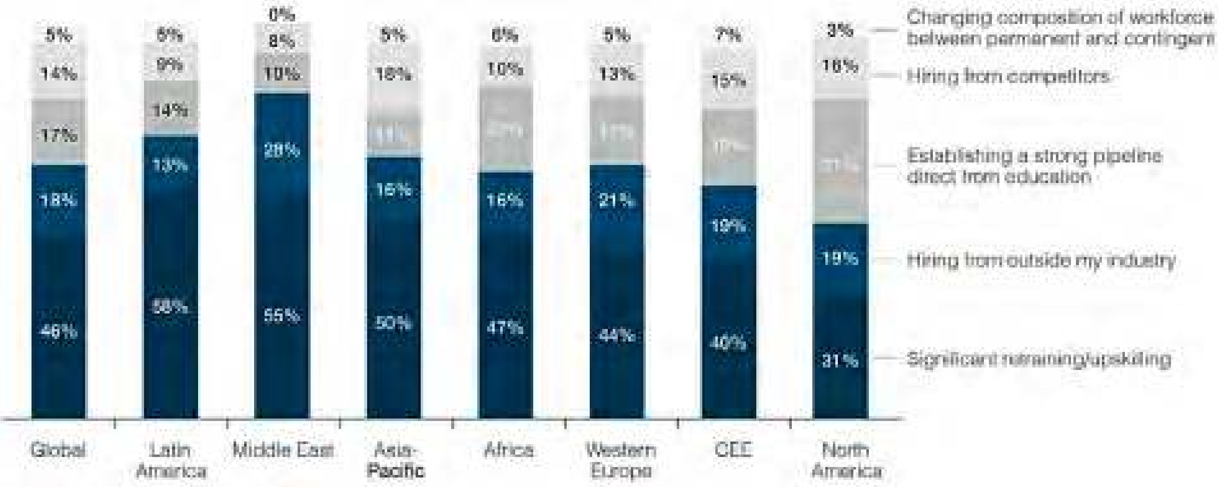
28.7 million
developers expected in **2024**[13]

Education programmes must be reviewed and aligned with the skills requirements of the market. Currently, college students do not feel that their education is adequately preparing them for their future workplaces; only 35 percent believe the skills they acquire are sufficient.[14] At the same time, "only 41 percent of adults participate in education and training in any given year, according to data from the OECD Survey of Adults Skills (PIAAC)". Adults with low-level skills are three times less likely to participate in training than those with high-level skills.[15] There is a clear need for new models of education, characterized by a long-term outlook, a strong emphasis on lifelong learning, greater connectivity with industry and the labour market, and utilizing new teaching methods built on new technologies. Individuals not only need to learn the skills necessary to harness technology, they also need to learn how to acquire knowledge that allows them to remain at the forefront of the latest methodologies/systems/technologies. They need to be comfortable entering and interacting with external environments/fields and be open to breaking with traditional/past working styles.

46% of CEOs believe they need to **invest in the retraining/ upskilling** of their employees.[16]

Businesses are aware of the challenges of reviewing the education system and are increasingly concentrating their efforts on upskilling their existing workforces. Across the globe, CEOs see the continuous retraining/upskilling of their employees as a key solution to tackle the growing skills gap and a means to ensure they have the right talent to drive the future growth of their businesses. This is particularly true in Latin America and the Middle East, where CEOs prefer to retrain/upskill their workforces rather than hire from competitors or change the overall composition of their workforces.[17]

Figure 1.4: Employee retraining is favoured to bridge the skills gaps



Source: PricewaterhouseCoopers, 2019a

Numerous industry-led initiatives demonstrate the commitment of businesses to re/upskilling existing workforces. IBM, for example, launched the IBM Skills Academy that assists universities in filling the gaps between academia and business; improves student learning through hands-on experiences with the latest technologies; and helps connect students to the job market.[18] Through partnerships with universities, students and educators in both IT- and non-IT-related fields can participate in multiple tracks that range from AI to Quantum. Each track has a number of distinct skill-focused learning objectives that are based on market research and in line with high-demand jobs in the market. Cisco's Networking Academy, on the other hand, offers a vast amount of freely available online learning streams that are open to students from all socioeconomic backgrounds.[19] The main themes covered by these courses are: networking, programming, IoT, cybersecurity, operating systems and entrepreneurship.

Another interesting concept is presented by Learning Factories 4.0, which were launched by the state of Baden-Württemberg (Germany) and showcase the importance of close collaboration between regional/ local public bodies, industry leaders and educational bodies in providing sustainable innovative training programmes. In providing sustainable innovative training programmes.[20] The Learning Factories are government-backed labs implemented in vocational schools that have the following two objectives:

(1) to teach students and train employees by providing real-life experience opportunities; and (2) to act as a research factory to demonstrate and test new technologies and approaches. They provide a key source of inspiration for new educational models that provide technical, digital and transversal skills throughout an individual's career.

All the re/upskilling efforts mentioned above align with and directly promote the realization of the 17 Sustainable Development Goals (SDGs) that were conceived at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. Indeed, skills also take centre stage in the 2030 Agenda for Sustainable Development,[21] which places wellbeing and prosperity of people at its core.

For instance, SDG 4 calls for inclusive and equitable quality education and lifelong learning perspectives that widen the focus on basic education to levels and programmes beyond compulsory education in all countries. It sets targets for achieving quality learning at all stages of life – from early childhood development (SDG Target 4.2), through pre-university education (Target 4.1) to technical and vocational education and training, and higher education (Targets 4.3, 4.4 and 4.6). It also seeks equity in the delivery of education (Target 4.5), including in terms of gender, socio-economic status and location, as well as for persons with disabilities and indigenous peoples. In addition, Target 4.7 calls for equipping students with the knowledge and skills to foster sustainable development as well as human rights, gender equality and global citizenship, thus linking education to the wider sustainable development objectives.[22]

In addition, SDG 8 promotes sustained, inclusive and sustainable economic growth, as well as full and productive employment and decent work for all. More specifically, Target 8.5 aims to achieve full and productive employment and decent work for all women and men, including young people and persons with disabilities, and equal pay for work of equal value by 2030. Target 8.6 calls for a substantial reduction in the proportion of youth not in employment, education or training by 2020, while Target SDG 8.b involves developing and operationalizing a global strategy for youth employment, as well as implementing the ILO Global Jobs Pact, also by 2020.[23]

Whether or not the Goals are achieved is highly dependent on the competencies, skills and knowledge of working populations that represent the active agents of change in their communities. Thus, embedding sustainable development skills and knowledge within leadership development and other programmes, rather than perceiving sustainable development as a separate field of study, is pivotal for innovation and vital for a productive and flexible workforce.[24] This further supports the development of 'H-shaped' skills that will enable individuals to develop a wide set of competences.

This report aims to support country leaders in anticipating future skills and knowledge needs, to align them with the SDGs, and implement sustainable national re/upskilling initiatives. By assessing the impact that emerging technologies will have on the workforce, country leaders will be able to discern the future skills needs of their workforces and collaborate with all stakeholders concerned to review the national educational and training programmes available. Moreover, by assessing the country profiles of other states, political leaders will be given the opportunity to learn from existing best practices and to adapt them (if possible) to their local needs.

Figure 1.5: The UN Sustainable Development Goals

Source: United Nations, 2015a.

1.2 Purpose and objectives

As mentioned above, the main purpose of this report is to assist country leaders in preparing their citizens for the future knowledge landscape and equipping them with adequate skillsets. It aspires to encourage proactive leadership amongst all nations to ensure the sustainable continued re/upskilling of workforces. The continued emergence of new technologies forces both employers and employees to continuously adapt to new systems and processes. By using real-time data to assess future fields of knowledge, political leaders and supporting stakeholders will be able to envision the future needs of their citizens in an objective and efficient manner.

To this end, this report presents the latest findings of the 'Future of Knowledge' series, which uses an innovative knowledge measurement tool to analyse big data and evaluate awareness of skills and technology in 40 countries. A Digital Intelligence Platform allows for the development of the Global Technology Awareness Index (GTAI) and the Future Skills Awareness Index (FSAI), to support the findings of the Global Knowledge Index (GKI).[25] This allows the reader to compare the awareness levels of different countries and to identify best practices in terms of technological advancement and future skills development. This report assesses the readiness of 40 countries, grouped into four clusters based on GKI 2019 findings.

The report consists of four chapters. Chapter 2 presents the detailed methodology employed to establish the study and ensure the comprehensiveness of the findings. Chapter 3 presents the main findings of the subsequent analysis and is followed by a set of key policy recommendations to ensure the widespread uptake of education/knowledge initiatives in Chapter 4.

The purpose of this study is twofold:

1. to gain a better understanding of the next wave of technological disruption by capturing and analysing real-time data associated with five key future fields of knowledge: artificial intelligence (AI), cybersecurity, blockchain, biotechnology and future skills; and

2. to accelerate and facilitate knowledge development by helping country leaders benchmark their performances over time and against those of front-runners.

Our objectives are to:

- conceptualize the future of knowledge creation and development as a multidimensional phenomenon that is deeply connected to the vision of a sustainable society;
- provide real-time data on future knowledge trends;
- evaluate the performance of 40 selected countries in terms of readiness (skills and technology) of the future; and
- encourage policymakers, business leaders, researchers and civil society to combine their efforts in developing technologies that will likely shape the near- and long-term future.

1.3 Future fields of knowledge

In this section, we explain the rationale for selecting AI, cybersecurity, blockchain, biotechnology and future skills as the key future fields of knowledge.

1.3.1 Key technologies for the future

The rise of new technologies affects the future of our societies and thus the realization of the Sustainable Development Goals (SDGs) presented above. We believe that certain types of technologies can help us overcome societal challenges such as ageing populations, lack of skills, increasing scarcity of resources, growing inequality, hunger, poverty and climate change. The European Union (EU), for example, defines six key enabling technologies that will be crucial to strengthen the industrial and innovation capacities of EU states:

- Advanced manufacturing technologies;
- Advanced materials and nanotechnologies;
- Life sciences technologies;
- Micro- and nano-electronics and photonics;
- Artificial intelligence; and
- Digital security and connectivity.[26]

Gartner recently identified the following top ten strategic technology trends for 2019:[27]

- Autonomous things;
- Augmented analytics;
- AI-driven development;
- Digital twins;
- Empowered edge;
- Immersive technologies;

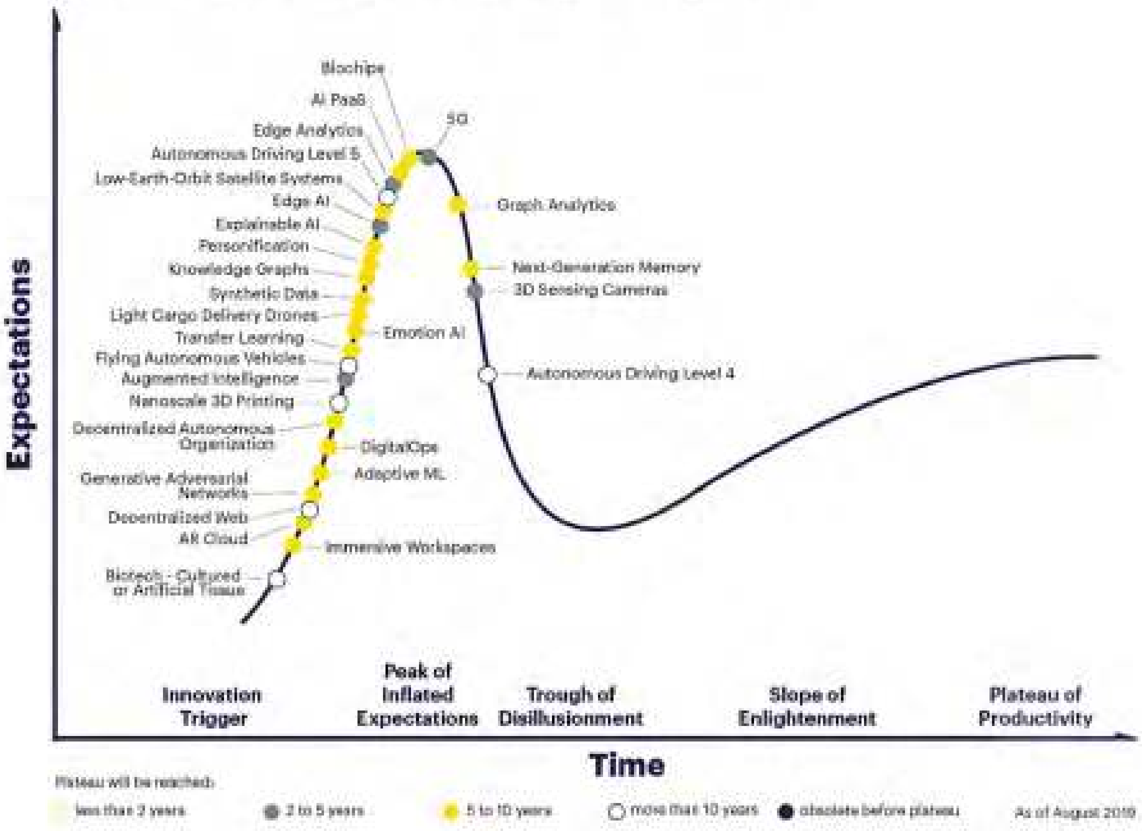
- Digital ethics and privacy;
- Quantum computing;
- Blockchain; and
- Smart spaces.

While addressing technologies from different perspectives, both the EU and the World Economic Forum (WEF) underline the importance of new technologies in creating a better future and supporting the implementation of the SDGs. In this report, we refer to these central technologies as 'key technologies for the future' that share two principal features:

1. they form an ecosystem in which each technology both exploits and fosters the development of others;[28] and
2. they enable the exponential acceleration of innovation, as each technological improvement leads to the emergence of new technologies and systems.[29]

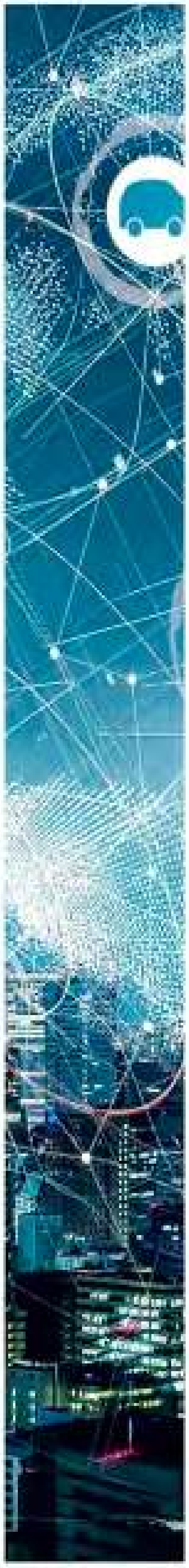
As highlighted in the 'Technology Profiles' section, AI, cybersecurity, blockchain and biotechnology possess these two features. For each of them, many avenues for future research, experimentation and innovation lie ahead, and could lead to unexpected results. We therefore believe that these four technologies will enable us to build instantaneous and practical solutions to the world's most intractable challenges, such as poverty and natural disasters, with greater speed and accuracy.

Figure 1.6: The Gartner Hype Cycle for Emerging Technologies, 2019



Source: Gartner, 2019.

TECHNOLOGY PROFILES



ARTIFICIAL INTELLIGENCE

Definition

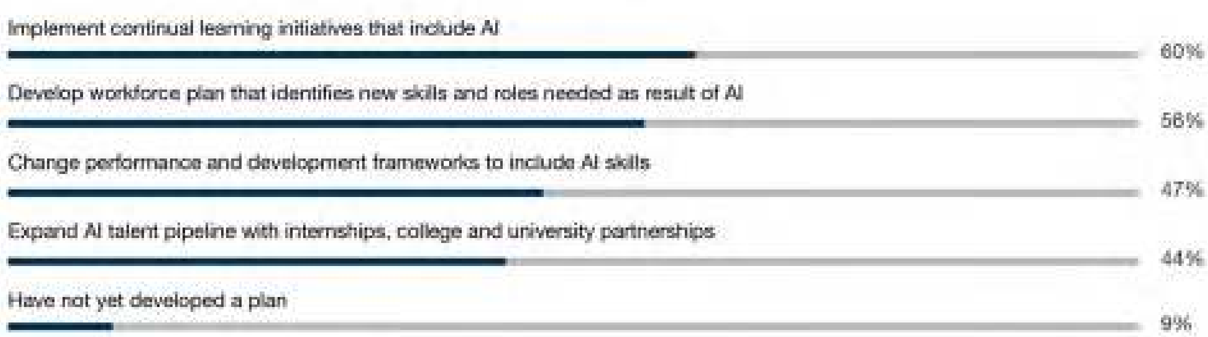
Artificial intelligence (AI) refers to the "ability of a computer or a computer-enabled robotic system to process information and produce outcomes in a manner similar to the thought process of humans in learning, decision making and solving problems". By extension, the objective of AI systems is to develop systems capable of tackling complex problems in ways similar to human logic and reasoning.[30]

+$15.7 trillion potential contribution to the global economy **by 2030** from AI.[31]

AI technologies are maturing and increasingly influence our daily life

Most of us use AI daily without knowing that we are doing so. AI has been significantly altering the way we live, socialize and work. For instance, AI enables power predictive Google searches, influences our Spotify recommendations and informs the smart assistants we use to shop online or control the temperature of our living spaces.[32] The various forms of AI available (e.g. machine learning, processing, predictive analytics, etc.) allow us to complete tasks in a much faster and smarter way, be it through chatbots, mobile banking, navigation, maps, etc. The use and development of AI technologies is evolving as AI-powered solutions increasingly target the professional developer community (AI platforms and AI services) and no longer require the involvement of a professional data scientist. The growing accessibility of, and improvements in, big data, social media-platforms and open-source communities are supporting the continued development and maturity of AI. At the same time, innovations in AI are supporting the further development of these technologies by influencing the way data is stored and shared across geographies. The widespread use of AI underlines the need for a workforce equipped with the necessary skills to use this technology to its fullest potential.

Figure 1.7: The importance of building an AI-ready workforce



Source: PricewaterhouseCoopers United States, 2019.

AI and the SDGs

AI is being used to address multifaceted developmental challenges. For example, a growing number of researchers are exploring the use of AI to diagnose skin cancer[33] and detect glaucoma,[34] while others use it to protect endangered animals by assessing wildlife populations.[35] AI can also be applied to the design and operation of wind and solar farms – as demonstrated by DeepMind and Google[36]– or to facilitate the detection of financial crimes by analysing ever-larger datasets.[37] McKinsey has developed a library of over 160 instances in which AI can be used for social impact and has identified possible upscale solutions,[38] while PwC and the WEF assessed the impact of AI across six environmental impact areas: climate change; biodiversity and conservation; healthy oceans; water security; clean air; and weather and disaster resilience.[39]

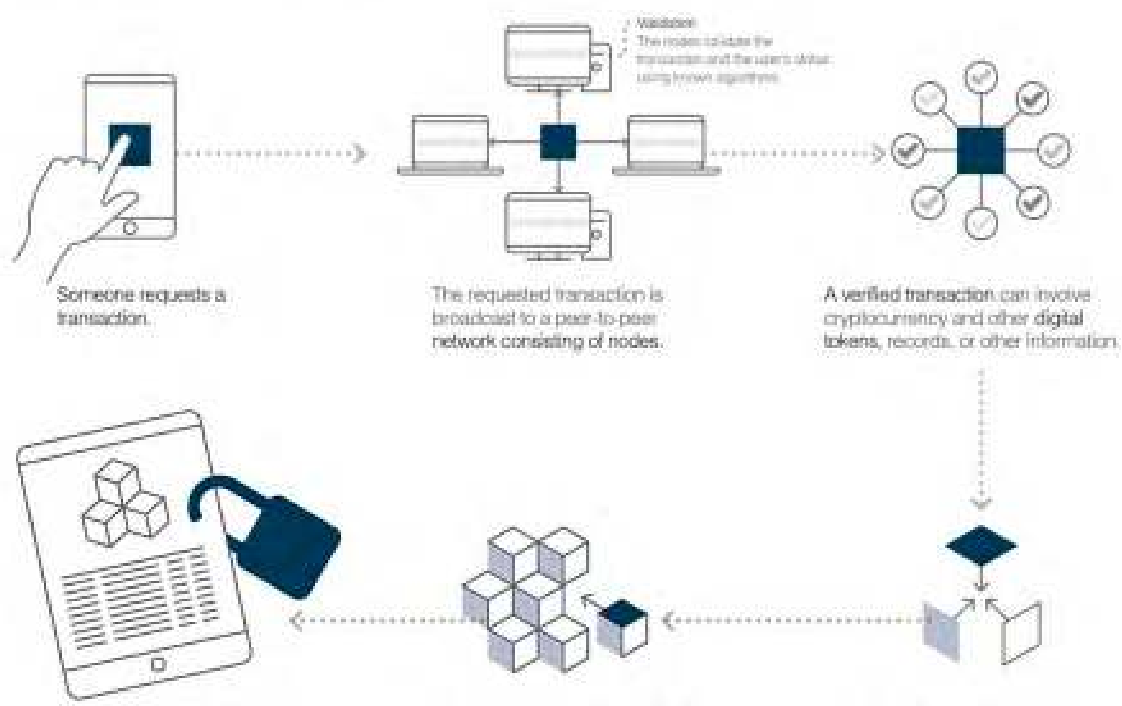
Clearly, AI is being widely explored and experimented within the context of achieving the SDGs. To expand its use even further, 2030 Agenda suggests articulating SDG-related problems in a way that allows AI to solve them. Further necessary improvements include the definition of a shared language and the subsequent interpretation of the findings. At the same time, any bias in the use of AI must be limited and its ethical use strengthened.

BLOCKCHAIN

Definition

Blockchain is a "distributed and tamper-proof database technology that can be used to store any type of data, including financial transactions, and has the ability to create trust in an untrustworthy environment."[40] By providing a high level of security, blockchain can be an important component in digital infrastructure, where trusted digital applications can be used.

Figure 1.8: How does blockchain work?



Source: PricewaterhouseCoopers, 2018b.

The increasing popularity of blockchain

Blockchain is becoming increasingly popular amongst large businesses as they move away from discussing the value of cryptocurrencies such as bitcoin and focus on the development of service solutions. Improvements are being made in nearly every industry, from insurance to food provision to luxury goods. LVMH, for example, launched AURA, a blockchain platform dedicated to proving the authenticity of luxury goods.[41]

The IBM Food Trust network, on the other hand, lets users trace time-sensitive foods and allows them to pinpoint where a product sustained damage in the food supply chain.[42]

Blockchain thus remains a key solution to secure and share information between different actors and directly contributes to advancements in other technologies. This characteristic makes it an interesting feature for digital twins. A digital twin is a digital replica of a living or non-living physical entity. By tapping into the 'Internet of Things' (IoT), blockchain could facilitate the transparent transmission of data and value over the Internet without intermediaries, thus providing an efficient way to generate, monitor and update digital twins. Other applications, in combination with AI, could further increase trust in facial recognition or self-driving cars by documenting their movements.

Blockchain and the SDGs

Through the advantages it creates, blockchain is increasingly used to support the realization of the SDGs through: the identification of ID-less people; supporting financial inclusion; improving access to clean and renewable energy; enhancing production and consumption patterns; protecting the environment; and improving aid effectiveness.[43] For instance, the World Food Programme (WFP) Building Blocks initiative uses blockchain to issue digital cash vouchers to ensure efficient, safe and transparent delivery of food aid, contributing to SDGs 1 (no poverty) and 2 (zero hunger).[44] The UN Climate Change secretariat further established the Climate Chain Coalition to facilitate collaboration amongst members to monitor, report and verify the impact of climate actions.[45]

CYBERSECURITY

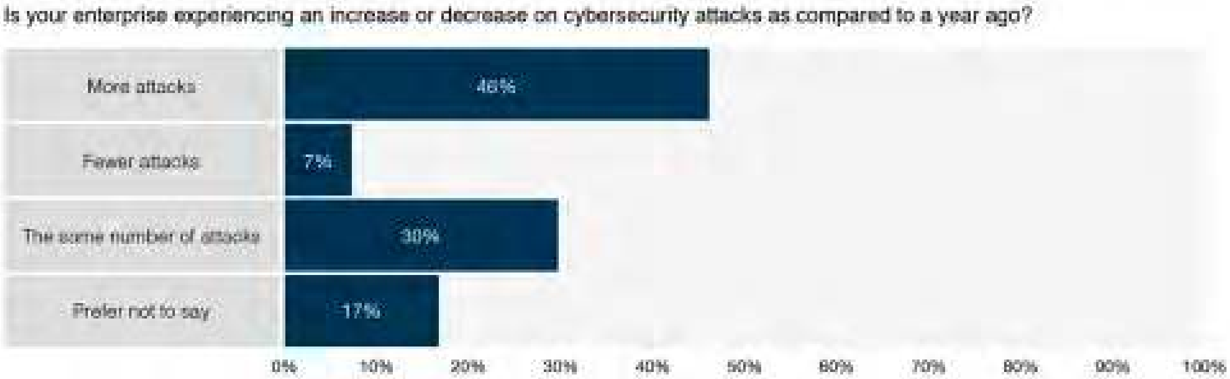
Definition

Cybersecurity refers to the technologies, processes and controls that aim to safeguard systems, networks and programmes against digital attacks. Such attacks commonly involve attempts to access, alter or damage sensitive information. When successful, these attacks can result in extortion of money, infringement on intellectual property rights or disruption of service provision.

Cybersecurity is central to the development of AI, blockchain and the IoT

With the advent of the Fourth Industrial Revolution, information and data are being shared in increasing volumes and at growing speeds. At the same time, cybercrime has increased, as more and more individuals try to gain access to data and use it for their own benefit. Cybersecurity therefore remains one of the main concerns for businesses, governments and citizens, with cyberattacks ranked by the WEF amongst the top five risks challenging global society in 2019.[46]

Figure 1.9: Status of cybersecurity attacks on private enterprises



Source: Isaca, 2019.

Cybersecurity is crucial to supporting the growth of digital information societies, as trust in the technologies used and information shared represent their core foundations. Society needs to be able to trust that data is being processed and shared in a secure way to guarantee the privacy and safety of individuals. Without sufficient security, the use of emerging technologies represents a source of risk rather than an opportunity for development. Cybersecurity therefore represents a crucial building block in our future society and interacts closely with the technologies mentioned above, for example, it can be used together with blockchain to protect the delivery of financial services. The continued growth of the IoT also relies heavily on cybersecurity to ensure that the data we share are not stolen or cloned. Together with AI and machine learning, strong algorithms are being developed to support the detection of cyber threats. However, businesses and individuals must also invest sufficiently in the protection of their information and educate themselves on how to limit risks.

Cybersecurity and the SDGs

Safer and seamless delivery of ICT services through effective cybersecurity can help in achieving the SDGs in the following ways:

- Cybersecurity supports economic growth by protecting access to information on the Internet and the safe transfer of data (SDG 1). For example, the transfer of digital cash allowances that the WFP is currently testing relies on the safe transfer of personal information. At the same time, information on food supplies and distribution sites can be communicated safely, thus ensuring a more effective distribution pipeline (SDG 2).

- Data protection is also crucial in order to protect patients' confidential information in the healthcare sector. While increased digitalization of health care services supports the wider delivery of medical support and thus improves the wider health and wellbeing of society, the information shared needs to be highly secure and protected from cyberattacks (SDG 3).

- Cybersecurity can also boost agricultural production and broaden access to information relating to economic interaction between private and public entities (SDG 9). The impact of global warming and future weather trends could be used to improve sustainable agricultural production; here, again, the data used must be shared securely and be safe from corruption.

BIOTECHNOLOGY

Definition

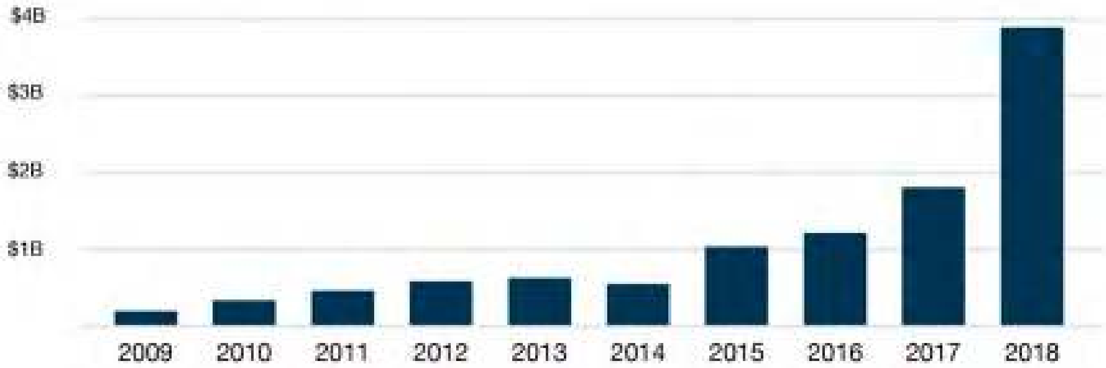
Biotechnology involves the manipulation of biological systems (living cells or cell components) for the efficient manufacturing of products. The field of biotechnology is the result of the combined application of physics, chemistry, mathematics and engineering at the molecular level for the study of living cells.[47]

$14 billion size of the synthetic biology market size **by 2026.**[48]

Progress in biotechnology is accelerating thanks to advances in other key technologies

Progress in biotechnology is accelerating and its effects are increasingly visible in our daily lives. The global synthetic biology[49] market alone is expected to reach around $14 billion by 2026.[50] Many people have switched to recyclable plastic bottles to reduce their plastic waste or buy genetically modified products that would otherwise not be available in their area. Advances in biotechnology will significantly contribute to food security, improving the supply of potable water and in supporting the development of sustainable methods of reforestation. AI, sensors, robotics and synthetic biology are all improving crop productivity and resilience. Concurrent improvements in machine learning have accelerated the discovery and development of new drugs, allowing quick identification of relevant information from clinical trials, patient records and scientific articles. Other applications might include facilitating organ donation, as synthetic biotechnology could extend the receiver pool as well as the viability of donor organs.[51] Developments in biotechnology are thus feeding other technologies such as AI, blockchain and big data, while simultaneously thriving from the innovation of the same technologies.

Figure 1.10: Funding for synthetic biology companies, 2009–2018



Source: Cumbers, 2019.

Biotechnology and the SDGs

Biotechnology plays a key role in the field of sustainable development and especially in the fight against poverty and disease prevention. As mentioned above, biotechnologies can greatly benefit activities in the health and food sectors, energy production, waste management as well as in pest control.
By supporting growth in sectors vital to the production of food such as farming, forestry and fishing, biotechnology contributes to the fight against poverty and hunger (SDGs 1 and 2). It also improves access to clean energy using bioethanol, which simultaneously reduces greenhouse gas emissions from fossil fuels. (SDGs 7 and 13). Finally, the use of biopackaging and biolubricants contributes to the reduction of plastic products and overall pollution (SDGs 14 and 15).

1.3.2 Future skills

As mentioned in the technology section, the emergence of new technologies directly affects the future of skills and work. Jobs that involve highly repetitive tasks will disappear while others (e.g. data scientists and AI specialists) will appear. A key challenge for policymakers is therefore to find a way to address the growing mismatch between the demand and supply of skills.

The skills of the future

Individuals need to learn new skills in order to improve their long-term competitiveness in the labour market. Digital skills such as coding and software programming are becoming increasingly important as businesses try to exploit the data they collect. The global developer population alone is expected to rise from 23.9 million developers in 2019 to 28.7 million in 2024.[52] Further roles that will emerge in the coming years include AI and machine learning specialists, software and application developers and analysts, big data specialists, information security analysts, blockchain specialists as well as digital transformation specialists. These emerging roles require new skills such as creativity, emotional intelligence, problem solving, data-driven decision-making and critical thinking. Soft or transversal skills are becoming increasingly important, as individuals need to be agile to progress in an ever-changing digital world.

Figure 1.11: Top 10 skills required in 2015 versus 2020

In 2015	In 2020
1. Complex Problem Solving	1. Complex Problem Solving
2. Coordinating with Others	2. Creative Thinking
3. People Management	3. Creativity
4. Critical Thinking	4. People Management
5. Negotiation	5. Coordinating with Others
6. Quality Control	6. Emotional Intelligence
7. Service Orientation	7. Judgement and Decision Making
8. Judgement and Decision Making	8. Service Orientation
9. Active Listening	9. Negotiation
10. Creativity	10. Cognitive Flexibility

Source: World Economic Forum, 2018b.

Introducing the 'H-shaped' skills concept

Over the last decade, the concept of 'H-shaped' (human-shaped) skills has emerged to meet these needs. This concept refers to a professional worker having a combination of deep technical and digital expertise in at least one domain as well as a range of transversal skills that can be used across industries. Professional workers are thus characterized by both the breadth and depth of their expertise. The breadth of skills reflects the individual's willingness and ability to collaborate across industries, sectors and disciplines. Its depth, on the other hand, refers to the level of expertise of industry-related and sectoral skills and knowledge that the individual possesses.The H-shaped model aims to keep the individual at the heart of all activities and acknowledges the inherent advantage of actively engaging him/her in a continual learning process.

It is closely aligned with lifelong learning, which encourages individuals to continuously acquire new skills. The ultimate aim of this effort is to bridge the ever-growing skills gap that currently affects all industries and sectors.

New education models need to be developed that will facilitate lifelong learning and meet market needs. Industry and academia need to work closely together to design training programmes that provide participants with the technical and soft skills they will need to compete in the labour market. By identifying important skills for the future and raising awareness of them, political leaders will be able to align their national skills curricula to industry needs and develop comprehensive sustainable education programmes. National skills gaps will subsequently decrease, supporting the realization of SDG 4 (quality education) and SDG 8 (decent work and economic growth).

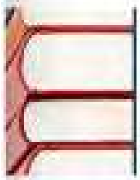
Figure 1.12: The H-shaped skills model

Source: Probst and Schaff, 2015.

1.4 Knowledge dimensions

Both future skills and emerging technologies are expected to reinforce the three pillars of sustainable development (i.e. economic, social and environmental) on which the SDGs are built, thereby helping to create a better future.

To fully benefit from this opportunity, investments in the five key dimensions will be necessary, in line with the findings of the Global Knowledge Index. The successful implementation of innovative knowledge societies requires active collaboration between all stakeholders, i.e. policymakers, scientists, academics and industry experts in the following areas.



Education

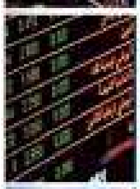
at its pre-university, technical, vocational and higher education levels, particularly focusing on the quality of education institutions and training programmes that target new technologies and address the current skills mismatch.

Research, development and innovation (RDI) and science

analysing available research infrastructures as well as the skills/knowledge of researchers and businesses to drive the development of new technologies and future skills.

Technology

delivering the technological infrastructure and ICT necessary for knowledge exchange and facilitating the development of new technologies and teaching methods.



Economy

focusing on the financial resources needed to deploy new technologies, drive innovation and support the development of new educational programs that align with the future of work.

Enabling environment

addresses the governance frameworks, policy protocols and regulations required to create an environment conducive to innovation and entrepreneurship.

GLOBAL KNOWLEDGE INDEX

The Global Knowledge Index (GKI)[53] is a roadmap for the sustainable development of societies. It helps countries formulate forward-thinking strategies to support knowledge and promote it as a main component in building a stronger knowledge economy while ensuring sustainable development.

The GKI aims to measure knowledge as a broad concept that intricately relates to all aspects of modern human life, in a systematic approach that builds on solid conceptual and methodological principles. It comprises seven sectoral indices covering: pre-university education; technical and vocational education and training (TVET); higher education; research, development and innovation (RDI); information and communications technology (ICT); economy; and general enabling environment.

The structure of the GKI reflects the many dimensions of knowledge. It proceeds from the assumption that the more these sectors interact with each other and are integrated in a given country, the greater the level of knowledge in a country. This virtuous cycle renders a nation more capable of achieving sustainable human development.

ENDNOTES

[1] De Nederlandsche Bank, 2018.
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[3] World Economic Forum, 2015.
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[18] See: https://www-03.ibm.com/services/weblectures/dlv/Gate.wss?handler=Default&sequence=1 customer=meap&offering=meai&language=en&action=index&from=top_navigation.
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[43] United Nations Development Programme, n.d.
[44] See: https://innovation.wfp.org/project/building-blocks
[45] United Nations Framework Convention on Climate Change, 2018.
[46] World Economic Forum, 2019d.
[47] World Economic Forum, 2016.
[48] Reuters, 2019.

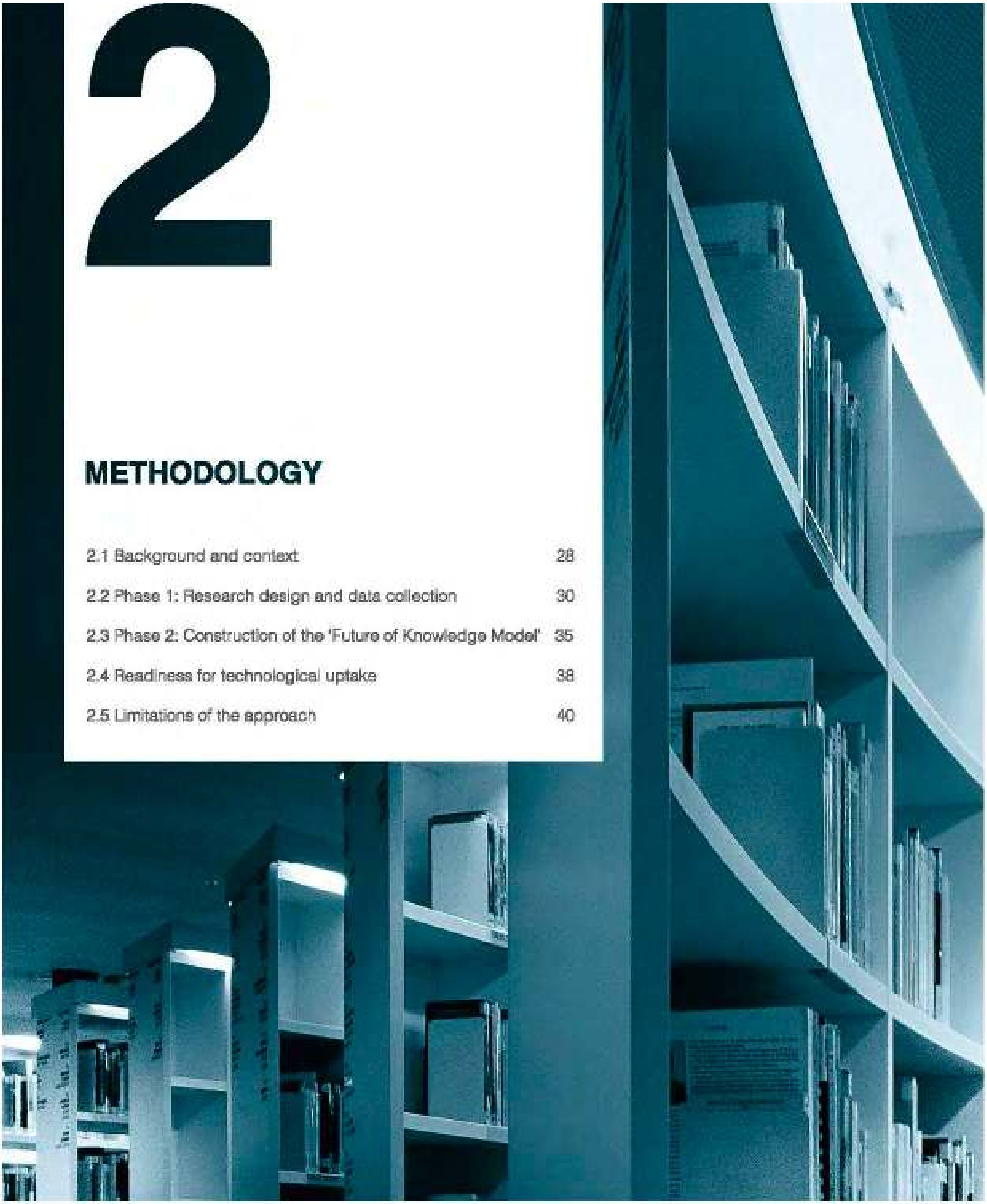
[49] The Biotechnology Innovation Organization defines synthetic biology as "a new interdisciplinary area that involves the application of engineering principles to biology. It aims at the re-design an fabrication of biological components and systems that do not already exist in the natural world. Synthetic biology combines chemical synthesis of DNA with growing knowledge of genomics to e able researchers to quickly manufacture catalogued DNA sequences and assemble them into new genomes." See: Biotechnology Innovation Organization, 2019.

[50] Reuters, 2019.

[51] World Economic Forum, 2019a.

[52] Evans Data Corporation, 2019.

[53] United Nations Development Programme and Mohammed Bin Rashid Al Maktoum Knowledge Foundation, 2017.



2

METHODOLOGY

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2 METHODOLOGY

2.1 Background and context

2.1.1 Knowledge: key factor in development

Knowledge growth is a key determinant of economic growth. It is directly related to technological adoption, which itself has a positive impact on productivity and therefore also on economic growth. At an aggregate level, economies that display higher productivity make better use of labour, capital and intermediate production inputs to produce wealth.

Technological uptake affects wealth creation through changes in market structure (competition) as well as in the labour (skills and leisure) and capital markets (competition for resources). In order to guide countries towards effective technological uptake, we devised a metric that allows fine-tuning of individual country analyses. This metric combines online and social media analytics with traditional statistics to capture variations in technological awareness across countries and time. It also provides a robust estimate of each country's current awareness of the need for technological uptake.

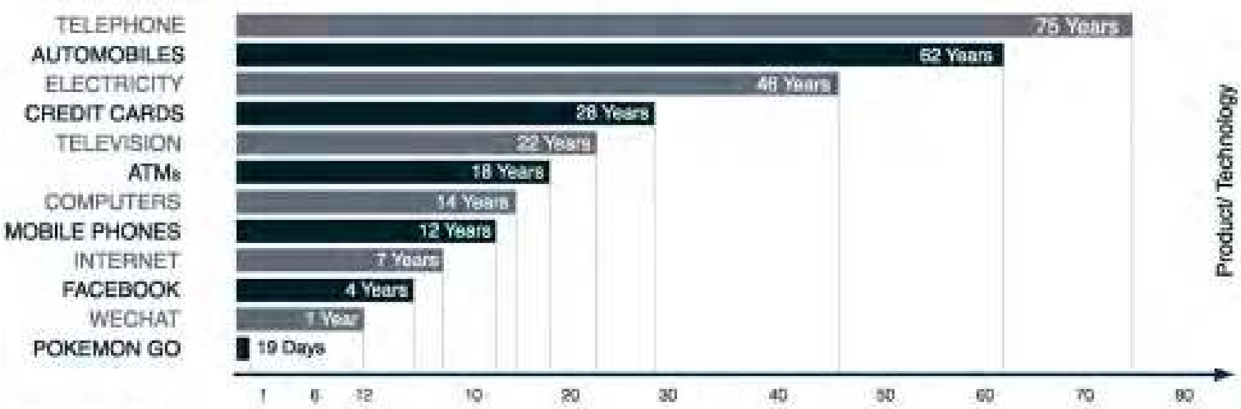
The practical value of this new knowledge metric is that it provides a robust and up-to-date estimate of the current availability of the technological awareness and infrastructure necessary for technological uptake at country level. It therefore serves as a fourth industrial revolution (4IR) roadmap for the development of suitable industrial policy that encourages knowledge-based sustainable development.

2.1.2 Measuring knowledge infrastructure

While knowledge is essential to development, its quantification in a way that allows for comparisons across particular countries and timeframes is exceedingly difficult. Examples of this endeavour include the Knowledge Economy Index (KEI) produced based on the World Bank's Knowledge Assessment Methodology (KAM)[1] and the Global Knowledge Index (GKI).[2] These indices use traditional statistics to measure differences across countries and time in terms of education, R&D and innovation, information and communications technology (ICT) and economy. This traditional approach to measuring 'knowledge performance' is extremely valuable, as it focuses on uptake, infrastructure and investment. Now that the KEI and KAM have been discontinued, the GKI is the sole index measuring knowledge at the global level.

Statistics concerning knowledge infrastructure often lag real world events by one to two years, while in some regions they are simply non-existent. In the current digital era, this is a significant barrier to effective, research-led policy development when knowledge creation and technological uptake occur extremely quickly.

Figure 2.1: Time to reach 50 million users for new technologies



Source: Davis, 2016

In order to support countries in their efforts to better channel resources towards effective technological uptake, there is a need for a new metric that allows for fine tuning forward-looking policies on the selected technologies and their relevant dimensions.

2.1.3 Alternative metrics based on big data

The rise of big data and the advent of web technologies and machine learning create new possibilities for the quantification of concepts in terms of their content and measurement frequency, technological awareness and real-time data collection. While traditional database systems support structured and repeatable analyses around structured data – and are unable to process massive amounts of data – big data offers the opportunity to handle vast amounts of unstructured data from a wide array of sources, and therefore to carry out iterative and exploratory analyses of those data. In addition, the use of web scrapping techniques allows the extraction of relevant information from vast amounts of data available online.

In the past few years, alternative metrics – also known as 'altmetrics' – have been increasingly used for impact assessments and to guide decision-making in the best interests of society. Altmetrics complement traditional evaluation metrics and build upon the growing use of publicly available information through webometrics.[3] Concurrently, the use of altmetrics for evaluation has evolved from expert-centric models to wider peer review models, thereby introducing societal inputs to the evaluation process. Companies, industry associations, social media users, bloggers and private individuals are therefore becoming the authors of information through their online presence and activity.

In line with those developments, the European Commission (EC) appointed an expert group on Altmetrics to assess the use of alternative metrics for impact assessment (applied to the impact of science and innovation) and to formulate recommendations for their future use. The group's final report *Next-generation metrics: Responsible metrics and evaluation for open science*,[4] lays the groundwork for the use of alternative metrics to complement traditional metrics in impact evaluation. More recently, another EC Expert Group (Indicators for Researchers' Engagement with Open Science and its Impacts[5]) issued policy recommendations for open science, including alternative metrics. In this context, PwC, on behalf of the European Commission, implemented the use of alternative metrics for evaluation under the prominent *Digital Transformation Scoreboard 2018*,[6] wherein the 'Digital Pulse' aimed to use media analytics to assess the uptake of 'Industry 4.0' technologies.

2.1.4 Future field awareness indices to complement the Global Knowledge Index

The 2018 Future of Knowledge Report furthered the understanding of knowledge performance quantification and constituted a new knowledge measurement tool, building upon the latest, state-of-the-art developments and based on real-time metrics to capture both strong and weak signals. This, in turn, revealed a clear distinction between technological awareness and technological readiness.

While the Global Knowledge Index assesses knowledge infrastructure through a stand-alone metric, future field awareness indices explore technological awareness through a knowledge metric that uses web and social media analytics together with traditional statistics to capture variations in technological awareness across countries and time. The future field awareness indices therefore complement the Global Knowledge Index by providing a robust and up-to-date estimate of the present situation at country level in terms of the availability of the technological awareness necessary for technological uptake.

Together, the Global Knowledge Index – as an infrastructure metric – and the future field awareness indices measure a country's technological readiness for technology adoption and capture how welcoming – or not – the environment is to technology adoption, therefore presenting a more complete and timely view of technological uptake.

In producing this metric, our base assumption is as follows: given a certain level of knowledge infrastructure, societies with a greater degree of technological awareness exhibit greater knowledge readiness. Technological awareness positively affects technological uptake by increasing the likelihood that individuals will embrace upskilling and will not view new technology as risky or disruptive. It also increases the importance that people attribute to living in an environment that is receptive to knowledge creation and technological uptake. These factors make technological adoption a more smooth and swift process and act as incentives for governments to design and implement innovation-friendly policies.

By assessing readiness, the Global Knowledge Index and the future field awareness indices can serve as a 4IR roadmap for the development of an industrial policy that targets technological uptake through two channels: infrastructure availability and attitudes towards technological adoption. In addition, an enhanced industrial policy can guide policymakers in achieving knowledge-based sustainable development.

2.2 Phase 1: Research design and data collection

2.2.1 Defining a rationale for using online social media metrics to measure knowledge development

We selected two types of metrics commonly used in social monitoring and listening to measure knowledge awareness:

The number of mentions of a specific topic (i.e. number of times a specific set of keywords assumed to define a specific topic are mentioned online);

The level of engagement on a specific topic (i.e. number of times an online publication has been forwarded, shared or commented on).

Our rationale for selecting these metrics stems from the process of knowledge creation itself. According to Nonaka's SECI model for knowledge creation,[7] new knowledge is created through the conversion of existing knowledge. Nevertheless, existing knowledge can only be transformed into new knowledge when two interrelated processes take place:

- **socialization,** which allows the sharing of tacit knowledge between individuals based on interactions, experiences and observations; and
- **combination,** which involves the conversion of explicit knowledge into more complex sets of explicit knowledge, depending on the existence of knowledge communication and diffusion processes.

The extent of socialization, the intensity of communication and the rate of dissemination of explicit knowledge occurring within a community can all act as proxies for that community's capacity for future knowledge creation.

In an innovative attempt to quantify these key processes for knowledge creation, this study uses the number of mentions and the level of engagement as representative measures of the current, real-time knowledge socialization, communication and dissemination within a country.

We extrapolated each country's potential for technology adoption by analysing the web data collected for these metrics around critical future fields.

This report focuses on mentions and engagement concerning a specific topic. While we are in a position to capture information on the sentiment surrounding a specific mention (i.e. overall attitude associated with the context in which a specific set of keywords appears, which can be either positive, neutral or negative), we choose not to take it under consideration in the quantification of country-specific index scores. Future research will work towards improving the consistency of the sentiment identification strategy before we incorporate the metric into the index.

2.2.2 Data collection using a social listening tool

In order to collect web data, we needed a social listening tool that can search public web pages and social media sites across the globe and in a wide variety of languages.

We chose the Digital Intelligence Platform (DIP) to collect data from 150 million public sources in over 180 languages. The DIP uses keywords and Boolean operators, as well as advanced analytics with artificial intelligence (AI) capabilities to extract the most relevant data. It also uses a machine learning algorithm to compute key metrics such as audience engagement and mentions, including the total number of audience interactions with a page/post, i.e. likes, shares, retweets and comments, and sentiment analysis (positive, negative or neutral).

2.2.2.1 Defining research scope

Countries

Forty countries were selected for study based on their rankings on the Global Knowledge Index 2019, and the DIP was used to retrieve, extract and analyse data on each. The 40 countries were clustered in four groups based on their GKI performance, using an unsupervised machine learning method called clustering; more specifically, the K-means clustering technique was employed, which aims to partition n observations (one for each country) into k clusters, minimizing within-cluster variances (squared Euclidean distances). Based on the variance of the countries' GKI 2019 results, we observed k=4 to be an optimal choice for the number of clusters (using the standard elbow method).

Table 2.1: Country clusters by GKI performance

LEADERS	STRONG	MODERATE	MODEST
Australia	Brazil	Egypt	Bangladesh
Finland	Chile	Ghana	Cameroon
France	Greece	India	Ethiopia
Germany	Kazakhstan	Indonesia	Senegal
Japan	Kuwait	Jordan	Tajikistan
Luxembourg	Malaysia	Lebanon	
Netherlands	Mexico	Morocco	
Singapore	Poland	Rwanda	
Sweden	Russian Federation	South Africa	
Switzerland	Saudi Arabia	Tanzia (United Republic of)	
United Arab Emirates	Viet Nam	Turkey	
United Kingdom			
United States			

To preserve comparability across the versions of the Future of Knowledge Model, we kept the 20 countries included in the previous version of the pilot study and used cluster analysis to select 20 new countries. More specifically, we grouped the countries in the GKI into clusters of similar knowledge performance to ensure that the report is meaningful for all countries – including those that were not selected.

After creating the groups, we selected target countries either through randomization, the establishment of a statistical rule or consultation with experts. This process yielded a representative and informative sample for a global analysis of knowledge performance.

Sources

We used the DIP to collect and analyse data from over 150 million public sources. The majority of results came from Twitter, followed by online news.

Instagram is not included in this analysis, because the platform returned higher levels of irrelevant results compared to the other sources. Additionally, Instagram content is mainly visual (images and illustrations) and thus very different from the other web sources (news sites, blogs, Twitter), that comprise mainly text content.

The total proportion of results found for each media type by country is presented below.

Table 2.2: Proportion of media by country

Media/ country	Online news	Newspaper	Magazine	Blogs	Forums	Twitter	Other
Australia	19.44%	1.06%	0.14%	6.34%	0.17%	72.74%	0.12%
Bangladesh	3.77%	0.28%	0.00%	2.13%	0.01%	93.79%	0.01%
Brazil	18.80%	3.18%	0.69%	29.06%	0.93%	46.46%	0.88%
Cameroon	3.76%	0.00%	0.00%	29.07%	0.05%	67.07%	0.05%
Chile	8.16%	2.97%	0.70%	14.20%	0.90%	72.62%	0.46%
Egypt	24.91%	0.00%	0.13%	20.67%	4.50%	49.66%	0.13%
Ethiopia	6.91%	0.00%	0.00%	21.13%	0.00%	71.93%	0.03%
Finland	11.71%	3.66%	1.35%	9.17%	1.32%	71.93%	0.86%
France	11.99%	1.54%	1.34%	12.67%	1.16%	69.30%	1.99%
Germany	28.29%	4.69%	1.90%	15.02%	10.01%	34.11%	5.99%
Ghana	9.54%	1.07%	0.00%	5.59%	0.00%	83.80%	0.00%
Greece	25.57%	1.80%	1.46%	42.42%	0.61%	27.76%	0.37%
India	17.26%	3.55%	0.10%	11.85%	0.23%	66.52%	0.50%
Indonesia	9.27%	0.46%	0.02%	13.16%	1.33%	75.35%	0.40%
Japan	14.96%	0.16%	0.05%	16.11%	1.43%	67.22%	0.06%

Jordan	52.14%	1.28%	0.00%	3.07%	0.00%	43.43%	0.09%
Kazakhstan	26.07%	0.00%	0.03%	8.93%	1.47%	63.50%	0.00%
Kuwait	14.34%	0.00%	0.00%	5.30%	0.01%	79.95%	0.40%
Lebanon	18.34%	0.13%	0.00%	4.94%	0.00%	74.92%	1.68%
Luxembourg	13.34%	2.13%	3.88%	4.78%	0.00%	75.29%	0.57%
Malaysia	7.61%	2.48%	0.52%	14.76%	1.90%	71.95%	0.79%
Mexico	16.64%	2.09%	0.29%	19.78%	0.13%	60.76%	0.10%
Morocco	37.95%	3.16%	0.75%	16.65%	0.64%	40.31%	0.55%
Netherlands	16.33%	0.37%	0.72%	22.21%	1.40%	58.60%	0.37%
Poland	57.23%	1.75%	0.95%	18.78%	4.19%	15.11%	1.99%
Russian Federation	23.60%	0.64%	0.12%	20.24%	3.86%	50.07%	1.48%
Rwanda	6.83%	0.00%	0.00%	4.20%	0.00%	88.97%	0.00%
Saudi Arabia	23.22%	0.56%	0.03%	7.20%	3.57%	65.25%	0.16%
Senegal	27.38%	2.30%	0.00%	10.93%	0.00%	59.19%	0.20%
Singapore	20.14%	0.97%	0.29%	6.61%	0.46%	70.81%	0.73%
South Africa	11.03%	0.59%	0.13%	7.61%	1.85%	78.62%	0.17%
Sweden	18.58%	5.86%	1.39%	15.02%	0.78%	57.95%	0.41%
Switzerland	18.18%	2.70%	0.79%	4.53%	6.09%	67.03%	0.69%
Tajikistan	24.31%	0.00%	0.00%	17.25%	0.00%	58.44%	0.00%
Tanzania (United Republic of)	5.78%	1.15%	0.00%	6.66%	0.64%	85.77%	0.00%
Turkey	22.45%	1.87%	0.63%	6.81%	0.57%	66.96%	0.70%
United Arab Emirates	18.50%	1.36%	0.41%	8.70%	0.08%	63.92%	7.03%
United Kingdom	9.83%	5.50%	1.16%	6.58%	0.69%	75.02%	1.23%
United States	12.27%	0.43%	0.87%	13.39%	5.86%	65.53%	1.65%
Viet Nam	38.77%	3.79%	0.11%	27.55%	4.86%	23.81%	1.10%

Time period

The DIP extracted two years' worth of data for each country. All data was published online between 18 September 2017 00:00:00 GMT+1 and 15 September 2019 23:59:59 GMT+1.

2.2.2.2 Definitions of 'queries' to retrieve pertinent and coherent real-time data within the scope of the study

Queries are requests for information from a database written in a specialized language, which in this case involves using Boolean operators. We used a similar approach as in 2018 version of The Future of Knowledge: A Foresight Report, to build efficient queries by carefully defining keywords, designing and translating the queries.

Keyword definition

We used an iterative review and validation process to define the keywords used to retrieve data from the DIP.

The first step was to define a set of English keywords for each future field of knowledge (artificial intelligence, cybersecurity, biotechnology, blockchain and future skills) and for each knowledge dimension (education, RDI and science, technology, economy and enabling environment) identified in Chapter 1. We based this on a review of literature, articles and social media posts, as well as input from experts with experience in using the platform.

Following this, we held a workshop with technology, education and development experts to refine and elaborate on the initial list. In addition, we commissioned a linguistic expert to review and test the edited list in order to increase the relevancy of the results and reduce the amount of 'noise' to a minimum. During the final review, we removed problematic keywords but also created a set of exclusion keywords, which helped to reduce unwanted results.

For instance, the initial keywords selected for the education dimension included 'course', 'e-learning','seminar','webinar','curriculum','hackathon','codingcamp','programmingcamp'and'training'. However, upon inspection of the results, we removed 'training' due to the high amount of irrelevant results related to training and machine learning, e.g. training a model, training data. We also discovered several cases of irrelevant results due to the multiple definitions of 'course' in English. In this case, the keyword remained in the query, but false positives were added to the exclusion list in order to avoid retrieving results with unwanted meanings, e.g. 'of course', 'golf course' and 'course of treatment'.

Query design

Once the keywords were validated, we constructed queries using special Boolean operators. These operators allow a higher probability of relatedness between two sets of keywords and thus a higher likelihood for the result to be relevant to the dimension.

In this case, they stipulated that a set of keywords must appear within a certain defined number of words from another set of keywords, i.e. that certain keywords must be near certain others. More specifically, the future field keywords were connected to the knowledge dimension keywords at a distance of ten words or less.

The final portion of the query was the geo-localization operator, which restricted the results to items originating from defined countries or regions. The platform determined location based on the metadata available for the result, according to the following hierarchy:

1. the geolocation of the article/post, if enabled by the user;
2. the location found within the contact/profile section (e.g. a company address or a Twitter profile's selected location); and
3. the IP address if the item originated on a news site or website, or the posting language if the source was a social media platform. For the latter, the item was assigned to the country with the most speakers of that language, e.g. if English and unknown, it was tagged as the United States.

In addition, the English language query had all 40 country filters applied to it, i.e. any matching results in English from any of the 40 countries were retrieved. For queries in languages other than English, geo-localization was applied only to countries with that language as an official language. For example, the German language query was appended only with the country filters for Germany and Switzerland.

Query translation

Following the validation of the English queries, they were translated into 22 languages corresponding to the 40 selected countries. In cases of multiple official languages within a country, we conducted an assessment of online social media to exclude languages not used by Internet users. The translations were performed by a professional agency and the 22 languages are listed below:

1. Arabic
2. Bengali
3. Dutch
4. Finnish
5. French
6. German
7. Greek
8. Hindi
9. Indonesian
10. Japanese
11. Kinyarwanda
12. Malay
13. Mandarin
14. Polish
15. Portuguese
16. Russian
17. Spanish
18. Swahili
19. Swedish
20. Tajiki
21. Turkish
22. Vietnamese

2.3 Phase 2: Construction of the 'Future of Knowledge Model'

To illustrate the 'Future of Knowledge Model', we aggregated the raw data across two axes and created a series of indices, as illustrated below.

Figure 2.2: Structure of the Future of Knowledge Model

We first created five future field awareness indices corresponding to the five future fields of knowledge:

- four technology awareness indices, corresponding to the four key technologies for the future i.e. AI, cybersecurity, blockchain and biotechnology; and
- the Future Skills Awareness Index.

To create these indices, we aggregated the raw data vertically (across knowledge dimensions), as shown in the Figure 2.2. We calculated these indices separately for each of the 40 countries.

Similarly, we aggregated the data horizontally, across all four technologies for the future, in order to create an index for each of the five knowledge dimensions (education, RDI and science, technology, economy and enabling environment).

In addition, we constructed the 'Global Technology Awareness Index' (GTAI) in order to portray the overall performance of each country across the four technology awareness dimensions.

To calculate the indices, we first aggregated the raw data (mentions and engagement), as per the level of aggregation defined by the index, and then built the index itself.

2.3.1 The structure of the model

Future field awareness indices

To construct each of the five future field awareness indices i, we followed the same approach as for the GTAI. The score for country j is based on the aggregation of the raw data across the five substitutable knowledge dimensions of equal importance ({education, RDI and science, technology, economy and enabling environment}) and determines the performance of the country within each one of the five indices.

$$\text{Future Fields Awareness Index}_{i,j} = \sum\nolimits_{k} \text{Knowledge dimension}_{k,i,j}$$

Each composite index is the result of a linear combination of two types of social media metrics: the number of mentions and the level of engagement. Section 2.2.2 discusses in detail how we moved from raw data to the aggregation stage for the construction of the composite indices.

Global Technology Awareness Index

The Global Technology Awareness Index (GTAI) is a composite index that refers to the four technology awareness indices that are conceptually different to the Future Skills Awareness Index; together they compose the technology awareness (sub-)dimension. We derived the ranking of each country, j, by aggregating the raw data and computing a score for all four technologies ({AI, blockchain, biotechnology and cybersecurity}). This form of ranking shows that we treat the components of the GTAI as substitutable and of equal importance. This means that, for instance, a deficit in AI can be compensated for by a surplus in blockchain.

$$\text{GTAI}_{j} = \sum\nolimits_{i} \text{Technology}_{i,j}$$

2.3.2 Calculation of composite indices

The Future of Knowledge Model has a hierarchy of four levels: the Global Technology Awareness Index, the future field awareness indices, and the knowledge dimension indicators and variables.

We selected two key social metrics: the number of mentions and the level of engagement. Data were retrieved for each of these metrics from a variety of online sources, taking into account the desired relationship between each future field and each knowledge dimension. The combination of two metrics for each of the 25 possible relationships between future fields and knowledge dimensions (5X5), for each of the 104 weeks of the study period and for 40 countries, resulted in 208,000 measures.

In order to calculate the composite index in any level of aggregation – and to allow comparisons across countries – we used a formula in which the two composites (mentions and engagement) are first standardized, then normalized and finally linearly combined.

First, we standardized the number of mentions by dividing them by the number of Internet users, which we derived from the data included in Table 2, to calculate the 'mention density'.

$$\text{Mention density} = \frac{\text{mentions}}{\text{Internet users}} * 1{,}000{,}000$$

Similarly, to compare different levels of engagement, we standardized engagement by dividing total engagement by the number of mentions for each country to compute the 'engagement density'.

$$\text{Engagement density} = \frac{\text{engagement}}{\text{mentions}}$$

Based on this, we calculated each composite index as follows:

$$\text{Composite index} = \frac{V1 + V2}{2}$$

V1 is the normalized value of mention density and V2 is the normalized value of engagement density.

The formula to calculate the normalized values of mention density and engagement density is a standard min–max normalization that is commonly used in calculating composite indices:

$$\text{Normalized value} = \frac{\text{Actual value - Min value}}{\text{Max value - Min value}} \times 100$$

The nature of the calculation of the composite indices results in a score in the range of 0 to 100.

It is necessary to note that the results are sensitive to the standardization and normalization procedures. However, there are reasons why they must be performed. Standardization helps to remove the effect of more mentions in countries with larger populations and to remove the effect of more engagement due to a higher number of mentions. Normalization is necessary because mention density and engagement density are in different scales: it removes the scale effect and enables the linear combination of the two variables comprising the indices.

According to the above calculations, a score of 0 means that both the mention density and the engagement density are the lowest for a specific knowledge dimension, future field or country. Conversely, a score of 100 means that both the mention density and the engagement density are the highest for future field or country.

2.4 Readiness for technological uptake

With the introduction of a readiness metric, the 2019 Future of Knowledge Report combines two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and technological awareness.

We propose a readiness metric to compare countries' receptiveness to adopt key technologies for the future. To highlight the comparative nature of the concept, we use a star system to rank country performance within groups of varying readiness for technological uptake: one star represents the least welcoming environment, and five stars the most welcoming.

To understand readiness, we calculate the relative performance of knowledge infrastructure (GKI sectorial scores), technological awareness and future skills awareness. We then compute the varying levels of readiness using quintiles within each index and knowledge dimension combination, thus subdividing country scores in five buckets (0–20%, 20–40%, 40–60%, 60–80%, 80–100%).

This metric allows for comparisons across time only in comparative terms, not in absolute terms. The performance level intervals may change from year to year, based on the degree of difference in technological uptake across the sampled countries.

Table 2.3: Internet users

Country	Year	Share of Internet users (% of total population) *	Total population#
Australia	2017	86.54504885	19,897,604
Bangladesh	2017	15	101,056,816
Brazil	2017	67.47128452	207,833,825
Cameroon	2017	23.20297197	24,566,070
Chile	2017	82.32748693	14,771,892
Egypt	2018	46.92433809	98,423,602
Ethiopia	2017	18.61805145	106,399,926
Finland	2018	88.88996	5,522,585

France	2018	82.04353422	64,990,512
Germany	2018	89.73912104	83,124,413
Ghana	2017	39	15,433,202
Greece	2018	72.9520942	10,522,244
India	2017	34.45	1,338,676,779
Indonesia	2018	39.78748305	267,670,549
Japan	2017	84.58806583	127,502,728
Jordan	2017	66.79031443	9,785,840
Kazakhstan	2018	78.90391906	18,319,616
Kuwait	2018	99.59999254	4,137,314
Lebanon	2017	78.18077489	6,819,373
Luxembourg	2018	97.06129871	604,244
Malaysia	2018	81.20170665	31,528,033
Mexico	2018	65.77263448	126,190,782
Morocco	2018	64.80386519	36,029,089
Netherlands	2018	94.71207372	17,059,560
Poland	2018	77.54173454	37,921,585
Russian Federation	2018	80.86472186	145,734,034
Rwanda	2017	21.76763262	11,980,960
Saudi Arabia	2018	93.31000185	33,702,757
Senegal	2017	46	7,286,505
Singapore	2018	88.16563603	5,757,503
South Africa	2017	56.16739447	57,009,751
Sweden	2018	92.14167705	9,971,630
Switzerland	2017	89.68614767	8,455,797
Tajikistan	2017	21.96	8,880,270
Tanzania (United Republic of)	2017	25	25,171,438
Turkey	2018	71.04276107	82,340,090
United Arab Emirates	2018	98.45000178	9,630,966
United Kingdom	2018	94.89674176	67,141,678
United States	2017	87.26611282	326,084,758
Viet Nam	2018	70.34963558	95,545,959

*Source: *International Telecommunication Union, 2019.*

#United Nations Department of Economic and Social Affairs, 2019

2.5 Limitations of the approach

The 2018 Future of Knowledge: A Foresight Report deployed a specific methodology for the observation of technological awareness. Like any methodology, it incorporates a number of limitations. We do not believe that these are detrimental to the validity of the current results, nor will they hinder future updates to the index. This section details the various instances that may threaten the validity of the methodological approach.

Events unrelated to technology

Major events unrelated to technology uptake will indistinctively drive online activity within a country. For example, while the spike in the price of bitcoin (and other cryptocurrencies) had an important effect on global online discussions in 2018, the announcement by Facebook of the launch of the Libra in June 2019 generated heightened attention for cryptocurrencies and therefore a more frequent use of the blockchain vocabulary in online discussions worldwide. The topic also generated longer-term online activity as partners of the project dropped out[8] and both governments and legislators ramped up their criticism against this project of a stable digital money.[9]

Following the entry into force of the General Data Protection Regulation (GDPR) on 25 May 2018, discussions relating to the implementation of the GDPR, the fines issued by national data protection authorities for non-compliance with the regulation[10] and the responsibility of social networks to uphold data privacy[11] greatly impacted online discussions taking place in the European Union. The topic also generated online activity outside the European Union with the adoption in California of the Consumer Privacy Act – the most comprehensive consumer data privacy regulation in the country.[12]

While those events generated a heightened level of activity, this does not directly imply technology adoption.

Elections and teacher shortages

Depending on the sampling period, the online activity for certain countries may be driven upwards due to specific situations and therefore inflate results above their real value. For example, elections, both national and local, and teacher shortages can introduce a bias in the score of a country by inflating the results of the country for a given period.

Several countries in all regions and clusters experienced a pre-election period between September 2018 and September 2019, including Brazil, Cameroon, the European Union as a whole, Rwanda and Russia. This drove the online activity upwards for the concerned countries, while it tended to drop after elections.[13]

Similarly, some of the countries in our sample have faced important debates on teacher shortages during the sampling period, including the Netherlands.[14] Turkey also faced issues in terms of teacher unemployment[15] and in Chile online activity has been sparked by teacher strikes.[16] The methodology rewards countries that have undergone a shortage in teachers and/or other related public debate on similar issues and solutions. However, in the absence of debate on teacher shortages, the methodology awards equal rank to countries unaware of such situations and countries that do not face the issue.

Limited Internet access

Limited access to the Internet also directly impacts the representativity of the results. For example, a sample ceases to be representative if only a small subgroup of the population can access the Internet.

This is the case in Bangladesh, where only 15 percent of the total population has access to the Internet,[17] which therefore does not constitute a representative sample of online activity. Moreover, Internet access is often a proxy of upper socio-economic status. Since the ranking methodology uses activity frequencies discounted by the size of the local online population, over-representation of individuals of upper socio-economic status is likely to bias results upwards. Similarly, a high degree of activity concentration amongst a small number of users will bias results upwards.

Biases in automatic geo-localization

The methodology does not consider the impact of 'monopoly power' users and the determination of author/site location. For instance, in the case of Singapore, it has been identified that the news site Reuters has 72 articles geo-located to Singapore that generate 29,000 instances of engagement (the site with the most engagement for Singapore; accounting for 16 percent of total likes/comments/retweets/shares).

We also find a similar incident in Morocco with Bloomberg's Facebook page, which has six relevant posts that have been geo-located to Morocco. Those six posts generate 14,600 instances of engagement, which accounts for 29 percent of the total engagement for the country.

Identifying the exact location of public web and social data is often difficult. The Digital Intelligence Platform runs through various criteria to determine the origin of a post or an article based on the information available (i.e. geo-coordinates when enabled on social media posts, profile location on social sites, contact details on business sites, domain and geo-IP for sites with no indication of location or geography).

Instances such as those above, in which larger top-tier internationally-oriented sites get geo-located to one country inaccurately, or sites that are categorized based on minimal information, may bias certain countries more than others, particularly in the cases of those countries that have more registered domains and/or host servers.

Data noise

Noise from linguistic idiosyncrasies also potentially inflates results upwards. However, there is little evidence of such in the sample that could be a challenge for text mining. The main linguistic challenge concerns future skills; as there is a high use frequency of relevant keywords in everyday discussions, this inflates the results for this field in all countries. However, the key metric is an index score that we interpret in comparative terms (ranking), so we expect this drawback to have little impact on the validity of the findings.

Press freedom

Press freedom has a dual effect on country results.

Suppression of freedom of speech leads to a reduced number of mentions and engagement, suggesting that individuals may not discuss technology/future skills adoption online. In this case, the methodology underestimates the true value of awareness, which is not reflected through online activity.

A low level of freedom of speech also impairs the quality of the information/ideas transmission mechanism, which is a central part of effective technological/future skills adoption and therefore can adversely affect this adoption and lower the level of awareness

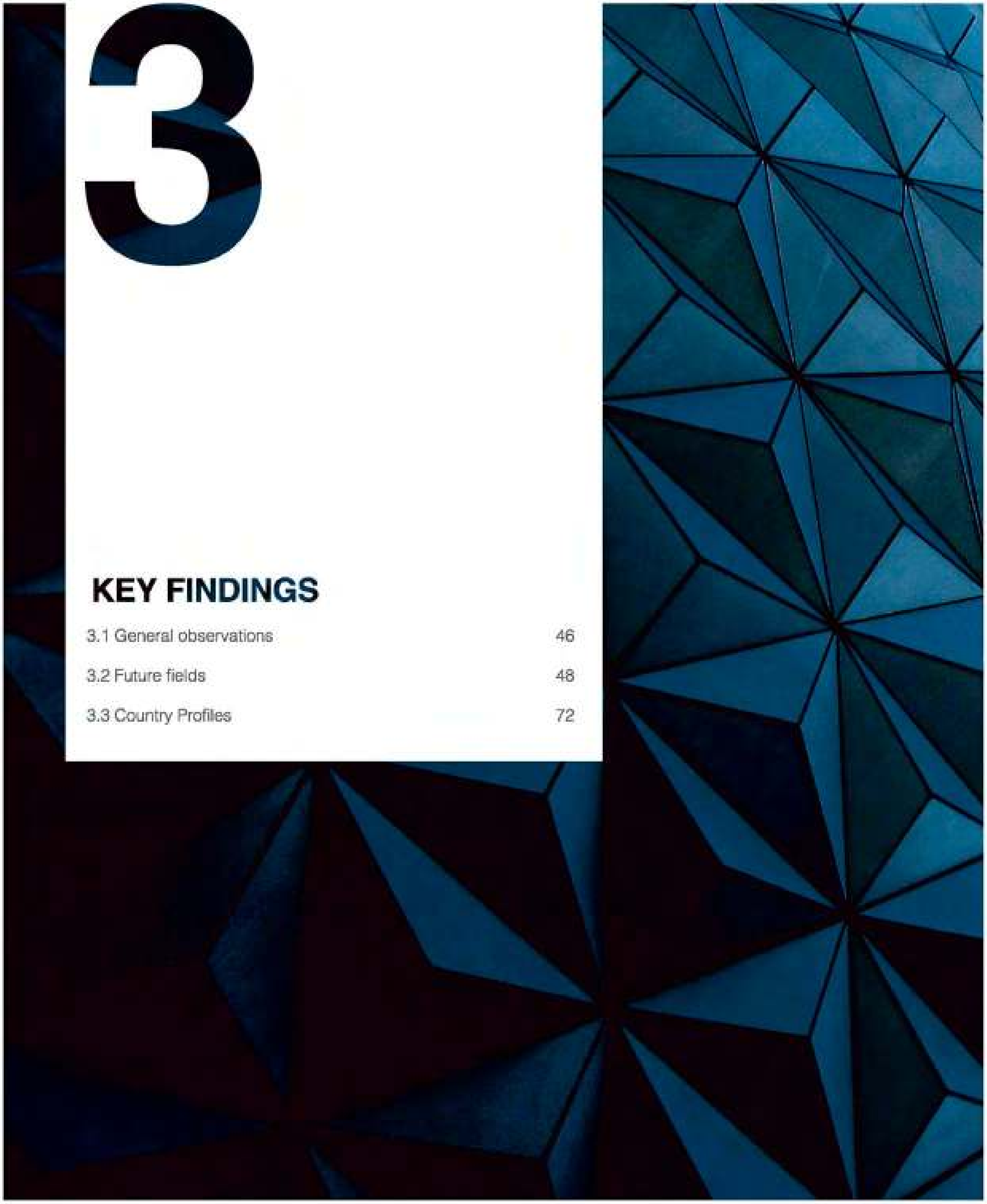
Other factors

To proceed to measuring awareness, we weighted all publication types equally. Neither the reach of the publications nor the influence and network centrality of the author were included in the analysis. Communication channels (e.g. blogs, newspapers, social media) were all addressed equally, while online activity was not captured through all existing media – as previously mentioned above, Instagram was not taken into account.

In terms of the definition of the sample size for online data collection, for the United States, a subsample of 15 percent of the data matching the queries was extrapolated to represent the whole-data results generated by the country.

ENDNOTES

[1] World Bank, n.d.
[2] See: http://knowledge4all.com/en/WorldMap.
[3] Examples of webometrics include simplistic counts and content analysis of web pages, counts and analyses of outgoing links from web pages or 'outlinks, and links pointing to web pages called 'inlinks', see Björneborn and Ingwersen, 2001.
[4] European Commission, 2017.
[5] European Commission, n.d.
[6] European Commission, 2018.
[7] Nonaka et al., 2000.
[8] Reichert and Morse, 2019.
[9] Wong, 2019.
[10] Cellan-Jones, 2019; for a tracker of the latest fines issued by National Protection Authorities, see: Enforcement Tracker, 2019.
[11] Berzinya, 2018 and Lonstein, 2019.
[12] Somers and Bogaert, 2018.
[13] Controversial figures such as Jair Bolsonaro may allow for a higher degree of persistence of the "election effect" on results.
[14] NOS, 2019.
[15] Hurriyet Daily News, 2018.
[16] De La Fuente, 2019.
[17] International Telecommunication Union, 2019.



3

KEY FINDINGS

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3 KEY FINDINGS

The methodology detailed in Chapter 2 generated millions of mentions and identified various levels of engagement that informed a multi-level analysis on future technology and skills awareness.

The first part of the observation period (September 2017 – September 2018) revealed that all 40 countries in the sample recognized the importance of embracing technological change and the need to support the development of associated skills amongst their citizens – raising the main challenge of the transformation of their education system.

According to the results of the Global Technology Awareness Index, Singapore, Mexico, Luxembourg, Switzerland and the United Kingdom are the countries best placed in terms of future technology awareness. Indeed, they appreciate the opportunities presented by technological advancement and maintain an active debate on the issue involving both public and private stakeholders.

These countries consider technology to be a driver of development and growth and have developed national initiatives to mobilize sectoral regulators (financial services, energy, telecoms), RDI institutions, the education sector and the economy through multiple, high-level conferences and innovative projects. They have also developed a general culture of understanding of new technologies and their adoption.

Most of the countries in the sample, however – even those with high GKI scores – have only raised limited awareness of the future technologies. This constitutes a significant weakness, given the potential impact of such technologies on the day-to-day life and society.

Meanwhile, the Future Skills Awareness Index revealed that societal debate about the future of the education system – including the role, remuneration and reward of teachers – accounts for the majority of debate. Online activity tends to suggest a crisis in this regard, rather than providing anticipatory strategic planning, while online activity concerning future skills as an impetus for, and reflection of, a country's positive transformation is still limited to high-performing countries such as Finland – which is the exception and role model in this field.

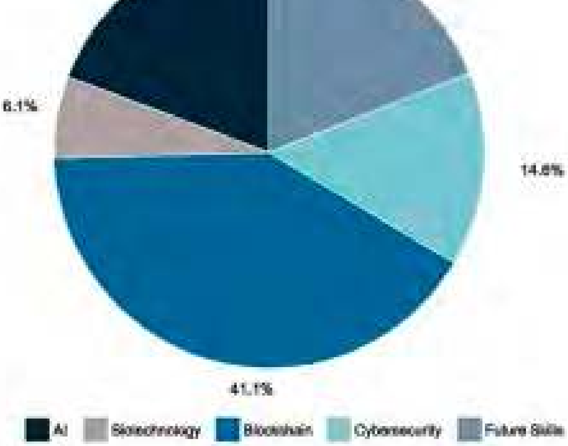
In Section 3.1, we first discuss the overall level of awareness of the five future fields in the countries sampled. We then separate these fields into two groups – technologies and skills – and investigate the level of awareness for each. Section 3.2 therefore adds depth to our two-level approach to awareness by examining comparative performance across countries to reveal how well a country is performing in terms of technological and future skills awareness in relation to others.

3.1 General observations

Most popular fields

A high-level analysis of mentions aggregated by future field for all 40 countries between 18 September 2017 and 15 September 2019 is presented in figure 3.1. Amongst the five future fields that this report investigates, blockchain accounted for 41.1 percent of relevant online discussions, while AI, future skills, cybersecurity and biotechnology accounted for 19.3 percent, 18.9 percent, 14.6 percent and 6.1 percent, respectively. These results are in line with recent trends in technological salience and the Gartner emerging technologies 'hype cycle'.

Figure 3.1: Online popularity of future fields



Comparison between countries

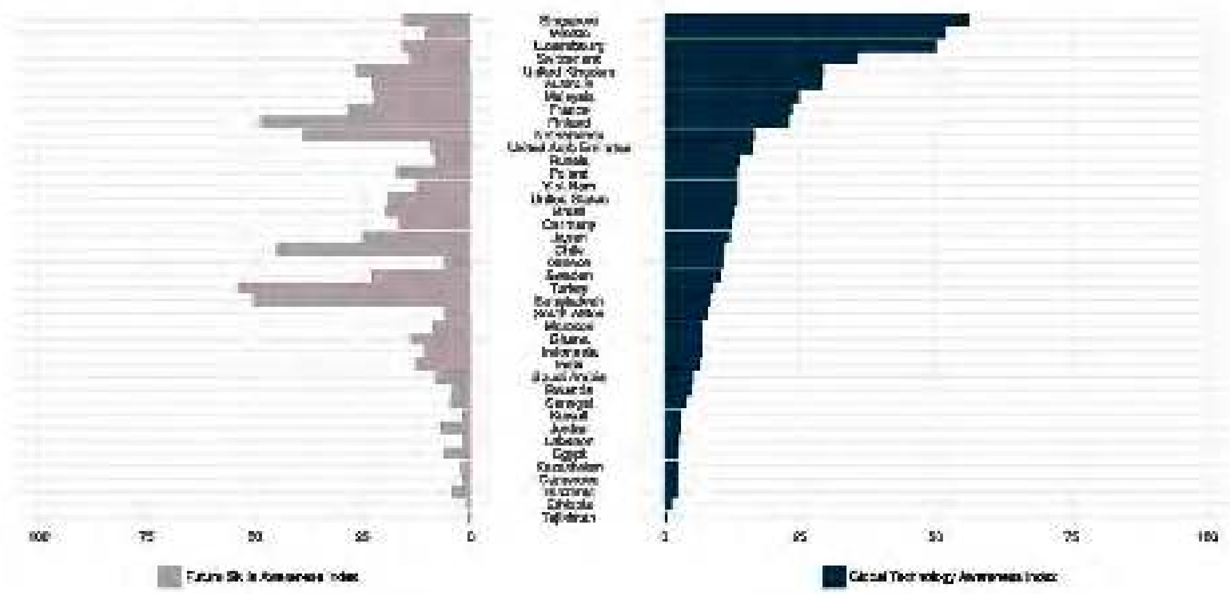
The Global Technology Awareness Index (GTAI) and the Future Skills Awareness Index are both appropriate indicators for the comparison of future awareness across countries. Figure 3.2 illustrates the scores on both indices.

An analysis of GTAI scores, aggregated over the period of observation for each of the 40 countries of interest, reveals clear differences in the prominence of emerging technologies in public debate. The scores are especially important for Singapore, Mexico, Luxembourg, Switzerland and the United Kingdom. Arab and African countries have the most distance to cover in terms of raising awareness and having experts/practitioners engage in online discussions. Tajikistan is the poorest performing country in our sample.

Analysis of the Future Skills Awareness Index scores across countries shows a significant concentration of scores in five countries: Turkey, Bangladesh, Finland, Chile and the Netherlands. A deeper analysis of online activity reveals that public debate on teacher shortages drives online activity upwards for Bangladesh and the Netherlands.

Finland stands out as a role model in this context, with its national forum for skills anticipation, 'Finland: Skills 2035',[1] raising national debate on the future skills requirements of Finnish society.

Figure 3.2: Future awareness across countries



**The discussions in Bangladesh, Turkey and Chile are fuelled by country-specific crises related to teachers' shortages and/or strikes.*

3.2. FUTURE FIELDS

ARTIFICIAL INTELLIGENCE (AI)

An analysis of AI Awareness Index scores – depicted in Figure 3.3 – identifies Luxembourg, Mexico, Singapore, Switzerland, the United Kingdom, France and Finland as the top performing countries, while the RDI and science dimension is the most discussed in the field. These countries have all developed national AI strategies that have been actively debated on the Internet.

A second group comprising Australia, the United Arab Emirates, the Netherlands, the United States, Japan and Sweden presents lower but nonetheless robust awareness levels.

Luxembourg leads the ranking, with RDI and science accounting for 53 percent of online discussions in the field, followed by enabling environment, which generated 28 percent of Luxembourg's online interaction in the field of AI.

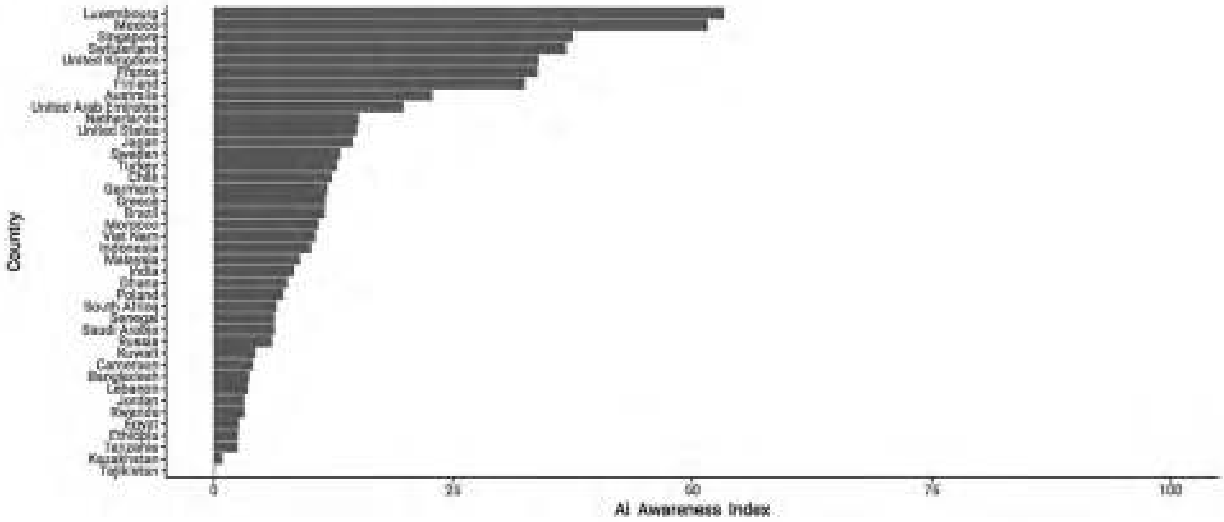
Luxembourg's online discussions on AI mostly related to the establishment of the national AI strategy based on a human-centric approach.[2] It also addressed ethical dimensions of AI and, more specifically, the launch by the European Commission of the pilot AI ethical guidelines, and how they might be developed and implemented in practice.[3]

In Mexico, the development of a national AI strategy, and the creation by researchers from Samsung's AI Centre in Moscow of a new system that can transform still facial images into video sequences of the human face making speech expressions,[4] captured the attention of Internet users. The first ever visualization of a black hole – the product of an algorithm created by Dr. Katie Bouman, a 29-year-old computer scientist, assisted by a team from MIT's Computer Science and Artificial Intelligence Laboratory[5] – also generated significant online activity.

The results of the AI Awareness Index largely reflect recent events, such as the launch of 'AI Singapore' (Singapore's national AI programme) in late August 2017. This led to the launch of a series of associated initiatives including, amongst others, the formation of an AI ethics advisory council and two programmes – AI for Everyone (AI4E)[6] and AI for Industry (AI4I)[7] – to showcase the utility of AI advances to a wider range of Singaporeans and industry professionals.

The results in terms of AI awareness are also in line with the recent analysis by Asgard, a venture capital firm, which places Switzerland as the leading AI nation with the most AI companies per capita[8].

Figure 3.3: Artificial Intelligence Awareness Index



In the United Kingdom, news relating both to AI use and private sector pioneers captured the attention of the online community, with a main focus on the RDI and science dimension. Two events, in particular, sparked online activity during the period of observation: the establishment by the National Health Service (NHS) of a national artificial intelligence laboratory to enhance research and patient care;[9] and the first-ever visualization of a black hole. The annual AI Summit held in London also contributed to the country's ranking by successfully engaging the online community in the discussion.[10]

The adoption of a regional perspective underscores the performance of the United Arab Emirates as a champion in the Arab region, ranking ninth best performer in a global comparison. This reflects the coordinated effort of the government to improve public services by employing AI solutions. During the sample period, we observed that the AI Everything Summit that took place in Dubai sparked online activity, as did various AI initiatives including the establishment in Abu Dhabi of the regional Research and Development headquarters of China's AI giant SenseTime.[11]

An analysis of the total sum of online mentions for the period displays a largely stable trend in the volume of mentions of AI (Figure 3.4). The same trend is not present in the engagement metric, which appears to be low and stable over time (Figure 3.5), with a major peak in April 2019 related to the first-ever visualization of a black hole.

Figure 3.4: Mentions of AI from September 2017 to September 2019 (expressed in thousands of observations)

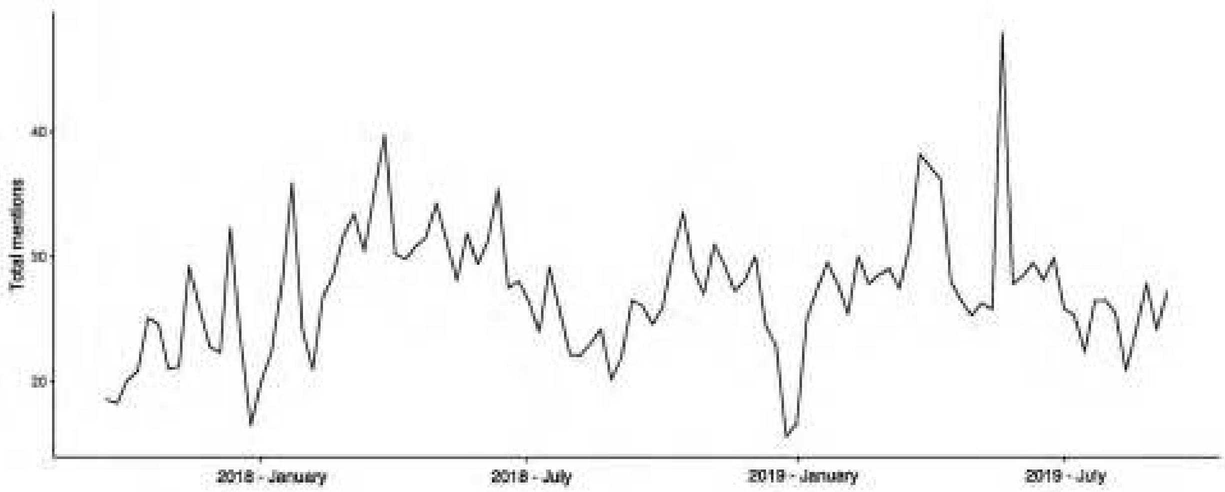
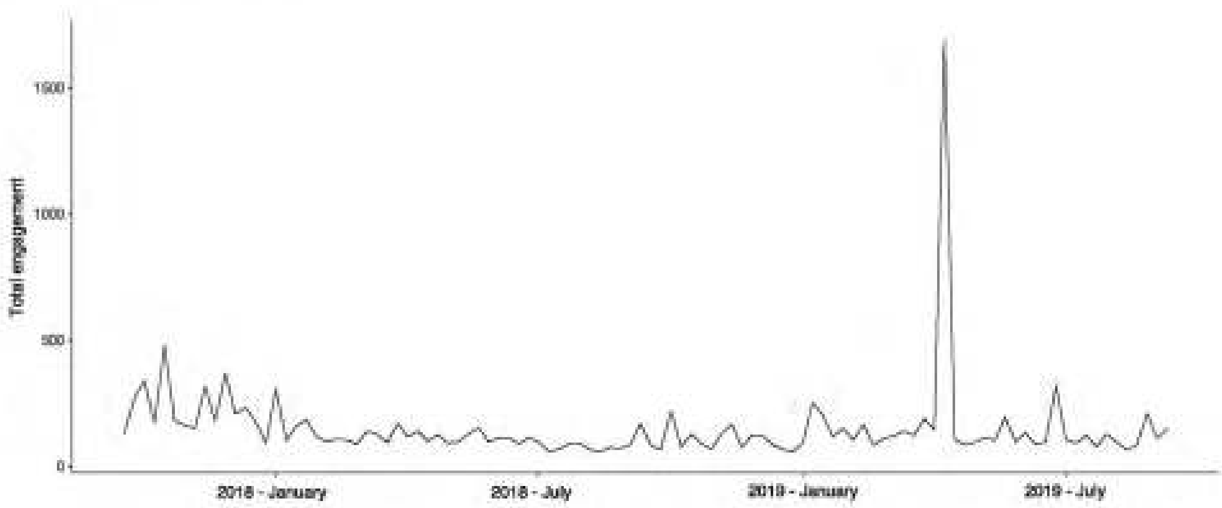
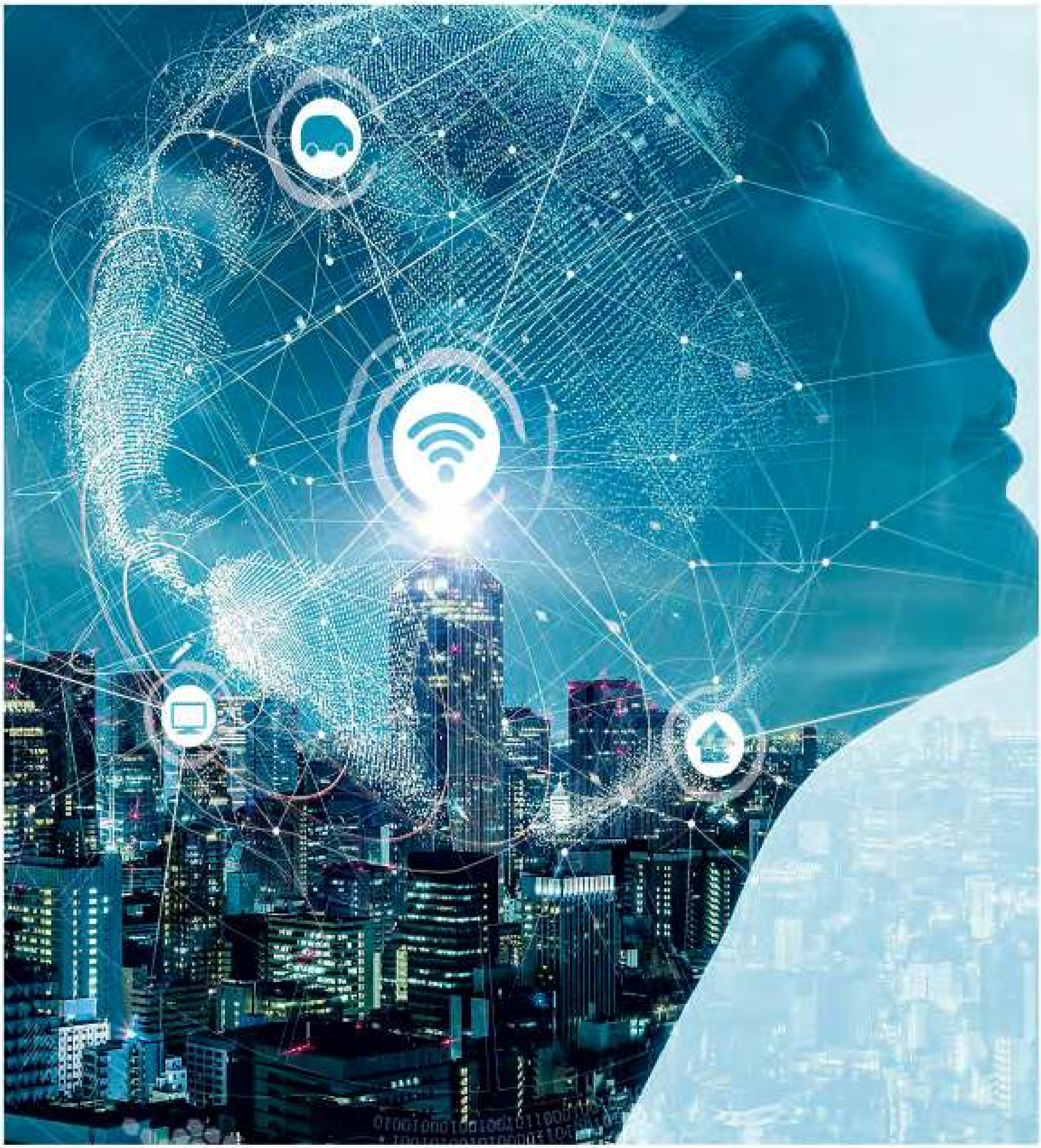


Figure 3.5: Level of engagement on AI from September 2017 to September 2019 (expressed in thousands of observations)





CYBERSECURITY

The analysis of the Cybersecurity Awareness Index presents a distribution of awareness amongst Internet users similar to that for AI, while the enabling environment was the most discussed dimension of the field.

Luxembourg, Mexico, Singapore, Finland and the United Kingdom are the five top performers. This is in line with the thematic overlap between AI and cybersecurity – developers increasingly use AI technology as a tool to hone the capabilities of cybersecurity applications, and adherence to the tenets of ethical AI presupposes the existence of a secure environment for the exchange and storage of information.

Luxembourg leads the ranking, with the enabling environment accounting for 50 percent of online activity in the field.

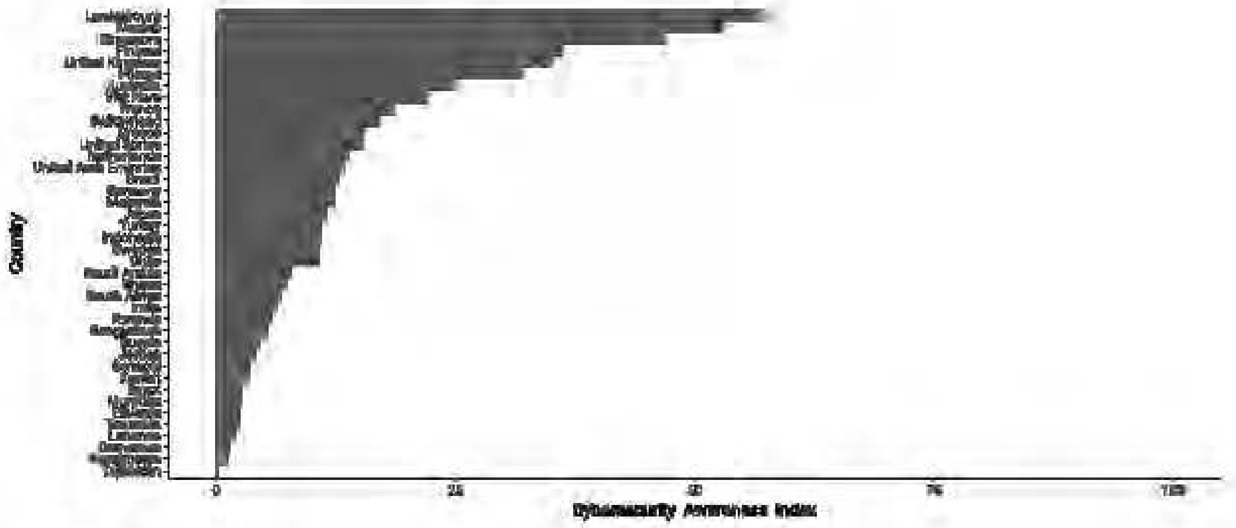
In Luxembourg, the General Data Protection Regulation, which has been in force since 25 May 2018, sparked most online activity, as did Cybersecurity Week Luxembourg, which took place in October 2018.[12]

Online activity in Mexico is also driven by the topic of data protection, and more specifically in the context of the United States – Mexico – Canada Agreement (USMCA), which falls short on data protection.[13] A conference given by the Federal Police on 'Crime Prevention and Cybersecurity' to university students also attracted the attention of the online community,[14] as did Patricia Rosalinda Trujillo Mariel becoming the representative of the Federal Police in the Institutional Operative Coordination of the National Guard (she is known for her numerous diplomas including in cybersecurity).[15]

Ranking sixth in the International Telecommunication Union 2018 Global Cybersecurity Index,[16] Singapore stands amongst the most committed countries in terms of capacity building, cooperation and technical awareness within the field of cybersecurity. The dependency of the local economy on the smooth flow of financial capital, air traffic and freight has ensured Singapore is a prominent proponent of the establishment and sharing of regional best practices. Singapore has promoted the adoption of new technologies in general, and bolstered member states' cyber defence capabilities during its chairmanship of the Association of Southeast Asian Nations (ASEAN) in 2018. For example, an ASEAN–Singapore Cybersecurity Centre of Excellence has been launched in 2019 to support the development of ASEAN nations' cybersecurity capabilities, as part of the ASEAN Cyber Capacity Programme.[17] During 2018, the country also successfully organized the third edition of Singapore International Cybersecurity Week.[18]

As in the first part of the observation period (September 2017 - September 2018), the issue of regulation prominently appears in Finland and the United Kingdom, where discussions in 2019 mostly relate to the implementation of the GDPR and in particular the fines issued by National Data Protection Authorities for non-compliance with the regulation[19] and the responsibility of social networks to uphold data privacy.

Figure 3.6: Cybersecurity Awareness Index



An analysis of the sum of online mentions for the period displays a stable trend in the volume of mentions of cybersecurity (Figure 3.7), with the exception of the period between April and June 2018. This spike reflects the rise in interest amongst European countries due (primarily but not exclusively) to the GDPR legislation, which is also the key driver of engagement through that period (Figure 3.8). The spike in engagement at the end of the period relates to the Equifax data breach, which exposed the social security numbers and other sensitive data of nearly 150 million Americans. In July 2019, a settlement was reached with the Federal Trade Commission and the Consumer Financial Protection Bureau on a $700 million fine, of which $425 million will go to the people affected by the breach.[30]

Figure 3.7: Mentions of cybersecurity from September 2017 to September 2019 (expressed in thousands of observations)

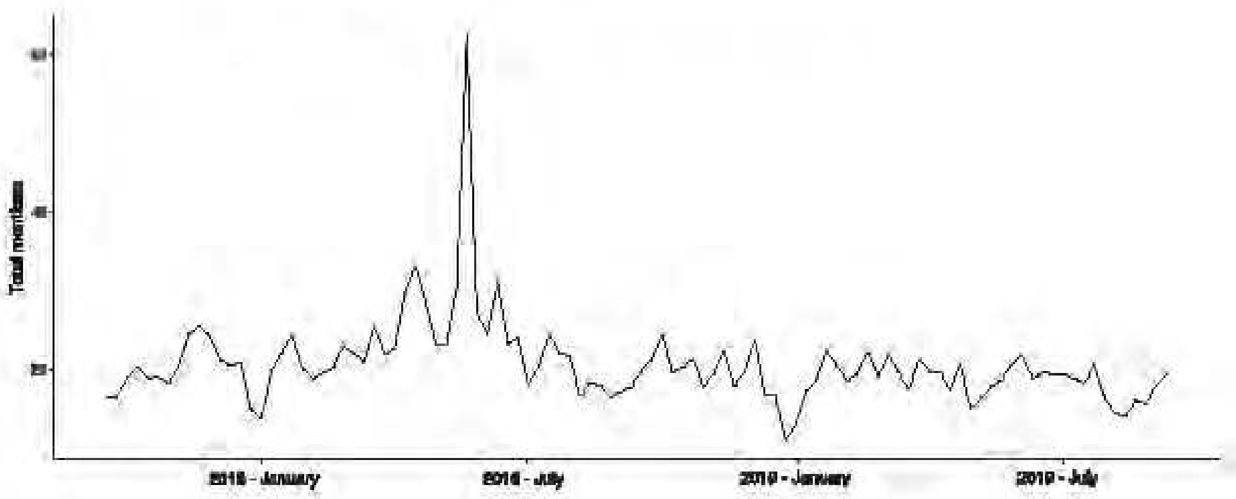
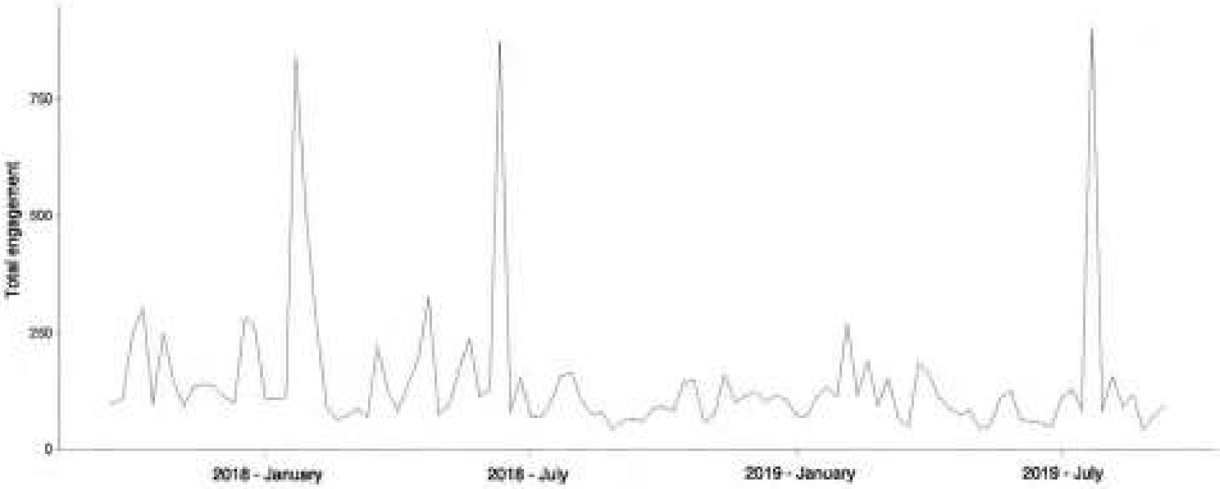


Figure 3.8: Level of engagement on cybersecurity from September 2017 to September 2019 (expressed in thousands of observations)



3

BIOTECHNOLOGY

Analysis of the Biotechnology Awareness Index scores (figure 3.9) points to Mexico, Switzerland, the United Kingdom, Bangladesh and Singapore as the top five performing countries, while the RDI and science dimension is the most discussed in the field.

Mexico leads the ranking, with the RDI and science dimension accounting for 92 percent of online activity in the field.

The high ranking of Mexico in terms of awareness reflects its growing biotechnology sector. Online discussion in Mexico is sparked by a wide array of news related to the outcomes of research and statements of scientists in the field and issued from various research centres and laboratories throughout the country. For example, online activity was sparked by the development of a vaccine to immunize pigs against cysticercosis developed at the National Autonomous University of Mexico. Currently only produced in the laboratory, it is intended to be administered to pigs to prevent the spread of the disease, especially in rural areas.[21] Online activity was also driven upwards as researchers at the National Autonomous University of Mexico (UNAM) developed proteins to slow the growth of the pathogenic bacteria listeria monocytogenes, which can cause listeriosis, an infection which is the third highest cause of death due to food contamination in the world.[22] The news that Cuba had begun providing free preventive HIV pills also generated significant online activity.[23] Other examples include the project led by the National Laboratory of Genomics for Biodiversity (Cinvestav) in Mexico, the Texas Tech University and the University of Buffalo, wherein Scientists sequenced the avocado genome, shedding light on its origins and laying the groundwork for future improvements in agriculture.[24]

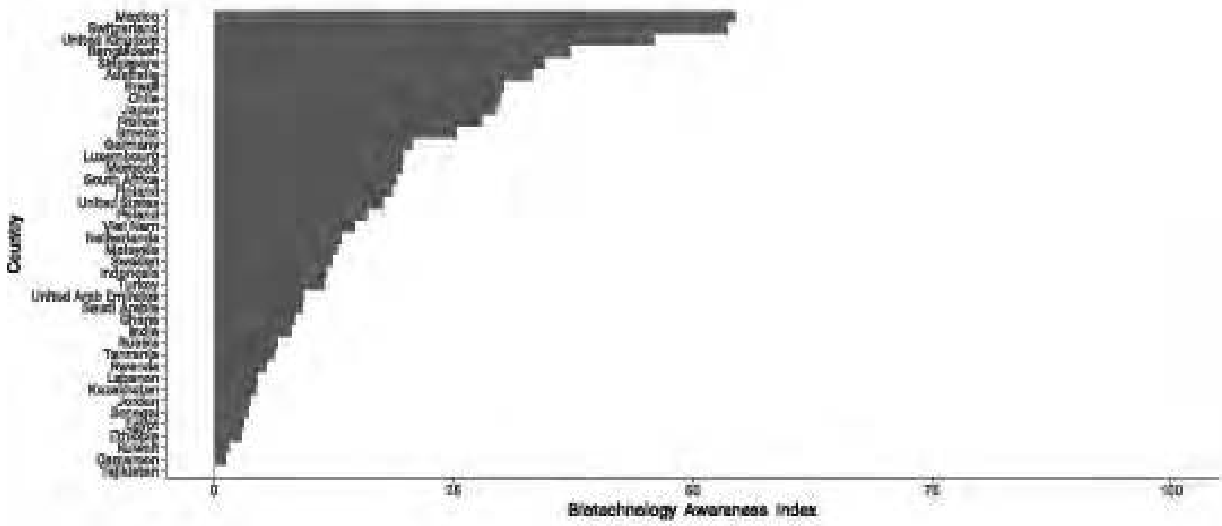
The high ranking of Switzerland in terms of awareness is mostly driven by RDI and science, which accounts for more than 70 percent of online activity. The biotechnology sector is the largest export industry in the country, which, together with chemistry and pharmaceuticals, accounted for 45 percent of total exports in 2018.[25] The publication of scientific articles in the field generated important online activity, such as the publication of articles dedicated to the 'Bioinformatics View of Glycan–Virus Interactions'[26], 'The Utility of Data Transformation for Alignment, De Novo Assembly and Classification of Short Read Virus Sequences'[27] and the 'Biogenesis and Function of Circular RNAs in Health and in Disease'.[28] The establishment by Geneva's University Hospital of the first centre for medical genomics also generated significant online activity.[29]

The United Kingdom is ranked third, with RDI and science, and economy accounting for 90 percent of total activity in the field, with applications such as genomics and bioinformatics featuring prominently. In March 2019, online activity significantly increased, as Chancellor Philip Hammond announced investment for the European Bioinformatics Institute (EMBL-EBI) in Cambridge in his Spring Statement, which promised to boost the UK's genomics industry with £45 million for Bioinformatics research.[30] The BBC's Reality Check on India's elections in 2019, also attracted the attention of the online community. Examining claims and pledges made by the main political parties indicating that the current Indian government's progress in specific sectors, such as the substantial investment in the biotech industry.[31]

Online activity in Bangladesh relating to biotechnology was driven upwards by the signature of a Memorandum of Understanding with Saudi Arabia establishing the Saudi – Bangladesh Institute of Biomedical Engineering and Technology.[32] Engagement online also concerned the creation, by two brothers studying at Chittagong Cantonment Public College, of an innovative gas leakage security system, whichautomatically and instantly detects the source of gas leakages, opening doors and windows automatically to disperse leaked gas.[33]

As in the United Kingdom, awareness in Singapore within these dimensions relate mostly to investment in biotechnology. Online activity was sparked following the agreement by GlaxoSmithKline to buy US cancer specialist Tesaro for $5.1 billion – a costly biotechnology investment by the drug maker to rebuild its pharmaceuticals portfolio.[34] The discovery of cyanobacteria nearly 2,000 feet underground, hinting at fresh possibilities for life on Mars, also generated interest amongst the online community.[35]

Figure 3.9: Biotechnology Awareness Index



Analysis of the total sum of online mentions for the period displays stability in the volume of mentions of biotechnology (Figure 3.10), with the exception of May 2019, which saw a spike in the number of mentions. This was not driven by one specific factor, but rather by a set of converging factors. Several major events took place in that period in different countries – such as the World Biotechnology Congress 2019 in Spain[36] and the Asia Pacific Biotechnology Congress in Japan.[37] The UK was discussing the introduction of a new law amending the current R&D tax credit system, which was expected to have a strong impact on the national biotech industry.[38] Finally, Switzerland was discussing the results of the Swiss Biotech Report.[39]

The engagement metric points to five distinct spikes – before and after January 2018 as well as in October 2018, February 2019 and April 2019. Nevertheless, none of the deviations from the trend appeared to relate to a specific event. The most prominent stories in 2019 in terms of engagement related to the discovery by researchers of almost 2,000 unknown bacteria in the human gut, as well as Cuba's distribution of free preventive HIV pills.[40]

Figure 3.10: Mentions of biotechnology from September 2017 to September 2019 (expressed in thousands of observations)

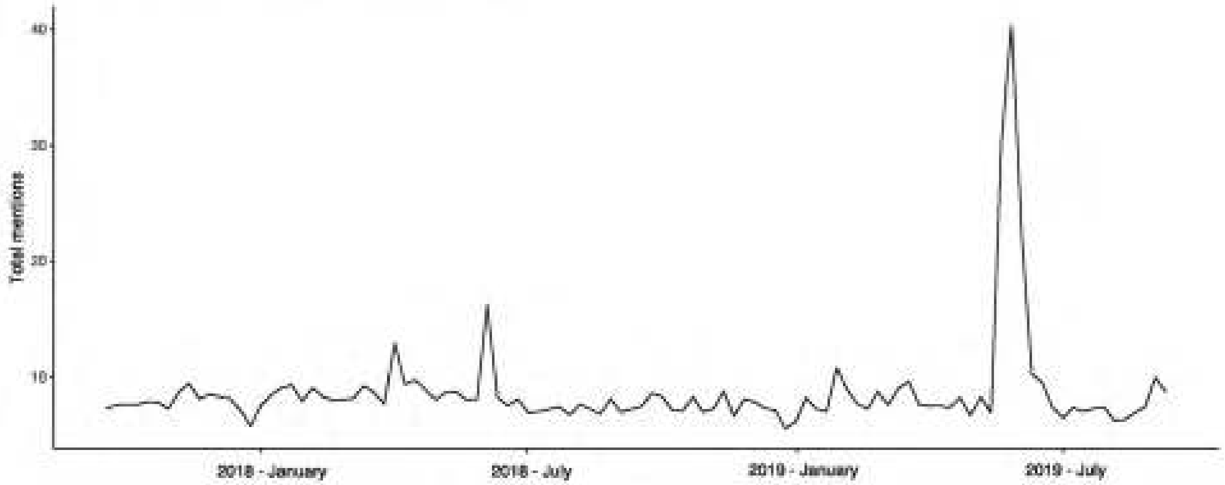
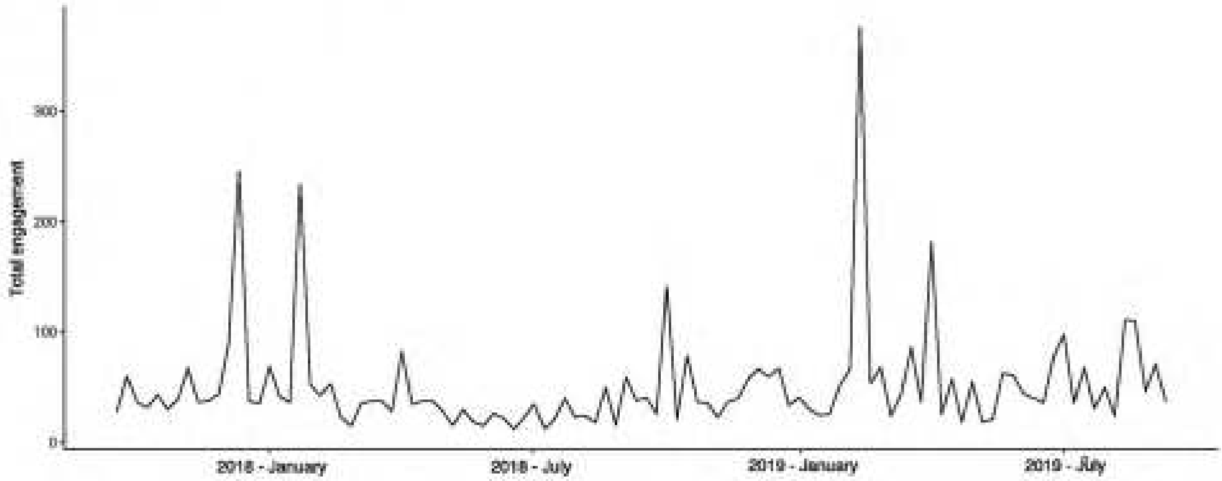
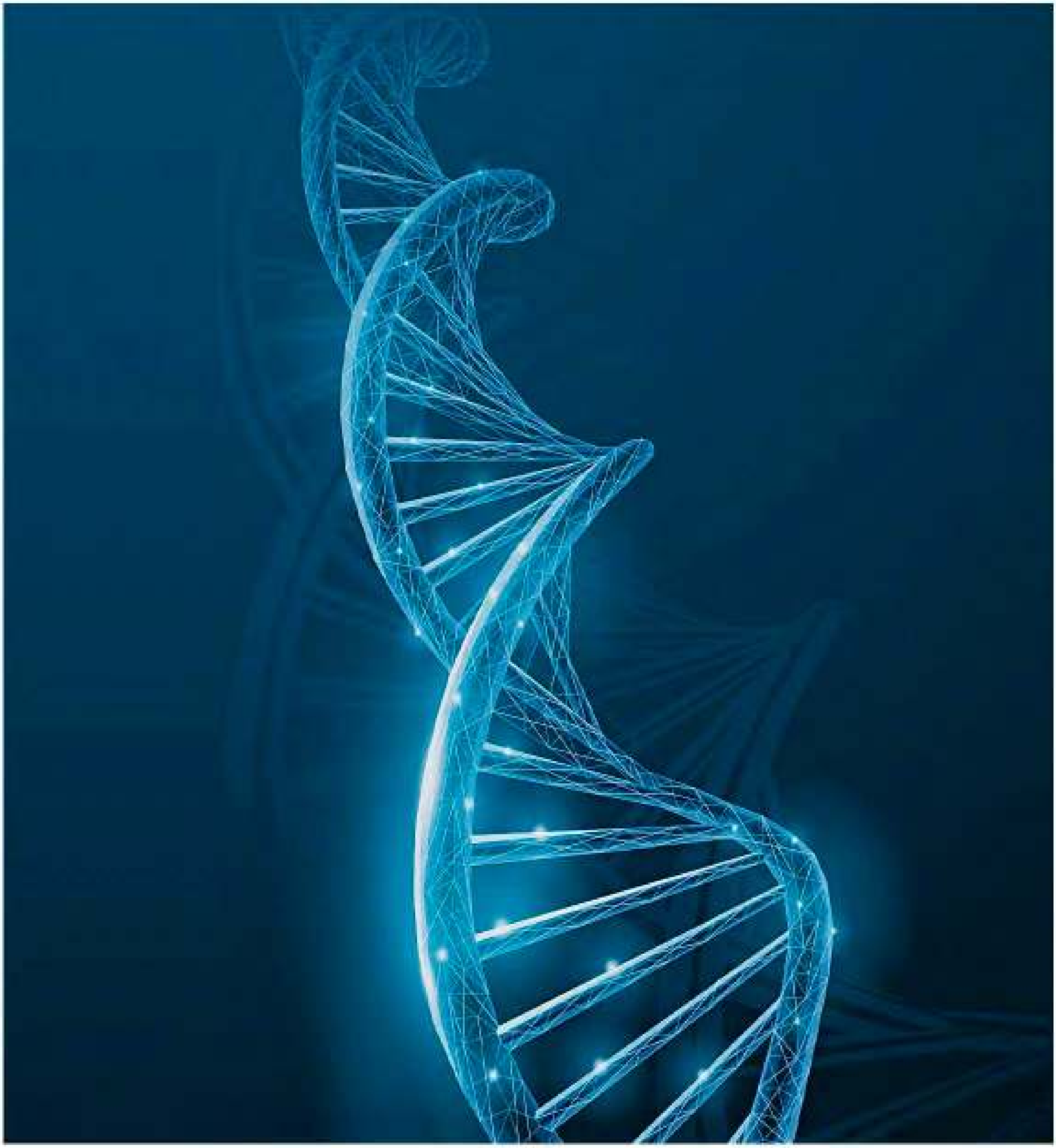


Figure 3.11: Level of engagement on biotechnology from September 2017 to September 2019 (expressed in thousands of observations)





3

BLOCKCHAIN

The results of the analysis of online debate surrounding blockchain technology stands out amongst the future fields owing to the media coverage of the spike in the value of Bitcoin. Thus, an overwhelming part of the discussions our algorithm captured relates to cryptocurrencies and not to the entire spectrum of applications that the distributed ledger technology incorporates.

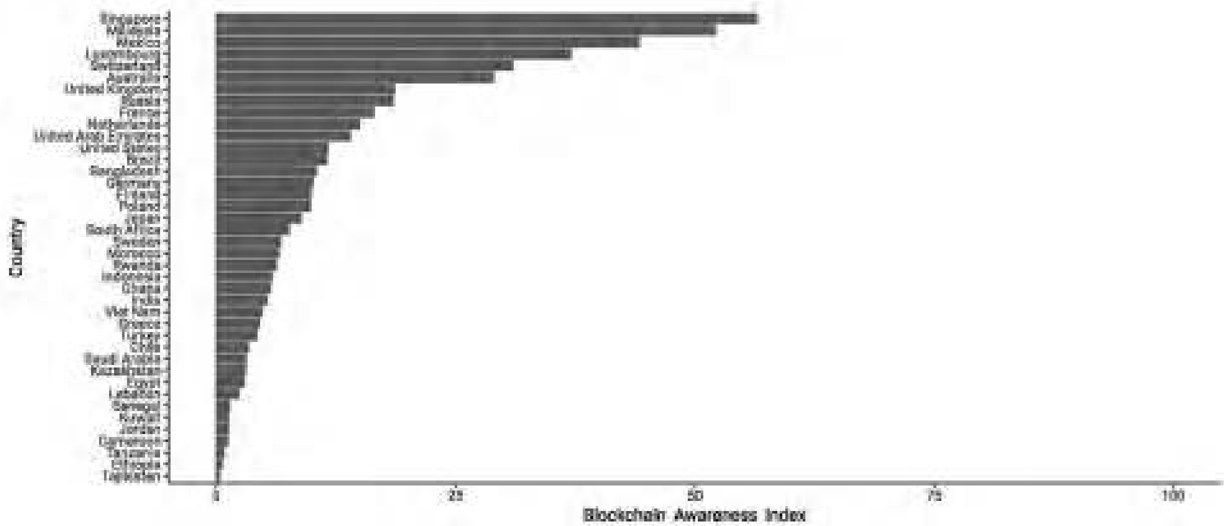
While RDI and science is the most discussed dimension of the field, analysis of the Blockchain Awareness Index scores (Figure 3.12) points to Singapore as the top performer. Malaysia, Mexico, Luxembourg and Switzerland complete the group of top five performing countries.

Singapore leads the ranking with the economy and RDI, and science dimensions accounting for 69 percent of online activity in the field. Singapore has become an epicentre of blockchain and crypto assets innovation, supported by government initiatives accelerating the uptake of new technologies, as illustrated by the success of OpenCerts. Reportedly the largest blockchain application of its kind, OpenCerts is a project initiated by the Government of Singapore and is a collaboration between the Government Technology Agency, SkillsFuture Singapore, the Ministry of Education and Ngee Ann Polytechnic, helping employers and people to validate certificates from 18 educational institutions.[41] Online discussion in Singapore was also sparked by various blockchain conferences occurring worldwide, and specifically the World Blockchain Summit held in Singapore in July 2019.[42]

In Malaysia, government efforts to promote blockchain technologies began in 2015. The initial initiatives were primarily directed toward the financial system via fintech development. In June 2019, Malaysia launched a Work Visa Program for blockchain tech professionals that resonated well within the blockchain community.[43] The government also published an updated list of blockchain initiatives involving government agencies in 2019.[44] Online engagement was also sparked by news related to accusations of the embezzlement of millions of dollars in digital currencies.[45]

Ranking third, Mexico became one of the first countries in Latin America to regulate blockchain and cryptocurrencies.[46] Amero-Isatek, a Mexican cryptocurrency exchange firm, launched its first physical cryptocurrency exchange in the town of Nuevo León, Monterrey, with plans to expand to another seven jurisdictions across Mexico.[47] The firm already made headlines earlier this year for participating in what it called the world's biggest cryptocurrency real estate exchange.[48] The Mexican state of Tamaulipas has incorporated blockchain technology in the tracking of grain for increased supply chain transparency.[49] Major gatherings, such as the Blockchain Summit Latam in Mexico,[50] also drove online activity upwards

Figure 3.12: Blockchain Awareness Index.



In Luxembourg, the parliament passed a law in February 2019 permitting the use of distributed ledger technology (DLT) for the circulation of securities, facilitating the use of blockchain technology in financial services.[51] The various events organized by the Luxembourg House of Financial Technology, which is particularly active in the field – such as the Infrachain Summit – also contributed to online activity.[52]

With a well-developed infrastructure, some of the best academic institutions in the world and a highly-skilled and motivated workforce, Switzerland has become one of the world's leading locations for blockchain companies, notably with the set-up of the Crypto Valley – a strong ecosystem for numerous companies and organizations in the blockchain sector.[53] Online activity in relation to blockchain was also sparked by the launch of the Libra and the registration by Facebook of the company, Libra Networks, in Geneva.[54]

Analysis of the total sum of online mentions for the period between September 2017 and September 2019 displays a rising trend that reaches its peak in late April 2018, before decreasing progressively and stabilizing at around 25,000 mentions per week for the ensuing period. During this period, no single event appears to drive the interest of the online community. In the field of blockchain, cryptocurrencies generate most of the mentions, followed by international conferences and events.

The engagement metric presents a somewhat different trend, where the steep hike in engagement (October 2017 to early February 2018) precedes the major spike in mentions. This could indicate a dynamic relationship wherein mentions are reactive to past engagements. The significant increase in engagement perfectly coincides with the rise in Bitcoin value. The spike in March 2019 relates to the Christchurch terrorist attack, the perpetrator of which mentioned in his manifesto that he earned money by investing in Bitconnect, an open-source cryptocurrency.[55]

Figure 3.13: Mentions of blockchain from September 2017 to September 2019 (expressed in thousands of observations)

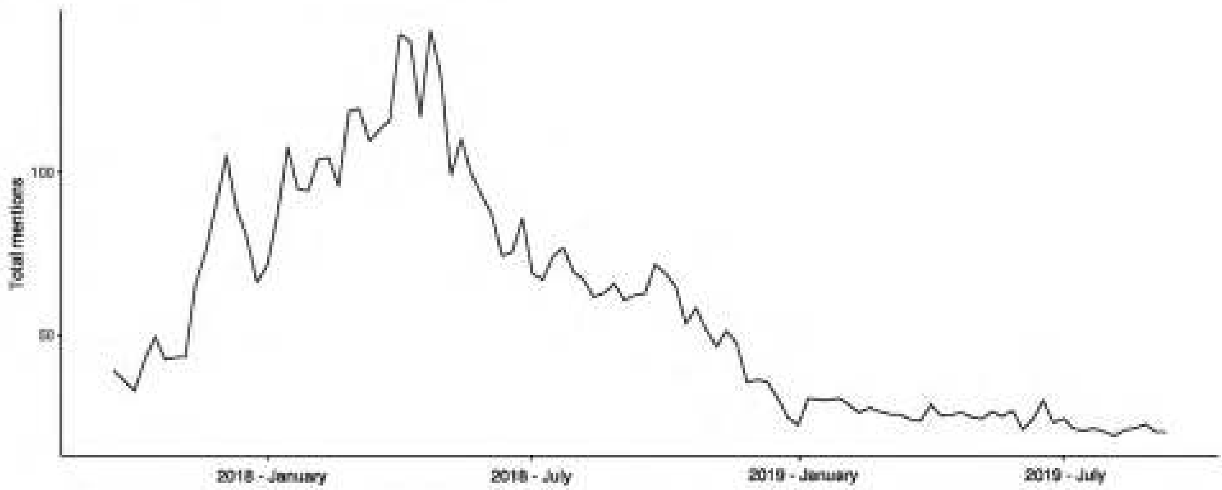
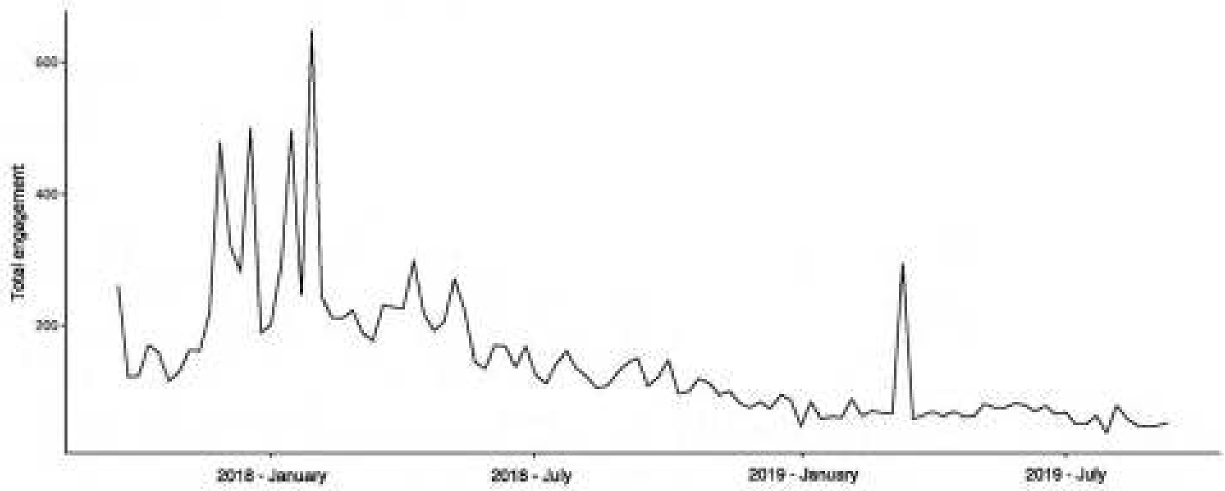


Figure 3.14: Level of engagement on blockchain from September 2017 to September 2019 (expressed in thousands of observations)



FUTURE SKILLS

Analysis of the Future Skills Awareness Index scores (Figure 3.15) points to Turkey, Bangladesh, Finland, Chile and Netherlands as the top five performing countries.

We also note that the key driver of overall activity in the area of future skills is education, which accounts for 64 percent of total activity, relaying tensions in the sector. Within education, a recurrent topic Concerns the deficit and status of teachers. This is most evident in primary and secondary education – critical stages for the development of the fundamental cognitive and soft skills that we have identified as necessary for the employment market of the future. Countries where this issue is most prevalent in online discussions are Bangladesh and the Netherlands.

Turkey leads the ranking, with education accounting for 75 percent of online activity in the field. In Turkey, unemployment amongst teachers is a prominent issue, driving online activity upwards. In December 2018, the Ministry of National Education announced the placement of 20,000 contracted teachers from amongst 130,000 applicants, which also sparked online activity through 2019. While the number of unassigned teachers increases every year, the shortage of teachers is also increasing.[56]

Online activity in Bangladesh reflects the issue of the lack of properly trained teachers in the country. While here has been significant investment in improving education, the country faces various challenges in implementing many reforms, with progress being hampered by funding problems and inadequate school infrastructure. As a result, classrooms are overcrowded and teachers are often poorly trained.[57] The Asian Development Bank (ADB) has approved a $500 million loan to support Bangladesh's Fourth Primary Education Development Program, which aims to provide quality education to all children from pre-primary to grade 5. The programme notably seeks to "reduce double-shift operations at schools by recruiting more teachers and building more classrooms", inter alia.[58]

Finland leads the discussion, with intense online exchanges focusing on teachers' wellbeing,[59] the impact of new learning methods[60] and the Finland Skills 2035 anticipatory report issued in May 2019[61], which highlights changes in competences and skills that will be needed by 2035.

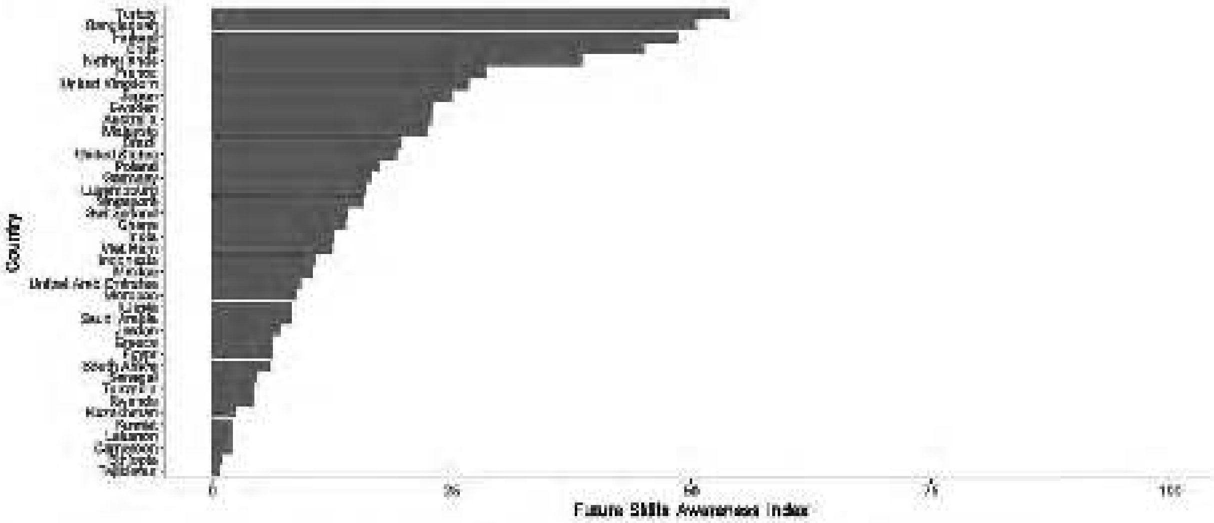
Online activity in Chile is mostly sparked by teacher strikes. Over 90,000 primary and secondary teachers were striking for seven weeks between June and July 2019[62] due to lack of government responses to their demands for better working conditions and structural changes.

In the Netherlands, awareness and debate about future skills was concentrated on the shortage of teachers, which creates a significant problem for the education system. While the number of schools facing a teacher shortage is decreasing, the number of open vacancies for teachers is increasing. According to the primary education council, PO-Raad, this indicates that schools already facing this challenge are having even more difficulties in filling vacancies.[63] As a result, there is increasing inequality in education, as schools with a 'complex pupil population' are more affected by the teacher shortage in primary education. Secondary special education is also losing teachers to mainstream secondary education, as the wages are better there.[64]

France and the United Kingdom also face issues regarding teacher shortages and status, while Malaysian teachers are amongst world's most dedicated to ensuring students' academic success.[65]

Overall awareness of the future of skills in the strategic debates of nations remains weak.

Figure 3.15: Future Skills Awareness Index



**The discussions in Bangladesh, Turkey and Chile are fuelled by country-specific crises related to teachers' shortages and strikes.*

According to the findings of the Worldwide Educating for the Future Index, Finland and the Netherlands rank amongst the countries with high score, whilst Chile and Turkey display a medium score and Bangladesh stands amongst low-scoring countries.[59]

Table 3.1: Worldwide Educating for the Future Index

High score	Medium score	Low score
Finland	Chile	Ethiopia
Switzerland	United States	Bangladesh
Sweden	Mexico	Egypt
Netherlands	Ghana	
Germany	Russia	
Singapore	Poland	
France	United Arab Emirates	
United Kingdom	Malaysia	
Australia	Brazil	
Japan	Kazakhstan	
	South Africa	
	Viet Nam	
	Turkey	
	India	
	Saudi Arabia	
	Indonesia	

Source: The Economist Intelligence Unit, 2018

The total sum of online mentions for the period appears very noisy, but oscillations take place around a stable weekly trend, with a magnitude of 25,000–30,000 observations, and a major peak in September 2019, which is explained by various news generated by the start of the new school year, encouragement on social media for success and teacher shortages. Bangladesh and Turkey appear to account for a large share of the results (jointly accounting for around 28 percent of total mentions). In terms of engagement, there is a similarly noisy trend, generated by a wide array of minor events.

Figure 3.16: Mentions of future skills from September 2017 to September 2019 (expressed in thousands of observations)

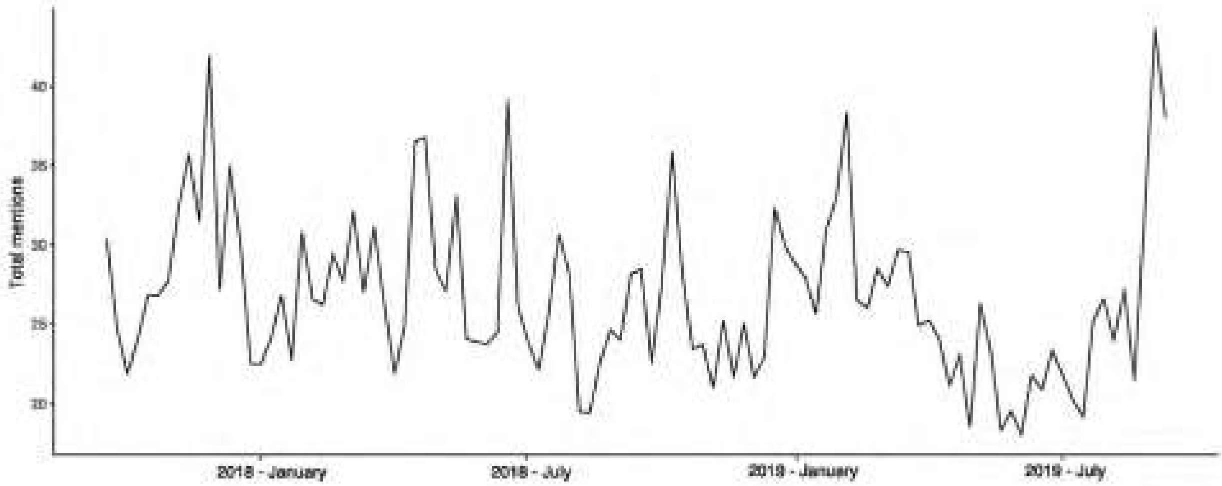
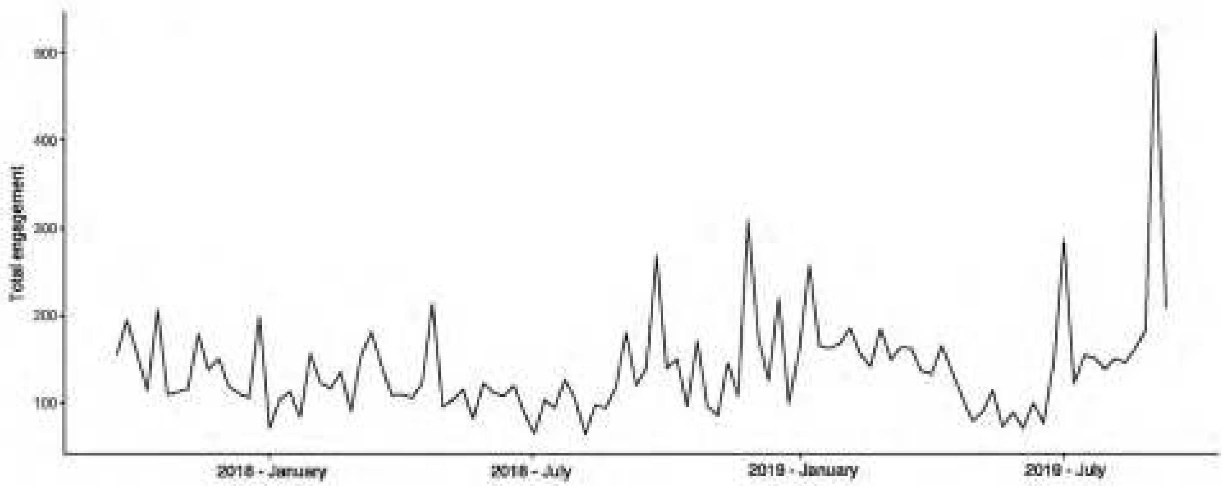


Figure 3.17: Level of engagement on future skills from September 2017 to September 2019 (in thousands)



KEY FINDINGS

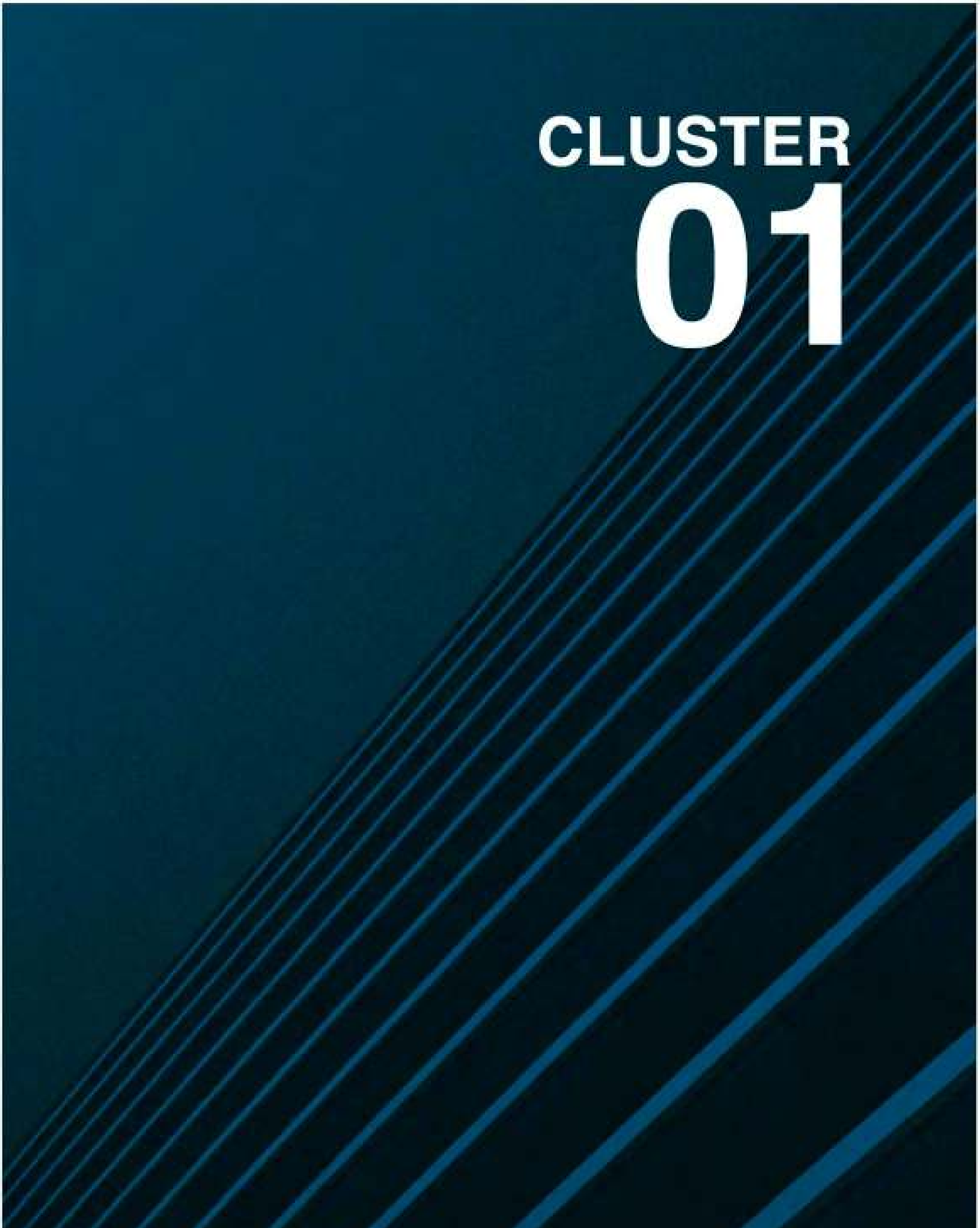
3

ENDNOTES

[1] European Centre for the Development of Vocational Training, 2019.
[2] Government of the Grand Duchy of Luxembourg, 2019.
[3] Digibyte, 2019.
[4] Kwan, 2019.
[5] Brito, 2019.
[6] See: https://www.aisingapore.org/talentdevelopment/ai4e/.
[7] Ibid.
[8] Asgard, 2017.
[9] Gallagher, 2019.
[10] See: http://london.theaisummit.com/.
[11] Khan, 2019.
[12] See: https://www.luxinnovation.lu/event/cybersecurity-week-2018/.
[13] Geist, 2018.
[14] Ely, 2018.
[15] Pavón, 2019.
[16] International Telecommunication Union, 2019a.
[17] Baharudin, 2019.
[18] See: https://www.sicw.sg/.
[19] Cellan-Jones, 2019; for a tracker of the latest fines issued by National Protection Authorities, see: http:/www.enforcementtracker.com/.
[20] Bates, 2019.
[21] Redacción Porcicultura, 2019.
[22] Milenio, 2019a.
[23] Mundo, 2019.
[24] UNOTV, 2019.
[25] Swiss Biotech, 2019.
[26] Le Mercier et al., 2019.
[27] Ibid.
[28] Haddad and Lorezen, 2019.
[29] Faas, 2019.
[30] Government of the United Kingdom, 2019.
[31] Khare, 2019.
[32] Independent Online Desk, 2019.
[33] Jago News 24, 2019.
[34] Hirschler, 2018.
[35] Wei-Haas, 2018.
[36] See: https://www.hilarisconferences.com/biotechnology.
[37] See: https://asiapacific.biotechnologycongress.com/.
[38] McConaghie, 2019.
[39] Swiss Biotech, 2019.
[40] Mundo, 2019.
[41] Ranosys Technologies, 2019.
[42] See: https://singapore.worldblockchainsummit.com/.
[43] Alexandre, 2019.
[44] Malaysia Government, 2019.
[45] Jamilul et al., 2018.
[46] Nasdaq, 2018.
[47] Coinbeat, 2019.
[48] Aguilar, 2019.
[49] Pirus, 2019.

[50] See: https://www.blockchainsummit.la/.
[51] Luxembourg for Finance, 2019.
[52] See: https://www.lhoft.com/en/meet-the-fintech-community/infrachain-summit.
[53] Tännler, 2019.
[54] Le Temps, 2019.
[55] Sutton et al., 2019.
[56] Yazisi, 2018.
[57] Alamgir, 2018; and Islam, 2019.
[58] Bar and Dwyer, 2018.
[59] Ronkainen, 2019.
[60] Pertulla, 2019.
[61] European Centre for the Development of Vocational Training, 2019.
[62] Chávez, 2019.
[63] Pieters, 2019a.
[64] Pieters, 2019b.
[65] Mokhtar, 2018.
[66] The Economist Intelligence Unit, 2018.

COUNTRY PROFILES



CLUSTER 01

KEY FINDINGS

Leading knowledge infrastructure cluster

30 leading knowledge infrastructure countries

- Australia
- Austria
- Belgium
- Canada
- Czechia
- Denmark
- Estonia
- Finland
- France
- Germany
- Norway
- Hong Kong China (SAR)
- Iceland
- Ireland
- Israel
- Japan
- Korea (Republic of)
- Luxembourg
- Malta
- Netherlands
- New Zealand
- Portugal
- Singapore
- Slovenia
- Spain
- Sweden
- Switzerland
- United Arab Emirates
- United Kingdom
- United States

The countries in this cluster are characterized by high GKI scores of between 57.3 and 73.2, with world rankings ranging from 1 to 30. Within the cluster, country performances are closer in general enabling environment, whereas there is a high variation in their scores relating to technical and vocational education and training, and RDI.

Hence, this cluster includes countries that display an above average performance in all sectors with very few exceptions, e.g. Canada and Germany in the pre-university education, and Malta in technical and vocational education and training, noting that their performance is slightly below the average.

The following section presents the country profiles of the 13 countries of this cluster: Australia, Finland, France, Germany, Japan, Luxembourg, the Netherlands, Singapore, Sweden, Switzerland, the United Arab Emirates, the United Kingdom and the United States.

Australia
Finland
France
Germany
Japan
Luxembourg
Netherlands
Singapore
Sweden
Switzerland
United Arab Emirates
United Kingdom
United States

AUSTRALIA

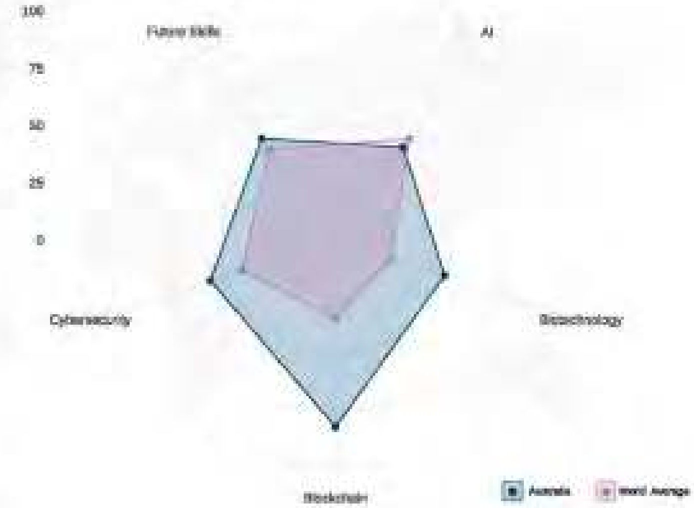
GDP per capita
$ 57,305
2018

HDI
0.939
2017

GKI
23/136
2019

2410
unique authors per million Internet users

Future field awareness indices

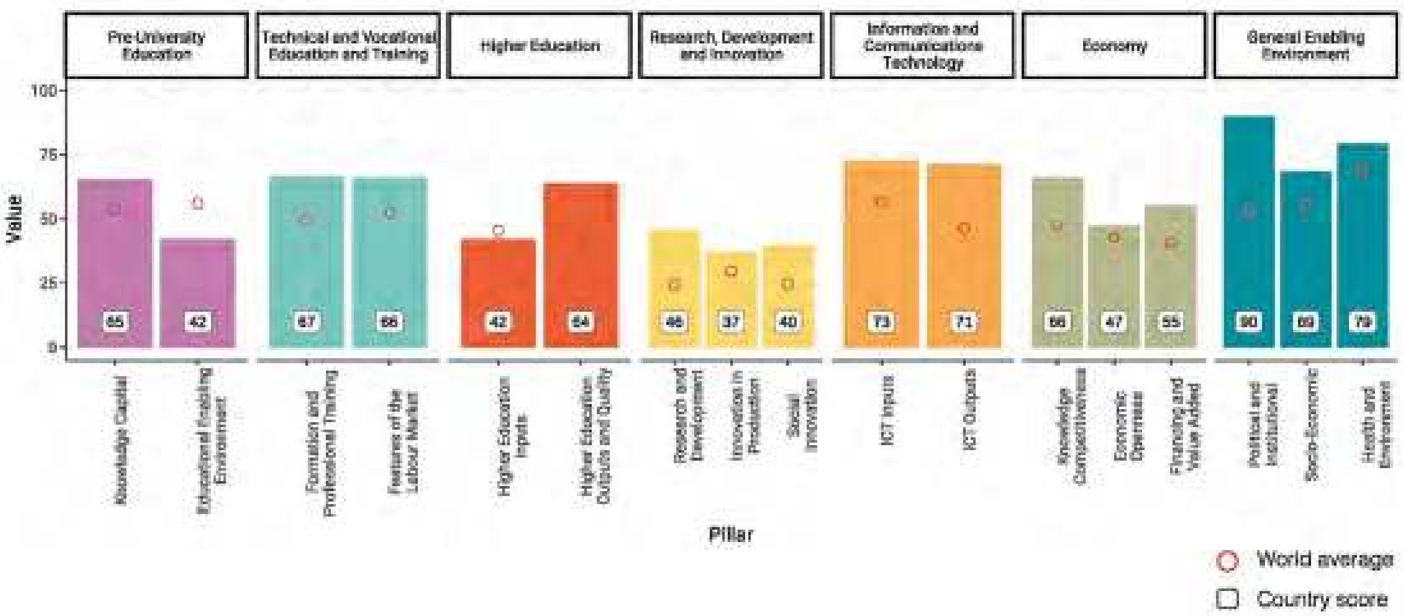


Knowledge infrastructure

In terms of knowledge infrastructure to support technological uptake, Australia is amongst the leading countries, standing alongside the United Arab Emirates and the Netherlands.

Australia is ranked 23rd on the Global Knowledge Index, outperforming 83.7 percent of other countries. Australia performs above the world average in all sectoral indices and is strongest in the areas of politics and institutions – ranking 11th in a global comparison – and especially in regulatory quality. Conversely, Australia faces challenges in the area of innovation in production, which may be attributed to the low number of designs within industrial design applications.

Global Knowledge Index – Australia

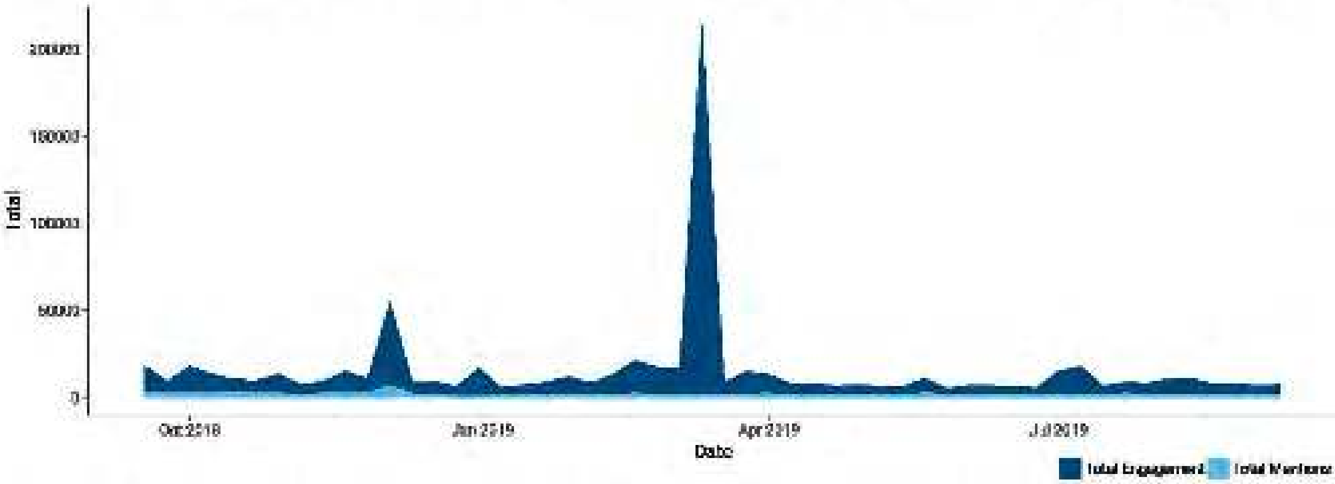


Technological awareness

86.5 percent of the Australian population have access to the Internet, with a mean download speed of 16.4 Mbps.

Between mid-September 2018 and mid-September 2019, there were 41,499 unique authors contributing to total content generation. The volume of online activity in Australia within the four technology fields chosen displays an average of 9,429.5 mentions and 51,427.8 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.00059. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.00017.

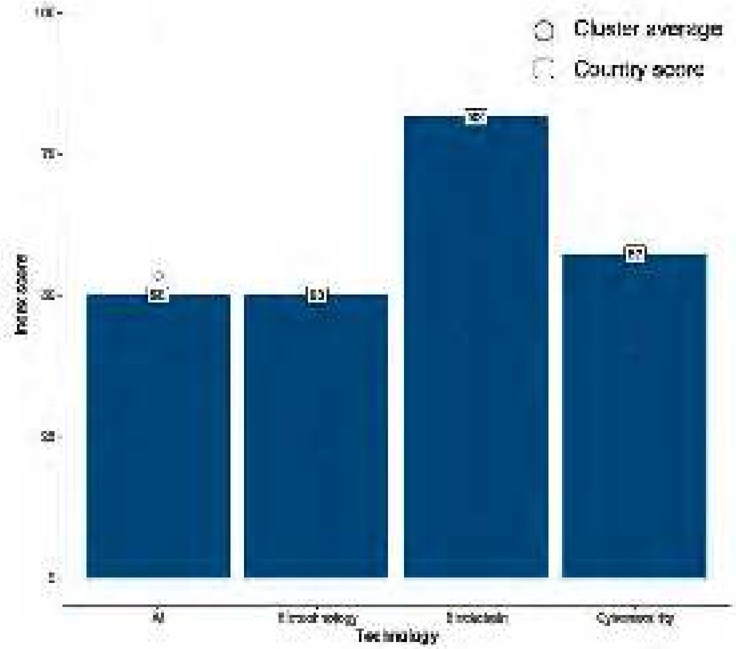
Volume of discussions and engagement level associated with the four key technologies for the future in Australia



The graph of online activity over time for Australia shows peaks in engagement and in mentions, in the area of cybersecurity (enabling environment). The peak results pertain to the encryption law that was passed by the Australian Parliament in early December 2018. The law was highly controversial in the country, as it can compel technology companies to grant police and security agencies access to encrypted messages.[1] The highest peak in engagement, observed in March 2019, was not directly linked to future technologies, but rather to the news of the Christchurch mosque shooting. A video of the act was spread across social media platforms, with artificial intelligence tools and human moderators failing to detect the live stream.[2]

Global Technology Awareness Index: Australia

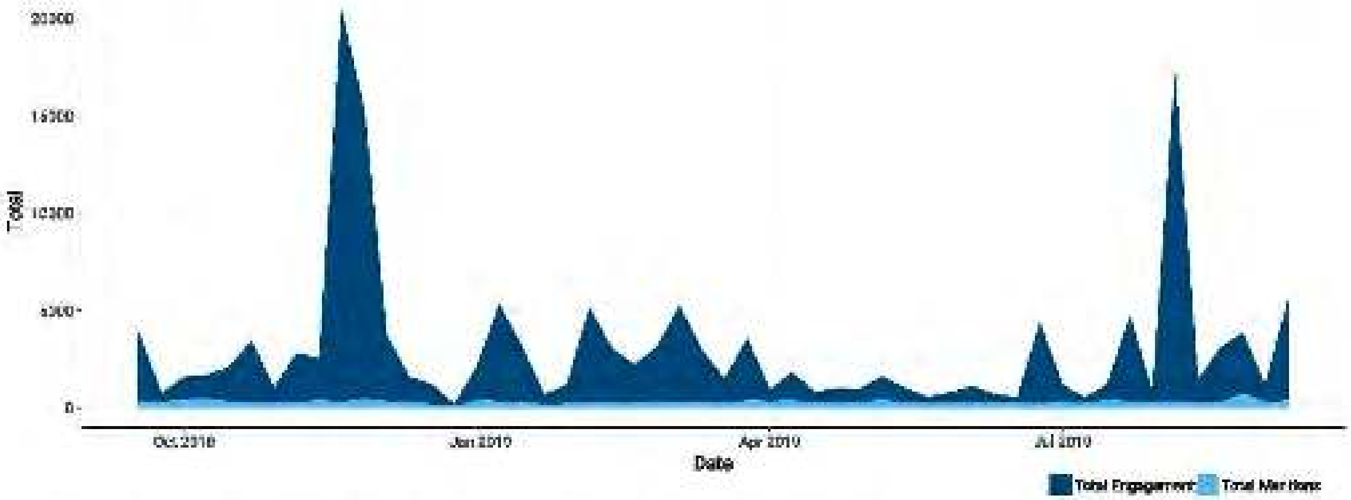
Australia outperforms the online activity cluster average in three out of four technology fields. In terms of activity distribution within the country, Australia displays a balanced overall performance. Nevertheless, blockchain stands out, owing to significantly higher scores than the three other technologies.



Future skills awareness

The online community exhibits a moderate level of online activity concerning future skills, with an average value of 1,250.6 mentions and 10,866.6 instances of engagement per month. Total online activity in the area of future skills in Australia is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Australia



The online activity trend over time for Australia shows a number of peaks in engagement and one peak in mentions related to education. The results associated with these peaks pertain mainly to national and international news regarding public education. In terms of engagement, activity in one peak concentrated on the OECD's Teaching and Learning International Survey and its finding that Australian teachers work longer hours than those in most developed countries. The survey conducted across 30 countries found that secondary school teachers in Australia work 44.8 hours per week on average, compared to a 38.8-hour international average.[3] The second peak in activity concerned proposed changes in the secondary school curriculum amidst a planned update to the Melbourne Declaration,[4,5] – a government document setting the vision for the national education system.

Regarding the peak in mentions, this focused on the 2019 NAPLAN (National Assessment Program – Literacy and Numeracy) results. While the performance of primary school students was above the 2008 average, secondary school attendees scored below the 2011 average.[6] However, the results came into question, since 2019 marked the first time the test could be taken online; technical issues had been reported, as well as problems with connectivity, which might have influenced outcomes.

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Australia performs well in terms of its knowledge infrastructure, technology awareness and future skills awareness, with high scores across all thematic dimensions. There is room for improvement in terms of the education dimension across all fields, however. Australian policymaking has proven efficient and well-informed regarding the technologies that will shape the near future and the skill sets that will enable Australian human capital to thrive and compete in the future.

Overview of Australia's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★☆☆	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★☆	★★★★☆			★★★★★	★★★★★	★★★★★
Future skills awareness	★★★★☆	★★★★☆			★★★★★	★★★★☆	★★★★★

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval); five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Australia's high scores in enabling environment reflect a focus, both in the media and on the Internet, on the governance of such technologies and programmes, with high levels of mentions and engagement relating to artificial intelligence, cybersecurity and blockchain.

Most articles concerning the enabling environment appear to focus on local news and policies; e.g. "AI is coming, whether Australia has the policies to deal with it or not, report warns", published by ABC[7]; "NSW government looks to develop AI ethics policy"[8]; or "Government tells business to speak up on AI regulation"[9], published by the Financial Review. However, there is still an international focus on key news and events (with an emphasis on news from China and the US); e.g., "Made in China 2025: Xi Jinping's plan to turn China into the AI world leader"[10] and "U.S. army assures public that robot tank system adheres to AI murder policy"[11]. This quantity and quality of media exposure and discussions lead to high awareness scores for Australia in the enabling environment dimension.

Across Australia's RDI and science online results, we see an international focus, with most results discussing centres, labs, think tanks, conferences, etc., located outside Australia – most notably the Samsung AI Center,[12] MIT Media Lab[13] and the World AI Conference in Shanghai.[14] The main local agencies referenced are the Australian Cyber Security Centre[15] and the Australian Institute of Machine Learning.[16]

Endnotes

[1] *BBC News 2018; and Butler, 2018.*
[2] *CNN, 2019.*
[3] *Carey, 2019.*
[4] *Baker, 2018.*
[5] *Firth, 2018.*
[6] *Mueller, 2019.*
[7] *Evans, 2019.*
[8] *Hendry, 2019.*
[9] *Fowler, 2019.*
[10] *Burrows, 2018.*
[11] *Novak, 2019.*
[12] *Nield, 2019.*
[13] *White, 2019.*
[14] *Gilbert, 2019.*
[15] *Borys, 2019.*
[16] *Kuper, 2018.*

FINLAND

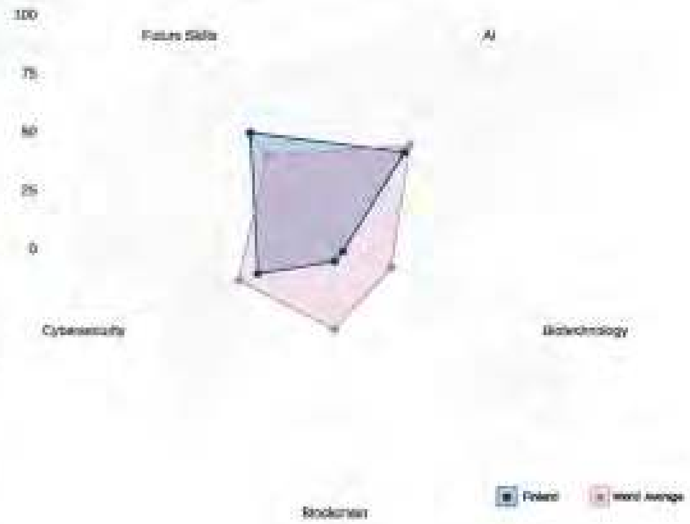
GDP per capita
$ 49,648 2018

HDI
0.920 2017

GKI
2/136 2019

2776 unique authors per million Internet users

Future field awareness indices

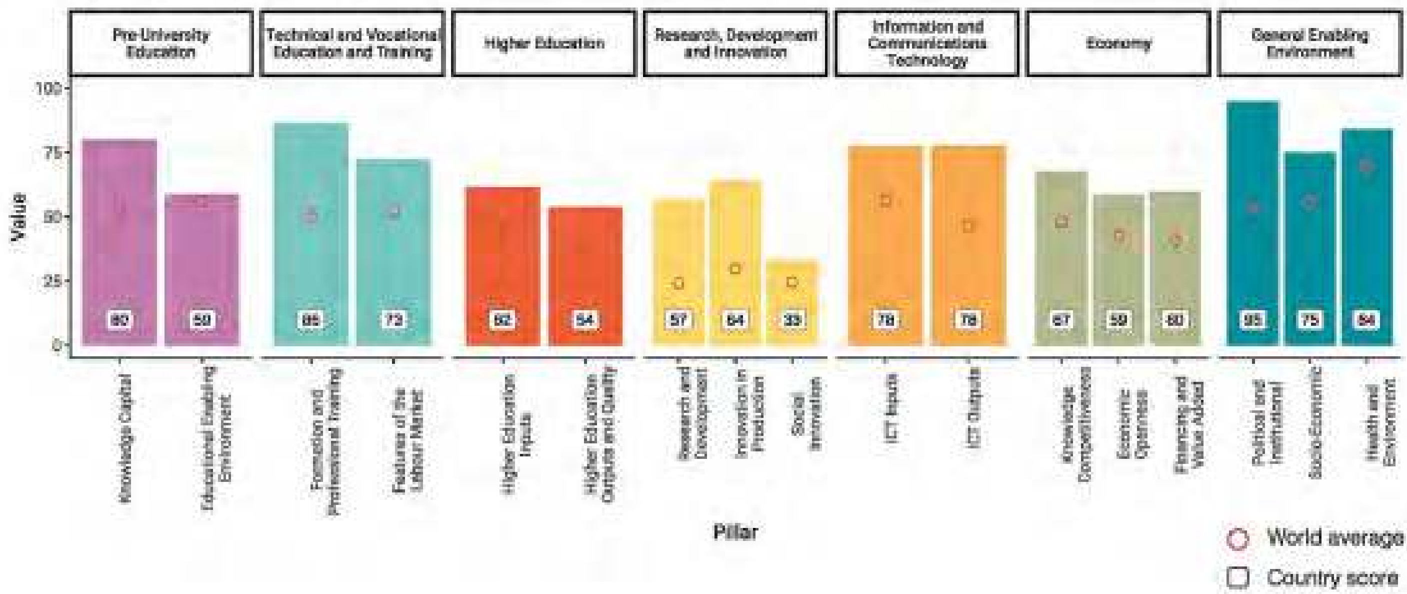


Knowledge infrastructure

In terms of knowledge infrastructure to support technological uptake, Finland is amongst the leading countries, standing alongside countries such as the United States and the United Arab Emirates.

Finland is ranked second on the Global Knowledge Index, outperforming 99.2 percent of other countries, performs above the world average in all sectoral indices and is strongest in the area of politics and institutions, ranking third in terms of judicial independence in a global comparison. Conversely, Finland faces challenges in the area of social innovation, which may be attributed to the low density of new businesses in the country.

Global Knowledge Index – Finland

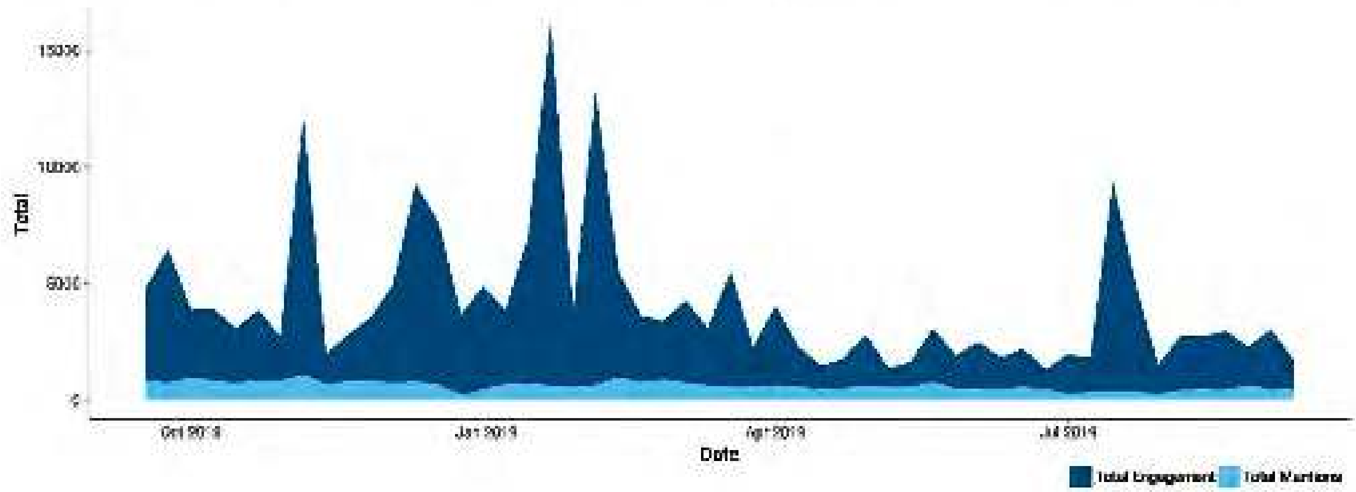


Technological awareness

88.9 percent of the Finnish population has access to the Internet, with a mean download speed of 29.3 Mbps.

Between mid-September 2018 and mid-September 2019, there were 13,629 unique authors contributing to total content generation. The volume of online activity in Finland within the four technology fields chosen displays an average of 2,448.9 mentions and 13,922.3 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0005. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.00019.

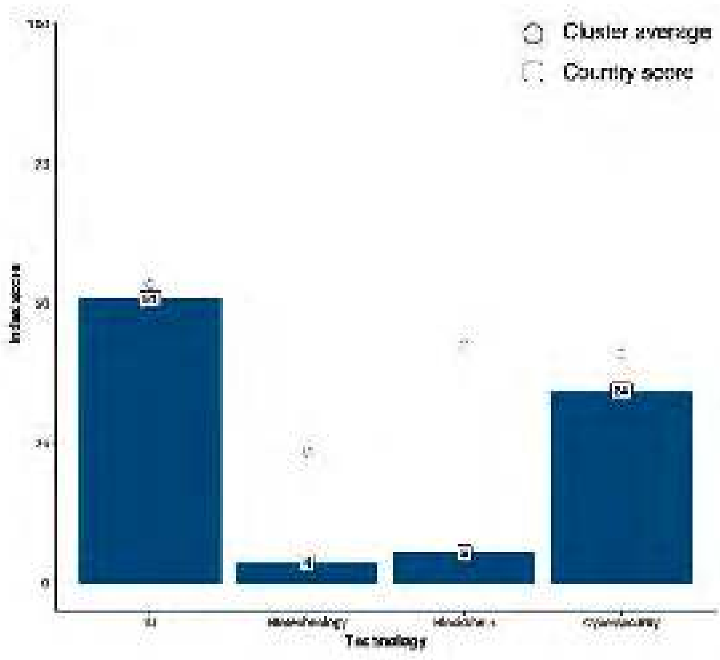
Volume of discussions and engagement level associated with the four key technologies for the future in Finland



The graph illustrating online activity over time in Finland shows peaks in engagement and mentions. All peaks relate to the area of cybersecurity (specifically in terms of the economy). The peak results pertain mainly to national news on data privacy regulation for social and health data,[1] as well as Finland leading the Good Country Index, which measures the contribution of each country to the common good of humanity, and the associated benefits it secures.[2] Additionally, the international scandal surrounding Facebook's use of private phone numbers also caused a significant peak in mentions.[3]

Global Technology Awareness Index: Finland

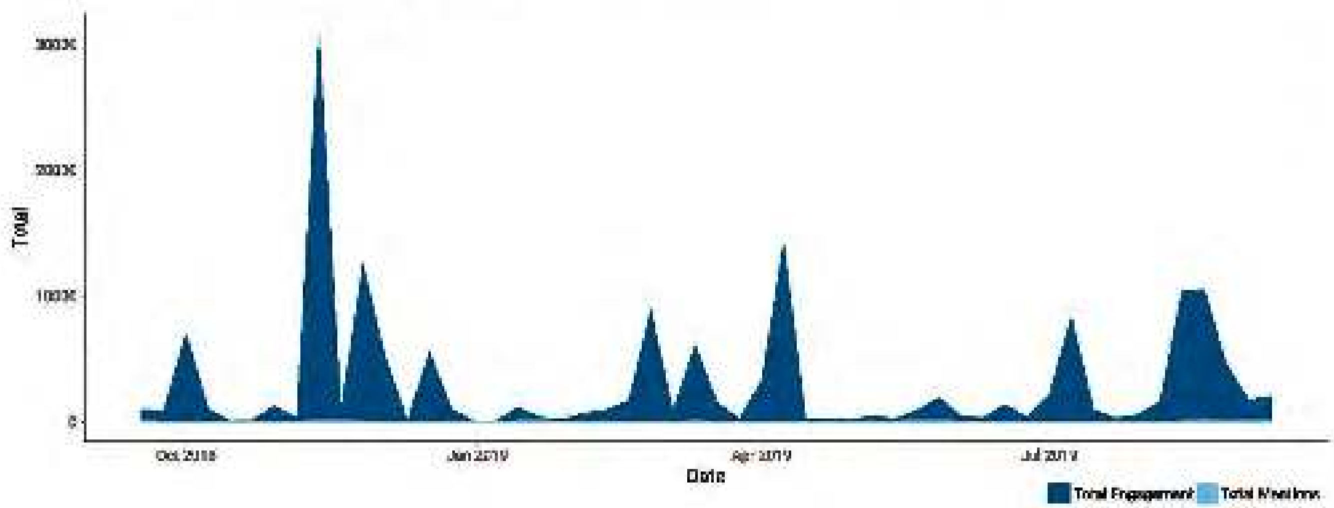
Finland scores below the online activity cluster average in all four technology fields. In terms of activity distribution within the country, Finland's discussions are mainly oriented towards AI and cybersecurity.



Future skills awareness

The volume of online activity relating to future skills displays an average value of 387.1 mentions and 11,848.4 instances of engagement per month. Total online activity in the area of future skills in Finland is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Finland



The trend of online activity over time for Finland shows a number of peaks in engagement and mentions mainly related to education. The results associated with these peaks pertain mainly to national news on the financing requirements of the education sector, particularly relating to teachers and adult students,[4] and new research on factors that significantly reduce children's learning abilities showing that the less time parents spend engaging with their children's schooling is directly reflected in their school success.[5] Finland's national forum for skills anticipation – Finland Skills 2035 – has raised national debate concerning future skills requirements amongst Finnish society.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Finland performs well in terms of its knowledge infrastructure, with high scores across all thematic dimensions. Overall, this high knowledge infrastructure score is in line with the technology and future skills awareness performance.

Overview of Finland's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★★	★★★★★			★★★★☆	★★★★☆	★★★★★
Future skills awareness	★★★★★	★★★★★			★★★★☆	★★★★★	★★★★★

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval); five stars the 'most welcoming environment' (i.e. in the highest quintile interval): 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is very well-positioned for the future, relying on both strong infrastructure and high levels of technology and skills awareness, although with room for improvement in the field of biotechnology.

Efforts in this direction are clear from initiatives such as the European Bioeconomy Scene event hosted in Helsinki, Finland. The bioeconomy conference focused on sustainability, and sought to raise awareness and promote public dialogue.[7] The aforementioned national forum, Finland Skills 2035, is another example of the current prominence of the topic. Generally speaking, Finland is becoming a leading innovator in terms of future-proofing its population with skills training.

Finland held the six-month rotating presidency of the EU Council in the second half of 2019, defining one of the presidency's priorities as the protection of the security of EU citizens, pushing for a review of the Union's internal security strategy and hybrid threats. Finland promotes a comprehensive approach to security, defining a broad range of risks from climate change to cyberattacks, including online disinformation campaigns. The presidency program highlights the importance of achieving high levels of cybersecurity and the need for coordinated EU action in this regard, and largely drove the discussion on this topic.[8,9]

After becoming the first country in Europe to adopt a national AI strategy in 2017, online activity reflects the fact that Finland has launched the largest AI retraining initiative in the EU – a programme that aims to reach one percent of its population, or 54,000 people. In February 2019, new partnerships were announced with neighbouring Sweden and Estonia to test AI technology across borders, including cross-border trials of autonomous shipping technology on the Baltic sea between Finnish and Swedish ports, and an experiment to combine parts of the Finnish and Estonian digital infrastructures.[10] These regional partnership plans come at a time when EU-level policy action on AI is intensifying.

The country's performance is particularly strong in AI. In December 2018, online discussion focused on the European Commission's coordinated plan on AI, involving all Member States in an effort to define joint actions aimed at increasing funding and data availability, fostering skills and raising awareness of the benefits of AI. At the time of the launch of the Commission's plan, Finland was one of only five Member States to have adopted a national AI strategy with a dedicated budget.[11]

Endnotes

[1] *Pantsu, 2019.*
[2] *Saavalainen, 2019.*
[3] *Kärkkäinen, 2019.*
[4] *Manner, 2019.*
[5] *Malmberg, 2018.*
[6] *Fleming, 2019.*
[7] *See: http://www.bioeconomy.fi/EUBioScene19/.*
[8] *Valero, 2019.*
[9] *Finland's Presidency of the Council of the European Union, 2019.*
[10] *Delcker, 2019.*
[11] *Vandystadt and Waldstein, 2018.*

CLUSTER
01

FRANCE

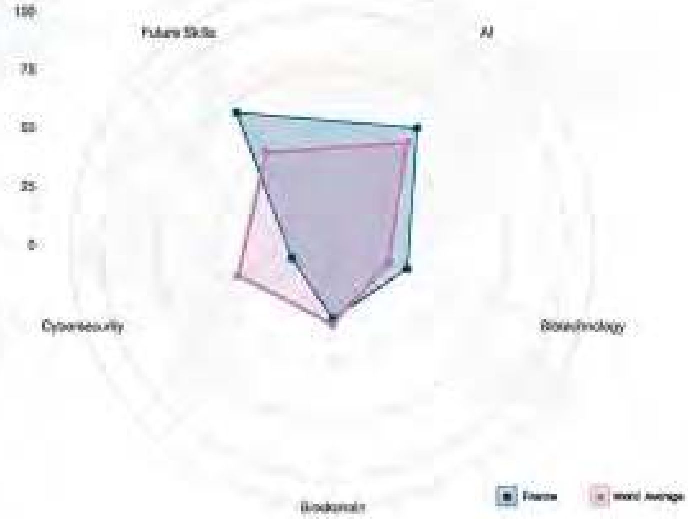
GDP per capita
$ 41,464
2018

HDI
0.901
2017

GKI
22/136
2019

2614
unique authors
per million
Internet users

Future field awareness indices

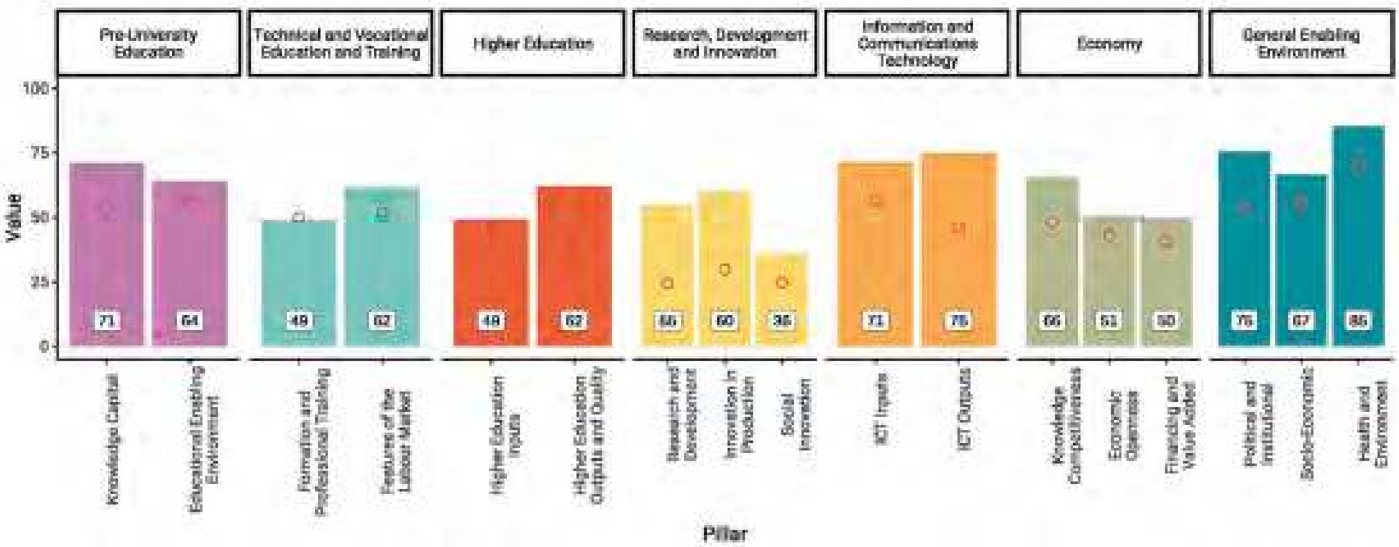


Knowledge infrastructure

In terms of knowledge infrastructure to support technological uptake, France is amongst the leading countries, standing alongside others such as Singapore and Sweden.

France ranks 22nd on the Global Knowledge Index, outperforming 84.4 percent of other countries. France performs above the world average in all sectoral indices and is strongest in the area of health and environment – ranking ninth globally. Conversely, France faces challenges in the area of formation and professional training, which may be attributed to low levels of government expenditure on vocational education and the shortfall in the share of students enrolled in vocational programmes.

Global Knowledge Index – France

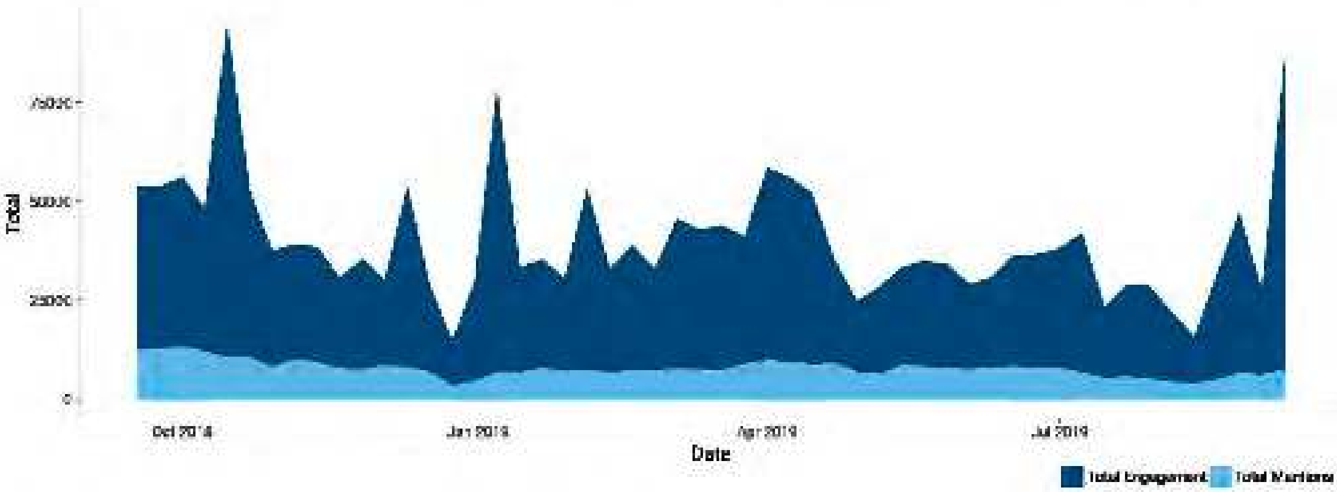


Technological awareness

82 percent of the French population have access to the Internet, with a mean download speed of 30.4 Mbps.

Between mid-September 2018 and mid-September 2019, there were 139,384 unique authors contributing to total content generation. The volume of online activity in France within the four technology fields chosen displays an average of 31,357.8 mentions and 128,888.6 instances of engagement. Online activity within the technology fields displays a degree of concentration of 0.00039. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.00052.

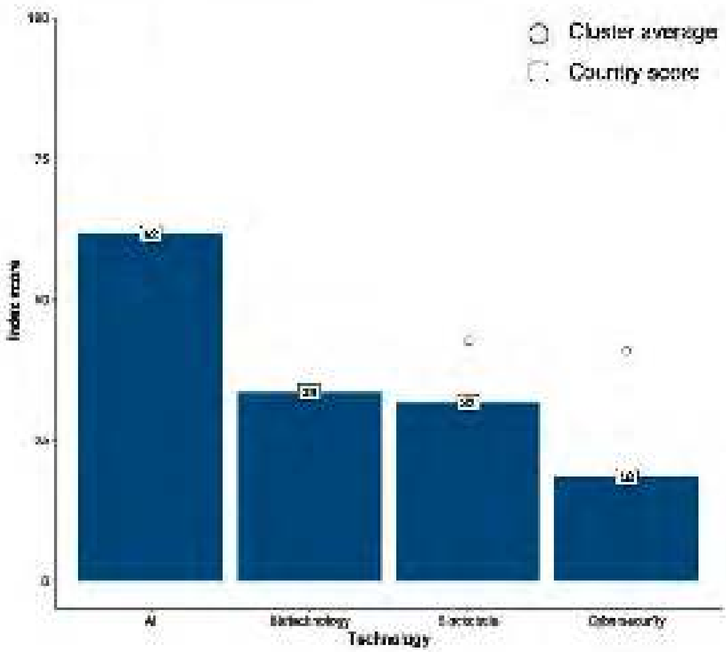
Volume of discussions and engagement level associated with the four key technologies for the future in France



The trend in online activity over time for France shows peaks in engagement related to the area of AI (RDI and science) and one peak in mentions in the area of blockchain (economy). The results associated with the peak in mentions mainly pertain to LOLIGO's, an ICO crowdfunding platform; the company proclaims itself to be the 'World's First ICO Safety Ecosystem' and promotes itself through numerous twitter posts posted on its official account.[1] The peak in engagement in January 2019 relates to the acquisition of one of the most powerful supercomputers in Europe. This is a particularly valuable tool for climate change simulations, materials studies and biology, and – for the first time – researchers in artificial intelligence.[2]

Global Technology Awareness Index: France

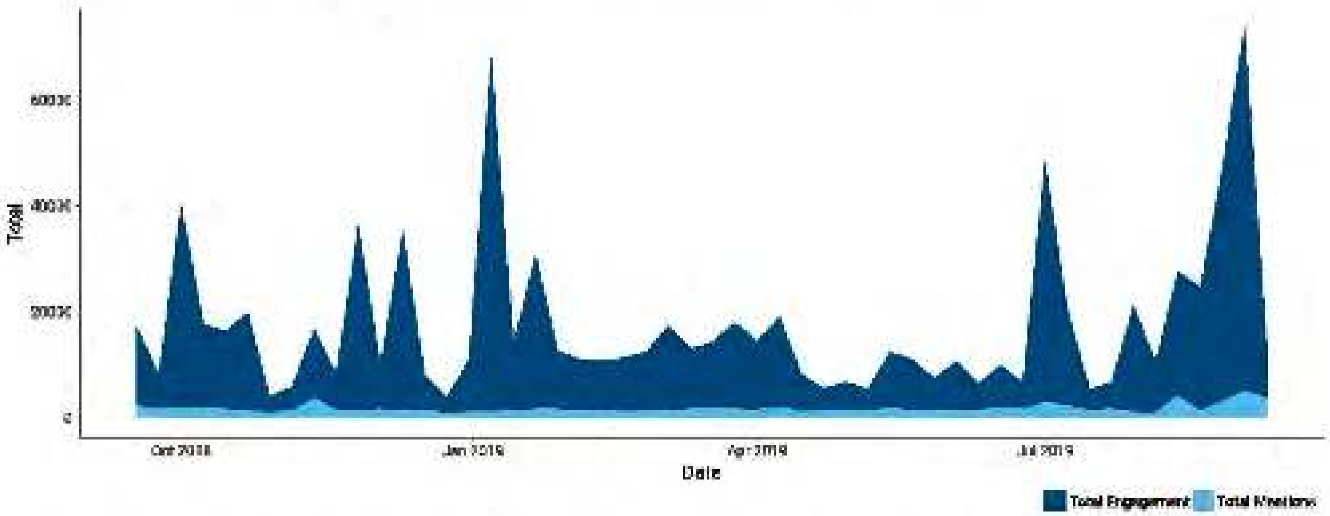
France outperforms the online activity cluster average in two out of four technology fields. In terms of activity distribution within the country, France shows small disparities across these technology fields, with AI being the most prominent and cybersecurity the least prominent technology.



Future skills awareness

The online community exhibits remarkable levels of online engagement concerning future skills, with an average value of 6,976.8 mentions and 63,316.5 engagement events per month. Total online activity in the area of future skills in France is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in France



The trend in online activity over time for France shows a number of peaks in engagement and mentions mainly related to education, and RDI and science. In terms of engagements, the first peak, in October 2018, pertains to BrainNet, a connected brain social network. It employs a device based on an electroencephalograph, which records the electrical activity of the brain via electrodes distributed around the head.[3] The peak in January 2019 related to the very often-mentioned idea in the French right party to affect the allocation of families of violent students in school.[4] A less expressed peak, in July 2019, concerns the Minister of Education, who, during the national assembly, asked to replace missing copies during the baccalaureate examination with notes of the continuous examination.[5] In terms of peaks in mentions, the first relates to the 'Global Compact for Migration' that took place in Marrakech and was adopted by 189 countries, including France.[6] The second peak referred to a virtual reality application that teaches HR managers how to lay off employees – a virtual reality app, complete with emotional intelligence, developed by Californian start-up Talespin.[7]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

France exhibits a very strong, remarkable performance, especially in terms of technology and future skills awareness, with a maximal score across almost all dimensions. Overall, there is room for slight improvement in terms of knowledge infrastructure in the technical and vocational education sector.

Overview of France's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★★	★★★★☆	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★★	★★★★★			★★★★☆	★★★★☆	★★★★★
Future skills awareness	★★★★★	★★★★★			★★★★★	★★★★☆	★★★★★

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is very well-positioned for the future, relying both on strong infrastructure and showing a high level of awareness of both future skills and technologies, with room for improvement in cybersecurity.

France is on track with these improvements, as cybersecurity was one of the main topics marking the French G7 presidency. In May 2019 the international conference 'Cybersecurity: Coordinating efforts to protect the financial sector in the global economy' was convened under the patronage of the French Ministry of the Economy and Finance and the French Central Bank.[8] Also, in November 2018 the French government officially launched its new national AI strategy at the Toulouse Institute of Computer Science Research. The strategy foresees EUR 665 million of dedicated funding for AI research over the next four years, coming from both public and private investments.[9]

Endnotes

[1] *See: https://loligo.co/.*
[2] *Samama and AFP, 2019.*
[3] *Zaffagni, 2018.*
[4] *Baheux, 2019.*
[5] *Piquemal, 2019.*
[6] *Lejeune, 2018.*
[7] *Ingrand, 2019.*
[8] *See: https://www.banque-france.fr/en/conferences-and-media/seminars-and-symposiums/research-conferences-and-symposiums/french-presidency-g7-2019-cybersecurity-coordinating-efforts-protect-financial-sector-global-economy.*
[9] *Innovatie Attaché Netwerk, 2018.*

CLUSTER 01

GERMANY

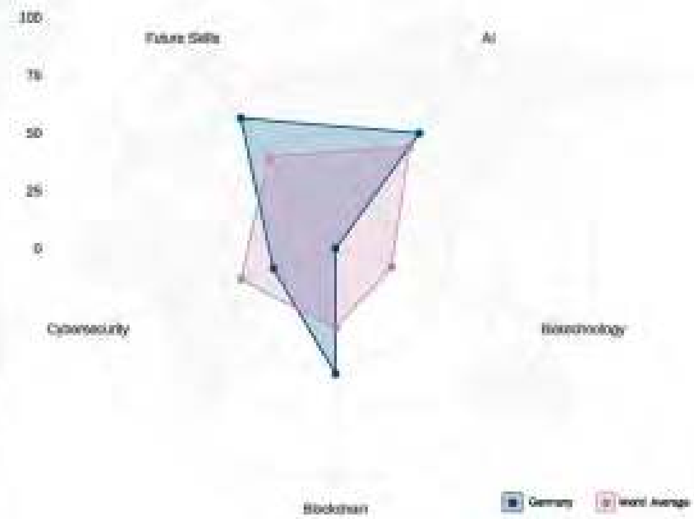
GDP per capita
$ 48,196 2018

HDI
0.936 2017

GKI
17/136 2019

1374 unique authors per million Internet users

Future field awareness indices

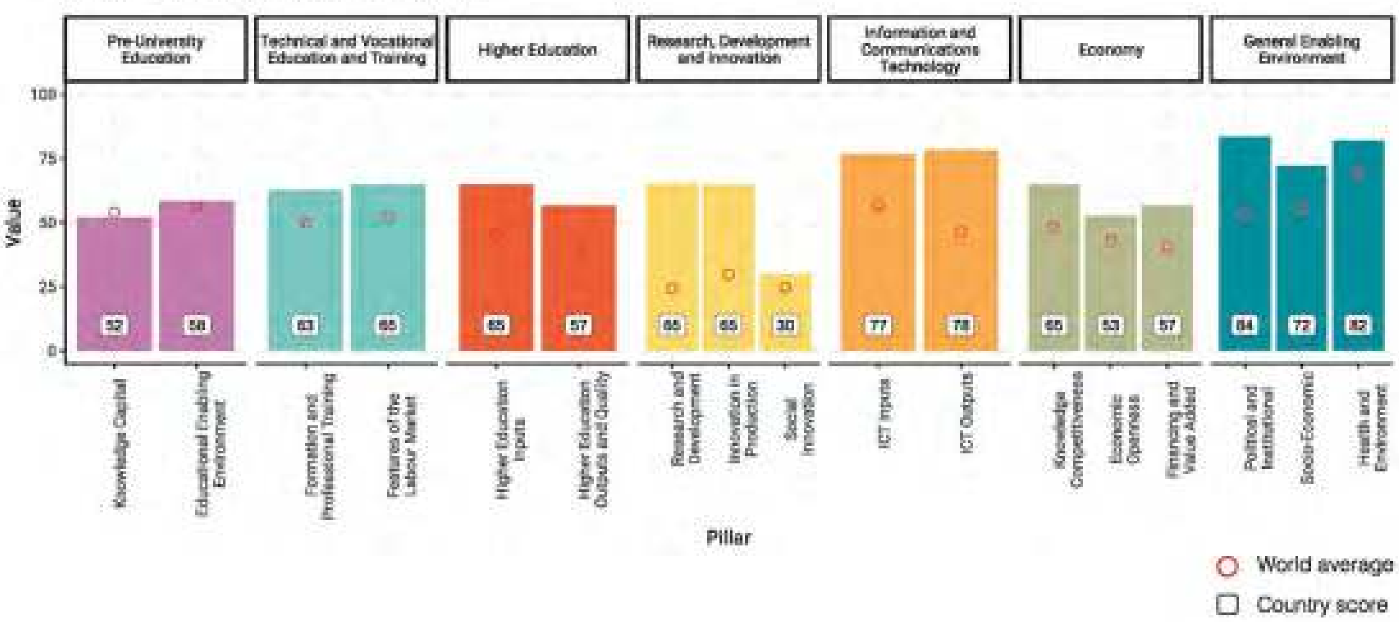


Knowledge infrastructure

In terms of current infrastructure to support technological uptake, Germany is amongst the leading countries in the world, standing alongside the likes of the United Kingdom and Japan.

Germany is ranked 17th on the Global Knowledge Index, outperforming 88.1 percent of other countries. Germany performs above the world average in six out of seven sectoral indices, with pre-university education being the weakest performing sector. It performs the strongest in areas of research and development – ranking fifth globally. Conversely, Germany faces challenges in the area of knowledge capital in pre-university education, which may be attributed to fairly low gross enrolment and graduation ratios in upper secondary education.

Global Knowledge Index – Germany

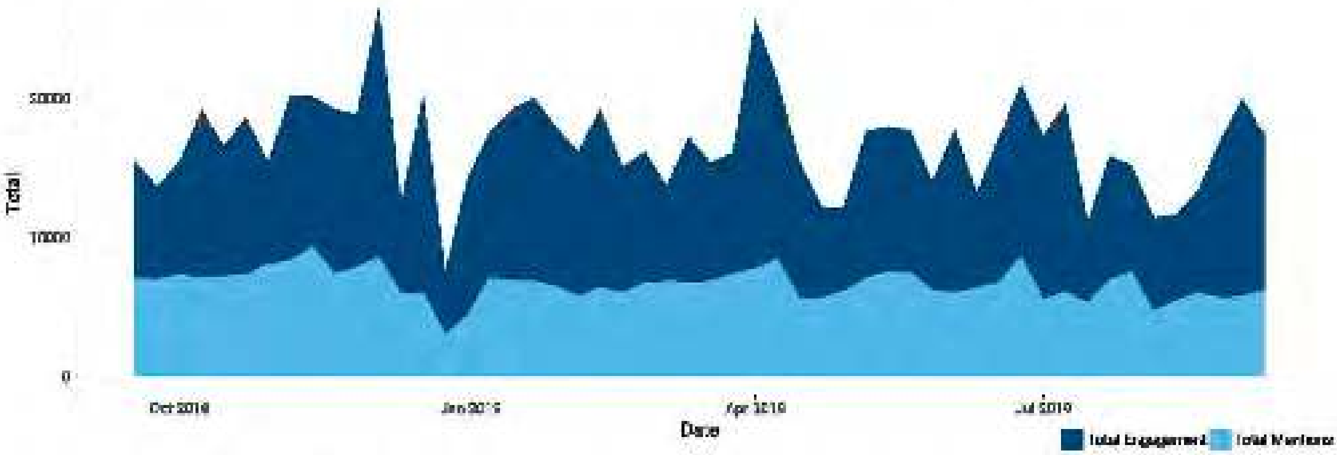


Technological awareness

89.7 percent of the German population have access to the Internet, with a mean download speed of 24.6 Mbps.

Between mid September 2018 and mid September 2019, there were 102,468 unique authors contributing to total content generation. The volume of online activity in Germany within the four technology fields chosen displays an average of 26,674.3 mentions and 40,189.7 instances of engagement per month. Online activity within these fields displays a degree of concentration of 0.002. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.0004.

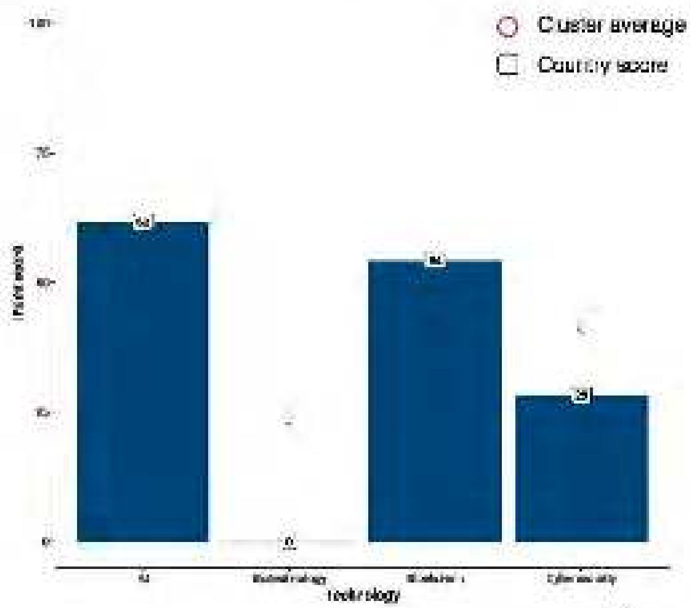
Volume of discussions and engagement level associated with the four key technologies for the future in Germany



The trend in online activity over time for Germany shows an active online community with two noteworthy peaks in engagement and two relevant peaks in mentions in the areas of AI (economy and enabling environment). The top results associated with the peaks in engagement pertain mainly to Germany's deteriorating global competitive position in terms of new technologies and, specifically, AI. Industry representatives and policymakers discussed the country's innovation capacity during the industrial fair 'Industrieschau Hannover Messe' in April 2019.[1] Additionally, at the digital summit of the German Federal Government, Angela Merkel announced the promotion of a third path with the US and China in terms of data protection and AI regulation.[2] The peaks in mentions resulted from the European Union's new ethical rules for the development and application of AI. Currently in a pilot phase, companies, research institutes and public authorities are now testing the ethical guidelines using assessment lists prepared by the AI expert group, and are due to communicate their experiences by 2020.[3] Finally, the second peak in mentions resulted from international news about the Israeli government refusing Germany access to cybersecurity sites in Israel.

Global Technology Awareness Index: Germany

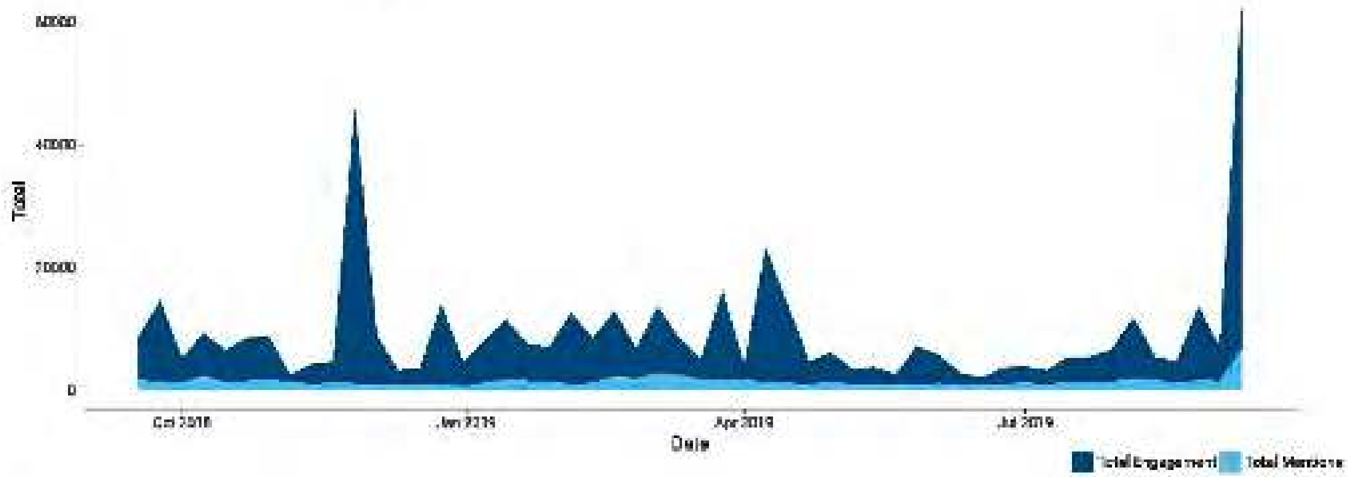
Germany outperforms the online activity cluster average in two out of four technology fields. In terms of activity distribution within the country, Germany displays a non-balanced performance – online activity concentrated on AI and blockchain, whilst biotechnology did not trigger online activity.



Future skills awareness

The online community presents a high level of online activity in the area of future skills, with an average value of 5,782 mentions and 31,020.7 instances of engagement per month. However, online activity in this area is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Germany



The trend in online activity over time for Germany shows two main peaks in engagement and two peaks in mentions, both in relation to education. The results associated with these peaks pertain to national news on the state of education at the primary school level in particular, as Germany lacks more than 26,000 primary school teachers.[4] The other peak in engagement resulted from national news on the increase in German classes for police students.[5] Both peaks in mentions discuss the increasing inequality gap between students – with varying levels of financial means – and called for an increase in financial but also education-related measures to ensure equal opportunities for Germany's students.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Germany exhibits high performance in terms of its knowledge infrastructure, technology and future skills awareness, with high scores across most thematic dimensions. Overall, there is room for improvement in the enabling environment and RDI dimensions of the awareness indices.

Overview of Germany's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★☆☆	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★☆	★★★★☆			★★★☆☆	★★★☆☆	★★★★☆
Future skills awareness	★★★☆☆	★★★★☆			★★☆☆☆	★★★☆☆	★★★★☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval): 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The low awareness scores in the enabling environment, and RDI and science dimensions, indicate that Germany relies on its strong infrastructure and is starting its transition to new technologies – especially AI and blockchain.

Limited discussion relating to biotechnology is noticed; however, developments in the area show that the country is on track in this regard. In July 2019 the Johannes Gutenberg University of Mainz broke fundraising records with its spinout BioNTech, which raised USD 325 million to finance its personalized treatments for cancer and other diseases. This represented the largest financing round of any biotechnology company in Europe, bringing the total sum raised from investors and partners to $1.4 billion to develop a technology for individual tailored treatments for the immune system.[7]

In terms of the country's enabling environment, room for improvement exists, as reflected by a lack of enforcement of legislative measures. While the country might have adopted encouraging policy commitments, there is a need to strengthen their implementation. This point was illustrated, for instance, in July 2019, when Germany was found to have continuously breached the EU's Nitrates Directive, with the country's groundwater being polluted over several years.[8]

The discussions around education were boosted by the adoption of a new national strategy – Work 4.0 – in November 2018, aimed at preparing the economy for the digital transition. The strategy identifies upskilling and lifelong learning as important pillars in responding to challenges and opportunities related to the adoption of new technologies. Needs are defined by economic sector and analysed in categories, such as workplace design, education and continuous training.[9]

The German government also issued its AI national strategy in November 2018 – the result of cooperation between the Federal Ministry for Economic Affairs and Energy, the Federal Ministry of Education and Research, and the Federal Ministry of Work and Social Affairs. The strategy establishes a framework for the holistic development and application of AI in the country, with the goal to strengthen Germany's position as an AI research hub and foster the adoption of AI by SMEs.[10]

Endnotes

[1] *Knitterscheidt and Scheuer, 2019.*
[2] *Brühl, 2018.*
[3] *European Commission, 2019.*
[4] *Duhm, 2019.*
[5] *WELT, 2018.*
[6] *Helbig and Pfister, 2019.*
[7] *Cookson, 2019.*
[8] *Michalopoulos, 2019.*
[9] *Federal Ministry of Education and Research, 2019.*
[10] *Federal Ministry for Economic Affairs and Energy, 2018.*

CLUSTER
01

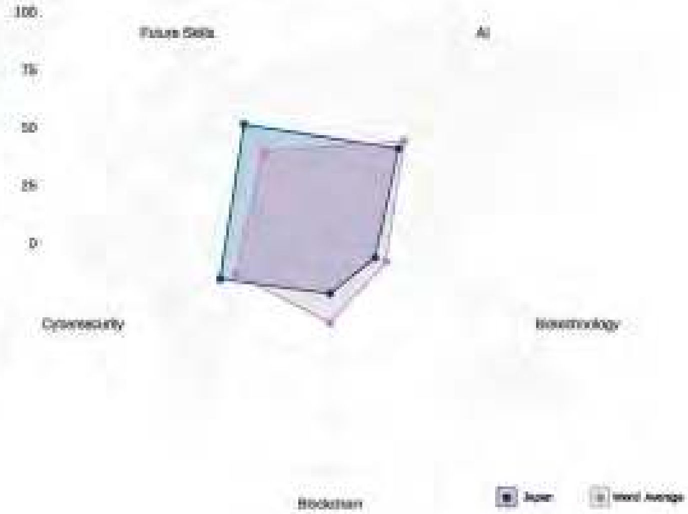
GDP per capita
$ 39,287
2018

HDI
0.909
2017

GKI
11/136
2019

1552
unique authors
per million
Internet users

Future field awareness indices

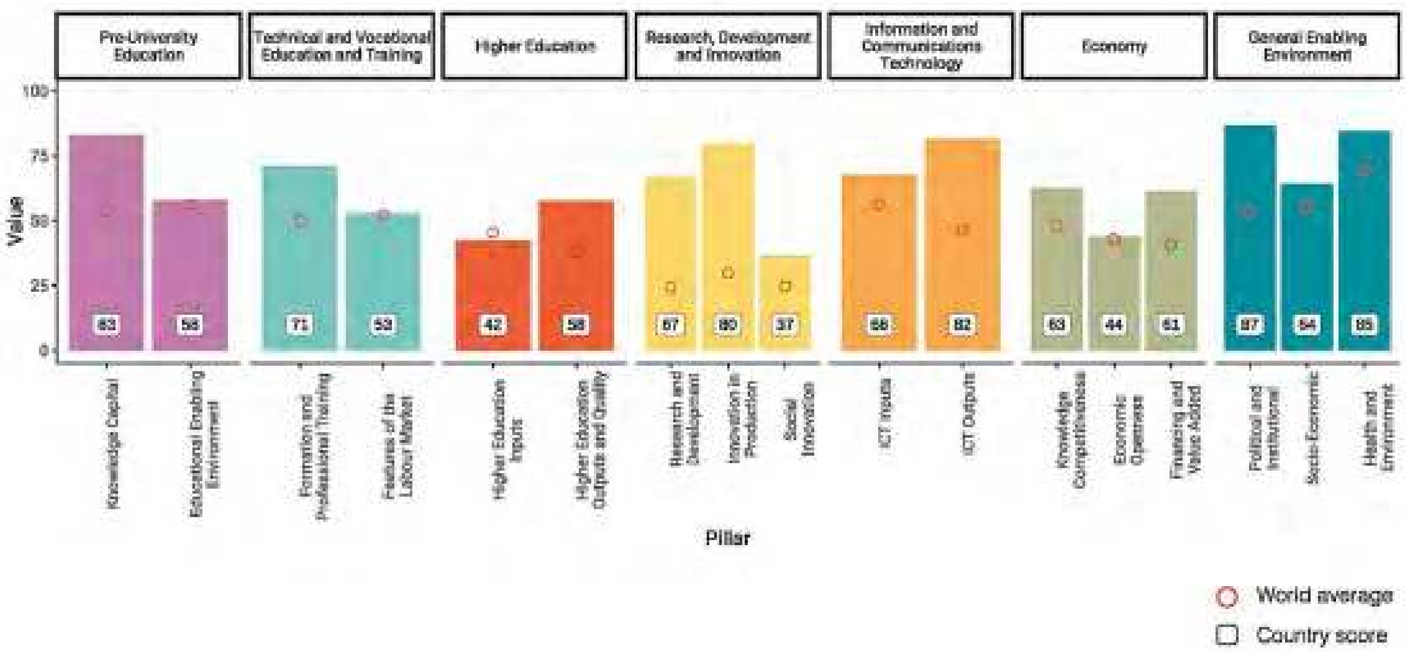


Knowledge infrastructure

In terms of knowledge infrastructure to support technological uptake, Japan is amongst the leading countries, standing alongside others such as Finland and France.

Japan is ranked 11th on the Global Knowledge Index, outperforming 92.5 percent of other countries. Japan performs above the world average in all sectoral indices and is strongest in the area of innovation in production – ranking first globally. Conversely, Japan faces challenges in the area of higher education inputs, which may be attributed to low levels of government expenditure on tertiary education.

Global Knowledge Index – Japan

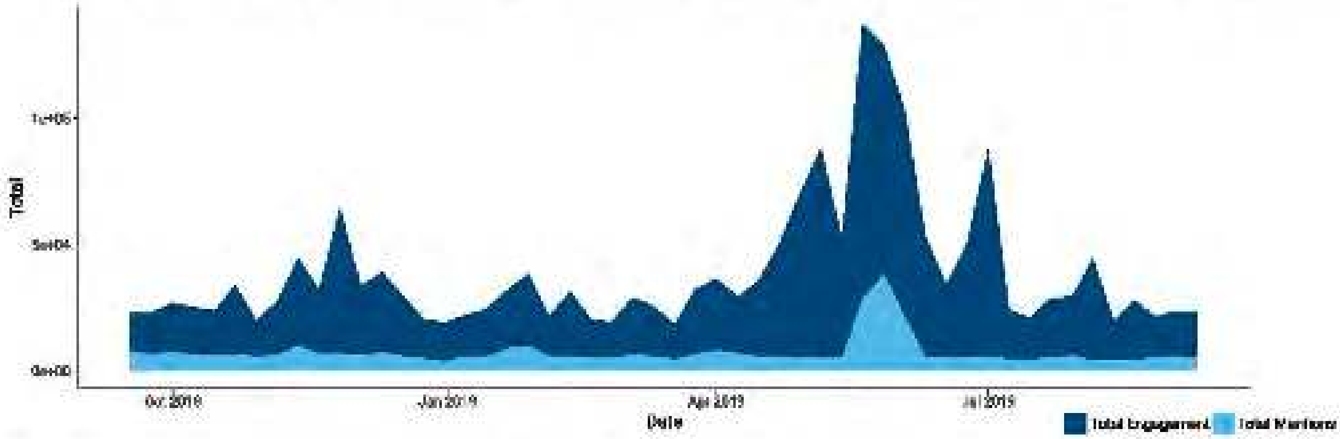


Technological awareness

84.6 percent of the Japanese population have access to the Internet, with a mean download speed of 42.8 Mbps.

Between mid-September 2018 and mid-September 2019, there were 167,417 unique authors contributing to total content generation. The volume of online activity in Japan within the four technology fields chosen displays an average of 29,354.4 mentions and 126,350 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0003. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.00035.

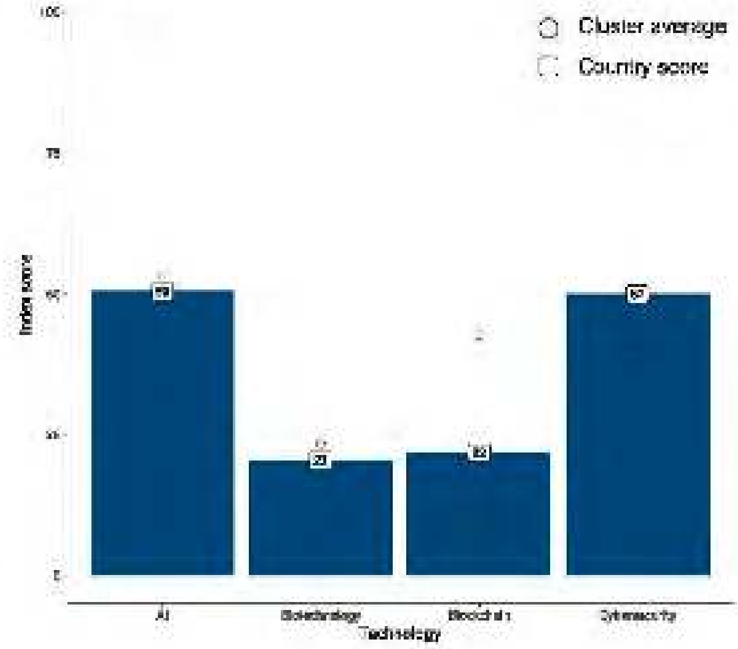
Volume of discussions and engagement level associated with the four key technologies for the future in Japan



The trend of online activity over time for Japan shows a number of peaks in engagement related to blockchain (RDI and science, and education). There is also a relevant peak in mentions related to RDI and science. The first peak in engagement pertains to local news – specifically 60,000 people registering for the game 'Satoshi's Treasure', in which contestants search for 100 million yen in Bitcoin.[1] The second peak in engagement resulted from national news about the Yano Research Institute's survey on the domestic blockchain-employed service market. The survey projected the value of this market to reach 17,150 million Yen by 2019 and 123,590 million Yen by 2022.[2] The third peak in engagement concerned national news of the Japanese Society for Rights of Authors, Composers and Publishers (JASRAC), which conducted a two year investigation into the illegal use of music in classrooms.[3] The final peak in mentions resulted from international news concerning the meeting of the G20 in Japan in June 2019; ministers of trade and digital economy met early in June to discuss the ethics and assess the implications of AI, 5G and other fast developing phenomena.[4]

Global Technology Awareness Index: Japan

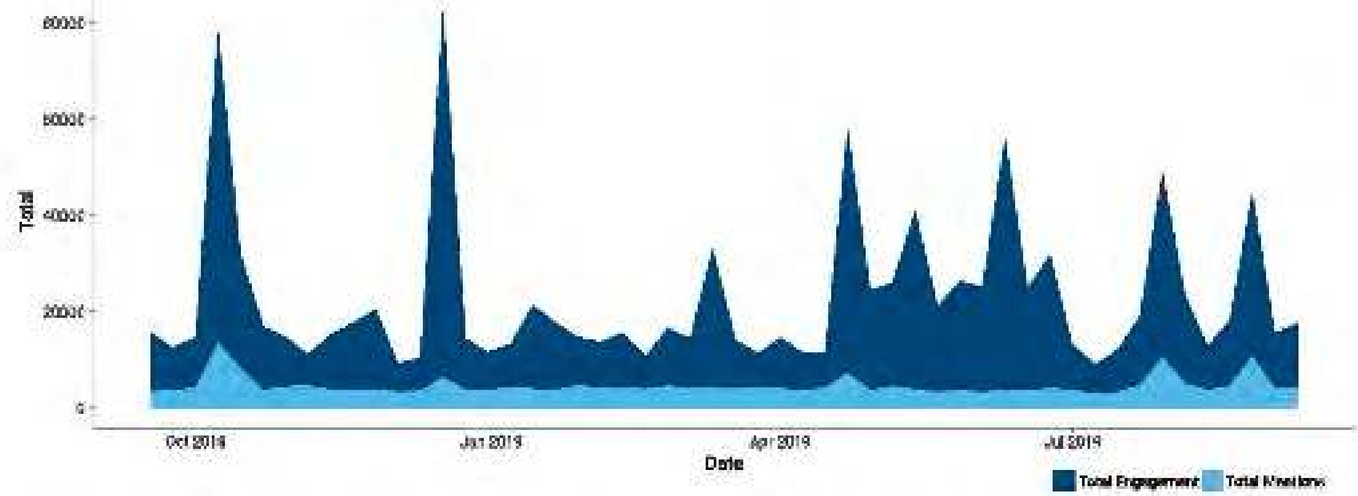
Japan outperforms the online activity cluster average in one out of four technology fields. In terms of activity distribution within the country, Japan's discussions are mainly oriented towards cybersecurity and AI, with lower activity concerning biotechnology and blockchain.



Future skills awareness

The online community exhibits a high level of online activity concerning future skills, with an average value of 18,404.9 mentions and 72,367.9 instances of engagement per month. Total online activity in the area of future skills in Japan is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Japan



The trend of online activity over time for Japan shows a number of peaks in engagement related to RDI and science, and education. The results associated with the first peak in engagement pertains to international news that the US NVIDIA had announced its open source GPU acceleration platform, 'RAPIDS', for data science and machine learning in October 2018.[5] The second peak in engagement resulted from the announcement of a visit to Japan by an expert group from renowned universities in the US to support the development of a 'designated national university' that aims to provide world-class education and research.[6] The third peak in engagement relates to Rice University offering scholarships to students from low-income families.[7]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Overview of Japan's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GK)	★★★★★	★★★★☆	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★☆	★★★★☆			★★★★☆	★★★★☆	★★★★☆
Future skills awareness	★★★★☆	★★★★☆			★★★☆☆	★★★★★	★★★★☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval); five stars the 'most welcoming environment' (i.e. in the highest quintile interval): 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Japan performed well in terms of its knowledge infrastructure, as well as its technology and future skills awareness – with high scores across all dimensions. Overall, the country is well-positioned for the future, relying on strong infrastructure and showing a high level of awareness on both future skills and technologies. However, there is room for improvement in terms of future skills in the enabling environment dimension.

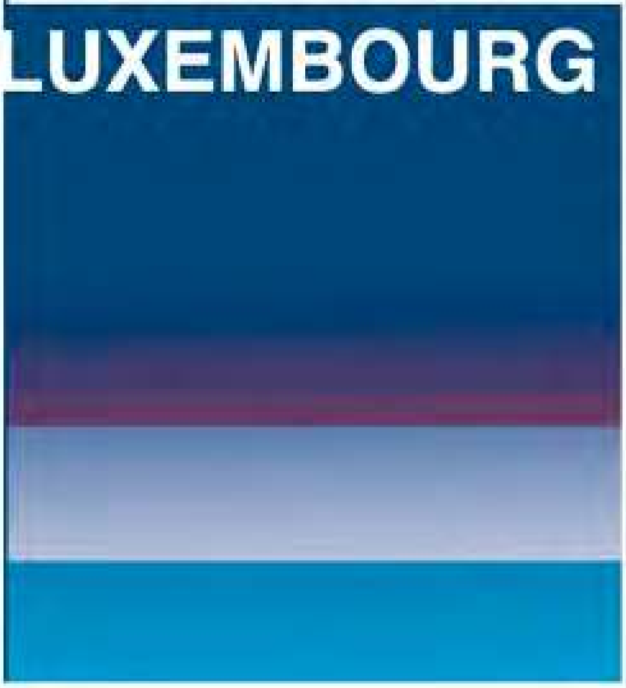
In this context, the country's government co-organised the Asia-Pacific Forum on Sustainable Development in March 2019, together with the governments of Indonesia and the Philippines. The event was held under the slogan 'empowering people and ensuring inclusiveness and equality', and aimed to facilitate discussions on creating decent, green jobs and sustainable livelihoods, and educating and enabling residents to join efforts to achieve sustainability.[8] Such initiatives targeting national policymakers and setting the tone for the region could be instrumental in raising awareness of the skills and technologies of the future. Finally, Japan has also progressed significantly in terms of enabling funding opportunities for start-ups, with innovative companies receiving more support. In fact, funding has surged eight-fold over the past five years.[9]

Endnotes

[1] *Yahoo Japan Corporation, 2019.*
[2] *Yano Research Institute Ltd, 2019.*
[3] *Asahi Shimbun Digital, 2019.*
[4] *The Financial Times LTD, 2019.*
[5] *PC Watch, 2018.*
[6] *Asahi Shimbun Digital, 2019.*
[7] *IT Media Inc., 2018.*
[8] *Government of Japan et al., 2019.*
[9] *Takahashi, 2019.*

CLUSTER
01

LUXEMBOURG



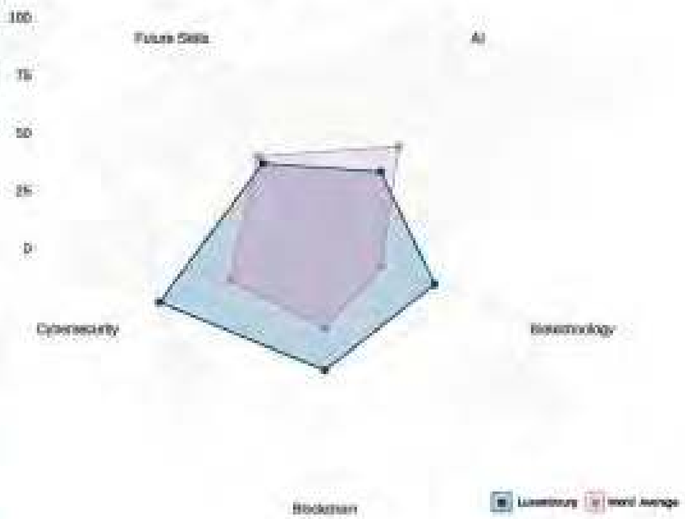
GDP per capita
$114,340
2018

HDI
0.904
2017

GKI
5/136
2019

5265
unique authors
per million
Internet users

Future field awareness indices

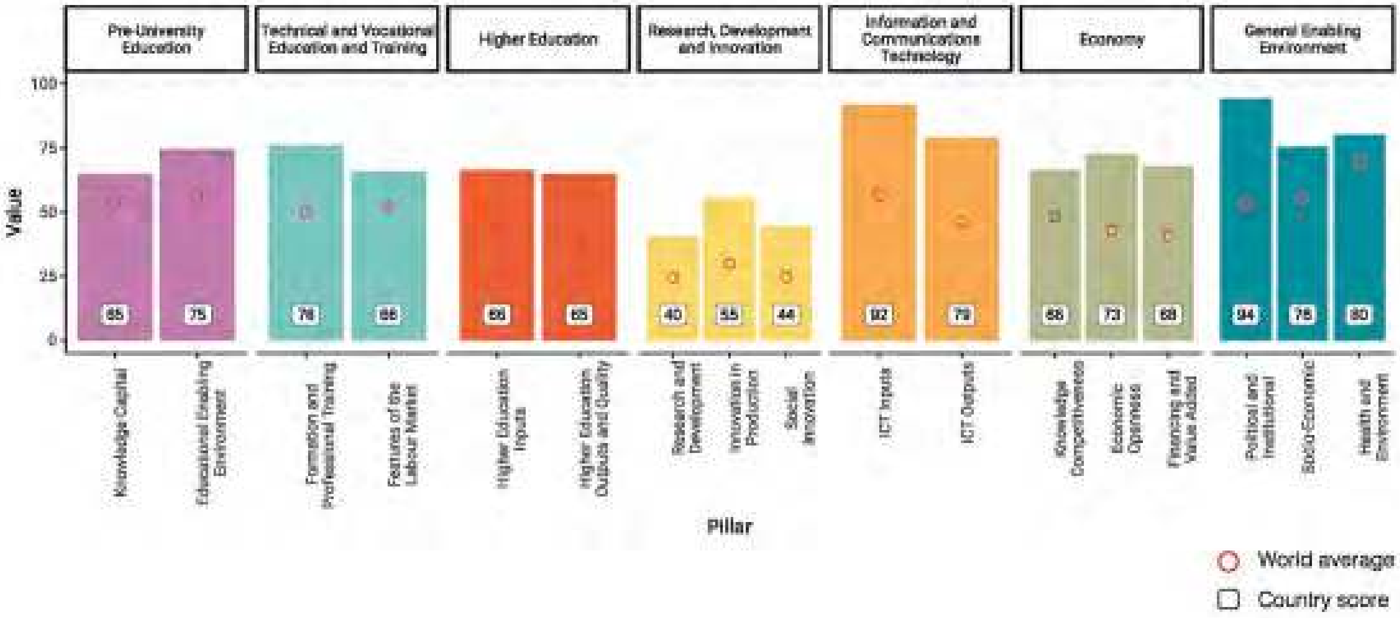


Knowledge infrastructure

In terms of knowledge infrastructure to support technological uptake, Luxembourg is amongst the leading nations, standing alongside countries such as the Netherlands and Singapore.

Luxembourg is ranked fifth on the Global Knowledge Index, outperforming 97 percent of other countries. Luxembourg performs above the world average in all sectoral indices and is strongest in the area of ICT inputs – ranking second globally. Conversely, Luxembourg faces challenges in in terms of the knowledge capital generated by pre-university education, which may be attributed to low levels of enrolment in primary and upper secondary education.

Global Knowledge Index – Luxembourg

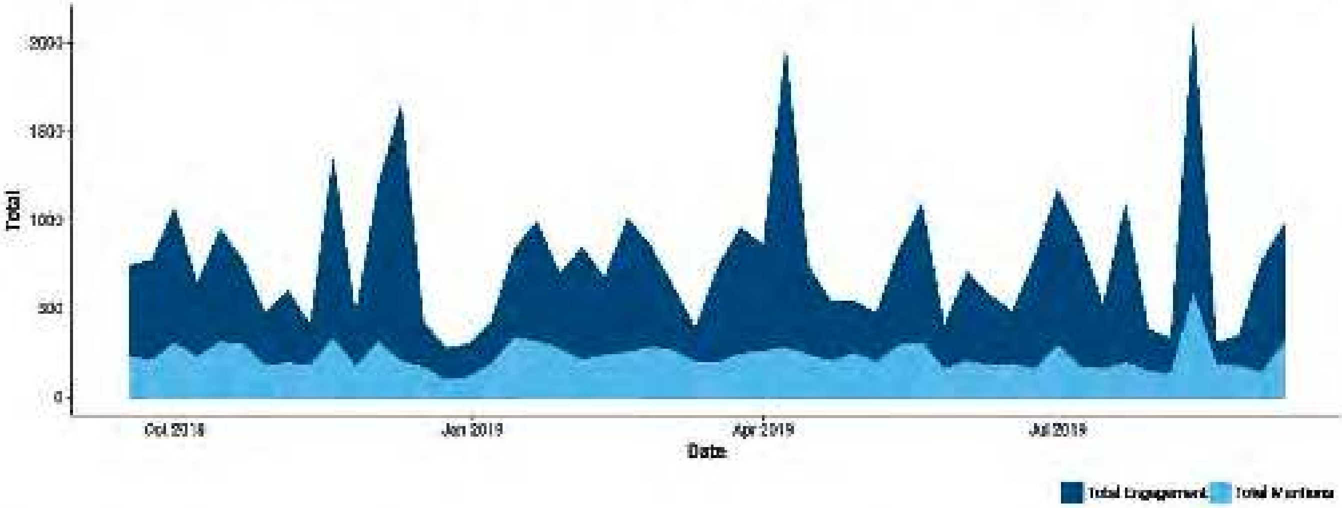


Technological awareness

97 percent of Luxembourg's population has access to the Internet, with a mean download speed of 41.7 Mbps.

Between mid-September 2018 and mid-September 2019, there were 3,088 unique authors contributing to total content generation. The volume of online activity in Luxembourg within the four technology fields chosen displays an average of 919.7 mentions and 2,157 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.015. In comparative terms, 2019 presents a higher concentration over the previous sampling period, with a value of 0.0096.

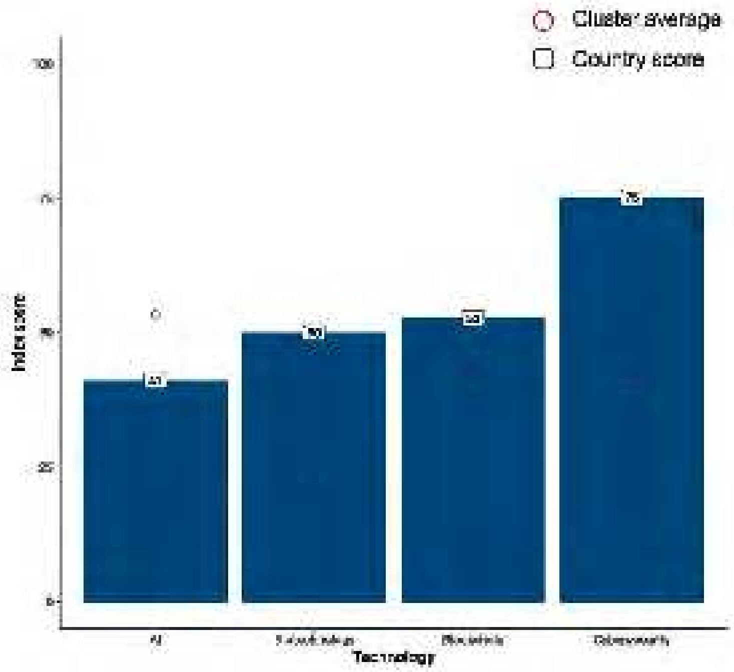
Volume of discussions and engagement level associated with the four key technologies for the future in Luxembourg



The trend in online activity over time in Luxembourg shows several peaks in engagement and mentions. Throughout the observation period, online activity was especially moved by the establishment of the national AI strategy 'for the country based on a human centric approach'[1], the Cybersecurity Week Luxembourg in October 2018, as well as the law passed by the parliament in February 2019 permitting the use of distributed ledger technology (DLT) for the circulation of securities, therefore facilitating the use of blockchain technology in financial services.[2] The peak in engagement around January 2019 related to blockchain (education) and specifically to the representation of 16 start-ups from Luxembourg at the CES – an annual trade show organised by the Consumer Technology Association.[3] Online activity in February 2019 was important in terms of cybersecurity (enabling environment), as the European Commission presented a set of recommendations for the creation of a secure system that will enable citizens to access their electronic health files across Member States, stressing that this will be in full compliance with European data protection rules.[4] In April 2019, there was an important engagement in the area of AI (RDI and science, and education) pertaining to the launch by the European Commission of the pilot phase of the AI ethical guidelines. This new step falls within the European Strategy on AI published in April 2018.[5] The peak in engagement at the end of the observation period is linked to a peak in mentions and relates to the area of blockchain (RDI and science). These peaks mostly pertain to the launch of Jur, a blockchain-based ecosystem that provides solutions to the legal and judicial industry for business-related issues, launched by OceanEx, an AI digital asset-trading platform.[6]

Global Technology Awareness Index: Luxembourg

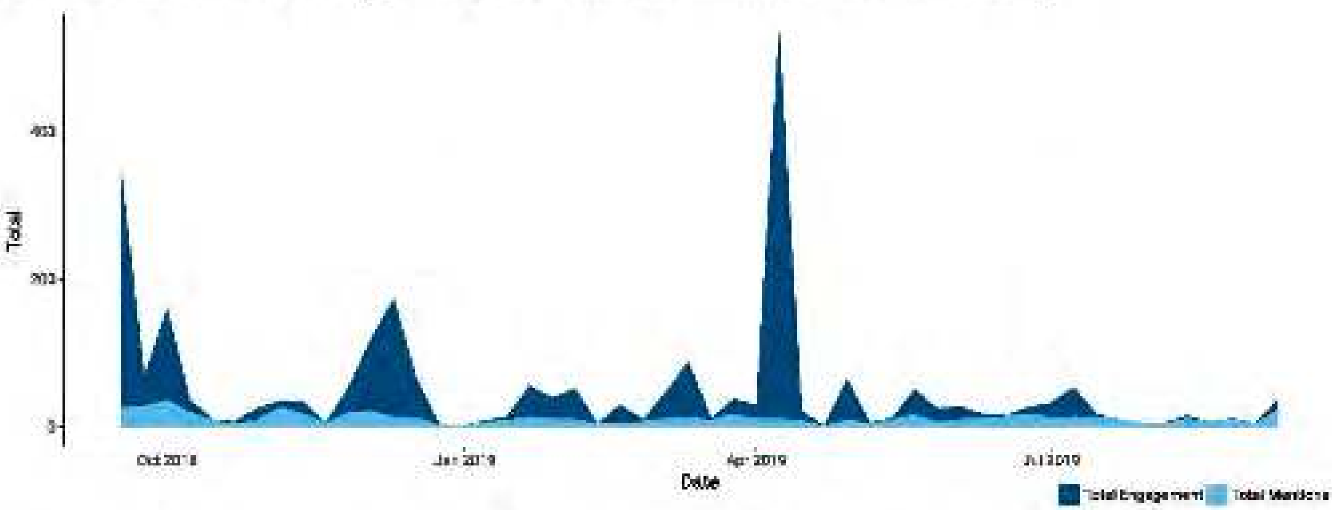
Luxembourg outperforms the cluster average in three out of the four technological fields in terms of online activity. Regarding activity distribution within the country, Luxembourg displays a more balanced overall performance, with online activity spread evenly across blockchain, biotechnology and AI; however, stronger results for online activity are evident in the area of cybersecurity in the country.



Future skills awareness

The online community presents a significantly lower involvement in online activity concerning this topic, with an average value of 46.5 mentions and 148.5 instances of engagement per month. Total online activity in the area of future skills in Luxembourg is lower than that relating to technologies of the future.

Volume of discussions and engagement level associated with future skills in Luxembourg



The trend in online activity in Luxembourg shows an important instance of online engagement at the beginning of the observation period, relating to the enabling environment – namely the adoption a new procedure allowing companies to produce green electricity at zero cost.[7] Another peak during the observed period in the area of future skills (technology) related to the launch of a pilot phase for ethical guidelines governing AI development and use to determine whether they can be implemented in practice. The Commission invited industry, research institutes and public authorities to test the detailed assessment list drafted by the 'high-level expert group', which complements the guidelines.[8] In terms of mentions, the trend in online activity over time shows two relevant peaks in mentions related to the enabling environment and economy. The first peak relates to the third National Plan for Sustainable Development (PNDD), presented by Mrs. Carole Dieschbourg, Minister of the Environment, to the participants of the collaborative process on 27 September 2018.[9] The second peak in mentions concerned the rating agency Standard & Poor's (S&P), which reconfirmed, on 13 September 2019, the Luxembourg's AAA rating and stable outlook. It joins DBRS, Moody's and Fitch in their assessment of the credit rating of the Grand Duchy. In its analysis, the agency highlights the country's economic prosperity, as well as its transparent and efficient institutional framework, prudent fiscal policy and robust economic growth.[10]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Luxembourg exhibits a particularly high performance in terms of its knowledge infrastructure, and technology and future skills awareness, with high scores across all sectors. Overall, there is room for improvement in terms of future skills awareness in the education and RDI and science dimensions, which are the lowest scoring dimensions. On the other hand, all of the other dimensions display strong results above the average.

Overview of Luxembourg's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★★	★★★★★			★★★★★	★★★★★	★★★★★
Future skills awareness	★★★★★	★★★☆☆			★★★★★	★★★☆☆	★★★★★

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0-20%), 2 stars (20-40%), 3 stars (40-60%), 4 stars (60-80%), 5 stars (80-100%).

The country is very well-positioned for the future, relying both on strong infrastructure and showing a high level of awareness on technologies and skills. An example of this awareness in Luxembourg is its national AI Vision, which underlines Luxembourg's ambition to become a living lab of real-world AI applications[11], or the recently passed law that facilitates the use of blockchain technology in financial services.[12] However, the country still has room for improvement in its terms of its future skills awareness. Luxembourg has already taken a step in this direction with the national upskilling strategy – 'Skills Bridge'[13] – and conferences such as 'Who is afraid of digital?' held in January 2019.

Endnotes

[1] *Government of the Grand Duchy of Luxembourg, 2019.*
[2] *Luxembourg for Finance, 2019.*
[3] *Ratzer, 2019.*
[4] *Vandystadt et al., 2019.*
[5] *Vandystadt and Waldstein, 2019a.*
[6] *OceanEx Official, 2019.*
[7] *Soriut, 2018.*
[8] *Vandystadt and Waldstein, 2019b.*
[9] *Magapau4, 2018.*
[10] *Luxembourg Ministry of Finance, 2019.*
[11] *Government of the Grand Duchy of Luxembourg, 2019.*
[12] *Luxembourg for Finance, 2019.*
[13] *See: https://www.skillsbridge.lu/.*

CLUSTER
01

NETHERLANDS

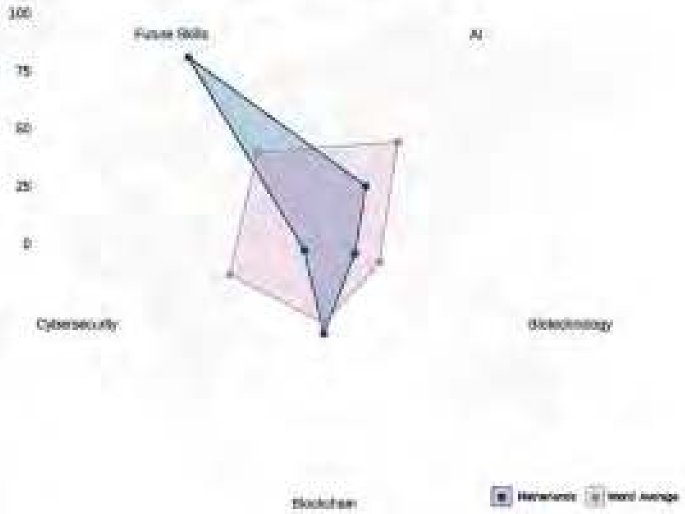
GDP per capita
$ 53,024
2018

HDI
0.931
2017

GKI
7/136
2019

2551
unique authors
per million
Internet users

Future field awareness indices

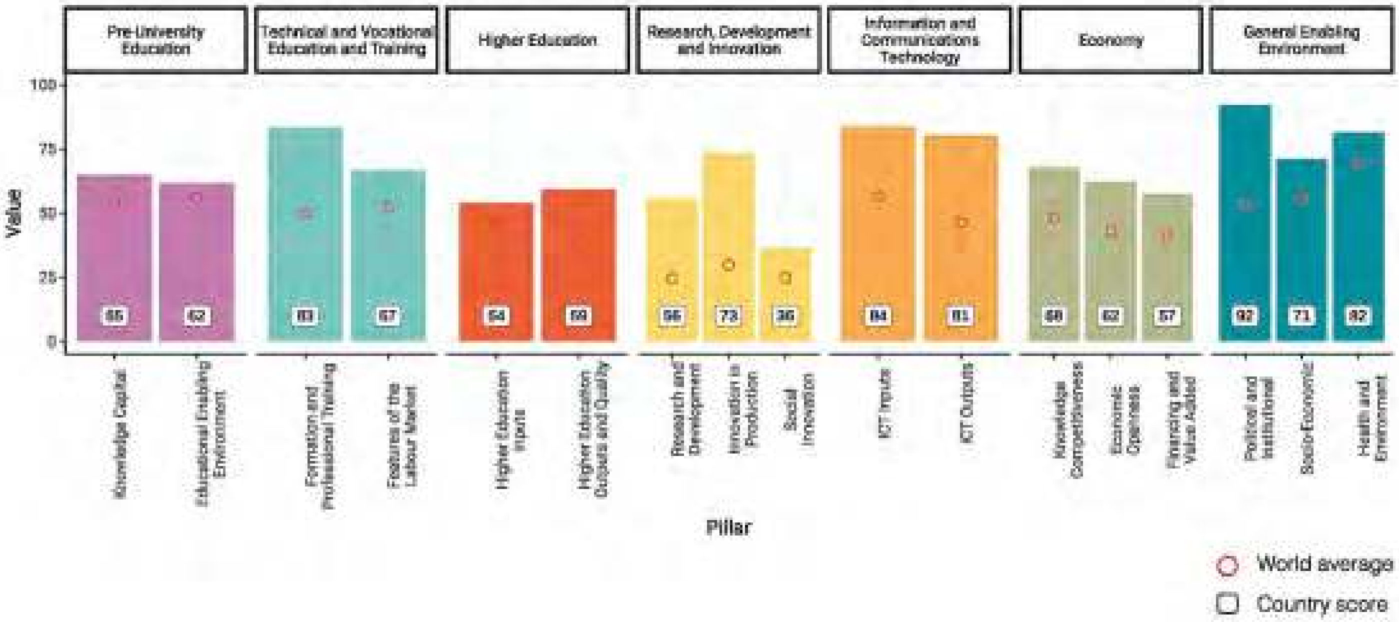


Knowledge infrastructure

In terms of knowledge infrastructure to support technological uptake, the Netherlands is amongst the leading nations, alongside countries such as the United Arab Emirates and Singapore.

The Netherlands is ranked seventh on the Global Knowledge Index, outperforming 95.5 percent of other countries. The Netherlands performs above the world average in all sectoral indices and is strongest in the area of the pre-university education enabling environment, which may be attributed to low government expenditures on primary education and a high pupil–teacher ratio in secondary education.

Global Knowledge Index – Netherlands

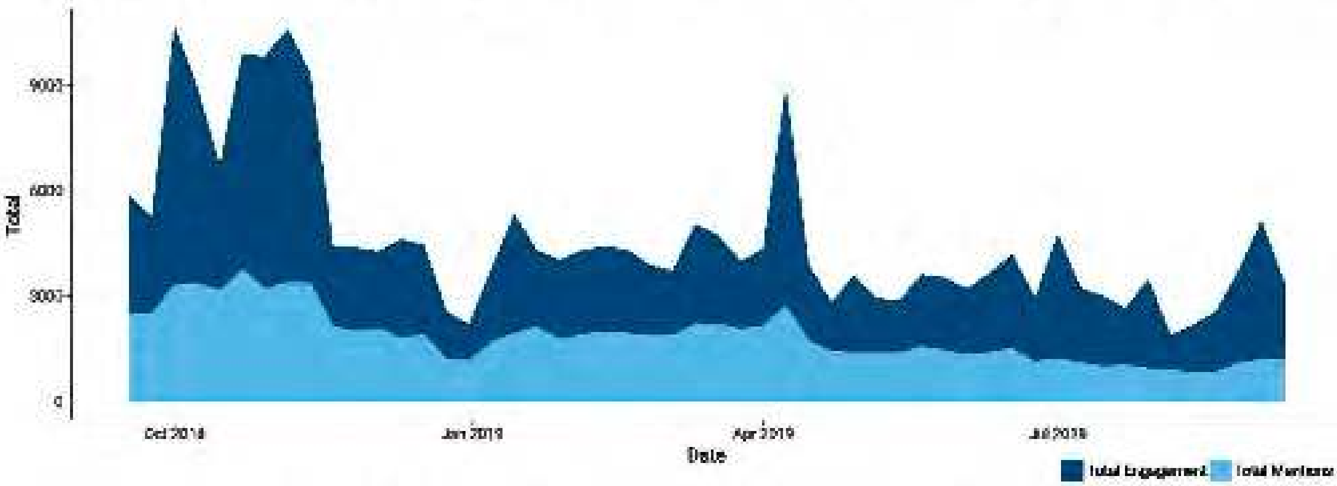


Technological awareness

94.7 percent of people in the Netherlands have access to the Internet, with a mean download speed of 40.2 Mbps.

Between mid-September 2018 and mid-September 2019, there were 41,210 unique authors contributing to total content generation. The volume of online activity in the Netherlands within the four technology fields chosen displays an average of 7,388.8 mentions and 11,181 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0023. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.0037.

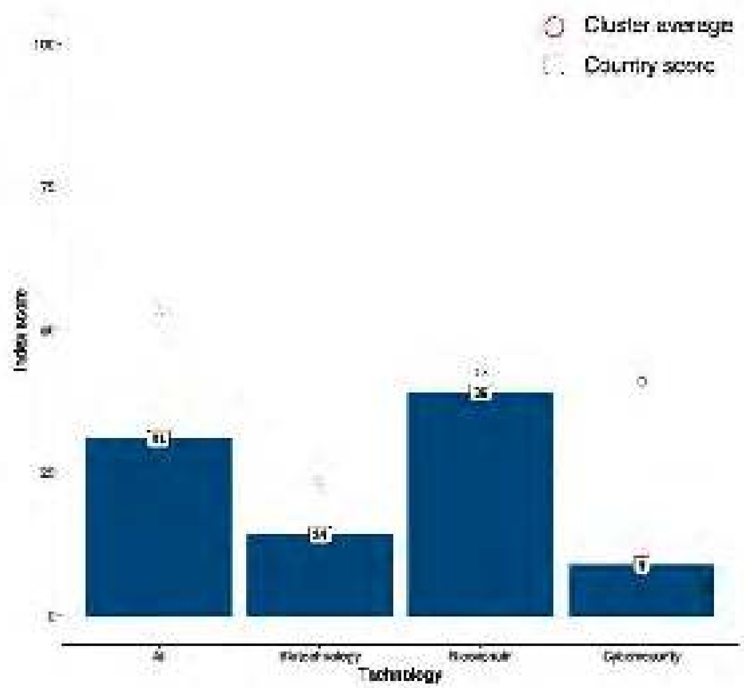
Volume of discussions and engagement level associated with the four key technologies for the future in the Netherlands



The trend in online activity over time for the Netherlands shows a number of peaks in engagement and mentions relating to blockchain (education and RDI and science) and AI (RDI and science). Instances of engagement associated with these peaks pertain mainly to local and international news and events. Notably, the blockchain and AI 'Odyssey Hackathon' that took place in Netherlands in April 2019, attracting 1,500 participants.[1] International blockchain conferences were also a focus of engagement, including the World Blockchain Summit in Amsterdam[2] and the IoT Solutions World Congress in Barcelona.[3] Private companies active in blockchain also generated engagement activity.

Global Technology Awareness Index: Netherlands

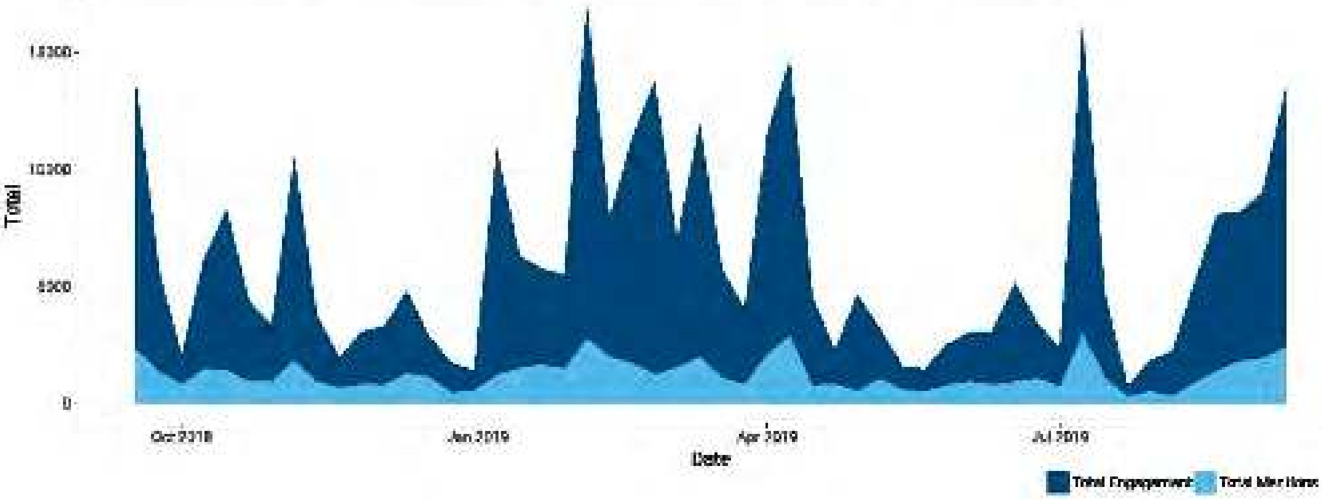
The Netherlands lags behind the online activity cluster average in all four technological fields. In terms of activity distribution within the country, the Netherlands displays online activity mostly focused on blockchain and AI, with cybersecurity being the least discussed field.



Future skills awareness

The online community exhibits a moderate level of online activity relating to this topic, with an average value of 4,916.7 mentions and 19,344.6 instances of engagement per month. Total online activity in the area of future skills in the Netherlands is lower in terms of mentions and higher in terms of instances of engagement than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in the Netherlands



The trend in online activity over time for the Netherlands shows several peaks in engagement and in mentions relating to education. The results associated with these peaks pertain mainly to the teacher shortage within the Netherlands, with national news covering disagreements regarding the education of immigrant children between the Democrats 66 council's Fonda Sahla and PVV parliamentarian Harm Beertema. Beertema stated that there are few teachers volunteering to teach immigrant students, and that this contributes to the shortage of teachers.[4] Additionally, national news on the severe shortage of teachers stated that the deficit is even greater than in previous years, with more than 3,500 vacancies for primary teachers expected.[5] The teacher shortage caused significant engagement, especially when national news called for not replacing sick schoolteachers, drawing attention amongst politicians and society to the pressure put on schools by the teacher shortage.[6] Finally, local news announced that Zaanstad is seeking to introduce a four-day school week due to the teacher shortage, which caused a peak in engagement and mentions.[7]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Overview of the Netherlands' readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★☆	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★☆	★★★★☆			★★★☆☆	★★★☆☆	★★★★☆
Future skills awareness	★★★★★	★★★★★			★★★★☆	★★★★☆	★★★★☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is very well-positioned for the future, relying both on strong infrastructure and showing a high level of awareness on both future skills and technologies, although with room for improvement in the area of cybersecurity. The country is investing in this area, with notable efforts to facilitate knowledge exchange. The Hardware Security Conference and Training event in the Hague in September 2019 presented international research on topics such as SD card hacking, Bluetooth 5 hacking and vulnerabilities in 4G and 5G networks. In parallel to the event, a hacking contest took place over the course of five days, in which competitors looked for bugs in devices from Google.[8] The Netherlands also signed a continuation agreement of the 'Cybersecurity Soft-landing Program' with Canada, originally launched in 2013. The programme supports businesses from both countries looking to set up their offices in the Netherlands and in Canada, respectively. The companies receive assistance to build regional networks, connect to new partners and possibly settle with a permanent presence in the new market.[9]

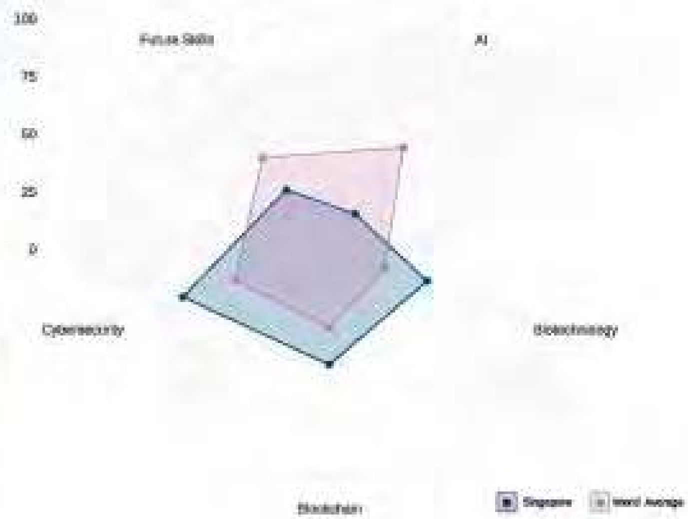
Endnotes

[1] *See: https://www.odyssey.org/odyssey-hackathon-2019/.*
[2] *See: https://amsterdam.worldblockchainsummit.com/.*
[3] *See: https://www.iotsworldcongress.com/.*
[4] *Engelbart, 2019.*
[5] *Steenbeeke, 2019.*
[6] *NOS Nieuws, 2019.*
[7] *RTL Nieuws, 2018.*
[8] *HSD Foundation, 2019a.*
[9] *HSD Foundation, 2019b.*

SINGAPORE

GDP per capita	HDI	GKI	5921
$ 64,582 (2018)	0.932 (2017)	4/136 (2019)	unique authors per million Internet users

Future field awareness indices

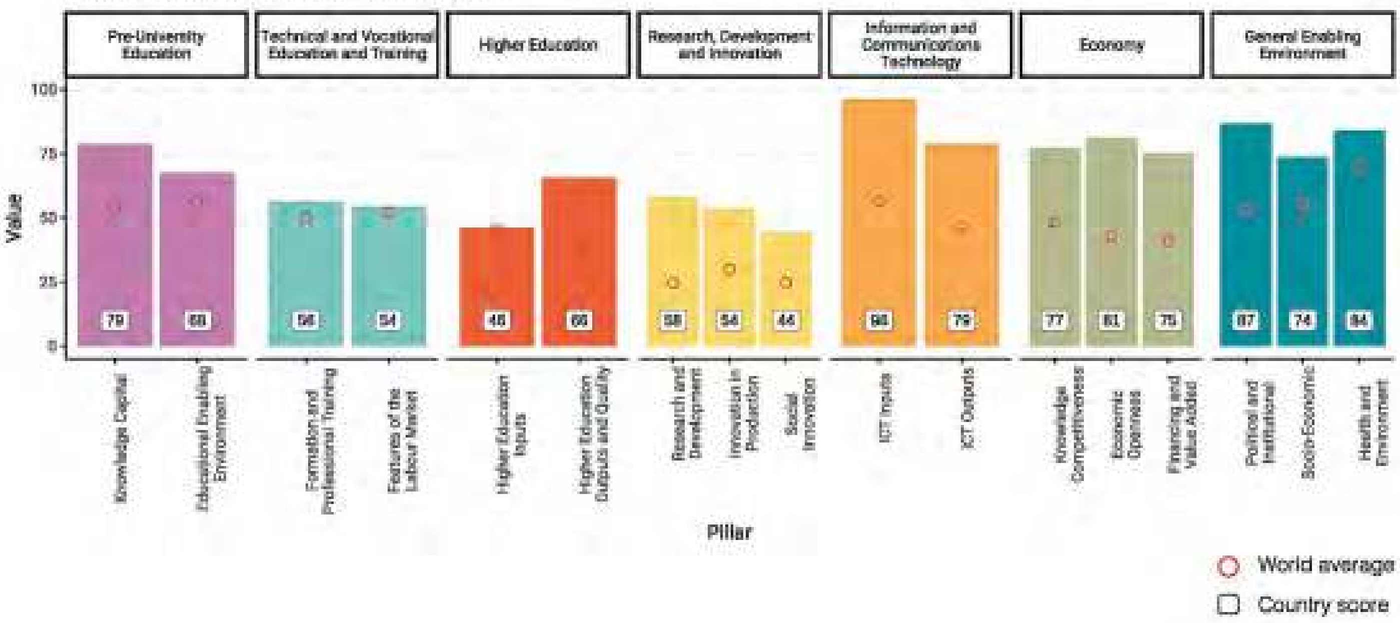


Knowledge infrastructure

Singapore is amongst the leading countries in terms of its knowledge infrastructure to support technological up-take, standing alongside nations such as Luxembourg and the United Arab Emirates.

Singapore is ranked fourth on the Global Knowledge Index, outperforming 97.7 percent of other countries. Singapore performs above average in all sectoral indices and is strongest in the areas of ICT and economy, ranking first globally on both sectoral indices. Conversely, Singapore faces challenges in the area of higher education outputs that may be attributed to the low share of researchers in higher education and moderate levels of government expenditure on tertiary education.

Global Knowledge Index – Singapore

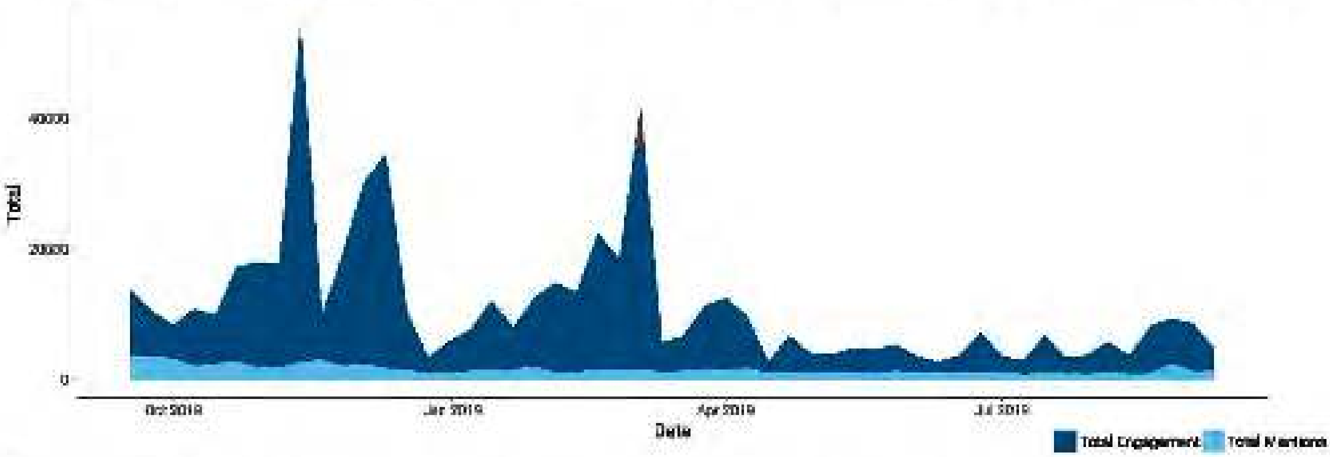


Technological awareness

88.2 percent of people in Singapore have access to the Internet, with a mean download speed of 70.8 Mbps.

Between mid-September 2018 and mid-September 2019, there were 30,058 unique authors contributing to total content generation. The volume of online activity in Singapore within the four technology fields chosen displays an average of 6,248.3 mentions and 38,321.1 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0016. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.00013.

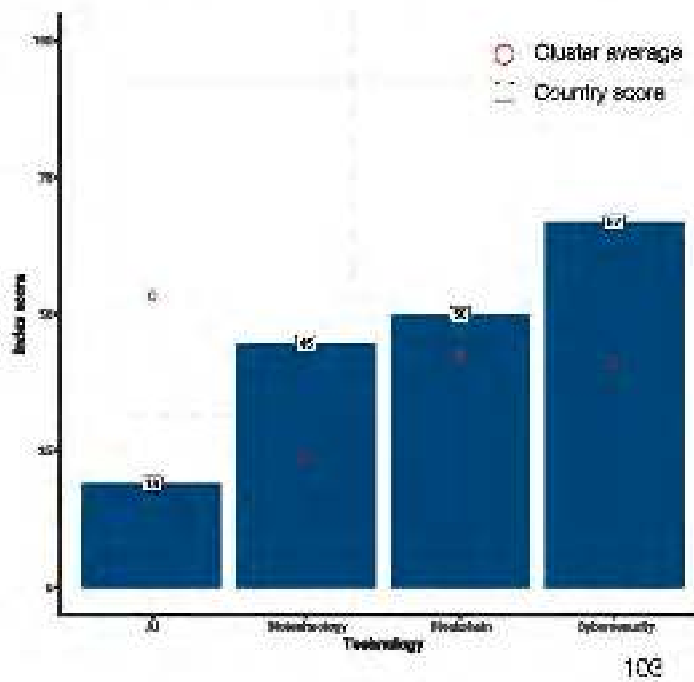
Volume of discussions and engagement level associated with the four key technologies for the future in Singapore



The trend of online activity over time for Singapore shows peaks in engagement and mentions mainly related to cybersecurity (economy) and blockchain (RDI and science). The peaks mostly refer to international news and events, such as the 2018 Mars Blockchain Summit, which took place in October 2018 in New York, gathering experts to discuss next steps in blockchain.[1] Around the same period, news reports of the drop in value of shares in chip designer Nvidia were linked to an increase in mentions. The company's results were associated with a drop in chip sales, caused by decreased activity in cryptocurrency mining.[2] A further peak in engagement from February 2019 referred to news about the Chinese multinational technology company Huawei: in the context of US allegations against the firm, British security officials stated that they would not support a full ban on Huawei's involvement in national telecom networks.[3] A speech by the Minister of Education, Ong Ye Kung, announcing changes in the national examination and certification framework, also resulted in a peak of engagement.[4]

Global Technology Awareness Index: Singapore

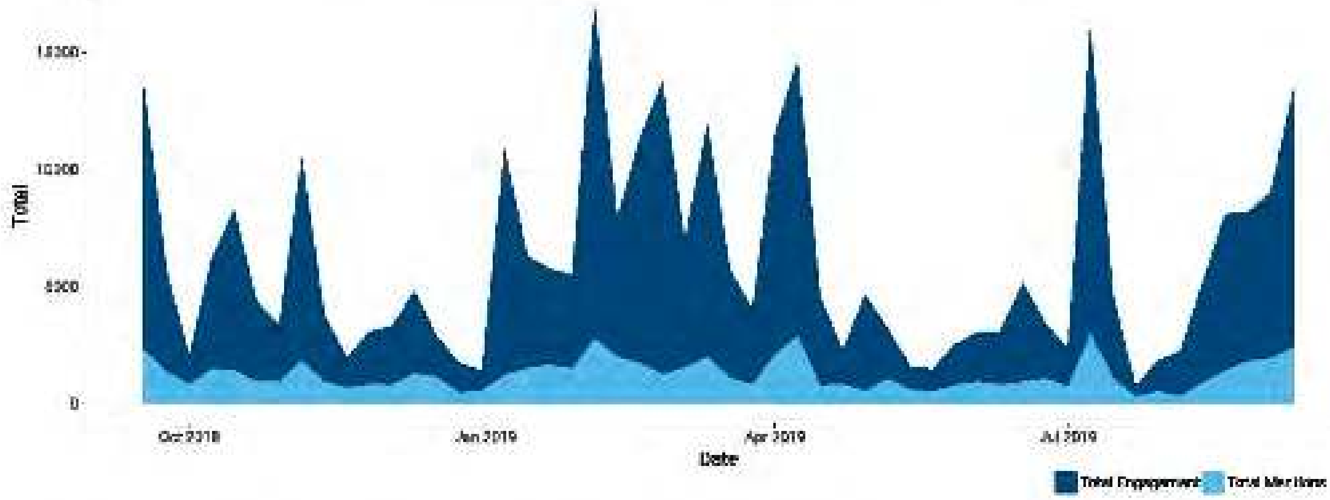
Singapore outperforms the online activity cluster average in three out of four technology fields. In terms of activity distribution within the country, Singapore performs above the cluster average in all technologies, except for AI.



Future skills awareness

The online community exhibits a low level of activity relating to future skills, with an average value of 196.2 mentions and 2,003.3 instances of engagement per month. Total online activity in the area of future skills in Singapore is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Singapore



The trend in online activity over time for Singapore contains peaks in engagement mainly pertaining to education. The largest peak in engagement, in October 2018, was linked to the release of the World Bank Human Capital Index. Singapore ranked first in this global comparison of 157 economies for developing and investing in human capital.[5] Another relevant peak in engagement from July 2019 refers to news of the inclusion of digital skills in the curriculum of four special needs schools. Over 700 students in four schools will acquire skills such as making e-payments, using emails and online chats as a follow up to a pilot initiative from earlier in the same year.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Singapore exhibits high performance in terms of its knowledge infrastructure, technology and future skills awareness, with a high score across all dimensions. It is evident from the results that Singapore's investment in a robust knowledge infrastructure has contributed to a well-balanced technology awareness. There remains room for improvement in terms of future skills relating to RDI and science.

Overview of Singapore's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★★	★★★★☆	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★★	★★★★★			★★★★★	★★★★★	★★★★★
Future skills awareness	★★★★☆	★★★★☆			★★★★☆	★★★☆☆	★★★★☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is very well-positioned for the future, relying on strong infrastructure and showing a high level of awareness on both future skills and technologies – and especially in cybersecurity. An example of the strong position of Singapore in terms of cybersecurity is the ASEAN–Singapore Cybersecurity Centre of Excellence that was launched in 2019 to support the development of ASEAN nations' cybersecurity capabilities.[7]

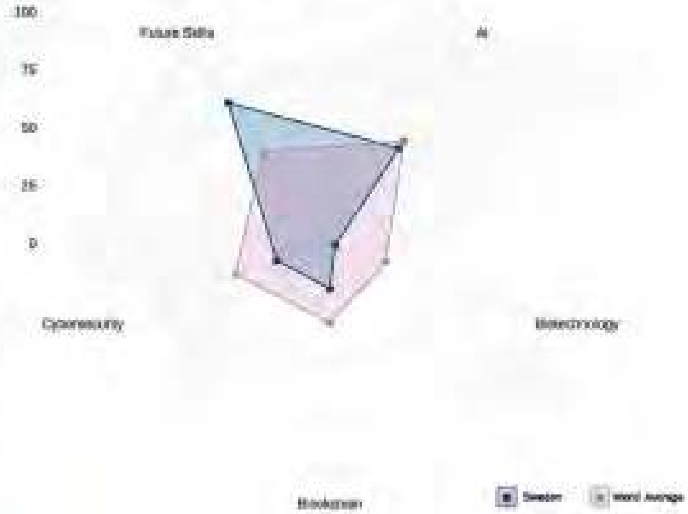
Endnotes

[1] *Coin Journal, 2018.*
[2] *Vengattil and Nellis, 2018.*
[3] *Stubbs and Singh, 2019.*
[4] *Chia, 2019.*
[5] *Yulisman, 2018.*
[6] *Neo, 2019.*
[7] *Baharudin, 2019.*

SWEDEN

GDP per capita **$ 54,112** 2018 | HDI **0.933** 2017 | GKI **6/136** 2019 | **1358** unique authors per million Internet users

Future field awareness indices

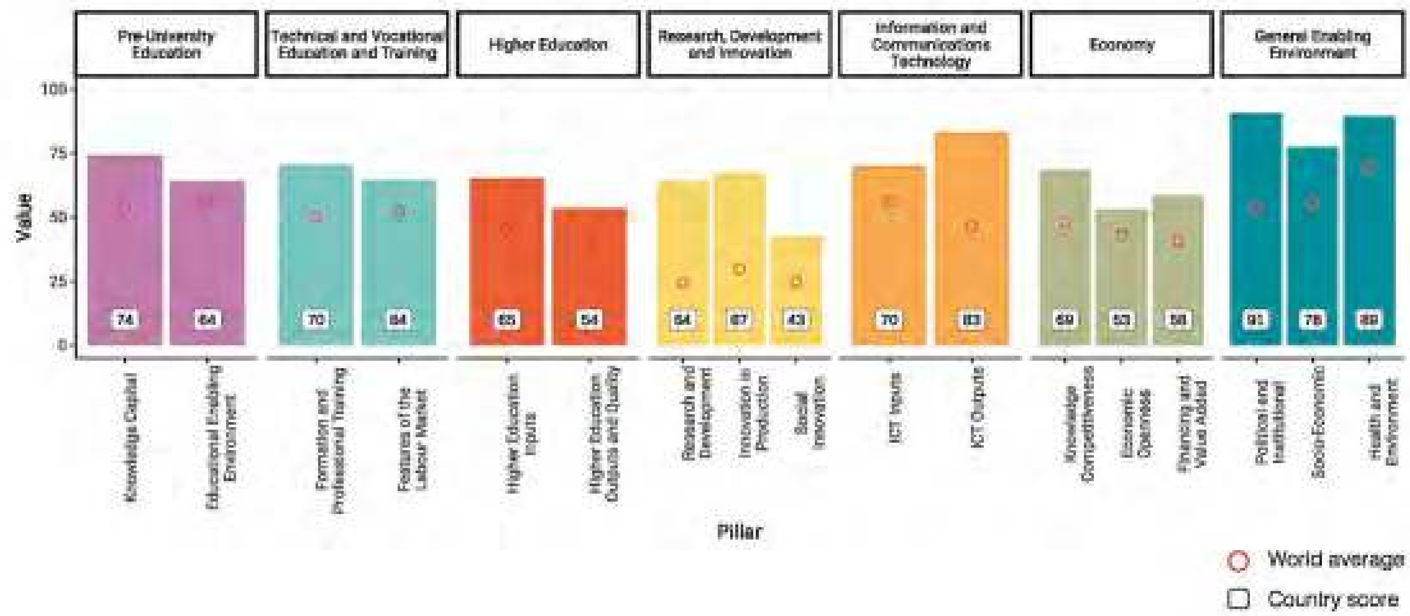


Knowledge infrastructure

In terms of knowledge infrastructure to support technological uptake, Sweden ranks amongst the leading countries, standing alongside states such as Japan and the United Kingdom.

Sweden is ranked sixth on the Global Knowledge Index, outperforming 96.2 percent of other countries. Sweden performs above the world average in all sectoral indices and is strongest in the areas of health and environment – ranking first globally. Conversely, Sweden faces challenges in the area of pre-university enabling environment, which may be attributed to high pupil–teacher ratios and moderate government expenditures on primary education.

Global Knowledge Index – Sweden

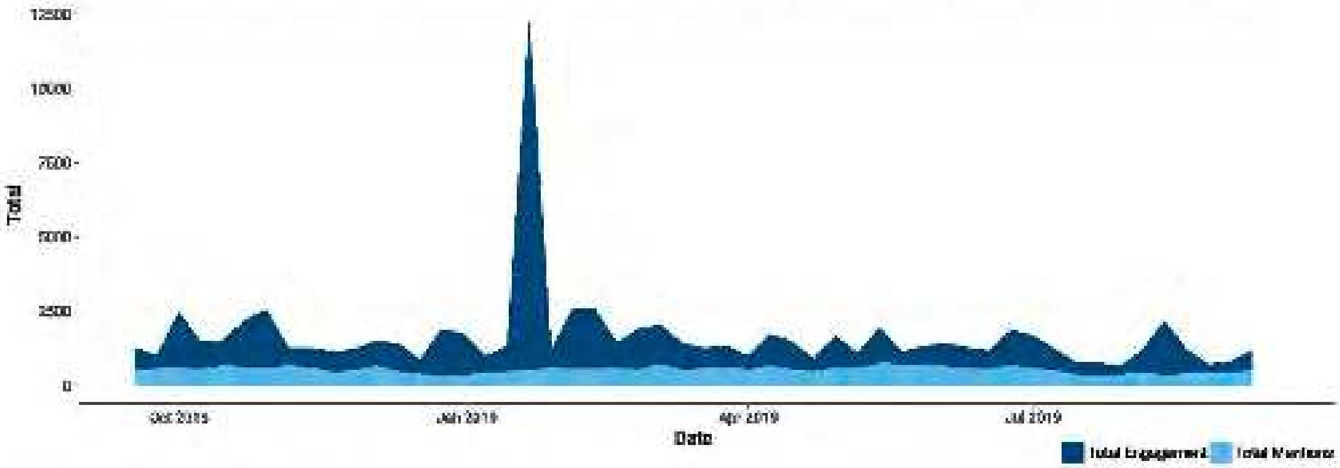


Technological awareness

92.1 percent of the Swedish population has access to the Internet, with a mean download speed of 55.2 Mbps.

Between mid September 2018 and mid September 2019, there were 12,477 unique authors contributing to total content generation in Sweden. The volume of online activity in Sweden within the four technology fields chosen displays an average of 2,151.5 mentions and 4,433.8 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0013. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.0017.

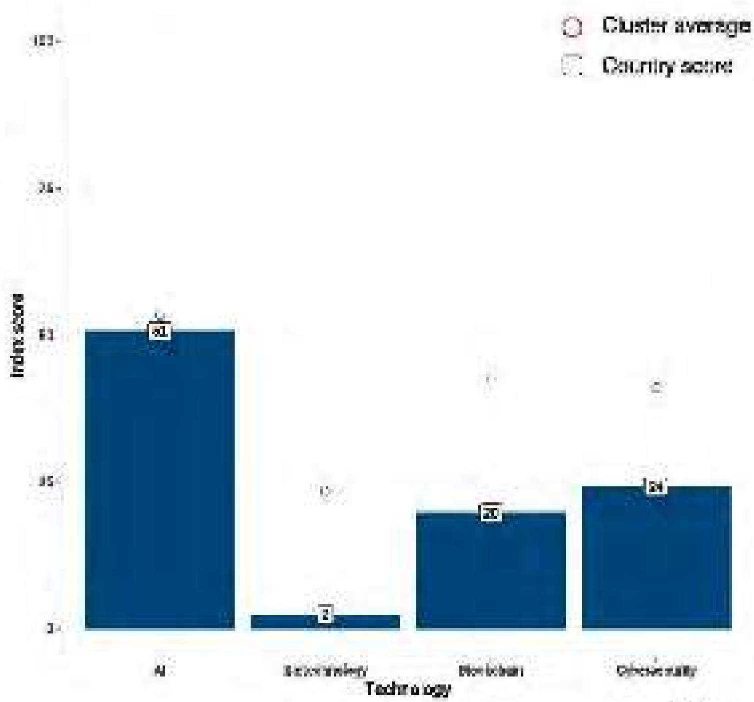
Volume of discussions and engagement level associated with the four key technologies for the future in Sweden



The trend of online activity over time for Sweden shows several peaks in mentions, the highest pertaining to AI (education) and more specifically to the launch of the online course 'Elements of AI' in Swedish, with the goal of educating 100,000 people in Sweden during 2019.[1] Further peaks in mentions were connected to AI (enabling environment) and blockchain (RDI and science). The former concerned posts related to the EU high-level expert group on AI releasing a list of recommendations for policy and investment.[2] The latter referred to the TRON Blockchain, which was integrated with the Samsung Blockchain KeyStore in October 2019.[3] online activity in Sweden displays one major peak in engagement relating to cybersecurity (RDI and science), and more specifically to Sweden being ranked in third place in the latest 'The Good Country Index'.[4]

Global Technology Awareness Index: Sweden

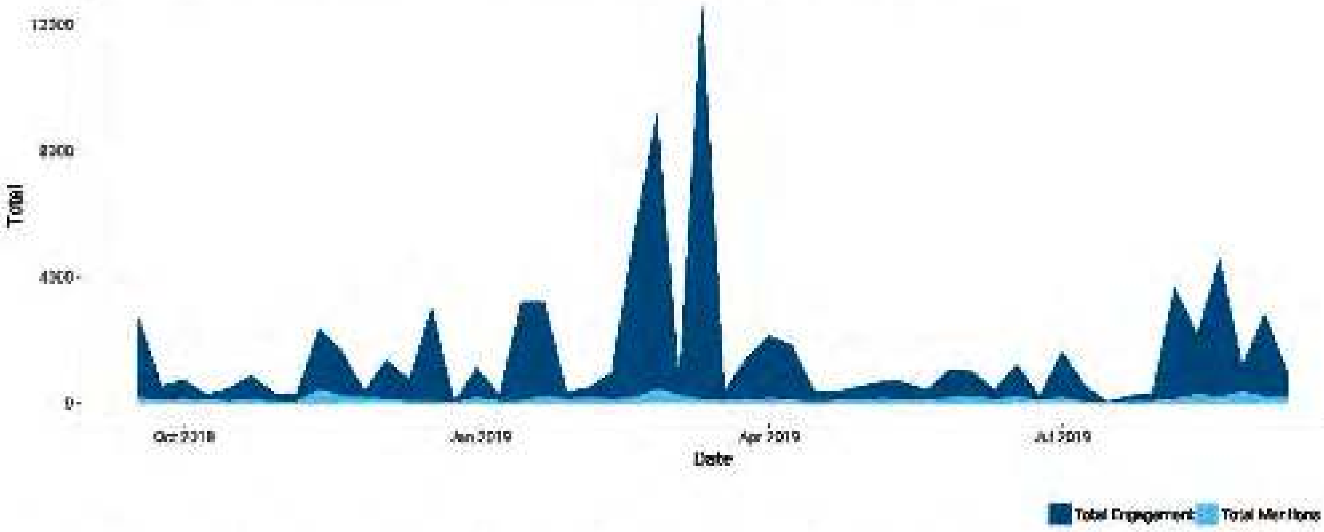
Sweden lags behind the online activity cluster average in all four technology fields. In terms of activity distribution within the country, Sweden displays a greater interest in AI than the other three technologies.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average value of 608 mentions and 5,864.5 instances of engagement per month. Total online activity in the area of future skills in Sweden is lower in terms of mentions and higher in terms of instances of engagement than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Sweden



The trend in online activity over time for Sweden shows two major peaks in engagement relating to education. One of them pertains to a news piece related to the working conditions of teachers, quoting an increase in the number of cases of violence and threats toward teachers reported to the Swedish Work Environment Authority. The other peak is linked to bullying culture at schools and students' behavior in the classroom in the context of a wider debate on conditions at public schools and teacher shortages.[5] In terms of mentions, the graph displays three relevant peaks, all related to the topic of teacher shortages.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Sweden exhibits high performance in terms of its knowledge infrastructure, with high scores across all dimensions, and moderate performance on both technology and future skills awareness. Overall, there is room for improvement in terms of future skills awareness relating to technology, which is the lowest scoring dimension. As for technology awareness, Sweden faces challenges relating to the enabling environment governing the technologies of the future.

Overview of Sweden's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★☆☆	★★★★☆			★★☆☆☆	★★★☆☆	★★★★☆
Future skills awareness	★★★☆☆	★★★★★			★★★☆☆	★★★☆☆	★★☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Even though the country scores highly on knowledge infrastructure, its moderate awareness scores highlight areas for improvement. The enabling environment and technology dimensions suggest that Sweden relies on its strong infrastructure and is starting its transition to the use of new technologies, especially in education. However, aside from some efforts relating to biotechnology – such as the Fifth International Conference of Biotechnology, Environment and Engineering Sciences in Stockholm in September 2019[7] – the field of biotechnology remains a key area for Sweden to invest in.

Sweden has already put in place comprehensive measures for skills development, as evidenced by high literacy, numeracy and basic computer skills. At the same time, around 40 percent of employers' experience hiring difficulties resulting from a mismatch between skills and market demand.[8] This is evident also in a report by the Swedish Public Employment Service, projecting a shortage of 100,000 people with the right skills for in-demand jobs by 2024. The fields expected to be most affected by the shortage are healthcare, teaching and ICT jobs.[9]

Endnotes

[1] *Pekkarinen, 2019.*
[2] *European Commission, 2019.*
[3] *Business Wire, 2019.*
[4] *Lindgren, 2019.*
[5] *Dragens Nyheter, 2019.*
[6] *Granath, 2018.*
[7] *See: https://biotechweek.org/events/5th-international-conference-biotechnology-environment-engineering-sciences-stockholm/.*
[8] *Espinoza, 2019.*
[9] *The Local, 2019.*

CLUSTER
01

SWITZERLAND

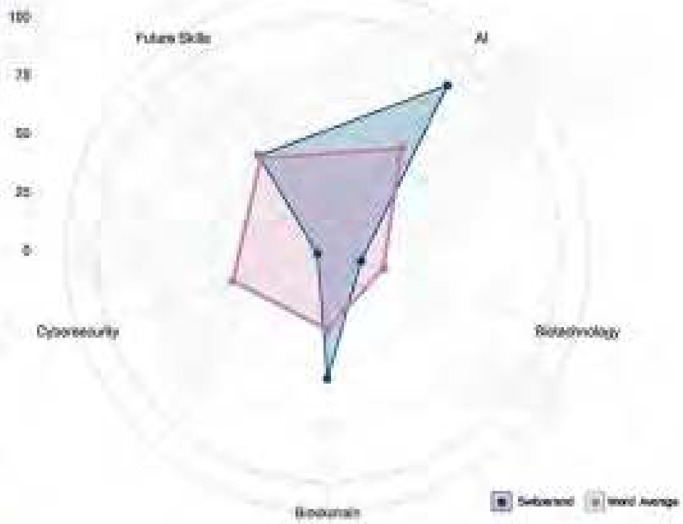
GDP per capita
$ 82,839
2018

HDI
0.944
2017

GKI
1/136
2019

4494
unique authors
per million
Internet users

Future field awareness indices

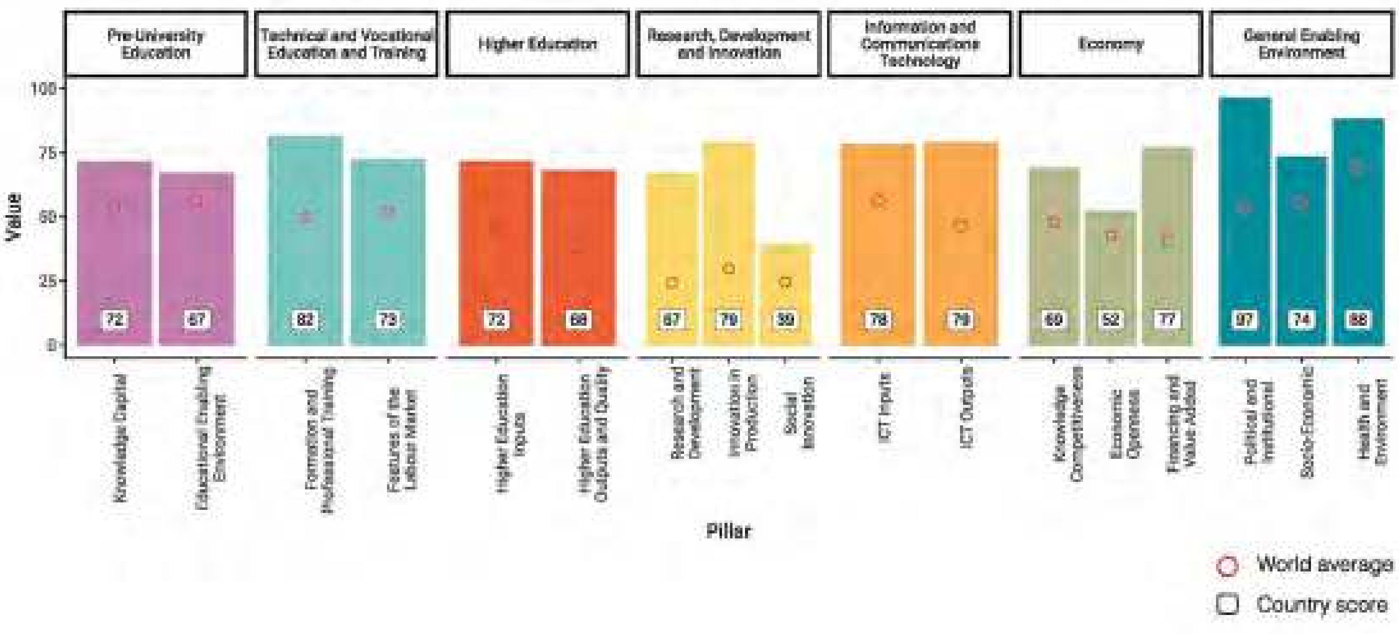


Knowledge infrastructure

Switzerland is amongst the leading countries in terms of knowledge infrastructure to support technological uptake, standing alongside the likes of Singapore and Germany.

Switzerland is ranked first on the Global Knowledge Index, outperforming all countries. Switzerland performs above the world average in all sectoral indices and is strongest in the area of research, development and innovation (RDI). Conversely, Switzerland faces challenges in the area of economic openness, which may be attributed to low levels of creative services exports.

Global Knowledge Index – Switzerland

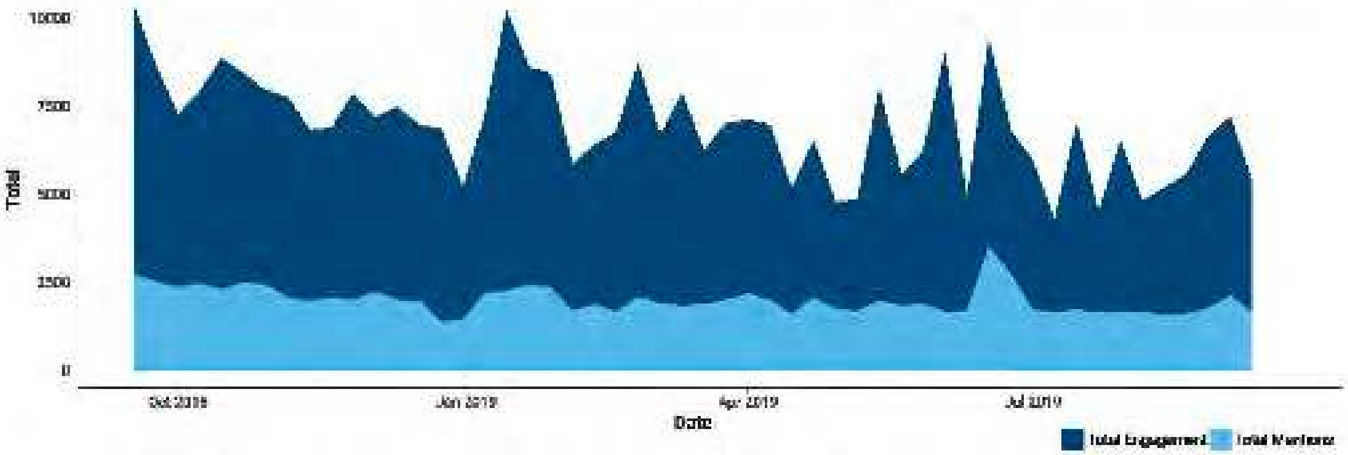


Technological awareness

89.7 percent of the Swiss population have access to the Internet, with a mean download speed of 38.8 Mbps.

Between mid September 2018 and mid September 2019 there were 34,079 unique authors contributing to total content generation. The volume of online activity in Switzerland within the four technology fields chosen displays an average of 7,953.6 mentions and 19,747.6 instances of engagement per month. Online activity within technological fields displays a degree of concentration of 0.0022. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.00068.

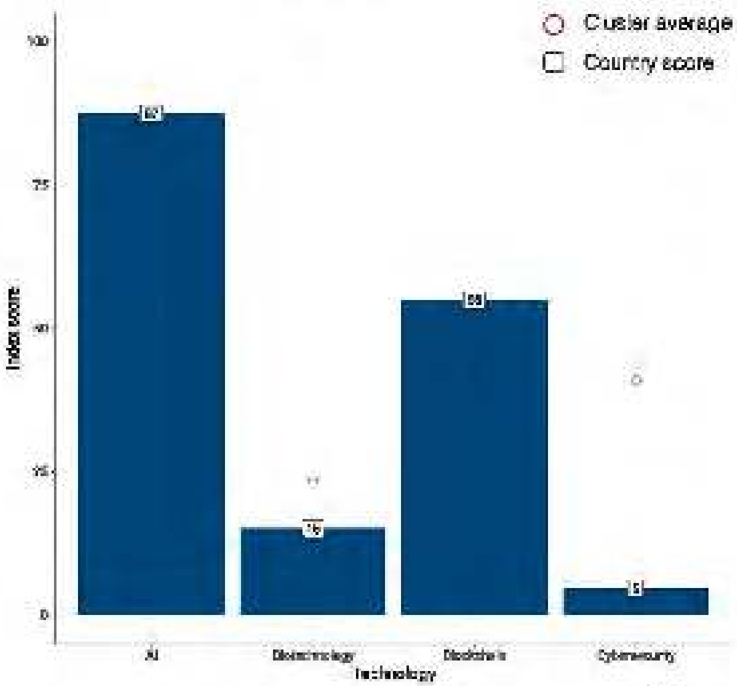
Volume of discussions and engagement level associated with the four key technologies for the future in Switzerland



The trend of online activity over time for Switzerland shows a generally highly-engaged online community. A peak in mentions in June 2019 relates to the area of blockchain (economy and technology), pertaining mostly to Facebook announcing the launch of the cryptocurrency, Libra.[1] The company chose Geneva as the headquarters for its new vision on the 'Internet of Money', looking to simplify and digitalise the way people deal with money. Online activity in Switzerland displays peaks in engagement relating to biotechnology (RDI and science). A research paper concerning the genomes of three closely-related Amazon parrots in the Caribbean proved popular, providing insights on the species' history and conservation.[2] Research on the human microbiome also caused a spike in engagement, revealing new insights on bacterial exposure prior to birth. The discovery demonstrates that bacterial DNA has the potential to influence the foetal immune system whilst in the womb.[3]

Global Technology Awareness Index: Switzerland

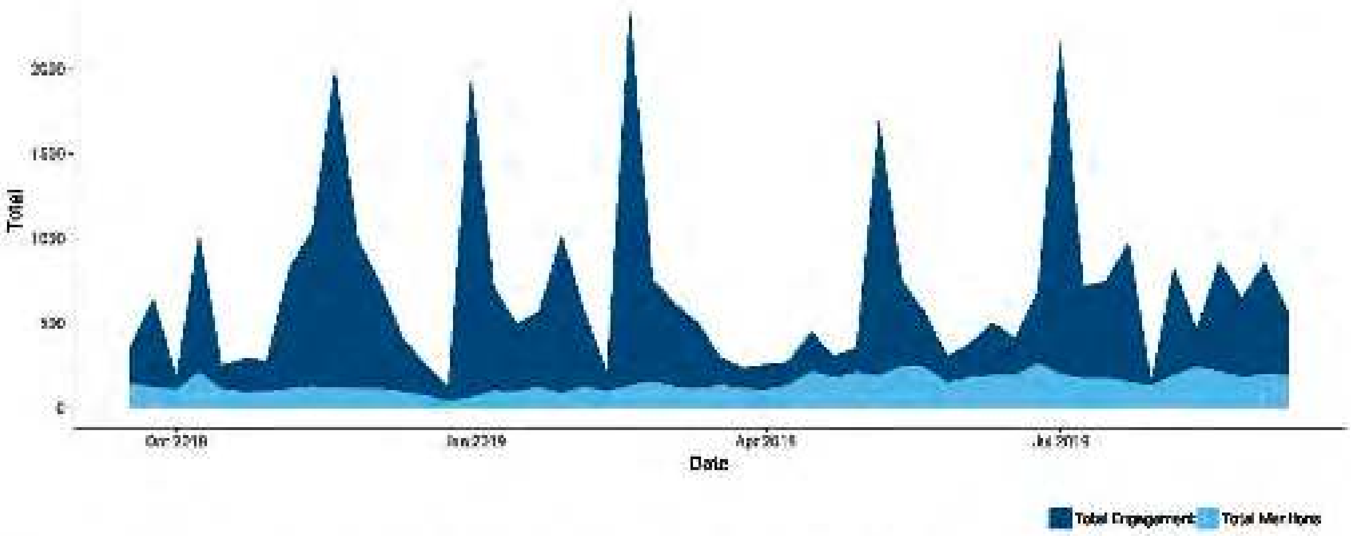
Switzerland outperforms the online activity cluster average in two out of four technology fields. In terms of activity distribution within the country, Switzerland's online activity displays a performance significantly higher than the cluster average for AI and slightly higher for blockchain, while it performs under the cluster average in terms of biotechnology and cybersecurity.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average value of 592.3 mentions and 2,141.75 instances of engagement per month. Total online activity for future skills in Switzerland is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Switzerland



The trend of online activity over time for Switzerland shows several peaks of engagement and mentions, mainly related to education. One of the peaks in engagement was linked to news concerning the state of the education system in Switzerland. Specifically, statistics show that only two percent of students participate in language exchange initiatives between Swiss language regions.[4] Further peaks in engagement were caused by news reports on teacher shortages, which are acute in many regions. Estimates suggest that over 10,000 teachers are needed across the country to close the gap.[5] The Cantone of Bern is tackling the deficit by offering jobs to already retired teachers, contacting 950 pensioners.[6] Online activity intensified in February 2019 amid news commentary on the issues female Muslim students face in obtaining their university degrees in teaching. Students who wear the hijab have substantial difficulties finding traineeship positions, which are part of the mandatory curriculum for aspiring teachers.[7]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Switzerland exhibits high performance in terms of its knowledge infrastructure, technology awareness and future skills awareness, with high scores across all dimensions. Overall, there is room for improvement in terms of future skills awareness, in the dimension of education.

Overview of Switzerland's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★★	★★★★★			★★★★☆	★★★★★	★★★★★
Future skills awareness	★★★★★	★★★☆☆			★★★★★	★★★★☆	★★★★★

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is very well-positioned for the future, with strong infrastructure and a high level of awareness on technologies; an example of this is the 'Digital Switzerland Strategy' adopted in September 2018.[8] AI is the technology that inspires the vast majority of the online activity amongst the four technologies of the future; this may partly be explained by the establishment of a national working group on the subject.[9]

Endnotes

[1] *Leisinger, 2019.*
[2] *Kolchanova, 2019.*
[3] *Stinson et al., 2019.*
[4] *Häfliger and Birrer, 2019.*
[5] *Beutler, 2019.*
[6] *SRF, 2019.*
[7] *Hehli, 2019.*
[8] *State Secretariat for Education, Research and Innovation, 2018.*
[9] *Ibid.*

CLUSTER
01

UNITED ARAB EMIRATES

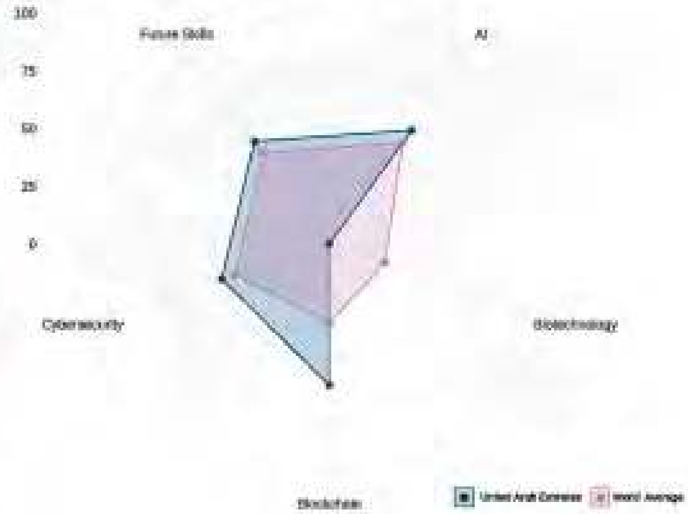
GDP per capita
$ 43,005
2018

HDI
0.863
2017

GKI
18/136
2019

1059
unique authors
per million
Internet users

Future field awareness indices

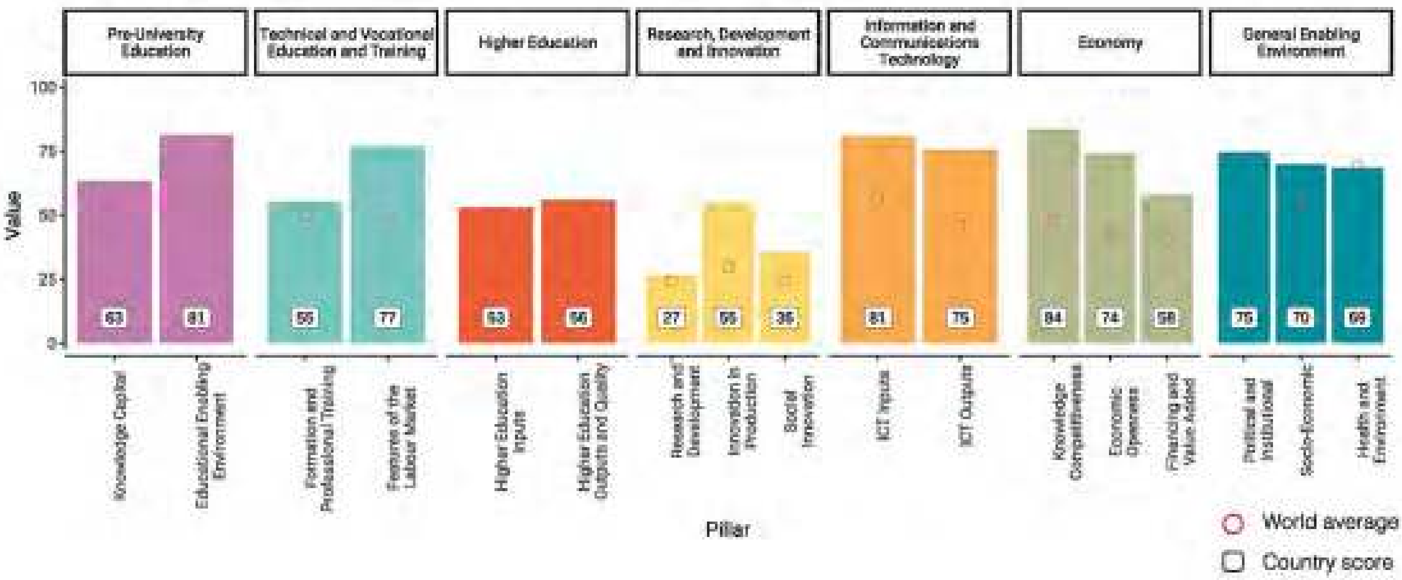


Knowledge infrastructure

In terms of knowledge infrastructure to support technological uptake, the United Arab Emirates (UAE) is amongst the leading countries, standing alongside countries such as the United States and Switzerland.

The United Arab Emirates is ranked 18th on the Global Knowledge Index, outperforming 87.4 percent of other countries. The UAE performs above the world average in all sectoral indices and is strongest in the area of knowledge competitiveness – ranking first globally. Conversely, the UAE faces challenges in the area of health and environment, which may be attributed to high levels of CO_2 emissions per capita and low renewable energy consumption.

Global Knowledge Index – United Arab Emirates

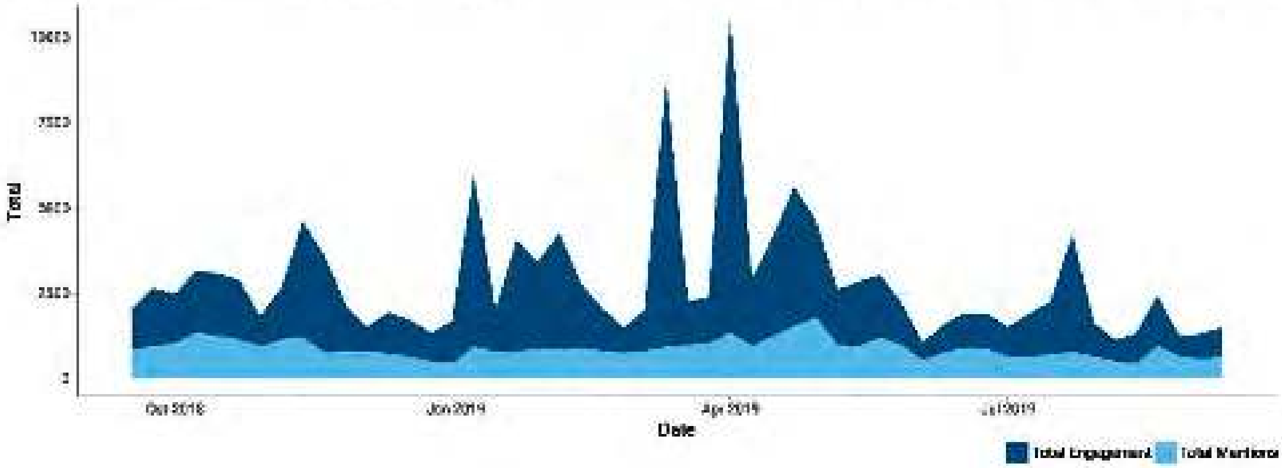


Technological awareness

98.4 percent of the Emirati population have access to the Internet, with a mean download speed of 9.6 Mbps.

Between mid September 2018 and mid September 2019, there were 10,044 unique authors contributing to total content generation. The volume of online activity in the UAE within the four technology fields chosen displays an average of 3,480.5 mentions and 7,628.8 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0041. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.0018.

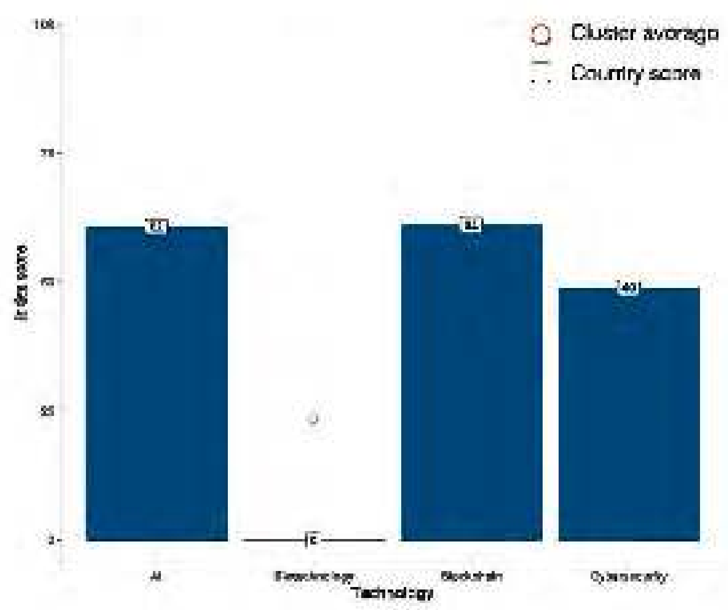
Volume of discussions and engagement level associated with the four key technologies for the future in the UAE



The online activity trend over time for the United Arab Emirates shows peaks in engagement and mentions in the areas of cybersecurity (enabling environment) and AI (economy). The peak results pertain mainly to local and international news and events. Online activity spiked amidst the news of Facebook removing hundreds of pages, groups and accounts from India and Pakistan because of 'coordinated inauthentic behaviour or spam'. This is part of Facebook's effort to fight allegations that the network is used to spread misinformation.[1] Engagement and mentions also peaked in January 2019 in relation to the launch of the Smart Dubai AI Toolkit, created to support industry, academia and individuals in the responsible use of AI systems.[2] The trend of online activity over time also shows a peak in mentions related to AI (RDI and science) and specifically to the AI Everything Summit convened in Dubai.[3]

Global Technology Awareness Index: UAE

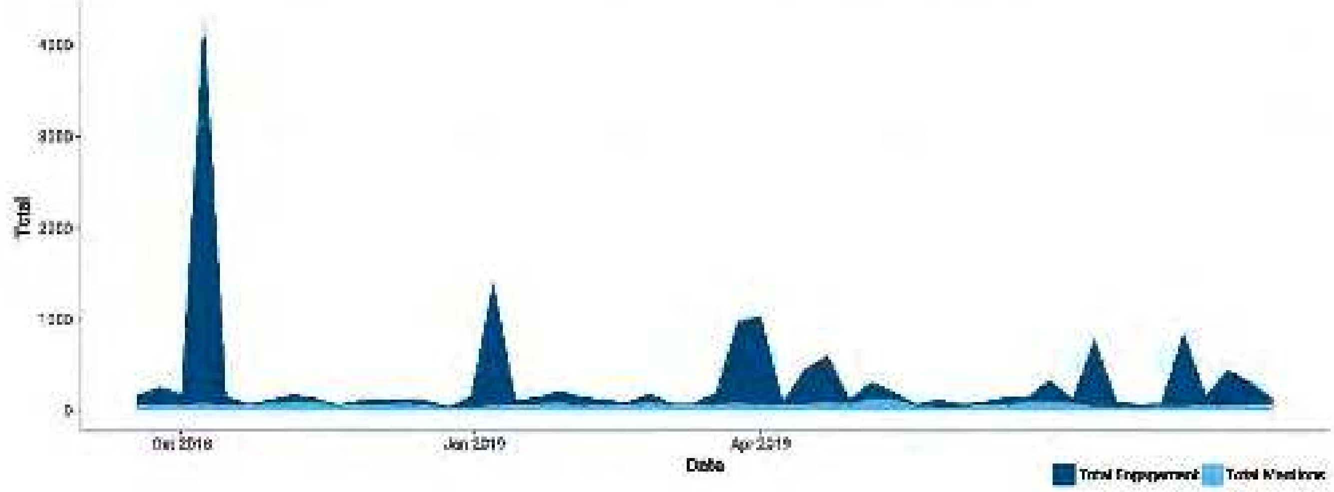
The United Arab Emirates outperforms the online activity cluster average in three out of four technology fields. In terms of activity distribution within the country, the United Arab Emirates displays balanced performance amongst the technologies, with only biotechnology not triggering online activity.



Future skills awareness

The online community exhibits a low level of online activity concerning future skills, with an average value of 257 mentions and 1,032.8 instances of engagement per month. Total online activity in the area of future skills in the UAE is lower than that relating to the technologies of the future. This may point to a weak interest in the field of future skills, or to an information network where online media is not the principal channel of information dissemination.

Volume of discussions and engagement level associated with future skills in the UAE



The online activity trend over time for the UAE shows a number of peaks in engagement mainly related to education. The peak in January pertains to the ratings achieved by Abu Dhabi schools showing that one in three educational institutions had improved its performance in the past two years.[4] A less expressed peak in engagement pertains to reports over the pricing of textbooks at the Indian High School in Dubai, with parents complaining that school materials are too expensive.[5] In terms of peaks in mentions, the trend also shows activity mainly related to education. The largest peak pertains to local news concerning the launch of the 'Government Design Initiative', which represents a new methodology in government work. The design is meant to foster the development of programmes and policies boosting people's societal participation.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

The United Arab Emirates exhibits a generally high performance in terms of knowledge infrastructure and technology awareness – with high scores across all dimensions – and a moderate performance in future skills awareness. Overall, there is room for improvement in terms of future skills awareness in education and enabling environment, which are the lowest scoring dimensions. The UAE has invested heavily in its knowledge infrastructure across all sectors and this is well-explained by the balanced results on the GKI, wherein it is positioned amongst the leading countries. Policymakers in the UAE are well-informed and proactive regarding the disruptive technologies that will shape the near future; this is evident in the technology awareness findings, which highlight the investments made by the government to ensure its people do not lag behind others.

Overview of UAE's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★★	★★★★★	★★★★☆	★★★★☆	★★★★★
Technology awareness	★★★★☆	★★★☆☆			★★★★☆	★★★☆☆	★★★★☆
Future skills awareness	★★★☆☆	★★☆☆☆			★★☆☆☆	★★★★☆	★★★★☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Discussions and engagement around learning strategies and educational research in the UAE are most noticeable on Twitter. These discussions and events appear to be mainly driven by teachers and/or other educational practitioners or researchers, sometimes using the hashtag #TeachUAEchat (e.g. workshops on active learning strategies;[7] and various bootcamps, training events and conferences[8,9,10,11]).

Within the online news media, there is a focus on individual local schools and programmes using innovative methods and strategies in pre-university education (e.g. transitioning from homework to home learning in UAE;[12] promoting inclusive learning environments in pre-school;[13] and training of students in cloud technology and soft skills[14]).

Endnotes

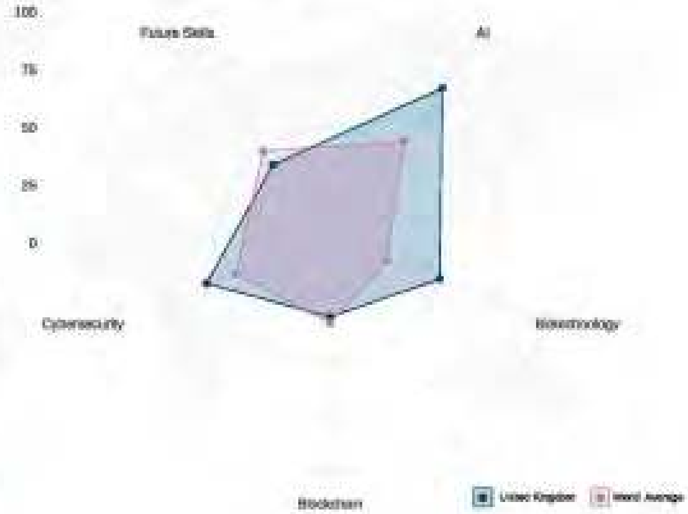
[1] *Mangi, 2019.*
[2] *See: https://www.smartdubai.ae/initiatives/ai-principles-ethics.*
[3] *See: https://ai-everything.com/.*
[4] *Rizvi, 2018.*
[5] *Gokulan, 2018.*
[6] *WAM, 2019.*
[7] *UAEU_News, 2018.*
[8] *KindergartenUAE, 2019.*
[9] *Rashi_Sawhney, 2019.*
[10] *McBlaneJames, 2019.*
[11] *87History, 2019.*
[12] *Masudi, 2018.*
[13] *Al Press, 2019.*
[14] *Rizvi, 2019.*

CLUSTER 01

UNITED KINGDOM

GDP per capita **$ 42,491** 2018 | HDI **0.922** 2017 | GKI **9/136** 2019 | **2592** unique authors per million Internet users

Future field awareness indices

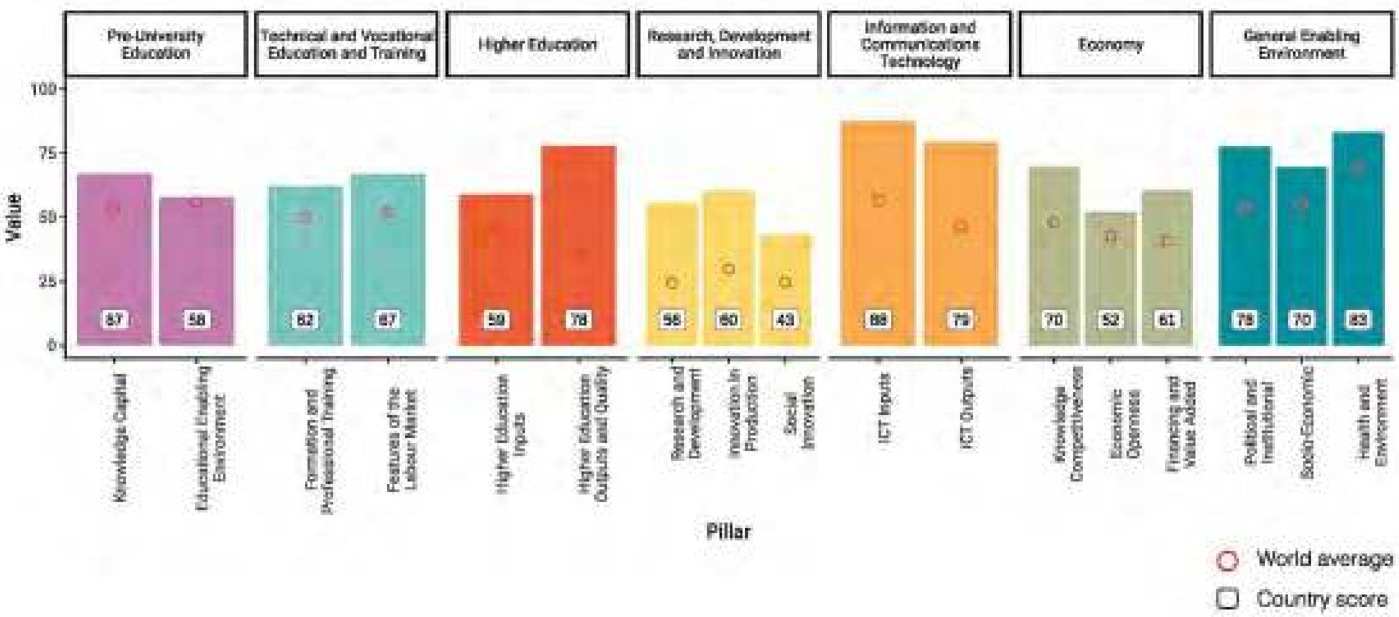


Knowledge infrastructure

The United Kingdom (UK) ranks amongst the leading countries in terms of knowledge infrastructure to support technological uptake, standing alongside Switzerland and Singapore.

The UK is ranked ninth on the Global Knowledge Index, outperforming 94 percent of other countries. The UK performs above the world average in all sectoral indices and is strongest in terms of higher education – ranking first globally. Conversely, the UK faces challenges in the area of pre-university educational enabling environment, which may be attributed to high pupil–teacher ratios.

Global Knowledge Index – United Kingdom

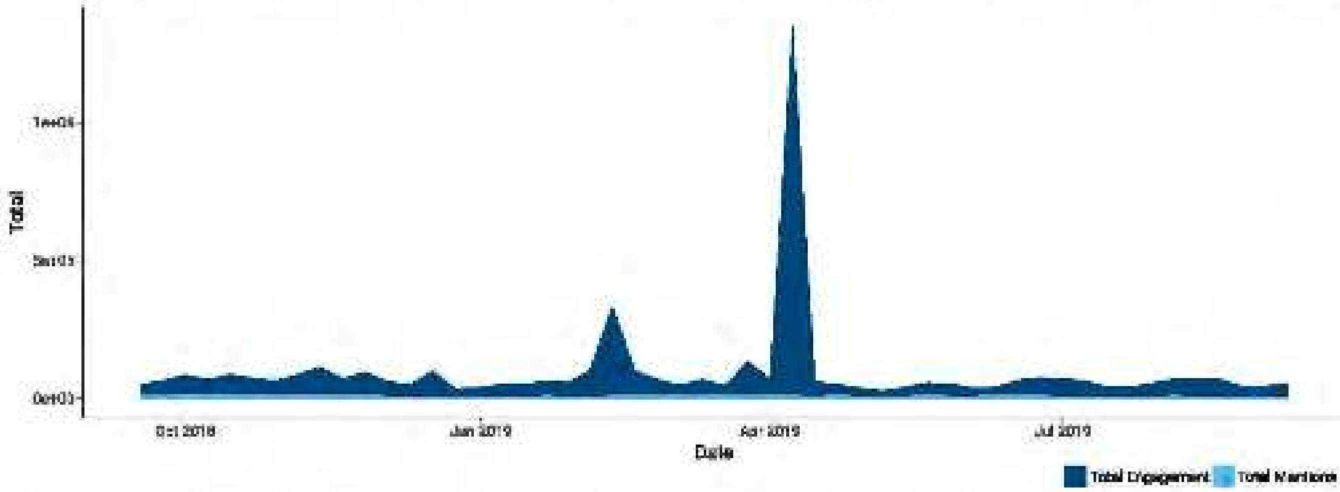


Technological awareness

94.9 percent of the UK population have access to the Internet, with a mean download speed of 22.4 Mbps.

Between mid-September 2018 and mid-September 2019 there were 165,159 unique authors contributing to total content generation. The volume of online activity in the UK within the four technology fields chosen displays an average of 38,518.7 mentions and 338,914.5 instances of engagement per month. Online activity within technological fields displays a degree of concentration of 0.00077. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.00031.

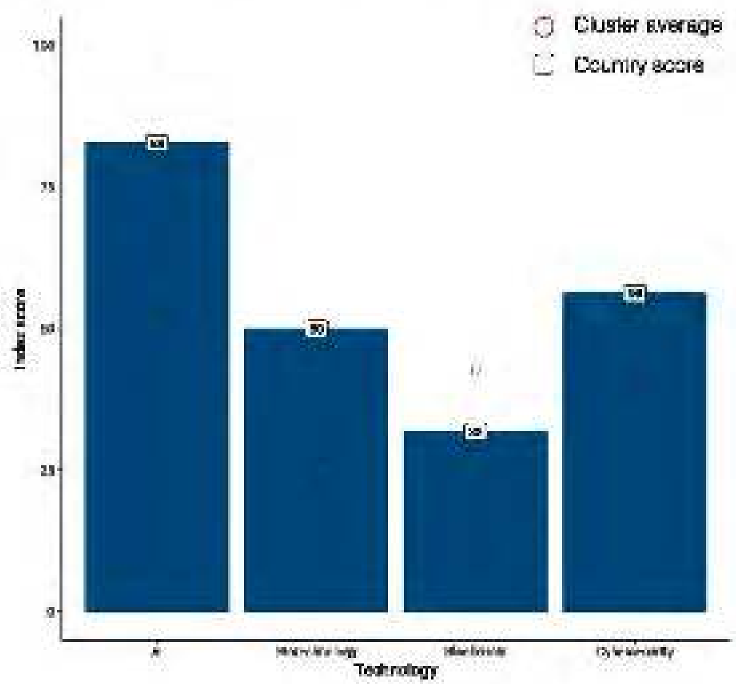
Volume of discussions and engagement level associated with the four key technologies for the future in the United Kingdom



The trend in online activity over time for the United Kingdom shows a generally high level of engagement, with a low number of larger peaks, mostly linked to the area of AI (RDI and science). The top results associated with a major peak in April 2019 pertains to the first-ever visualization of a black hole, thanks to the creation of an algorithm by Dr. Katie Bouman, a 29-year-old computer scientist.[1] The peak in engagement in February 2019 pertains to biotechnology (RDI and science). A comment by a TV host on the American Fox News network went viral on social media, provoking discussions about hygiene awareness and bacteria. Regular hand washing remains one of the best ways to remove germs and prevent the spread of diseases – this reminder from the US Center for Disease Control and Prevention comes after the host's claim to not wash their hands as a way to inoculate themselves.[2]

Global Technology Awareness Index: United Kingdom

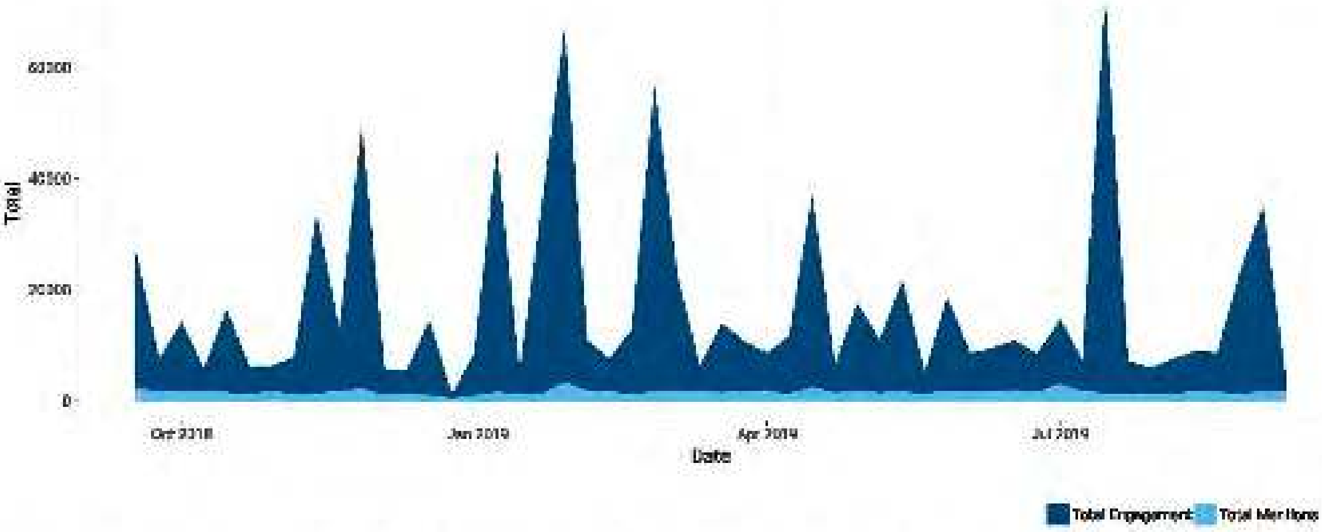
The United Kingdom outperforms the online activity cluster average in three out of four technology fields. In terms of activity distribution within the country, the United Kingdom displays interest in all technologies, with AI being the most prominent and blockchain the least prominent.



Future skills awareness

The online community presents a high level of online activity relating to future skills, with an average of 6,070.2 mentions and 61,343.9 instances of engagement per month. Total online activity regarding future skills in the United Kingdom is higher than the cluster average.

Volume of discussions and engagement level associated with future skills in the United Kingdom



The trend in online activity over time for the United Kingdom shows several peaks in engagement related to education. Peaks are mainly related to local and national news pertaining to teacher shortages in the country. To tackle the issue, the government is planning to offer teachers cash incentives and a better work-life balance, along with training opportunities for young teachers. The shortage is only expected to worsen, with projections of the number of secondary school pupils increasing by 15 percent by 2025.[3] A further peak in engagement was associated with the news of a chair design that blocks 'manspreading', which was part of a student's final year project. A British design graduate built a chair with a triangular seat encouraging a sitting position with closed legs for men to restrict the encroaching of adjacent seating space.[4] A peak in mentions from July 2019 was linked to the results of the National Student Survey, with schools across the country publishing articles about their score in the ranking. Notably, students at Cambridge University boycotted the survey for a third consecutive year, resulting in a survey response rate 29 percent below the required threshold for usable data, in a protest against the government's higher education reforms. The survey has been criticised for its links with tuition fee increases.[5]

Readiness for technological uptake

To conceptualize the readiness of the United Kingdom for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

The United Kingdom exhibits high performance in terms of its knowledge infrastructure, technology awareness and future skills awareness, with high scores across all dimensions. Overall, there is room for a slight improvement in terms of the enabling environment governing future skills in the UK.

Overview of the United Kingdom's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★★☆	★★★★★	★★★★★	★★★★★	★★★★★
Technology awareness	★★★★★	★★★★★			★★★★★	★★★★★	★★★★★
Future skills awareness	★★★★★	★★★★★			★★★★☆	★★★★☆	★★★★★

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is very well-positioned for the future, relying on strong infrastructure and showing a high level of awareness of both future skills and technologies.

The technology that inspires the most online activity within the country is AI. The score is mainly due to engagement inspired by the UK being the third nation in the world, behind only the US and China, in terms of investments in AI. Moreover, it is expected that AI could deliver a 22 percent boost to the UK economy by 2030.[6] Indeed, the current environment and strengths in the United Kingdom in terms of data analytics and computer science research emphasise the existence of a suitable ecosystem for AI development.[7]

Cybersecurity is also a significant topic of discussion in the country, accounting for a significant volume of online activity. The United Kingdom is determined to become the safest place to live and do business online, being already the largest security market in the world.[8]

Regarding future skills awareness, the UK displays strong results, revealing that the population recognizes the need to adapt skills to the technologies of the future. According to a recent survey, more than half (54 percent) of adults and 67 percent of those aged 18–34 in the UK claim that they are ready to learn new skills to improve their future employability.[9]

Endnotes

[1] *BBC News, 2019b.*
[2] *BBC News, 2019a.*
[3] *Jeffreys, 2019.*
[4] *Young, 2019.*
[5] *Ma and Lillywhite, 2019.*
[6] *Bughin et al., 2019.*
[7] *Computer Business Review, 2019.*
[8] *The International Trade Administration, 2019.*
[9] *PricewaterhouseCoopers UK, 2019.*

UNITED STATES

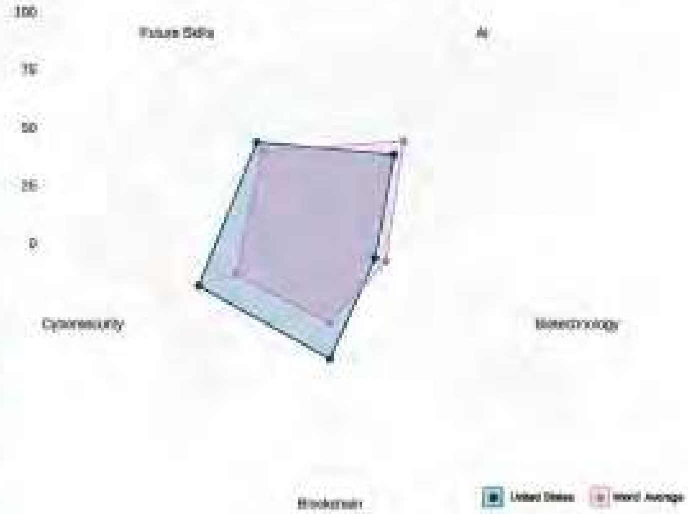
GDP per capita
$ 62,641
2018

HDI
0.924
2017

GKI
3/136
2019

6478
unique authors
per million
Internet users

Future field awareness indices

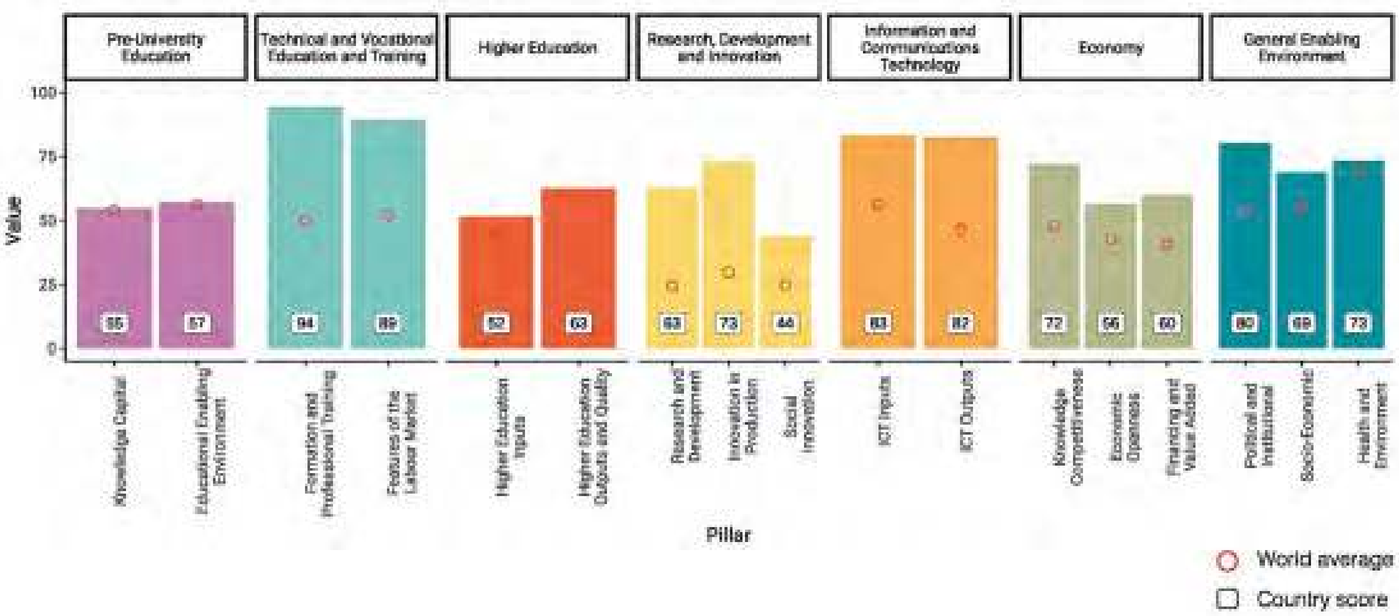


Knowledge infrastructure

The United States (US) is amongst the leading countries in terms of its knowledge infrastructure to support technological uptake, standing alongside countries such as Singapore and Germany.

The US is ranked third on the Global Knowledge Index, outperforming 98.5 percent of other countries. The US performs above the world average in all sectoral indices and is strongest in the area of formation and professional training – ranking first globally. Conversely, the US faces challenges in the area of pre-university enabling environment, which may be attributed to high pupil–teacher ratios in secondary education and moderate expenditures on educational institutions.

Global Knowledge Index – United States

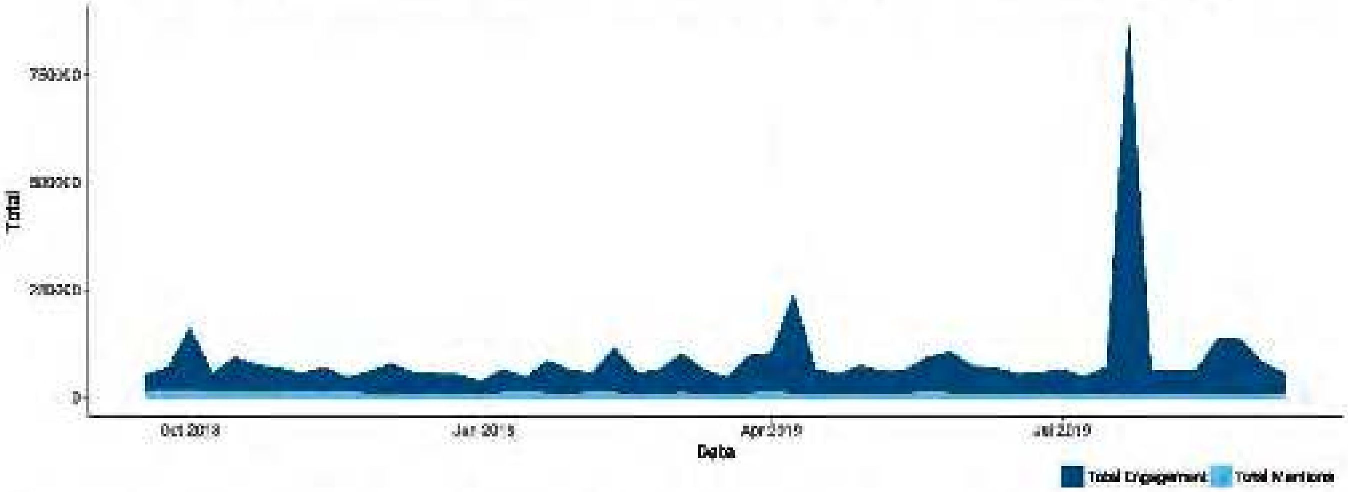


Technological awareness

87.3 percent of the US population has access to the Internet, with a mean download speed of 32.9 Mbps.

Between mid-September 2018 and mid-September 2019, there were 1,837,807 unique authors contributing to total content generation. The volume of online activity in the US within the four technology fields chosen displays an average of 44,244.2 mentions and 321,663.4 instances of engagement per month. Online activity within technological fields displays a degree of concentration of 0.00022. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.000032.

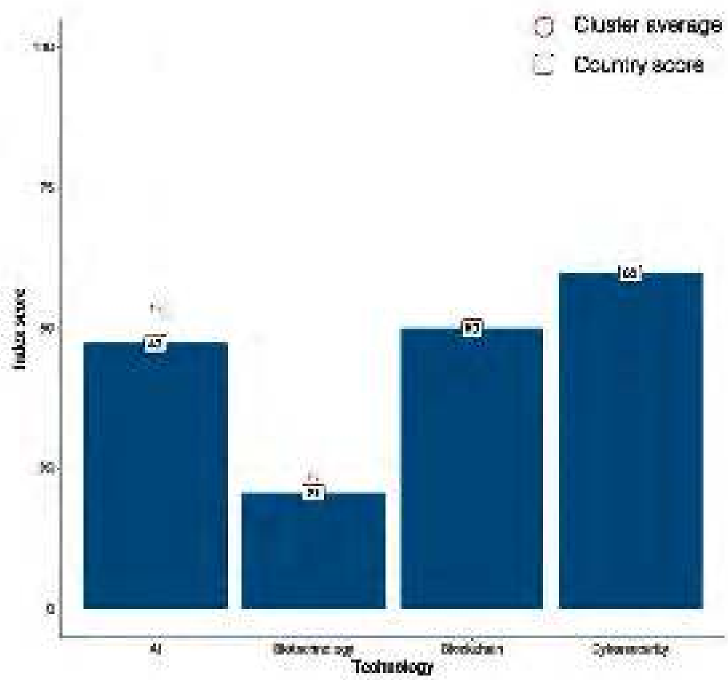
Volume of discussions and engagement level associated with the four key technologies for the future in the United States



The trend in online activity over time for the United States shows a major relevant peak in engagement in cybersecurity (economy) relating to the Equifax data breach in 2017, which exposed the social security numbers and other sensitive data of nearly 150 million Americans. In July 2019, Equifax settled with the Federal Trade Commission and the Consumer Financial Protection Bureau with a $700 million fine, of which $425 million will go to the people affected by the breach.[1] A less expressed peak in engagement referred to the news of the first image of a black hole and Dr. Katie Bouman, the computer scientist behind it.[2] In terms of mentions, the results associated with the main peak pertained to blockchain, which generated important online activity in September due to the Global Blockchain conference held in Boston.[3]

Global Technology Awareness Index: United States

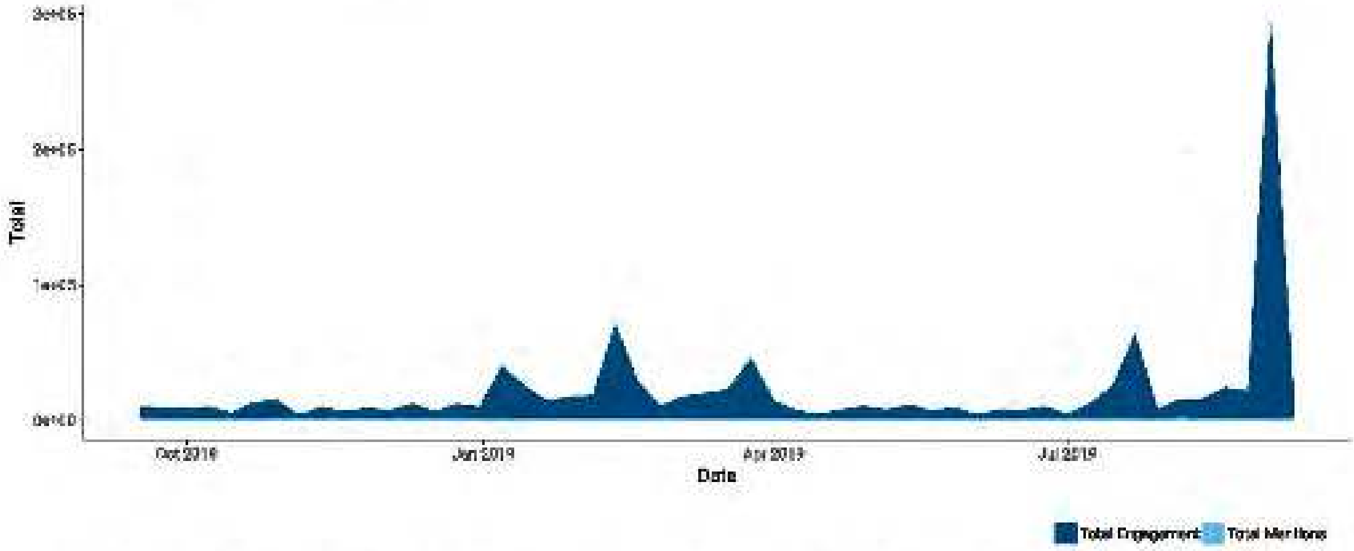
The United States outperforms the online activity cluster average in two out of four technology fields. In terms of activity distribution within the country, the US displays a relatively balanced interest in technologies, with biotechnology being the least discussed technology.



Future skills awareness

The online community presents a high level of online activity relating to future skills, with an average value of 5,146.9 mentions and 78,806.5 instances of engagement per month. Total online activity in the area of future skills in the US is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in the United States



The trend in online activity over time for the United States shows a major relevant peak in engagement related to education. The results associated with this peak pertain to national news related to the education system. Amidst an intense national discourse on educational reforms, an analysis of the perceived shortage of teachers argues that the problem lies in remuneration and employment conditions, rather than a shortage of human capital in the profession.[4] Another, less expressed peak in engagement referred to PhotoMath, a free mobile application that can be used to read and solve mathematical problems using a smartphone camera.[5]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

The United States exhibits high performance in terms of its knowledge infrastructure and a rather moderate performance in technology awareness and future skills awareness, with scores ranging between moderate and high across all dimensions. There is room for improvement, especially in terms of future skills awareness in the economy dimension.

Overview of the United States' readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★★	★★★★★	★★★☆☆	★★★★★	★★★★☆	★★★★★	★★★★★
Technology awareness	★★★★★	★★★☆☆			★★★★☆	★★★★☆	★★★★☆
Future skills awareness	★★☆☆☆	★★★★☆			★★★★☆	★★★☆☆	★★★☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

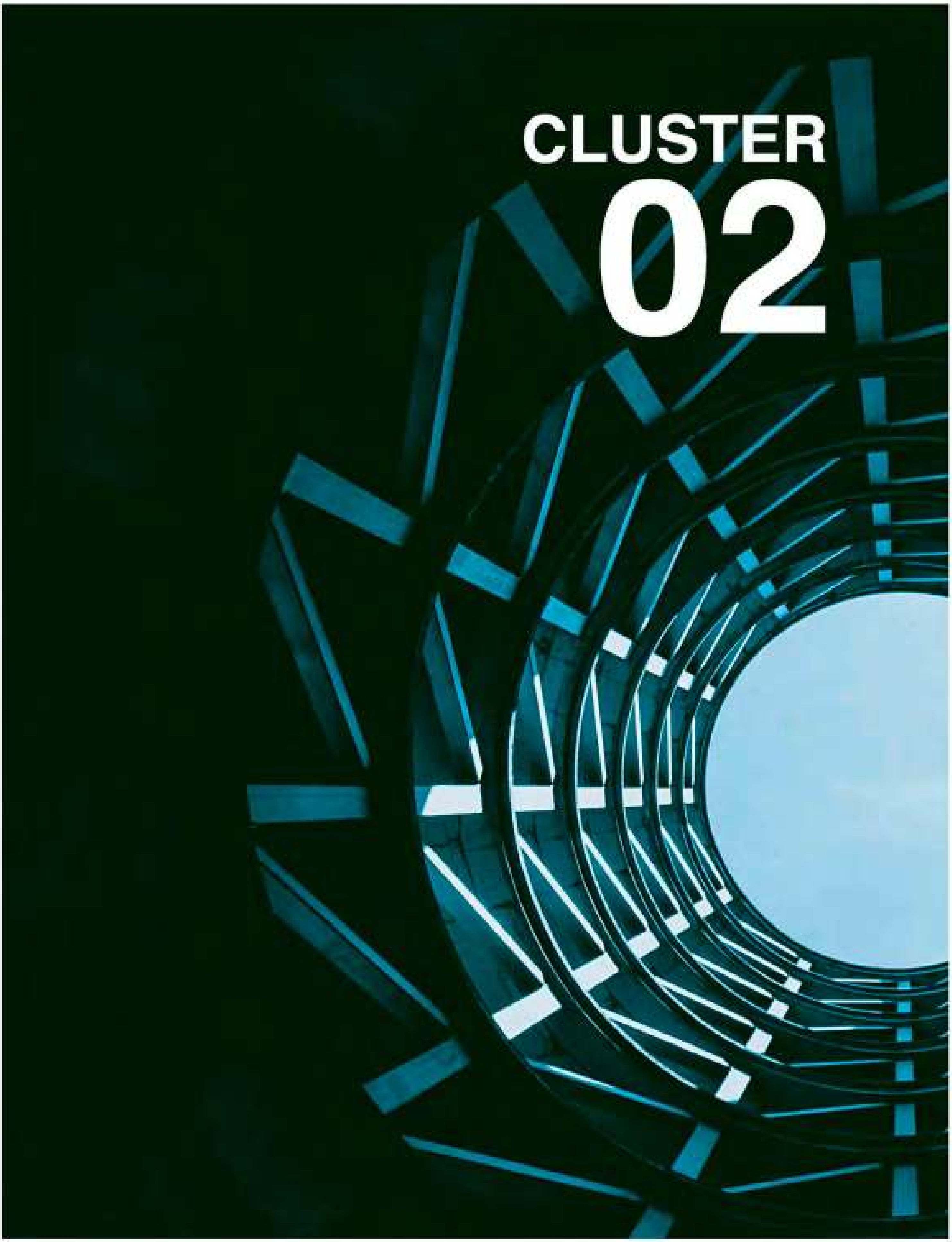
Low awareness scores in the field of future skills related to the economy indicates that the United States relies on its strong infrastructure and is beginning its transition to new technologies, especially in education. However, it may be inferred from the results that discussion regarding biotechnology is limited. Efforts appear to be underway, however, with an executive order on "modernizing the regulatory framework for agricultural biotechnology products" issued in June 2019. The order refers to an update of the 2016 national strategy and is based on recommendations from the Task Force on Agriculture and Rural Prosperity established in April 2017. In particular, the update aims to facilitate innovation and ensure coordination across regulatory agencies.[6] Besides regulatory activity, the biotechnology industry is also issuing new patents. The PDS Biotechnology Corporation has granted US and European patents for medication aimed at overcoming tumour immune suppression, for example.[7]

One aspect contributing to the high score in the education dimension under future skills awareness is the private sector's commitment to pushing upskilling solutions forward. For example, Amazon is helping to address high rates of veteran unemployment through the investment of $700 million to upskill 100,000 veterans in the United States by 2025.[8]

Endnotes

[1] *Bates, 2019.*
[2] *BBC News, 2019b.*
[3] *See: http://www.globalbigdataconference.com/boston/global-blockchain-conference/event-107.html.*
[4] *Greene, 2019.*
[5] *See: https://www.photomath.net/en/.*
[6] *The White House, 2019.*
[7] *PDS Biotechnology Corporation, 2019.*
[8] *Day, 2018.*

CLUSTER 02



Strong knowledge infrastructure cluster

39 strong knowledge infrastructure countries

- Albania
- Azerbaijan
- Bahrain
- Barbados
- Belarus
- Brazil
- Brunei Darussalam
- Bulgaria
- Chile
- China
- Colombia
- Costa Rica
- Croatia
- Cyprus
- Georgia
- Greece
- Hungary
- Italy
- Kazakhstan
- Kuwait
- Latvia
- Lithuania
- Malaysia
- Mauritius
- Mexico
- Oman
- Philippines
- Poland
- Qatar
- Romania
- Russian Federation
- Saudi Arabia
- Serbia
- Seychelles
- Slovakia
- Thailand
- Ukraine
- Uruguay
- Viet Nam

The countries in this cluster are characterized by average GKI scores of between 45.2 and 56.2, with world rankings ranging from 31 to 69. Within the cluster, country performances are close in ICT, whereas the highest variation in scores relates to RDI.

Hence, this cluster includes countries that perform within the average for most sectors, with the weakest performance being in the sectors of RDI, and technical and vocational education and training.

The following section presents the country profiles of the 11 countries of this cluster: Brazil, Chile, Greece, Kazakhstan, Kuwait, Malaysia, Mexico, Poland, the Russian Federation, Saudi Arabia and Viet Nam.

Brazil

Chile

Greece

Kazakhstan

Kuwait

Malaysia

Mexico

Poland

Russian Federation

Saudi Arabia

Viet Nam

BRAZIL

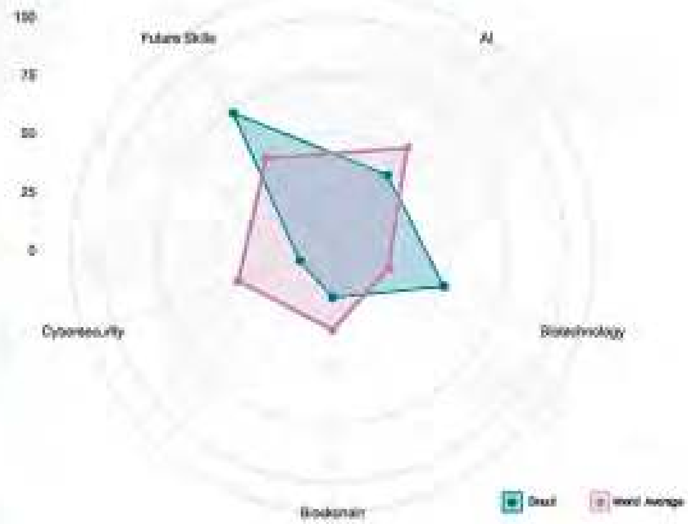
GDP per capita
$ 8,921 2018

HDI
0.759 2017

GKI
68/136 2019

823
unique authors
per million
Internet users

Future field awareness indices

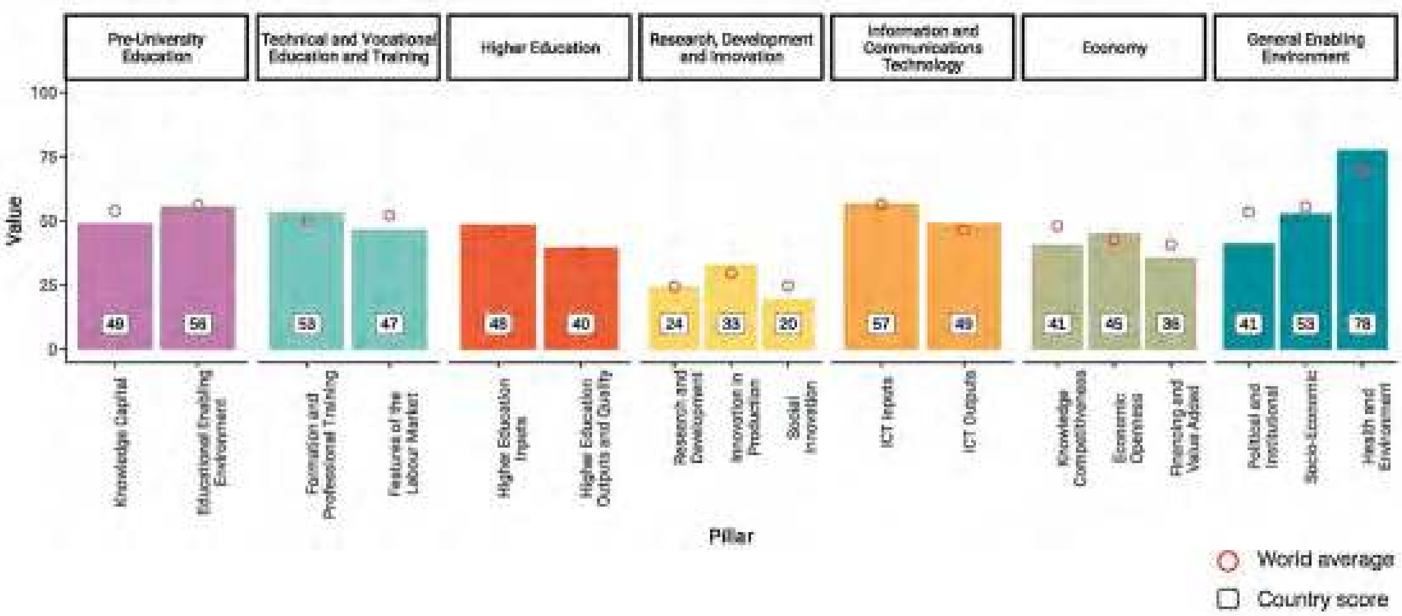


Knowledge infrastructure

Brazil is amongst the strongest countries in terms of its knowledge infrastructure to support technological uptake, standing alongside Poland and Kazakhstan.

Brazil is ranked 68th on the Global Knowledge Index, scoring slightly below the world average, and performs above the world average in two of the seven sectoral indices, namely higher education and ICT. It performs strongest in the area of research and development, mainly relating to expenditure on R&D. Conversely, Brazil faces challenges relating to employment opportunities, trade, political stability and government effectiveness.

Global Knowledge Index – Brazil

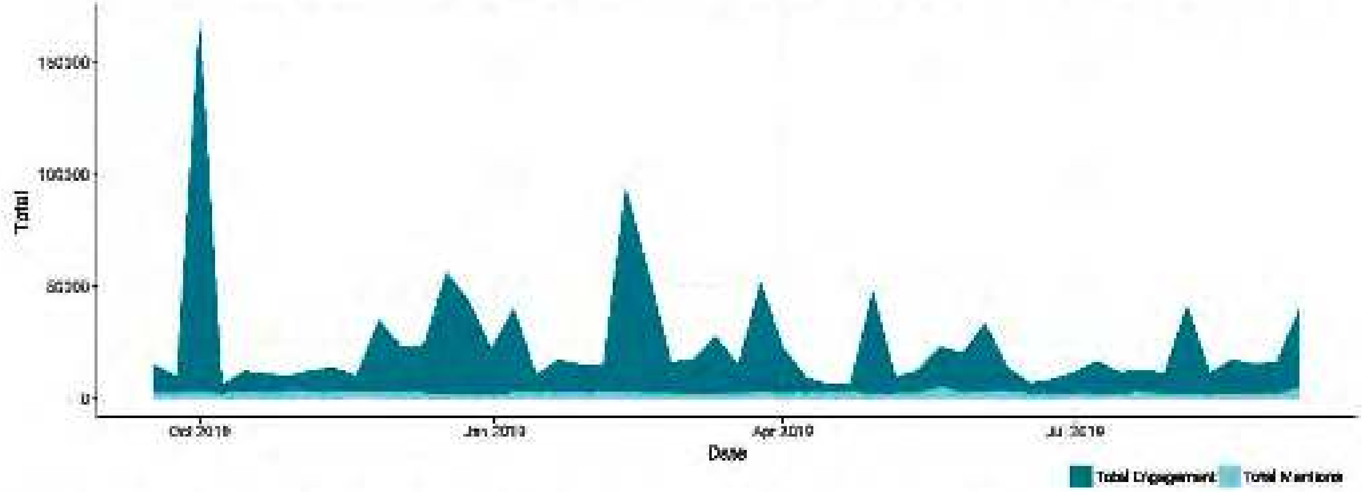


Technological awareness

67.5 percent of the population in Brazil have access to the Internet, with a mean download speed of 4.8 Mbps.

Between mid-September 2018 and mid-September 2019 there were 115,355 unique authors contributing to total content generation. The volume of online activity in Brazil within the four technology fields chosen displays an average of 11,080.4 mentions and 86,923 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.00015. In comparative terms, 2019 presents a lower concentration than the previous sampling period, which produced a value of 0.00021.

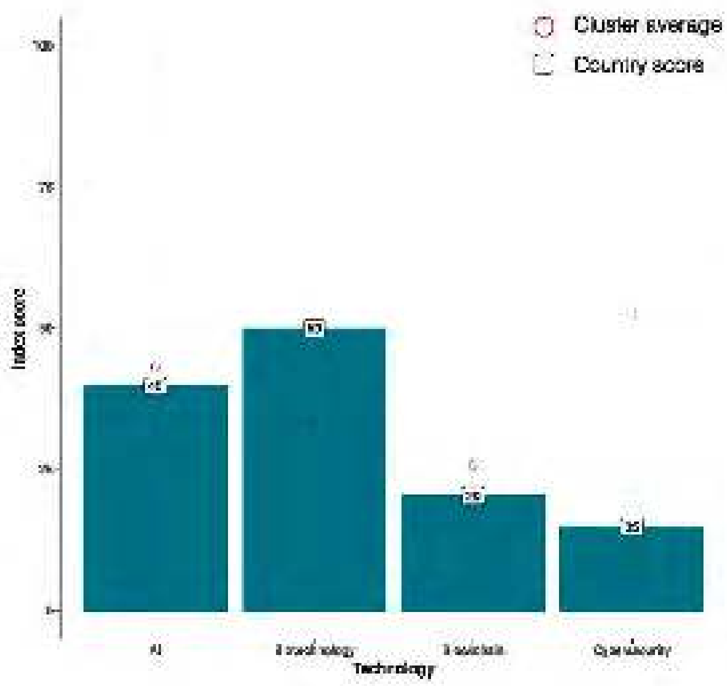
Volume of discussions and engagement level associated with the four key technologies for the future in Brazil



The online activity trend over time for Brazil shows two relevant peaks in mentions relating to blockchain (economy) and cybersecurity (economy). The results associated with these peaks pertained mainly to local news, particularly a fraud investigation involving cryptocurrencies and investments worth over $120 million by residents of the Brazilian town Caxias.[1] A further rise in mentions was due to the adoption of a national cybersecurity strategy.[2] A less expressed peak was due to the sudden death of Gustavo Schiavon, co-founder of Foxbit, Brazil's leading bitcoin exchange company.[3]

Global Technology Awareness Index: Brazil

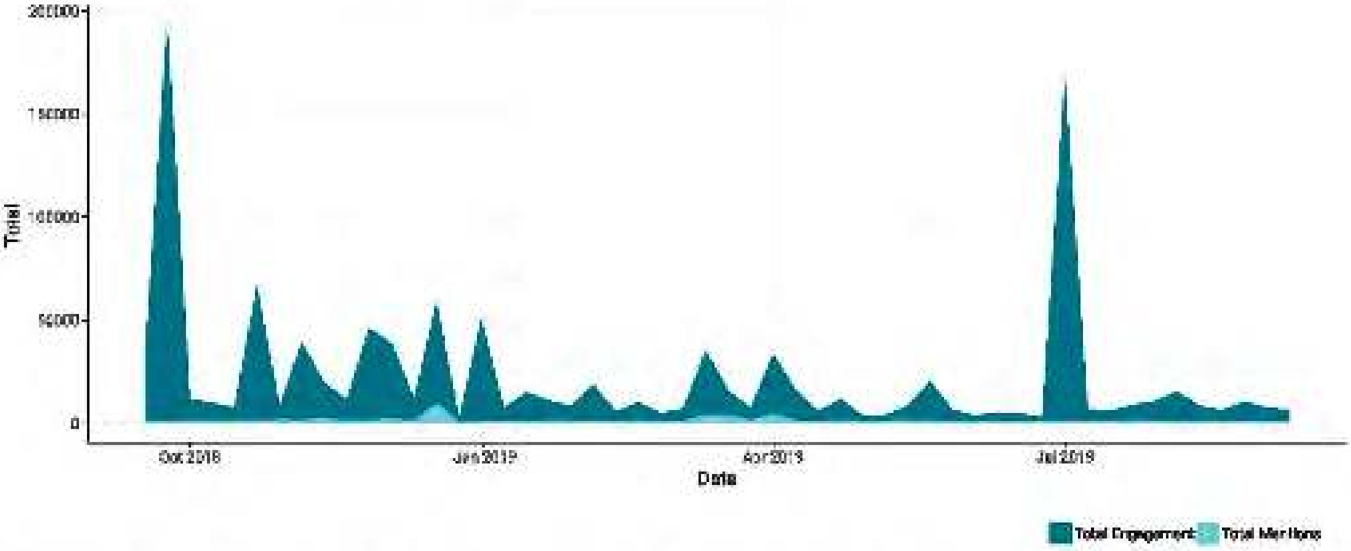
Brazil outperforms the online activity cluster average in one out of four technology fields. In terms of activity distribution within the country, Brazil displays a less balanced overall performance than the cluster average, with online activity mostly concentrated on biotechnology and AI.



Future skills awareness

The volume of online activity relating to future skills displays an average of 6,531.9 mentions and 79,640 instances of engagement per month. Total online activity in this area in Brazil is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Brazil



The online activity trend over time for Brazil shows two relevant peaks in engagement relating to education. The results associated with the first peak pertained to the Federal University of Santa Maria ranking amongst the top 50 universities in Latin America.[4] The second peak pertained to an autistic student from Vitoria winning the gold medal in the Brazilian mathematical olympiad.[5] A less expressed peak in mentions related to the participation of Sesi students in the US robotics championships, where they competed in the field of automation, robotics and artificial intelligence.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Brazil exhibits moderate performance in terms of its knowledge infrastructure, technology and future skills awareness, and moderate-to-high scores across most dimensions.

Overview of Brazil's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★☆☆☆	★★★★☆	★★☆☆☆	★★★☆☆	★★★☆☆	★★★★☆	★★★☆☆
Technology awareness	★★★★☆	★★★★★			★★★★☆	★★★★☆	★★☆☆☆
Future skills awareness	★★★★★	★★★★☆			★★★★★	★★★★☆	★★★★★

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is reasonably positioned for the future with moderate infrastructure and showing a rather strong level of awareness of both future skills and technologies, although with room for improvement in biotechnology.

Brazil's high score in the education dimension of technology awareness appears to be connected mainly to artificial intelligence and biotechnology. In terms of AI, there is a large volume of mentions and engagement in Brazil around the news of Microsoft offering free AI courses.[7] Locally, news stories around the Federal University of Goiás AI undergraduate course – the first in the country[8] – and seminars given by the government[9,10] generated a significant amount of online engagement.

From the online activity in Brazil, there also appears to be a strong interest in studying biotechnology amongst Brazilian online users, especially on Twitter. For example, a sizeable portion of the biotechnology education results come from a viral Twitter prompt wherein users posted the top 5–10 courses they would like to take.[11,12] Over 700 authors listed biotechnology within their top five.

Endnotes

[1] Duarte, 2019.
[2] Zaidan, 2019.
[3] Chepicap, 2019.
[4] Diario, 2019.
[5] Magesk, 2019.
[6] Santos, 2019.
[7] Pederneiras, 2019.
[8] Bianca, 2019.
[9] JusticiaGovBR, 2019.
[10] MinEconomia, 2019.
[11] RtJez, 2019.
[12] jobsquepariu, 2019.

CHILE

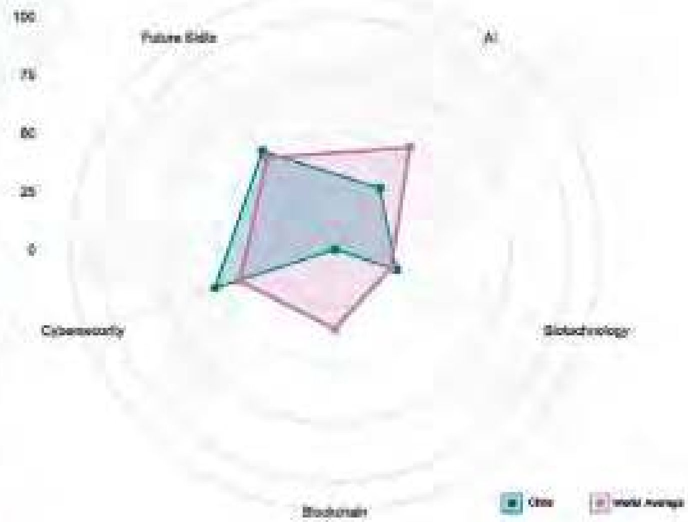
GDP per capita
$ 15,923
2018

HDI
0.843
2017

GKI
41/136
2019

833
unique authors
per million
Internet users

Future field awareness indices

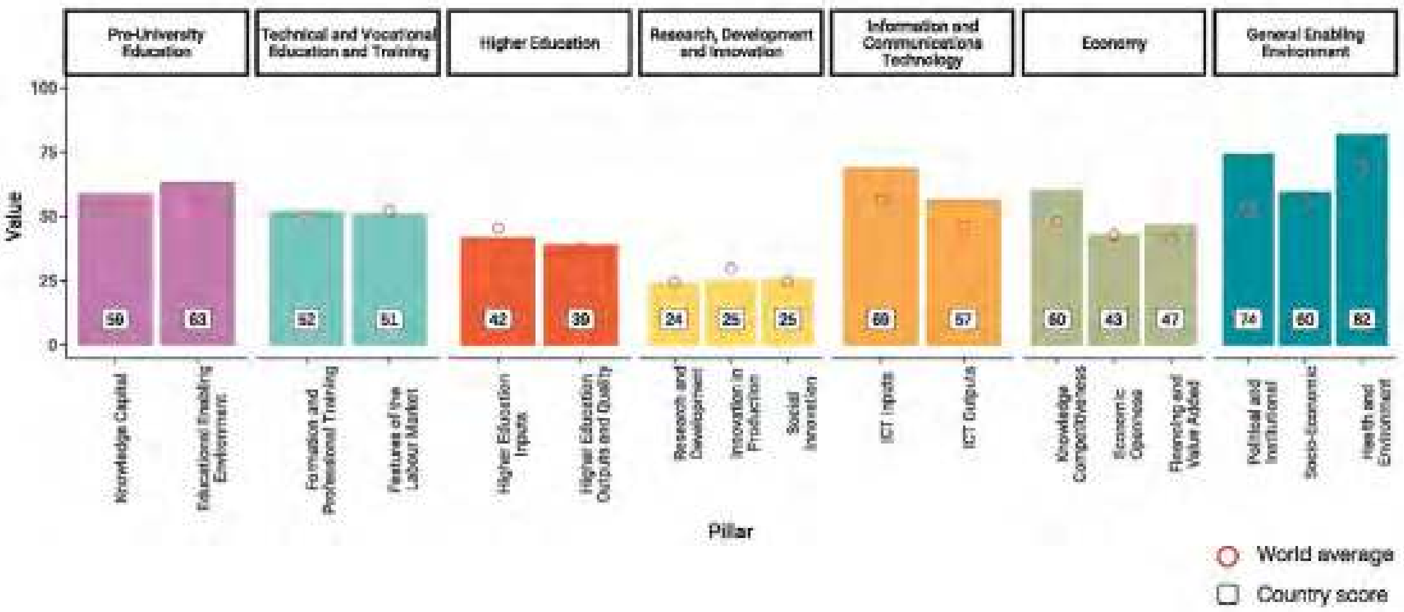


Knowledge infrastructure

Chile is amongst the strongest countries in terms of its knowledge infrastructure to support technological uptake, standing alongside Saudi Arabia and Russia.

Chile is ranked 41st on the Global Knowledge Index, outperforming 70 percent of other countries. Chile performs above the world average in five out of the seven sectoral indices. It performs strongly in areas related to knowledge competitiveness, health and institutions. Conversely, Chile faces challenges related to gender parity, inputs of higher education and innovation in production, which may be attributed to high unemployment rates, low levels of industrial design applications and low enrolment ratios in tertiary education.

Global Knowledge Index – Chile

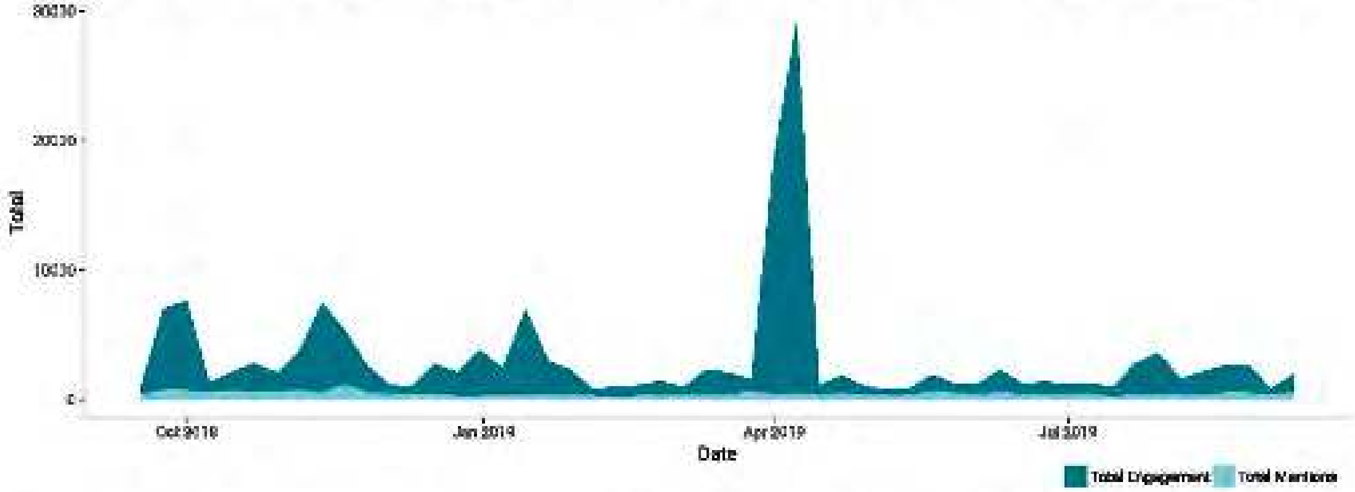


Technological awareness

82.3 percent of the population in Chile has access to the Internet, with a mean download speed of 3.9 Mbps.

Between mid-September 2018 and mid-September 2019, there were 10,128 unique authors contributing to total content generation. The volume of online activity in Chile within the four technology fields chosen displays an average of 1,799.5 mentions and 10,735.5 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0013. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.057.

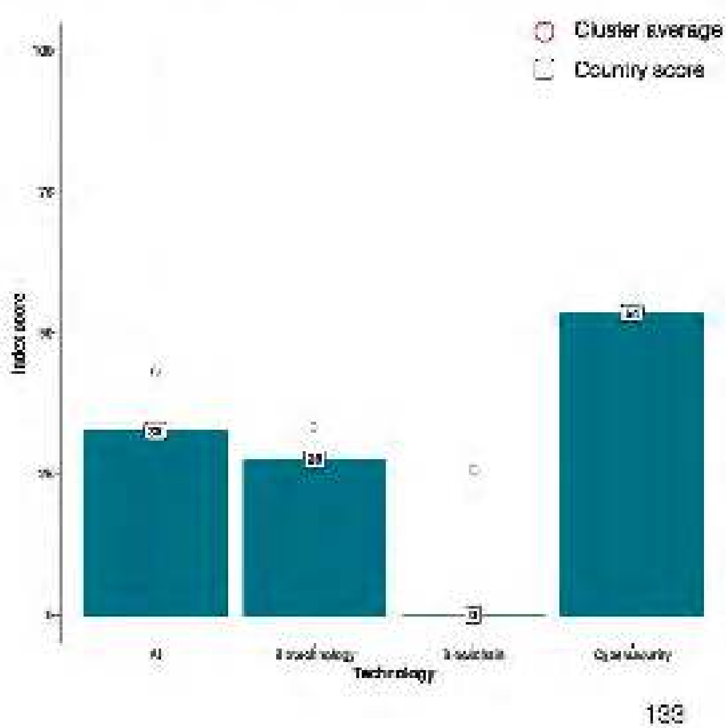
Volume of discussions and engagement level associated with the four key technologies for the future in Chile



The online activity trend over time for Chile shows a number of relevant peaks in engagement and mentions related to AI (education) and biotechnology (RDI and science). The results associated with these peaks pertained mainly to local and international news and events concerning the first image of a black hole, which was captured in April 2019,[1] as well as advancements in biotechnology, specifically in cancer treatment – specifically the news that stem cells extracted from baby teeth could be used to help regenerate cells in other parts of the body.[2] The 14th International Seminar on Artificial Intelligence also garnered attention.[3] There was also engagement concerning the recent findings of Parkinson's research conducted by two Chilean researchers, distinguishing various symptoms and how these impact respective patients using an innovative model based on the fruit fly.[4]

Global Technology Awareness Index: Chile

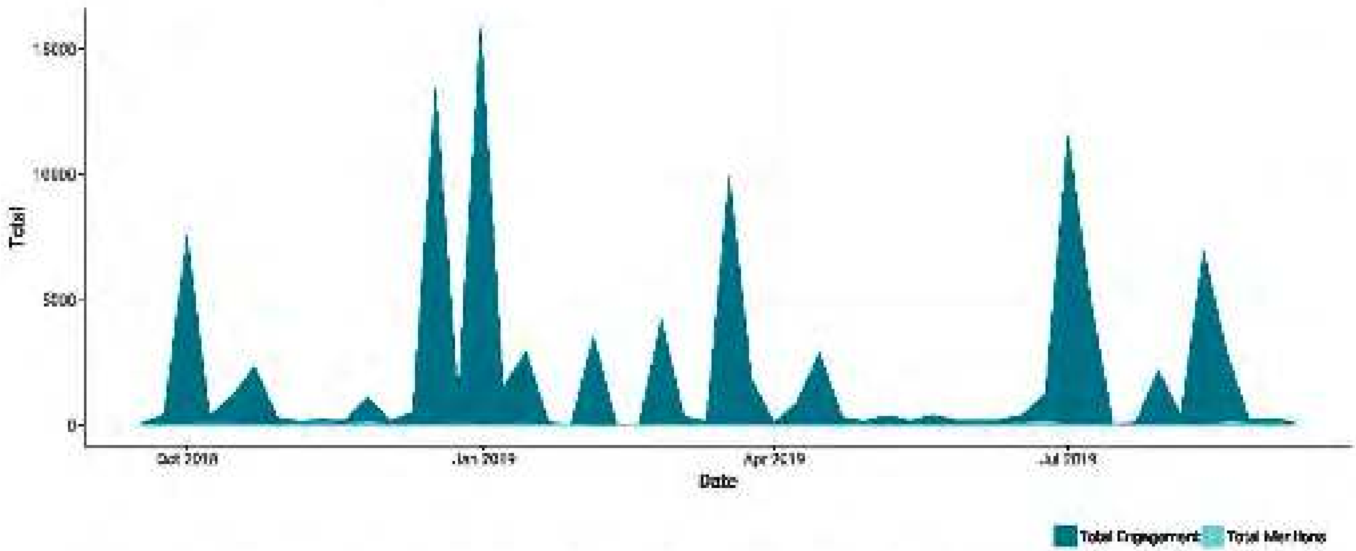
Chile performs below the online activity cluster average in all four technology fields. In terms of activity distribution within the country, the discussion in Chile is concentrated on cybersecurity followed by AI and biotechnology.



Future skills awareness

The volume of online activity relating to future skills displays an average value of 292.2 mentions and 8,005.2 instances of engagement per month. Total online activity in the area of future skills in Chile is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Chile



The trend in online activity over time for Chile shows several relevant peaks in engagement and one relevant peak in mentions relating to education and enabling environment, respectively. Chile's engagement activity is mostly sparked by teacher strikes. Indeed, over 90,000 primary and secondary teachers were on strike for seven weeks between June and July 2019[5] due to the lack of government response to their demands for better working conditions and structural changes.[6] The peak in mentions related to local news covering citizens with hearing disabilities who can now successfully obtain their driver's licenses due to a new course offered by the National Training and Employment Service (SENCE).[7]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Chile exhibits moderate performance in terms of its knowledge infrastructure, technology and future skills awareness, with scores ranging between moderate and strong across the dimensions.

Overview of Chile's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★☆	★★★☆☆	★★★★☆	★★★☆☆	★★★★☆	★★★★☆	★★★★☆
Technology awareness	★★★☆☆	★★★☆☆			★★★☆☆	★★★★★	★★☆☆☆
Future skills awareness	★★☆☆☆	★★★★★			★★☆☆☆	★★★★★	★★☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is fairly well-positioned for the future, with moderate performance in infrastructure, displaying an average level of awareness on both future skills and technologies but with room for improvement in the area of blockchain.

Chile's high score across technology and future skills awareness relating to RDI and science is mainly a result of the high volume of engagement related to innovation and research in biotechnology – locally, regionally and internationally. Topics range from reports on research from the Biotechnology Centre of the University of Chile[8] and the inauguration of a new applied biotechnology lab at San Sebastián University,[9] to reports on local achievements ("Chilean chosen as one of the 10 most promising scientists in the world"[10]). Other key institutes within the country are also prominent within the results, most notably Fraunhofer Chile,[11] the Chilean branch of the German applied research firm.

Endnotes

[1] *Suazo, 2019.*
[2] *Cooperative CL, 2019.*
[3] *Álvarez, 2018.*
[4] *Yáñez, 2018.*
[5] *Chávez, 2019.*
[6] *Ibid.*
[7] *Díaz, 2018.*
[8] *Orellana, 2019.*
[9] *AQUASocial, 2018.*
[10] *Suazo, 2018.*
[11] *FraunhoferChile, 2019.*

GREECE

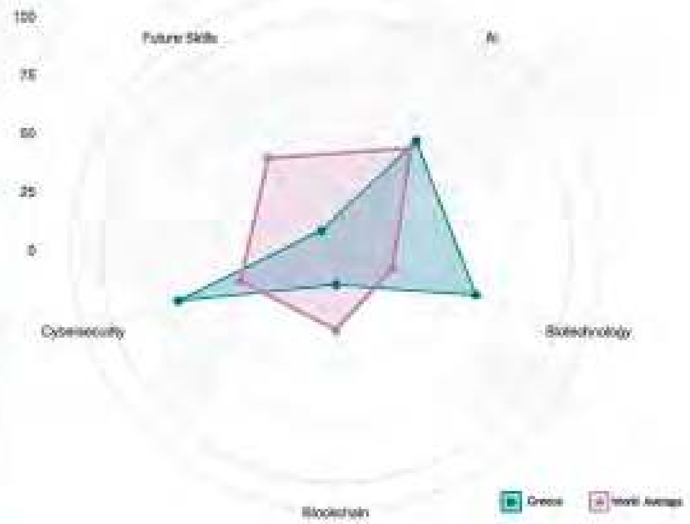
GDP per capita
$ 20,324
2018

HDI
0.870
2017

GKI
58/136
2019

1100
unique authors
per million
Internet users

Future field awareness indices

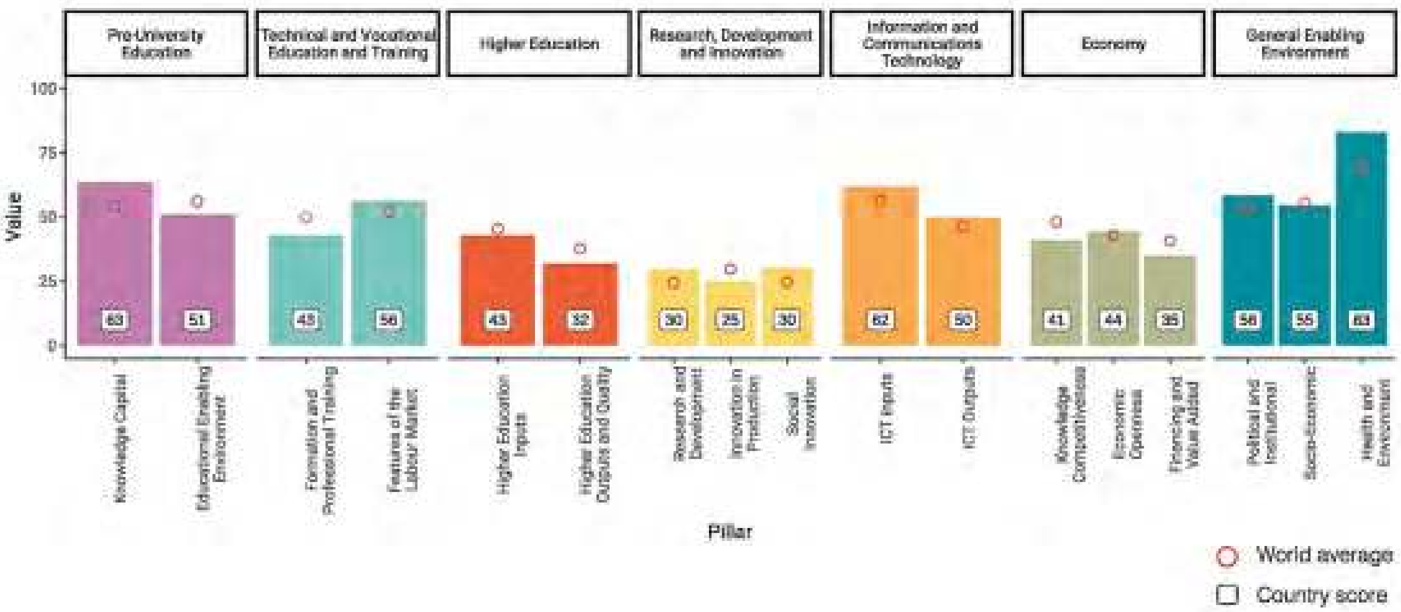


Knowledge infrastructure

Greece is amongst the strongest countries in terms of its knowledge infrastructure to support technological uptake, standing alongside Poland and Saudi Arabia.

Greece is ranked 58th on the Global Knowledge Index, outperforming the world average. Greece performs above the world average in four out of seven sectoral indices. It performs strongly in areas related to health and social innovation. Conversely, Greece faces challenges related to the enabling environment of pre-university education that may be attributed to low levels of expenditure on education and low enrolment ratios in early childhood development. Furthermore, the knowledge competitiveness of the economy is limited, and this is due to the economic infrastructure and competition – mainly the unavailability of venture capital and gross fixed capital formation.

Global Knowledge Index – Greece

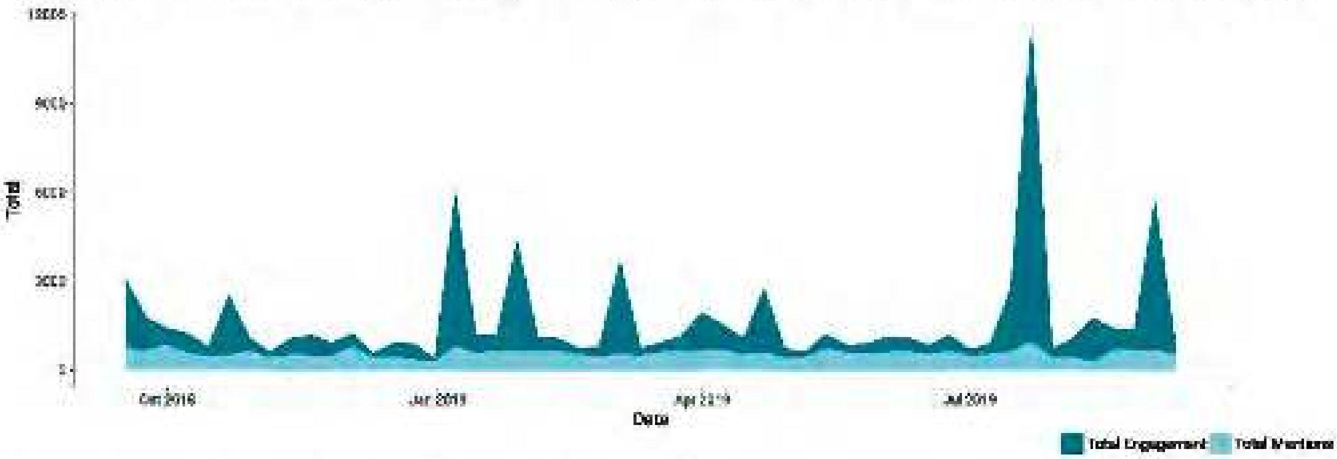


Technological awareness

73 percent of the population in Greece has access to the Internet, with a mean download speed of 13.4 Mbps.

Between mid-September 2018 and mid-September 2019 there were 8,444 unique authors contributing to total content generation. The volume of online activity in Greece within the four technology fields chosen displays an average of 2,277.5 mentions and 4,373.5 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.002. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.001.

Volume of discussions and engagement level associated with the four key technologies for the future in Greece

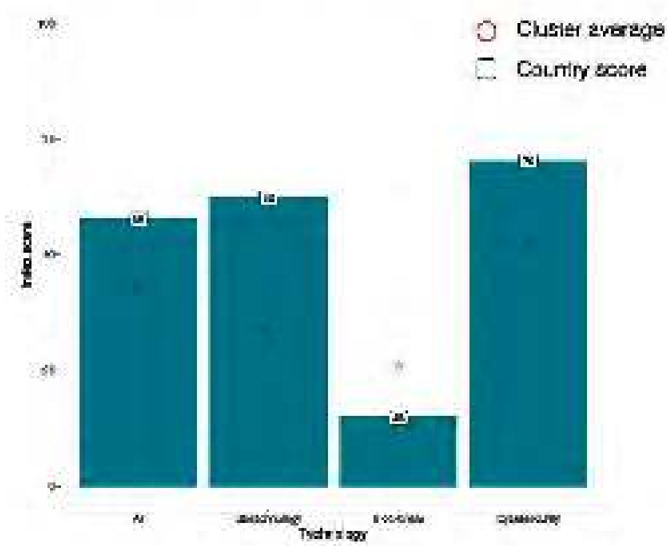


The trend in online activity over time for Greece shows one relevant peak in mentions, related to cybersecurity (enabling environment). The peak pertains mainly to the question raised by Alexis Georgoulis, a Greek Member of the European Parliament, on safety and protection of users. This referred to a mobile app that was widely downloaded, especially amongst young people, that requires user permission for access to a huge amount of personal data.[1]

The main peak in engagement over the summer of 2019 related to biotechnology (RDI and science). US investment firm Chatsworth Securities LLC agreed with Onex Elefsis Shipyards LLC to participate in an investment of up to EUR 400 million over the course of 15 years in the shipyards of Elefsina, western Attica, as part of efforts to save the complex from bankruptcy. Chatsworth's areas of focus include shipping, biotechnology, real estate, insurance, transport, financial markets, capital markets, asset backed securities, alternative energy, and oil and gas.[2] A second peak in engagement in that period relates to a mission of the Demokritos National Center for Scientific Research to the Silicon Valley, marking the successful transfer of technology from research laboratories to businesses and, ultimately, to markets.[3] This peak also relates to the announcement by Ernst & Young of a new Artificial Intelligence Centre of Excellence in Greece, in cooperation with the Demokritos National Center for Scientific Research and its Software and Knowledge Engineering Laboratory (SKEL).[4]

Global Technology Awareness Index: Greece

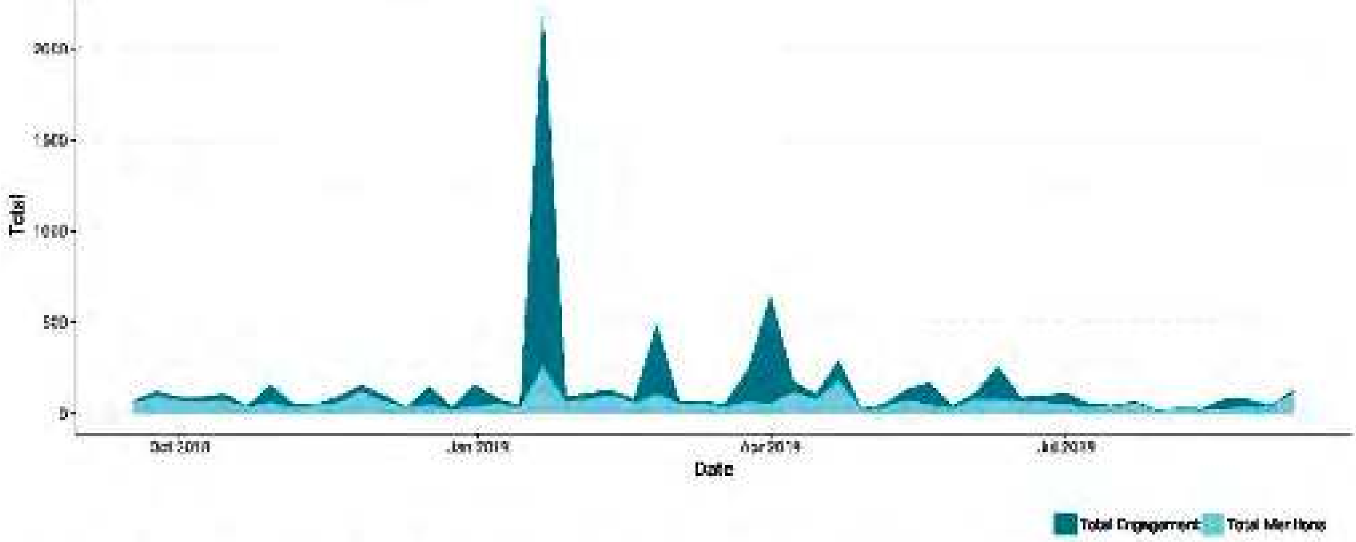
Greece outperforms the online activity cluster average in three out of four technology fields. In terms of activity distribution within the country, Greece displays a more balanced overall performance than the cluster average, with online activity spread almost evenly across AI, biotechnology and cybersecurity. Blockchain is the only technology that performs below the cluster average and on which online activity is slightly lower.



Future skills awareness

The volume of online activity relating to future skills displays an average value of 247.8 mentions and 360 instances of engagement per month. Total online activity in this area in Greece is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Greece



The online activity trend over time for Greece shows a major relevant peak in engagements as well as one peak in mentions relating to the economy. The results associated with these peaks pertain mainly to the proposition of structural reform. Prime Minister Mitsotakis has sought to restore confidence in the Greek economy, but emphasises that this cannot be achieved through further austerity or a return to the conditions of the past. To this end, he proposes the implementation of structural reforms that will make Greece competitive, change the business climate and attract significant domestic and foreign investment.[5]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Greece exhibits an average performance in terms of its knowledge infrastructure, technology and future skills awareness, with an overall average score across most dimensions.

Overview of Greece's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★☆☆☆	★★☆☆☆	★★★☆☆	★★★☆☆	★★★★☆	★★★★☆	★★★★☆
Technology awareness	★★☆☆☆	★★☆☆☆			★★★☆☆	★★★☆☆	★★★☆☆
Future skills awareness	★★☆☆☆	★★☆☆☆			★★★★★	★★☆☆☆	★★★★★

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is fairly well positioned for the future, with moderate performance in infrastructure and displaying an average level of awareness on both future skills and technologies, but with room for improvement in blockchain.

Through the observation period, online discussion has been sparked concerning cybersecurity, notably since the European Union Agency for Network and Information Security (ENISA) agreed to maintain its seat in Greece.[6] Concerning artificial intelligence, the report "Greece: With an AI to the Future", developed by Accenture in collaboration with Microsoft, also raised the attention of the online community, as it stressed the potential that AI has for the country and, more specifically, the potential cumulative uplift in GDP of $195 billion over a 15-year period (from 2020 to 2035).[7] In May 2019, Greece adopted the OECD's principles on artificial intelligence.[8]

There is an active discussion in Greece related to skills and technology, as there is an e-skills gap in Greece that the government seeks to address as a way to ensure the recovery of the country's economy. While Greece has long had a strong track record of university attendance amongst young people, the country lags behind many of its European neighbours in ensuring that all of its children have strong foundational skills, and that it retains ICT specialists in the country.[9] Through the observation period, there have been various initiatives aimed at increasing training in digital skills for the workforce, for education, for ICT professionals, and for democratic citizenship, notably within the framework of the National Coalition for Digital Skills and Employment.[10] As a result of this same framework, Greece has set up a National Action Plan, "Enhancing Digital Skills & Jobs in Greece". Through the EU Code week, children from 21 schools from all over the country had the opportunity to learn coding.[11] The Alliance for Digital Employability (AFDEmp) aims to tackle unemployment, especially amongst young people, through education and the development of high-quality digital skills, and to create 500,000 new IT jobs in Greece, primarily over the next decade.[12]

Endnotes

1 *Proto Thema, 2019.*
2 *Kathimerini, 2019a.*
3 *Khathimerini, 2019b.*
4 *Ekathimerini, 2019a.*
5 *Hellenic Daily News, 2019.*
6 *Mouratidis, 2019.*
7 *Accenture, 2019.*
8 *Ekathimerini, 2019b.*
9 *Muller, 2019.*
10 *Blog Activ, 2019.*
11 *Revive Greece, 2018.*
12 *See: https://www.afdemp.org/.*

CLUSTER
02

KAZAKHSTAN

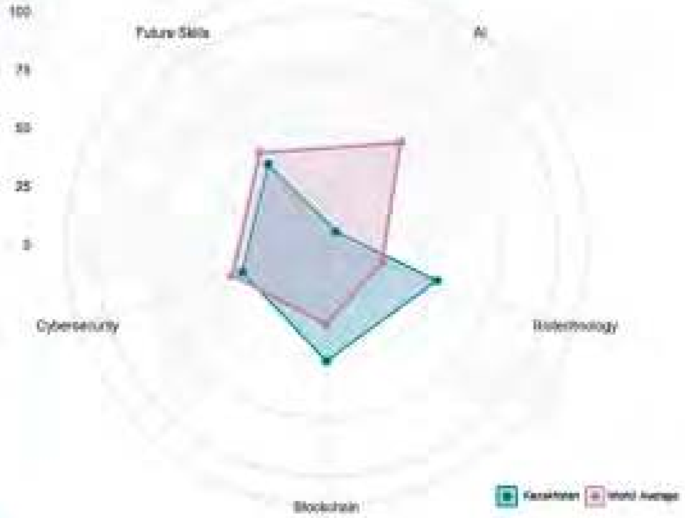
GDP per capita
$ 9,331
2018

HDI
0.800
2017

GKI
64/136
2019

133
unique authors
per million
Internet users

Future field awareness indices

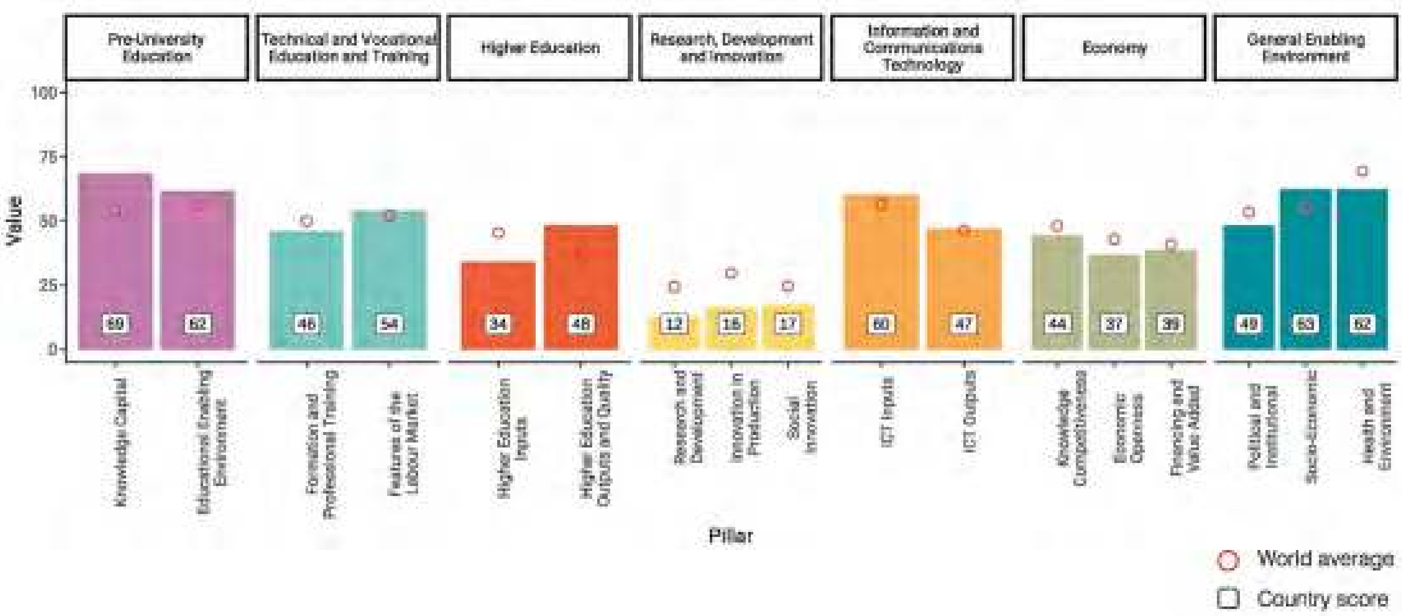


Knowledge infrastructure

Kazakhstan is amongst the strongest countries in terms of knowledge infrastructure to support technological uptake, standing alongside countries such as Saudi Arabia and Greece.

Kazakhstan is ranked 64th on the Global Knowledge Index, scoring the world average. Kazakhstan performs above the world average in three out of seven sectoral indices. It performs strongly in areas related to the knowledge capital generated by pre-university education. Conversely, Kazakhstan faces challenges related to R&D, innovation in production and economic infrastructure, which may be attributed to low levels of intellectual property receipts and industrial design applications, and limited intensity of local competition.

Global Knowledge Index – Kazakhstan

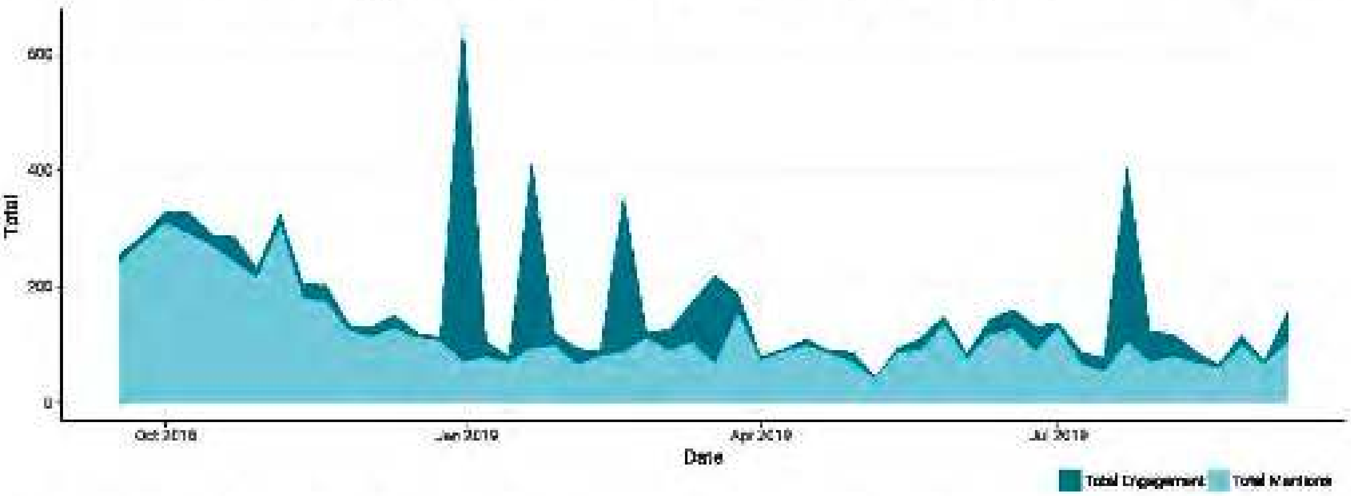


Technological awareness

78.9 percent of the population in Kazakhstan has access to the Internet, with a mean download speed of 4.7 Mbps.

Between mid-September 2018 and mid-September 2019, there were 1,919 unique authors contributing to total content generation. The volume of online activity in Kazakhstan within the four technology fields chosen displays an average of 485.5 mentions and 199.8 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.006. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.0036.

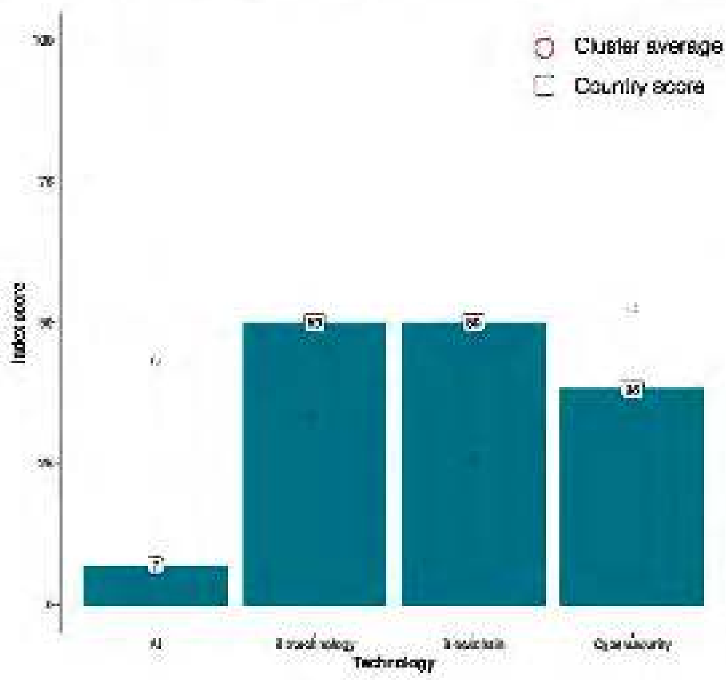
Volume of discussions and engagement level associated with the four key technologies for the future in Kzakhstan



The trend in online activity over time for Kazakhstan shows two relevant peaks in engagement relating to biotechnology and cybersecurity in education. The first peak relates to the simplification of the procedure to obtain Kazakhstani citizenship for software developers, IT specialists and specialists in bioengineering and bioinformatics.[1] The second peak concerns the fact that Kazakhstan is looking for ways to legalise cryptocurrencies, according to the vice president of the National Blockchain and Cryptocurrency Association despite the ban placed by the National Bank on cryptocurrencies in Kazakhstan, government agencies are looking for ways to regulate them.[2] In terms of mentions, the results associated with the main peak pertained to blockchain, generating significant online activity in November. This was due to the 'Blockchain Start-ups Weekend' in Astana[3] and 'Blockchain Life 2018'[4], "the biggest event in the cryptocurrency, blockchain and ICO industry in Russia and Eastern Europe that was held in St. Petersburg'[5].

Global Technology Awareness Index: Kazakhstan

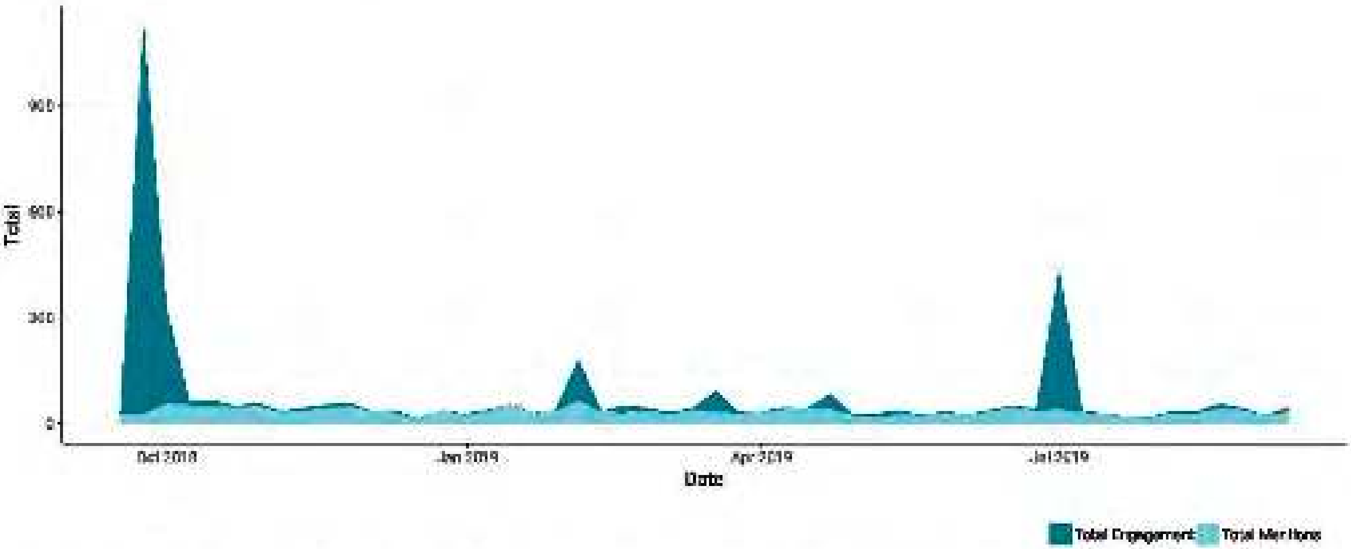
Kazakhstan outperforms the online cluster average in two out of four technology fields. In terms of activity distribution within the country, discussion in Kazakhstan is balanced amongst three technologies: biotechnology, blockchain and cybersecurity.



Future skills awareness

The online community exhibits a low level of online activity relating to this topic, with an average value of 134.3 mentions and 171.8 instances of engagement per month. Total online activity in this area in Kazakhstan is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Kazakhstan



The trend in online activity over time for Kazakhstan shows a major relevant peak in engagement and one peak in mentions relating to education, and RDI and science. Regarding engagements, the results concern the launch of courses to improve the efficiency of public servants in Kazakhstan announced by Ravil Tyulebaev, Director for Control in the Public of the Agency of the Republic of Kazakhstan, at a public council briefing.[5] In terms of mentions, the results are associated with a special platform 'ReLive' for stroke patients developed by Kazakh scientists, founded by Beibit Abdikenov. This unique invention is able to read and recognise brain signals, and then mentally control an exoskeleton mounted on the upper limbs.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Kazakhstan exhibits an average performance in terms of its knowledge infrastructure. In terms of technology and future skills awareness, it performs relatively weakly.

Overview of Kazakhstan's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★☆☆	★★★☆☆	★★★★☆	★★★☆☆	★★★☆☆	★★☆☆☆	★★★☆☆
Technology awareness	★☆☆☆☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★☆☆☆☆
Future skills awareness	★★★★☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★☆☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

There is room for improvement in terms of infrastructure, but Kazakhstan also needs to prepare for the future in skills and technologies. Blockchain is where signs of progress can be expected in the coming years. An indication of this is the recent implementation of blockchain technologies to support the management of Kazakh kindergartens and their waiting lists.[7] Another example is the recently announced strategic cooperation between Astana International Financial Centre and the blockchain company, Bitfury, who aim to collectively create projects using blockchain technology.[8]

The country's performance is particularly strong in the economy dimension under future skills awareness. An example of this is the establishment of the Astana Hub; its concept is to create a favourable system for start-up development by fostering interactions with private and public stakeholders, in an effort to create and promote industry expertise in the field of smart city technologies.[9]

While the country receives a low score on the education dimension, under technology and future skills awareness, there are signs of progress. An example is the recent announcement by the Ministry of Digital Development, Defense and Aerospace Industry of Kazakhstan to actively make the evolution of human capital assets a priority by teaching basic digital skills. In 2018 alone, the modernization of the school curricula from second to eleventh grade, and the training of over 700,000 people,[10] have seen significant steps into this direction.

Endnotes

[1] *Forbes, 2019*

[2] *Karimova, 2019.*

[3] *CSN Platform, 2018.*

[4] *See: https://cryptoslate.com/event/blockchain-life-2018/.*

[5] *Dzhakupova, 2018.*

[6] *Kolmakova, 2019.*

[7] *Berman, 2019*

[8] *Astana International Financial Centre, 2019.*

[9] *Boteu, 2018.*

[10] *Azer News, 2019.*

KUWAIT

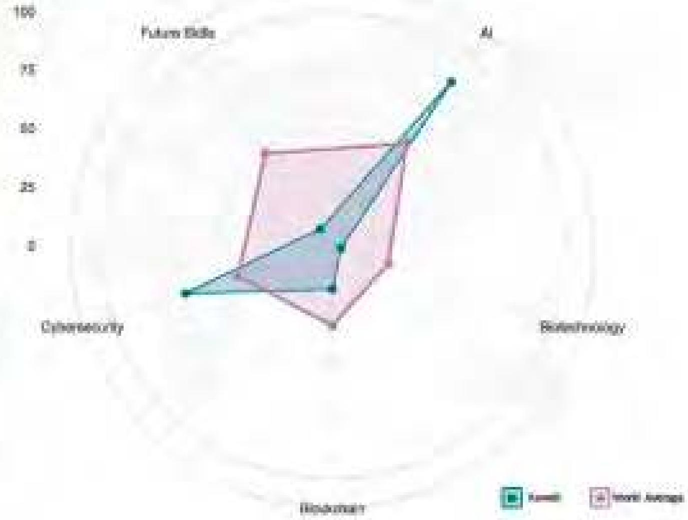
GDP per capita
$ 34,244
2018

HDI
0.803
2017

GKI
62/136
2019

382
unique authors
per million
Internet users

Future field awareness indices

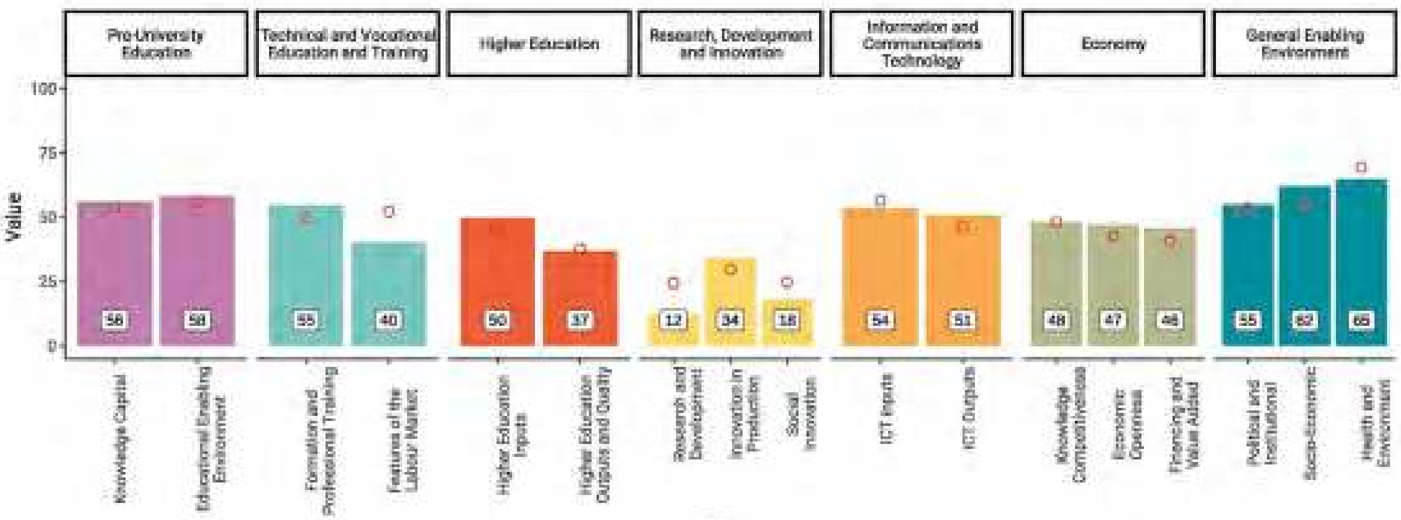


Knowledge infrastructure

Kuwait is amongst the strongest countries in terms of its knowledge infrastructure to support technological uptake, standing alongside Poland and Malaysia.

Kuwait is ranked 62nd on the Global Knowledge Index, scoring slightly above the world average. Kuwait outperforms the world average in five out of seven sectoral indices. It performs strongly in areas related to financing and taxes – namely low taxes and contribution rates and high availability of domestic credit to the private sector. Conversely, Kuwait faces challenges relating to the environment, social innovation and R&D, which may be attributed to high rates of CO_2 emissions per capita, limited expenditures on R&D and limited outputs of social innovation –especially trademark applications, films and printing and publishing.

Global Knowledge Index – Kuwait

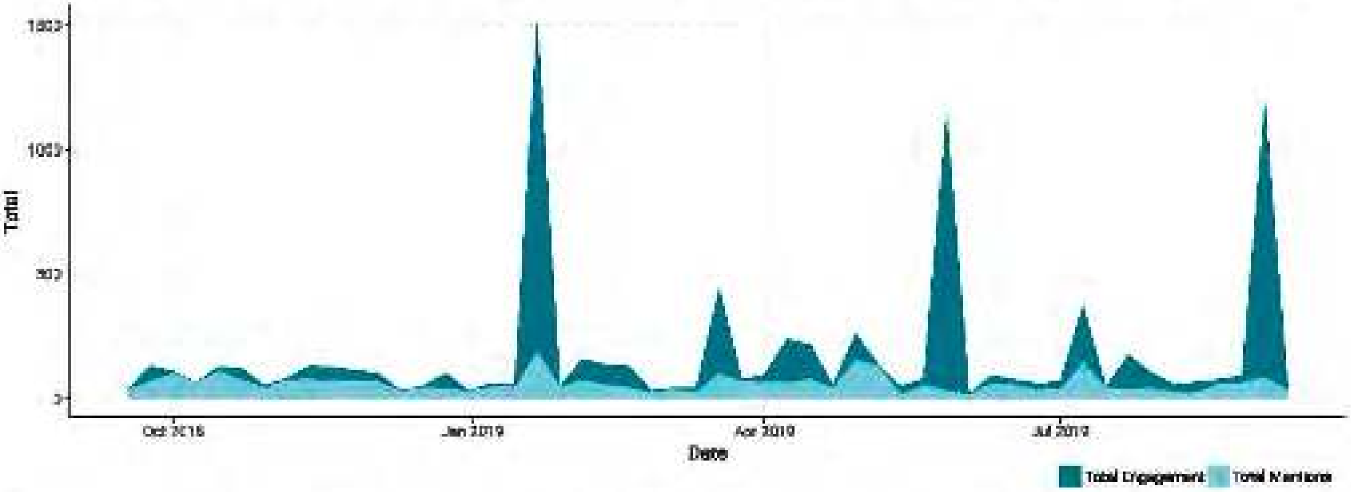


Technological awareness

99.6 percent of the population in Kuwait has access to the Internet, with a mean download speed of 3.9 Mbps.

Between mid-September 2018 and mid-September 2019, there were 1,575 unique authors contributing to total content generation. The volume of online activity in Kuwait within the four technology fields chosen displays an average of 247.9 mentions and 442.8 instances of engagement per month. Online activity concerning technological fields displays a degree of concentration of 0.0012. In comparative terms, 2019 presents a lower concentration than the previous sampling period, which produced a value of 0.0018.

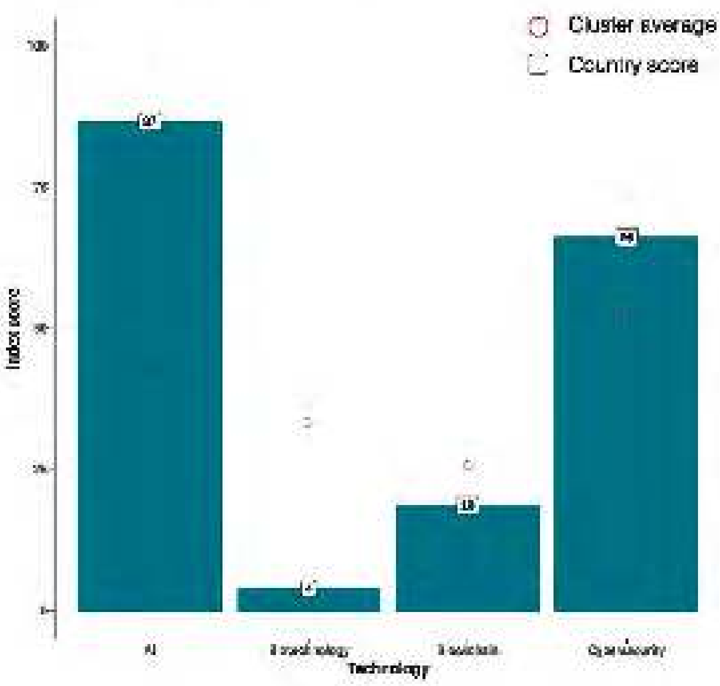
Volume of discussions and engagement level associated with the four key technologies for the future in Kuwait



The trend in online activity over time for Kuwait shows a number of relevant peaks in both engagement and mentions relating to AI (RDI and science and enabling environment) and cybersecurity (enabling environment). The results associated with the first peak in mentions and the first peak in engagement mainly pertain to the Saudi International Exhibition & Conference for the Internet of Things held in Riyadh in February 2019.[1] The second peak in mentions mostly relates to a three-day conference on AI in Salalah, Oman; the 2nd Artificial Intelligence Conference: 4th Industrial Revolution and Future Prospects, attracted experts and specialists in AI technologies, including experts from Kuwait.[2] The last peak in engagement refers to a publication warning of the possible dangers of using AI to produce fake news, for example by falsifying videos or statements.

Global Technology Awareness Index: Kuwait

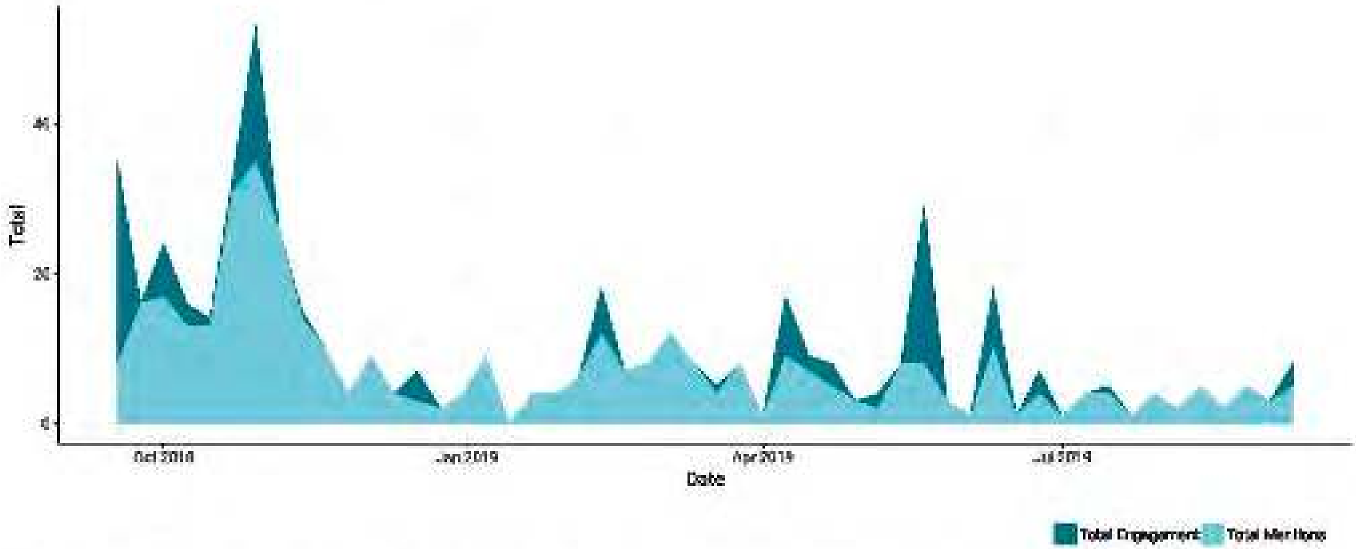
Kuwait outperforms the online activity cluster average in two out of the four technology fields. In terms of activity distribution within the country, Kuwait's activity is mainly concentrated on AI and cybersecurity.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average of 29.9 mentions and 9.3 instances of engagement per month. Total online activity in this area in Kuwait is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Kuwait



The trend in online activity over time for Kuwait shows a main peak in engagement and mentions relating to education. The results associated with these peaks pertained mainly to national and international news around the issues of public education.

In an attempt to address these challenges, in 2017 the Kuwaiti government unveiled an ambitious plan entitled 'Vision 2035', seeking "to transform the country into a leading regional financial, commercial and cultural hub within 17 years".[3] In October 2018 and April 2019, Q8 EduEx, which is the largest International Higher Education Expo held twice a year, also generated significant online activity, given its reputation as a good networking platform of the worlds' best universities and college representatives to engage with Kuwaiti and expatriate students as well as their parents and counsellors.[4] In October 2018, Canon brought its 'Education for Life' roadshow to Kuwait to demonstrate its commitment to addressing the challenges faced by the education sector in alignment with Kuwait's 2035 vision.[5]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Kuwait exhibits average performance in terms of its knowledge infrastructure. In terms of technology and future skills awareness, Kuwait's performance is weak across all dimensions.

Overview of Kuwait's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★☆	★★★☆☆	★★★☆☆	★★★☆☆	★★★☆☆	★★☆☆☆	★★★☆☆
Technology awareness	★☆☆☆☆	★☆☆☆☆			★★☆☆☆	★★☆☆☆	★☆☆☆☆
Future skills awareness	★☆☆☆☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★☆☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country has room for improvement on the infrastructure front, but also needs to prepare for the future in both skills and technologies. AI is where signs of progress can be expected in the coming years. An indication of this is Kuwait's recently announced, 'Vision 2035'. As part of this new national strategy, the Kuwaiti government announced its establishment and development of smart cities from scratch. For example, South Saad Al Abdullah city will be home to 400,000 people and will be managed by an AI system.[6] Furthermore, the government announced that it will increase investments in the information and communications technology sector to assist the country's transition to a knowledge economy.[7]

Regarding future skills awareness, a first sign of potential progress comes from AMIDEAST, which recently announced that it will offer skills workshops in Kuwait providing a wide range of professional skills courses to both public and private sector institutions. Workshop topics include innovation and creativity and fostering innovation.[8]

Endnotes

[1] *See: https://saudiiot.com.*
[2] *Muscat Daily, 2019.*
[3] *Olver-Ellis, 2019.*
[4] *See: https://www.q8eduex.com/.*
[5] *Sutton, 2018.*
[6] *Vassiliadis, 2019.*
[7] *Financial Tribune, 2018.*
[8] *Garcia, 2019.*

CLUSTER
02

MALAYSIA

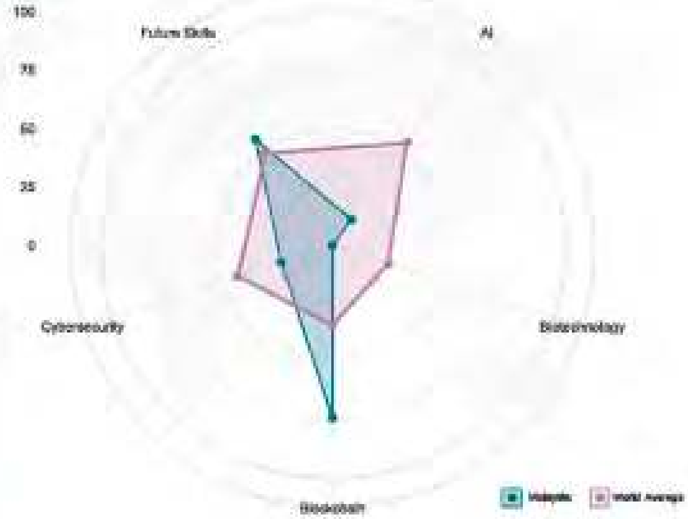
GDP per capita
$ 11,239 2018

HDI
0.802 2017

GKI
33/136 2019

1051 unique authors per million Internet users

Future field awareness indices

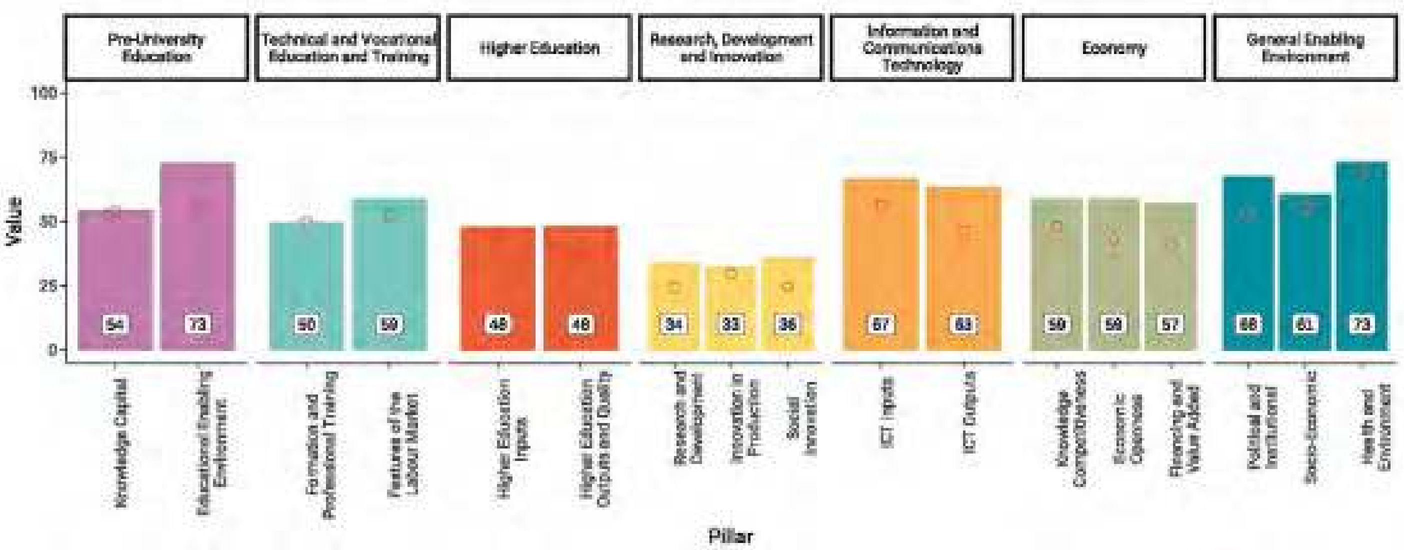


Knowledge infrastructure

Malaysia is amongst the strongest countries in terms of its knowledge infrastructure to support technological uptake, standing alongside Chile and Kuwait.

Malaysia is ranked 33rd on the Global Knowledge Index, outperforming 76.2 percent of other countries. Malaysia performs above the world average in all sectoral indices. It performs strongly in areas related to economic openness, financing and value added and the educational enabling environment of pre-university education. Conversely, Malaysia faces challenges related to formation and professional training, environment and gender parity, which may be attributed to limited training by firms, low consumption levels of renewable energy and low female participation in the labour market.

Global Knowledge Index – Malaysia



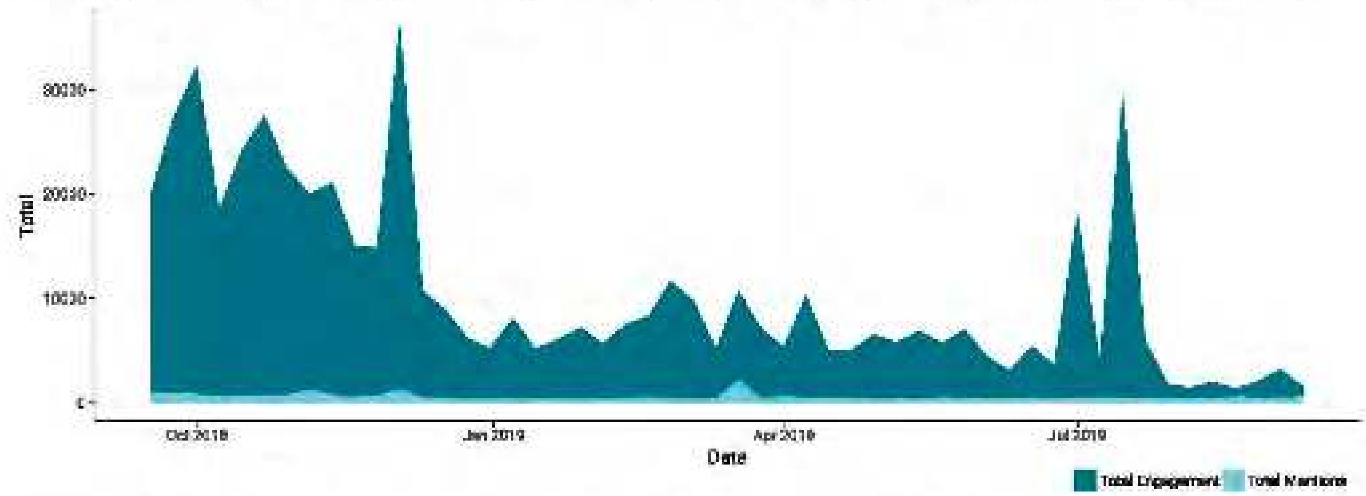
○ World average
□ Country score

Technological awareness

81.2 percent of the population in Malaysia has access to the Internet, with a mean download speed of 23.9 Mbps.

Between mid-September 2018 and mid-September 2019, there were 26,917 unique authors contributing to total content generation. The volume of online activity in Malaysia within the four technology fields chosen displays an average of 2,274.3 mentions and 39,765.5 instances of engagement per month. Online activity concerning technological fields displays a degree of concentration of 0.0013. In comparative terms, 2019 presents a lower concentration than the previous sampling period, which produced a value of 0.0018.

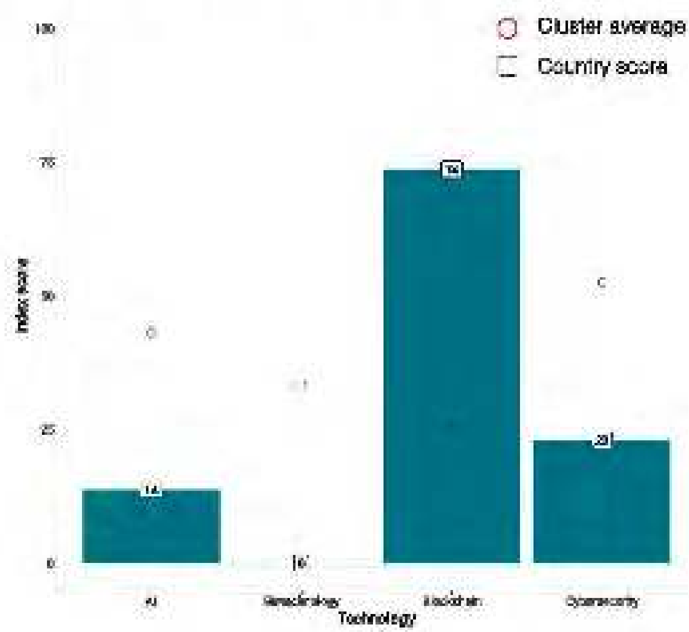
Volume of discussions and engagement level associated with the four key technologies for the future in Malaysia



The trend in online activity over time for Malaysia presents an important peak at the end of the observation period related to the confirmation by CyberSecurity Malaysia of the authenticity of intimate videos allegedly featuring a Minister.[1] Online activity is also especially high in terms of engagement at the end of 2018. This was due to the National Cybersecurity Strategy Development Conference that took place in December, during which it was announced that a national cybersecurity policy will be introduced in the first quarter of 2019 to curb cyber-attacks.[2] Online activity is particularly important in terms of blockchain – with the efforts from government to promote blockchain technologies starting in 2015. While initiatives were primarily directed to the financial system via fintech development, Malaysia launched a work visa programme in June 2019 for blockchain tech professionals which resonated amongst the blockchain community.[3] Online engagement was also sparked by news related to accusations concerning the embezzlement of millions of dollars in digital currency investments.[4]

Global Technology Awareness Index: Malaysia

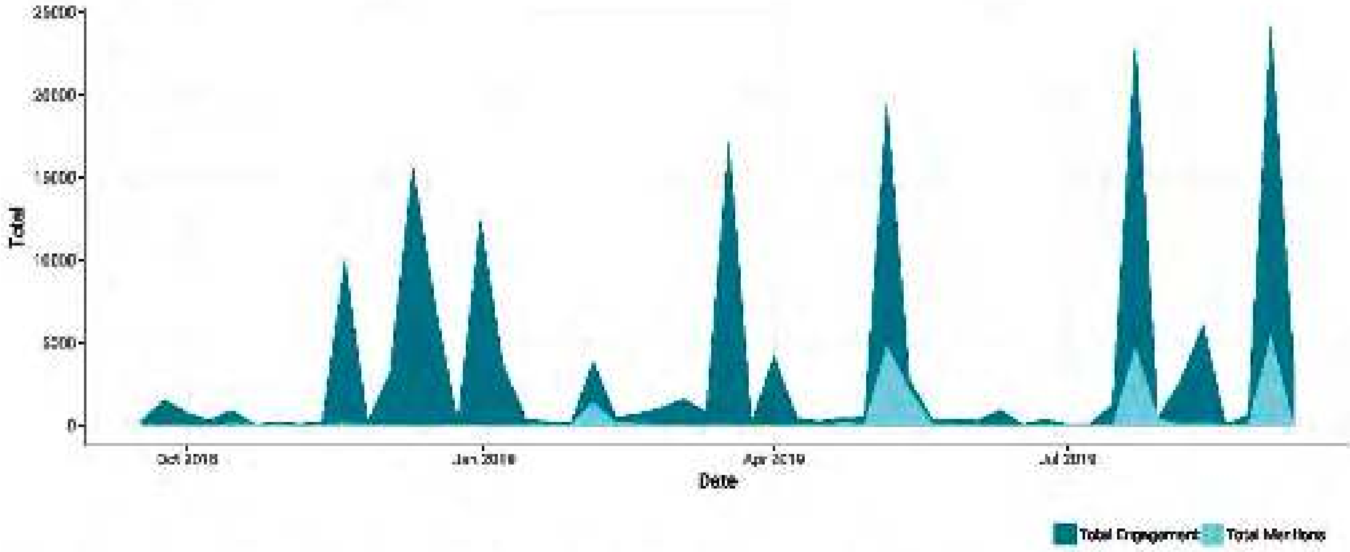
Malaysia outperforms the online activity cluster's average in one out of the four technology fields. In terms of activity distribution within the country, discussion is mainly concentrated on blockchain, with limited activity on AI and cybersecurity.



Future skills awareness

The online community presents a moderate level of online activity relating to future skills, with an average of 1,728 mentions and 11,799.8 instances of engagement per month. Total online activity in this area in Malaysia is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Malaysia



The trend in online activity over time for Malaysia shows significant activity relating to education at the end of 2018, with the release of the first-ever Global Education Census Report 2018 that stated Malaysian teachers are amongst the world's most dedicated to ensuring students' academic success.[5] The lack of English teachers also inspired online activity around April and May 2019.[6] An article on the need to foster a quality education system attracted the attention of the online community at the end of the observation period.[7] In the same period, Minister of Education Maszlee Malik urged state governments to set aside funds in their respective 2020 budgets for extra classes on science, technology, English and mathematics (STEM) subjects in primary schools.[8]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Malaysia exhibits high performance in terms of its knowledge infrastructure, technology and future skills awareness, with a high score across most dimensions.

Overview of Malaysia's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★★	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Technology awareness	★★★★★	★★★★☆			★★★★★	★★★★★	★★★★★
Future skills awareness	★★☆☆☆	★★★★☆			★★★★★	★★★☆☆	★★★☆☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is very well-positioned for the future, relying on strong infrastructure and showing a high level of awareness on future skills and technologies, but with room for improvement in biotechnology.

Online activity is especially intense in terms of future skills awareness, as the country has set up a framework for actions to prepare Malaysia for the future of work. The Malaysian 'Vision 2020' National Development Plan was designed to keep Malaysia on course towards its development goals through actions to ensure the upskilling of its population. The Ministry of Education, in line with the Malaysia Education Blueprint 2015–2025, has carried out initiatives and programmes to ensure that it produces future-proof talents that meet the demands of industry.[9] In October 2018, a panel was set up to review education policy.[10]

Coverage of the achievements of Malaysian students at the international level – such as "Early marriage did not prevent Jannah from being a brilliant student"[11] and "Gobind fetes Cybersecurity Malaysia team for winning regional competition"[12] – as well as discussions related to local government planning to invest in digital currency and advisory in AI by Japan's richest man, also added to the strong score achieved in terms of technology awareness.[13,14]

Endnotes

[1] *Astro Awani, 2019.*
[2] *New Straits Times, 2018.*
[3] *Alexandre, 2019.*
[4] *Donin and Bahaudin, 2018.*
[5] *Mokhtar, 2018.*
[6] *Sinar Harian, 2019.*
[7] *Hock, 2019.*
[8] *Mok, 2019.*
[9] *Malay Mail, 2019.*
[10] *Rajaendram, 2018.*
[11] *Alimin, 2019.*
[12] *Tee, 2019.*
[13] *Astro Awani, 2018.*
[14] *FirdausAzil, 2018.*

MEXICO

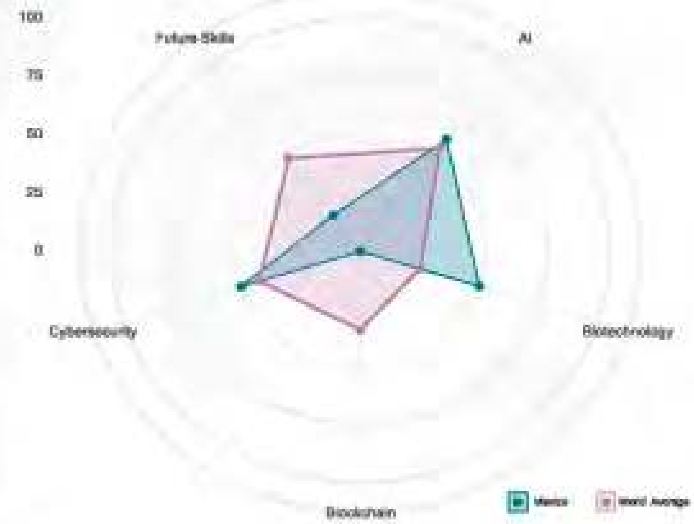
GDP per capita
$ 9,698 2018

HDI
0.774 2017

GKI
57/136 2019

354 unique authors per million Internet users

Future field awareness indices

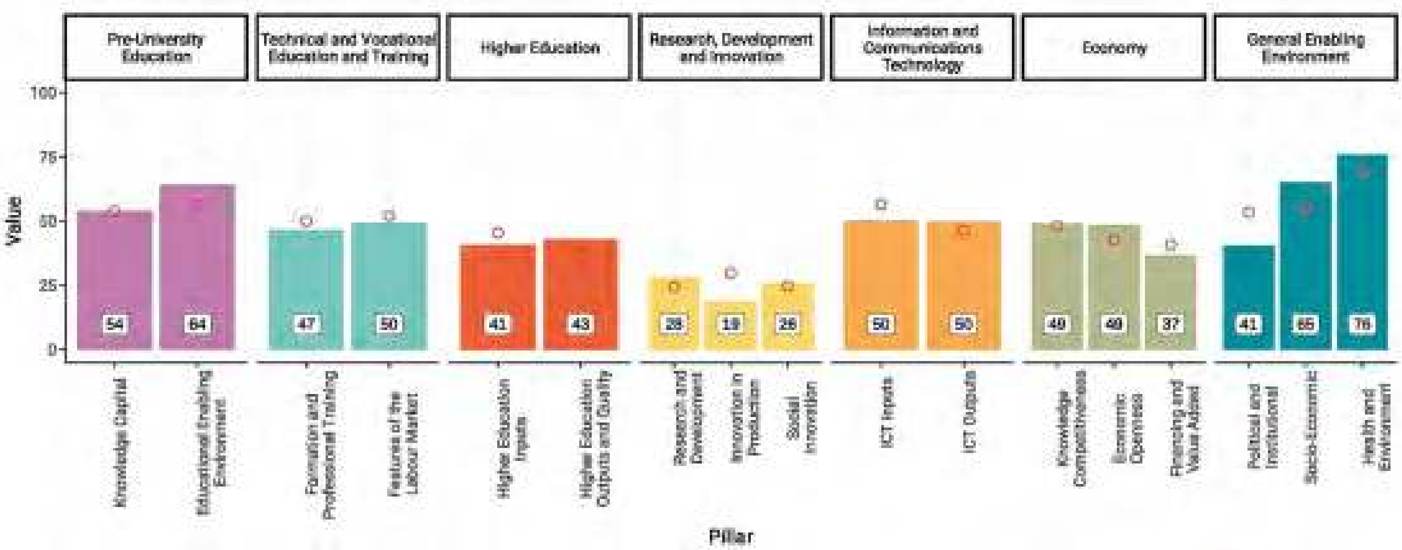


Knowledge infrastructure

Mexico is amongst the strongest countries in terms of its knowledge infrastructure to support technological uptake, standing alongside Malaysia and Saudi Arabia.

Mexico is ranked 57th on the Global Knowledge Index, scoring above the world average. Mexico performs above the world average in six out of seven sectoral indices. It performs strongest in areas related to R&D. Conversely, it faces challenges related to higher education inputs, innovation in production and ICT inputs, which may be attributed to poor ICT infrastructure, low levels in intellectual property receipts and industrial design applications and limited government expenditure on tertiary education.

Global Knowledge Index – Mexico

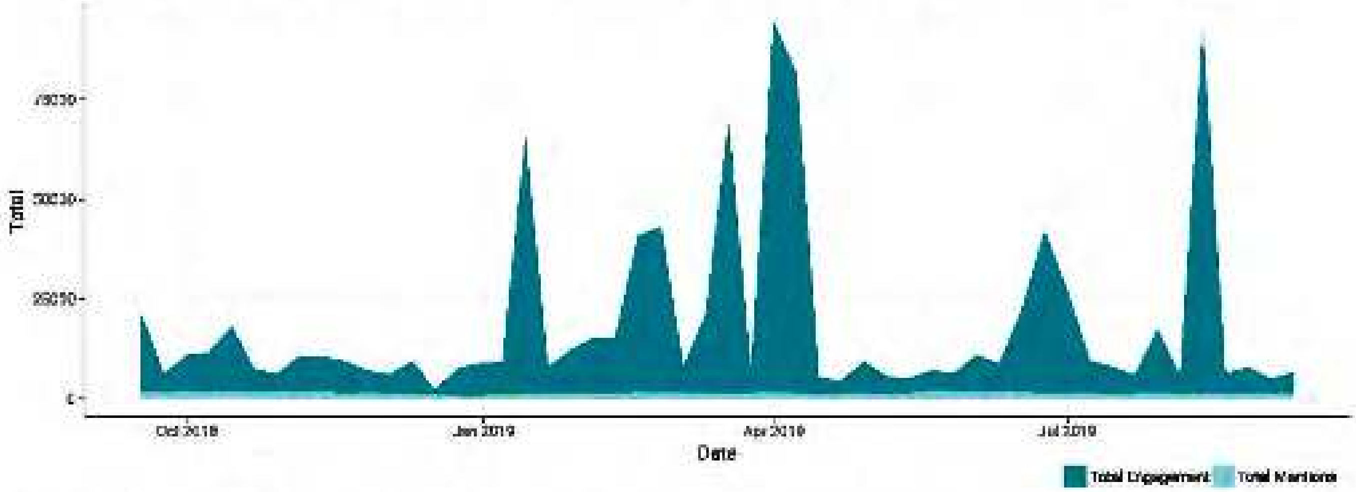


Technological awareness

65.8 percent of the population in Mexico has access to the Internet, with a mean download speed of 6 Mbps.

Between mid-September 2018 and mid-September 2019, there were 29,416 unique authors contributing to total content generation. The volume of online activity in Mexico within the four technology fields chosen displays an average of 5,554.1 mentions and 67,982.8 instances of engagement per month. Online activity concerning technological fields displays a degree of concentration of 0.00036. In comparative terms, 2019 presents a lower concentration than the previous sampling period, which produced a value of 0.00039.

Volume of discussions and engagement level associated with the four key technologies for the future in Mexico

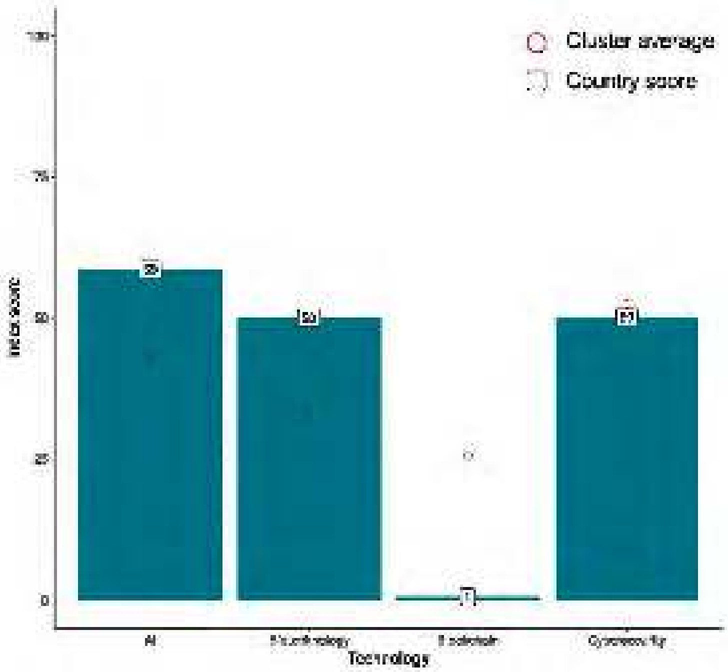


The trend in online activity over time for Mexico shows a relevant peak in mentions relating to AI (RDI and science). The peak pertains mainly to a group of researchers from the Samsung AI Center in Moscow who discovered an algorithm that animates images to produce videos using 'deepfake' technology.[1] The researchers used this to bring the famous Mona Lisa painting to life.

In terms of engagement, the news that Cuba had begun free delivery of the HIV preventive pill sparked online activity around April 2019.[2] The engagement of the online community was also significant concerning the outcomes of a study published by the American Chemical Society and conducted by the Center for Research and Advanced Studies in the area of biotechnology and biochemistry at the National Polytechnic Institute (CINESTAV) in Mexico.[3] Earlier in 2019, online activity was sparked as BP said it has discovered two new oilfields in the Gulf of Mexico and had identified an additional billion barrels of oil at an existing field thanks to new seismic technology. Indeed, the company has placed heavy emphasis on technology and data processing capabilities in recent years in order to unlock new resources and cut costs[4]. The project led by the National Laboratory of Genomics for Biodiversity (LANGEBIO) in Mexico, Texas Tech University and the University at Buffalo generated significant online activity at the end of the observation. Through this project, scientists have sequenced the avocado genome, shedding light on its origins and laying the groundwork for future improvements in agriculture.[5]

Global Technology Awareness Index: Mexico

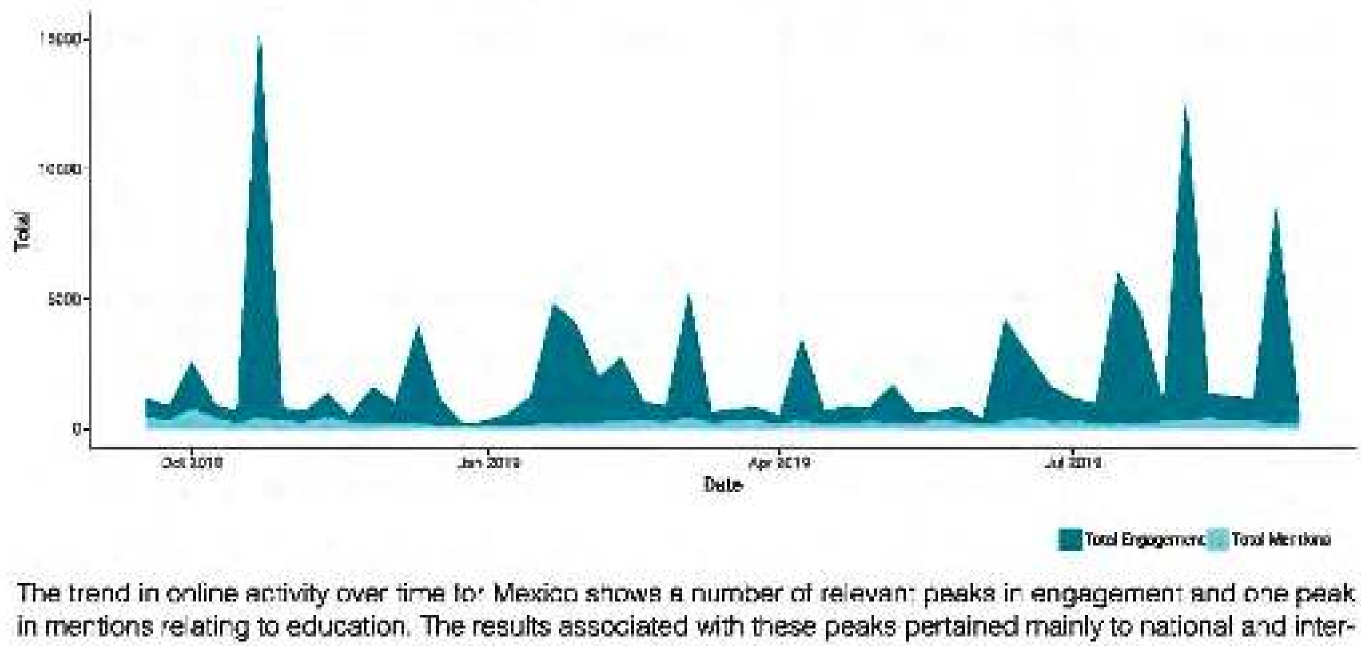
Mexico outperforms the online activity cluster average in two out of the four technology fields. In terms of activity distribution within the country, Mexico displays relative balance in discussion across AI, biotechnology and cybersecurity.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average of 1,160.2 mentions and 7,768.2 instances of engagement per month. Total online activity in this area in Mexico is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Mexico



The trend in online activity over time for Mexico shows a number of relevant peaks in engagement and one peak in mentions relating to education. The results associated with these peaks pertained mainly to national and international news concerning issues of public education. Namely, in terms of engagement, activity in one of the peaks was concentrated on a national student who won the first prize at an Latin American Astronomy and Astronautics Olympiad.[6] The second peak in activity concerned a group of Mexican students who won two gold medals at the South African International Mathematics Competition.[7] The third peak in activity related to educational reform and state power in Mexico.[8] In terms of the peak in mentions, these mainly concerned educational research and new plans and models to enhance education.

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Mexico exhibits average performance in terms of its knowledge infrastructure, technology and future skills awareness, with moderate-to-high scores across all dimensions.

Overview of Mexico's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★☆☆	★★★☆☆	★★★☆☆	★★★☆☆	★★★☆☆	★★★★☆	★★★☆☆
Technology awareness	★★☆☆☆	★★★★☆			★★★★☆	★★★★★	★★★☆☆
Future skills awareness	★★☆☆☆	★★★☆☆			★★★★☆	★★★☆☆	★★★★☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is fairly well-positioned for the future, with moderate performance in infrastructure and displaying an average level of awareness in terms of both future skills and technologies, with room for improvement in the area of blockchain.

Mexico performs highest in RDI and science in terms of technology awareness. We see discussions and engagement around studies published by the National Center for Biotechnology Information (e.g. "Avocado decreases risk of cancer",[9] news around the development of contraceptives for men,[10] as well as the creation of an antibiotic for tuberculosis[11]). The UNAM (National Autonomous University of Mexico) has also driven engagement with articles and tweets on both artificial intelligence and biotechnology, such as the creation of a new artificial intelligence lab,[12,13,14] news of a UNAM student given a scholarship to study AI in South Korea,[15] and both patents and research performed by the university's Institute of Biotechnology.[16,17] Similarly, there are a multitude of articles and tweets concerning local cybersecurity programs and events such as the lab of the National Polytechnic Institute of Mexico (IPN)[18,19] and the creation of the first cybersecurity hub within Latin America in Mexico.[20,21] Online activity was also sparked by the launch of the national AI strategy.[22]

Endnotes

[1] *Milenio, 2019d.*
[2] *Mundo, 2019.*
[3] *Acevedo, 2019.*
[4] *Bousso, 2019.*
[5] *UNOTV, 2019.*
[6] *Televisa News, 2018.*
[7] *Pillado, 2019.*
[8] *Arroyo, 2019.*
[9] *Televisa News, 2019.*
[10] *Alcázar, 2019.*
[11] *Milenio, 2019c.*
[12] *UNAM_MX, 2019.*
[13] *MSFTMexico, Twitter, 2019.*
[14] *Directorate General of Social Communication, 2019.*
[15] *Milenio, 2019b.*
[16] *El Financiero_Mx, 2019.*
[17] *Forbes_Mexico, 2019.*
[18] *Excelsior, 2019.*
[19] *IPN_MX, 2019.*
[20] *Fuente, 2018.*
[21] *Pérez, 2019.*
[22] *Martinho-Truswell and Mont, 2018.*

POLAND

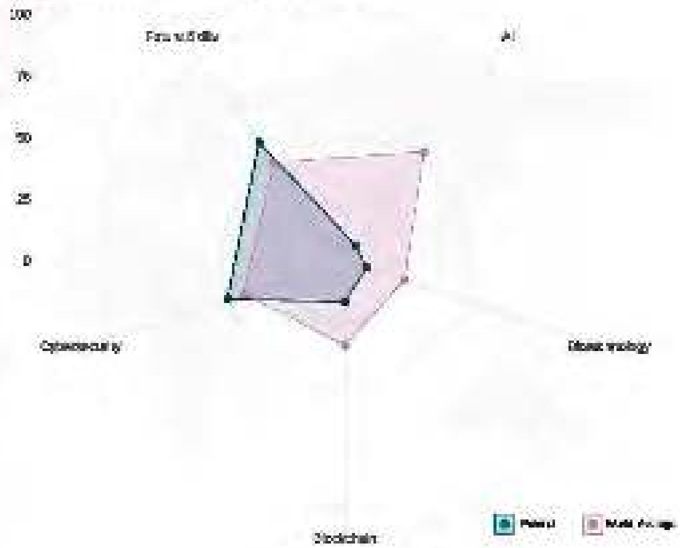
GDP per capita
$ 15,424
2018

HDI
0.865
2017

GKI
35/138
2019

1220
per million

Future field awareness indices

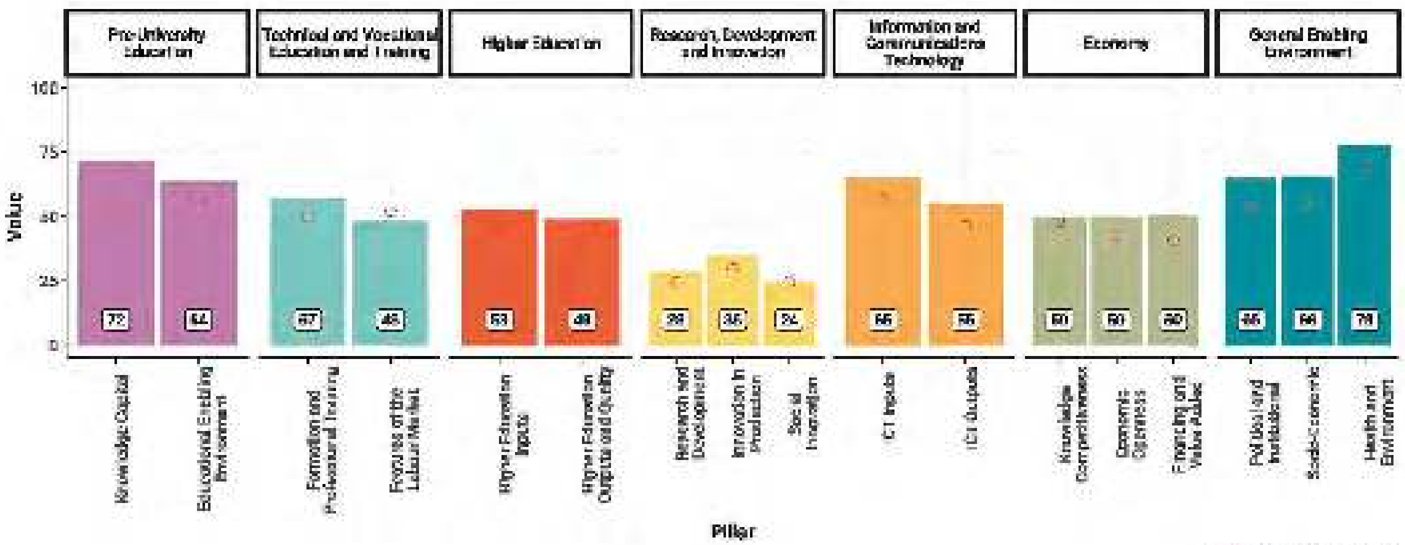


Knowledge infrastructure

Poland possesses strong knowledge infrastructure to support technological uptake and stands alongside Brazil and Malaysia.

Poland is ranked 35th on the Global Knowledge Index, outperforming 74.8 percent of other countries. Poland performs strongly in relation to knowledge capital generated by pre-university education. Conversely, it faces challenges related to the features of the labour market, which may be attributed to restrictive labour regulations and difficulty in finding skilled employees.

Global Knowledge Index – Poland

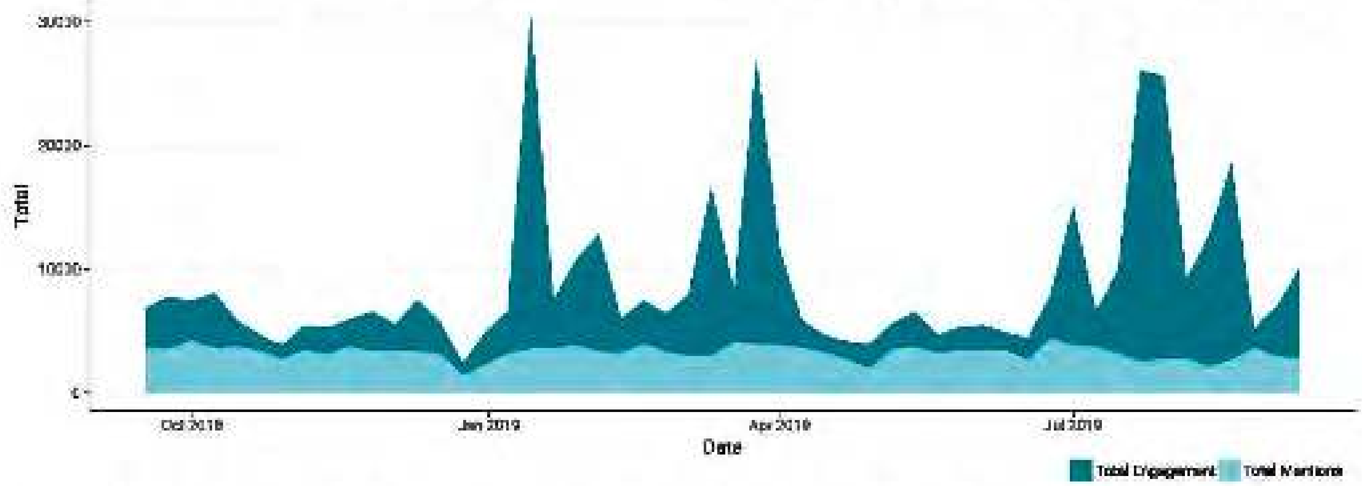


Technological awareness

77.5 percent of the population in Poland has access to the Internet, with a mean download speed of 24.4 Mbps.

Between mid-September 2018 and mid-September 2019, there were 35,874 unique authors contributing to total content generation. The volume of online activity in Poland within the four technology fields chosen displays an average of 13,025.4 mentions and 22,310.8 instances of engagement per month. Online activity concerning technological fields displays a degree of concentration of 0.0025. In comparative terms, 2019 presents a higher concentration than the previous sampling period, which produced a value of 0.00049.

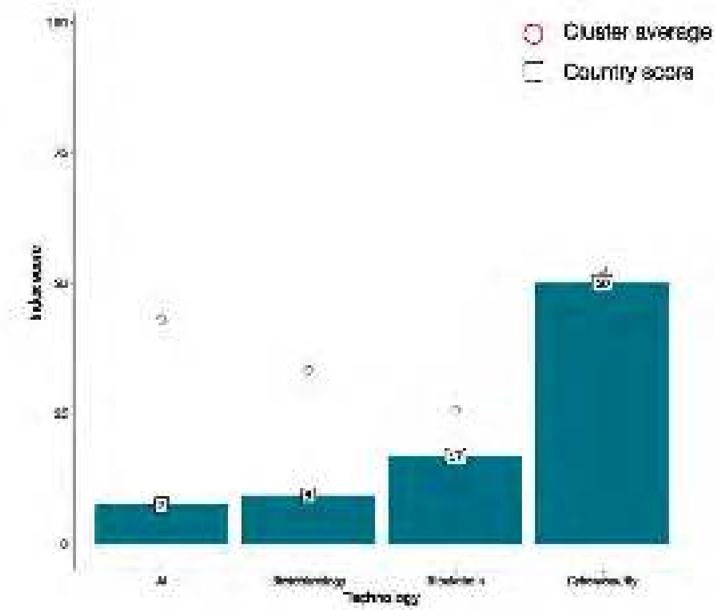
Volume of discussions and engagement level associated with the four key technologies for the future in Poland



The trend in online activity over time for Poland shows a number of relevant peaks relating to cybersecurity (RDI and science) due to the Polish-American conference "A New Initiative for Poland: A Future Global Leader in Securing the 4th Industrial Revolution" held in January 2019. This conference, focusing on cybersecurity, was the result of the cooperation agreement signed between the US investment fund CVC Capital Partners (belonging to it the Żabka chain of stores) and Father Tadeusz Rydzyk, director of the omni-influential Radio Maryja.[1] This peak is followed by another peak related to the same area, as the head of the Ministry of National Defence announced the creation of the Cyberspace Defence Forces.[2] The main peak at the end of the observation period relates to cybersecurity (enabling environment) and more specifically an article debating the protection of personal data by the Catholic Church: the provisions of the General Data Protection Regulation (GDPR) do not impose serious restrictions on the processing of personal data on religious communities.[3] In general, online activity is also largely driven by the issue of regulation, with discussions in 2019 mostly relating to the implementation of the GDPR.

Global Technology Awareness Index: Poland

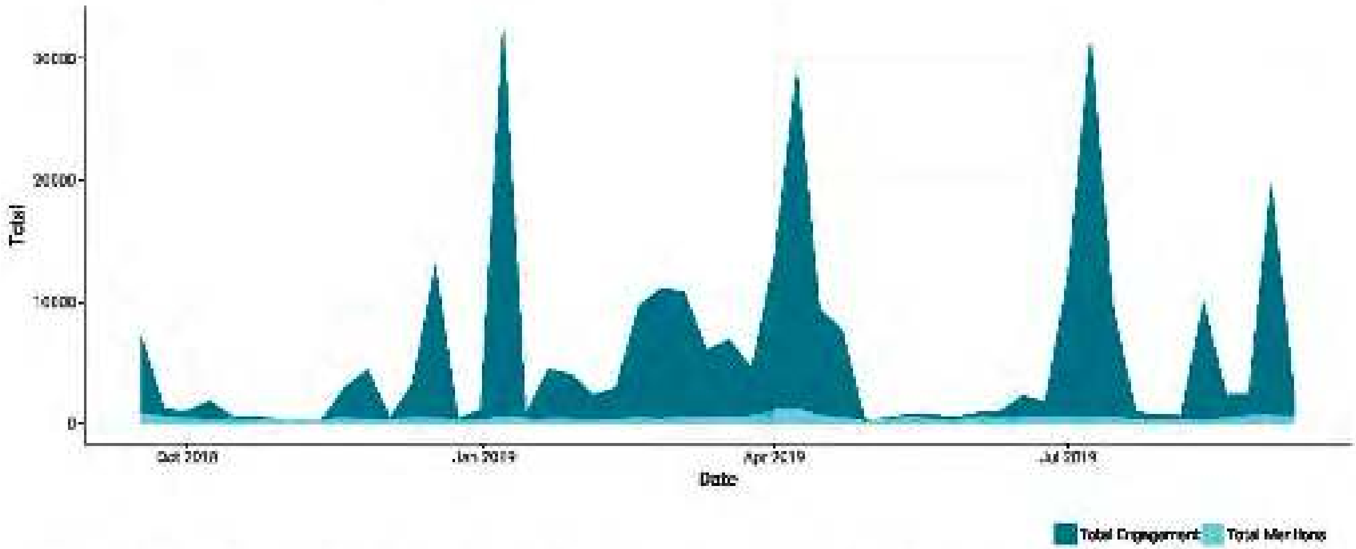
Poland scores below the online activity cluster average in all four technology fields. In terms of activity distribution within the country, Poland's online discussions are mainly oriented around cybersecurity.



Future skills awareness

The online community presents a high level of online activity relating to future skills, with an average of 1,948.4 mentions and 20,626.2 instances of engagement per month. Total online activity in this area in Poland is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Poland



The trend in online activity over time for Poland shows a number of relevant peaks in engagement and one peak in mentions relating to education. The results associated with these peaks pertained mainly to national news around issues concerning public education. Namely, in terms of engagement, activity in one of the peaks was concentrated on the place of religion in school.[4] The second peak in activity that also corresponded with the peak in mentions mostly concerned a wave of payments for teachers on strike.[5] The final peak in activity related to the lack of school places.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Poland exhibits a relatively strong performance in terms of its knowledge infrastructure, technology and future skills awareness, with moderate-to-high scores across all dimensions.

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★☆	★★★★☆	★★★★★	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Technology awareness	★★★☆☆	★★★☆☆			★★★★★	★★★☆☆	★★★☆☆
Future skills awareness	★★★☆☆	★★★★☆			★★★☆☆	★★★★★	★★★☆☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The awareness score related to future skills (RDI and science) is driven by media mentions of the Institute for Educational Research, the Ministry of National Education and local education policies concerning curriculum, student performance and teachers' working conditions.

A high volume of online discussion is observed in Poland around key topics in education reform, e.g. equality in education,[7] STEAM (Sciences, Technology, Engineering, Arts and Mathematics) education initiatives,[8] as well as poor results and curriculum changes.[9,10,11] However, the most engaging topic over the course of the year was the teacher strike over pay.[12] These themes showcase the high quantity of media coverage and awareness surrounding current issues in education within the country.

Endnotes

[1] *Radio Poland, 2019; and Drabik, 2019.*
[2] *Grzegorczyk, 2019.*
[3] *Gzyra-Iskandar, 2019.*
[4] *Pacewicz, 2019.*
[5] *Oko Press, 2019.*
[6] *Ambroziak, 2019b.*
[7] *Olejarczyk, 2019.*
[8] *Fundacja Digital Poland, 2018.*
[9] *Kwolek, 2019.*
[10] *Bukowiecka-Janik, 2019.*
[11] *Bizness, 2019.*
[12] *Ambroziak, 2019a.*

CLUSTER 02

RUSSIA

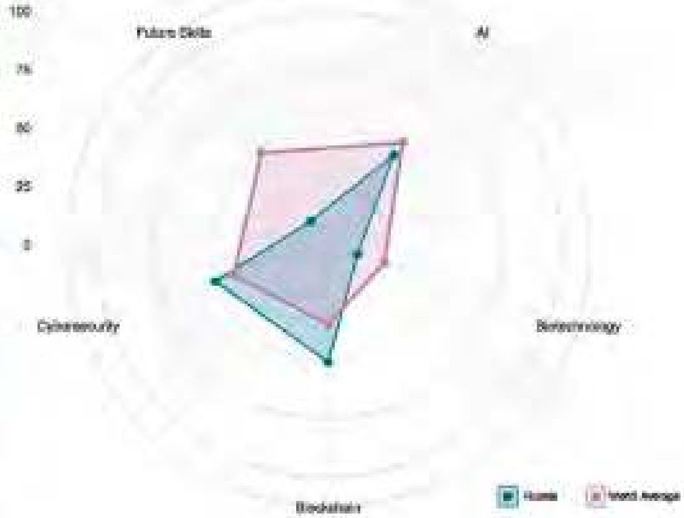
GDP per capita
$ 11,289 2018

HDI
0.816 2017

GKI
47/136 2019

701 unique authors per million Internet users

Future field awareness indices

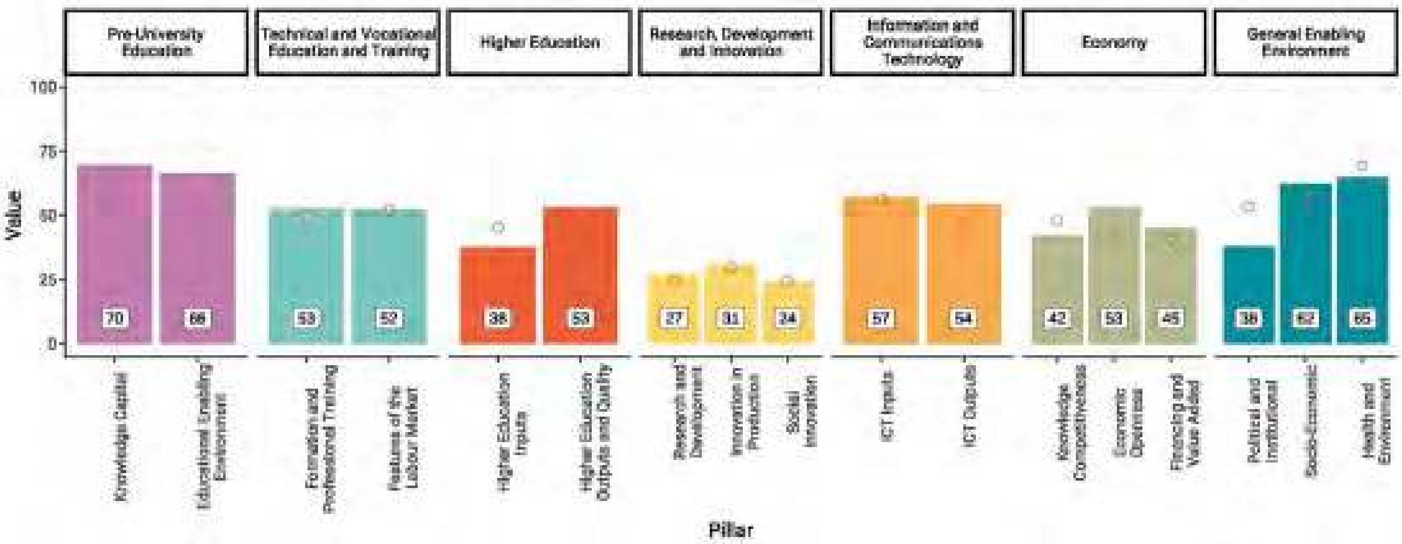


Knowledge infrastructure

The Russian Federation exhibits strong knowledge infrastructure to support technological uptake, standing alongside Poland and Mexico.

Russia is ranked 47th on the Global Knowledge Index, outperforming 65.9 percent of other countries. Russia performs above the world average in six out of seven sectoral indices. It performs strongly in areas related to knowledge capital created by pre-university education. Conversely, Russia faces challenges related to the knowledge competitiveness of the economy and the political and institutional environment, which may be attributed to low levels of foreign direct investment, low levels of investment in telecom services and weak regulatory quality.

Global Knowledge Index – Russia

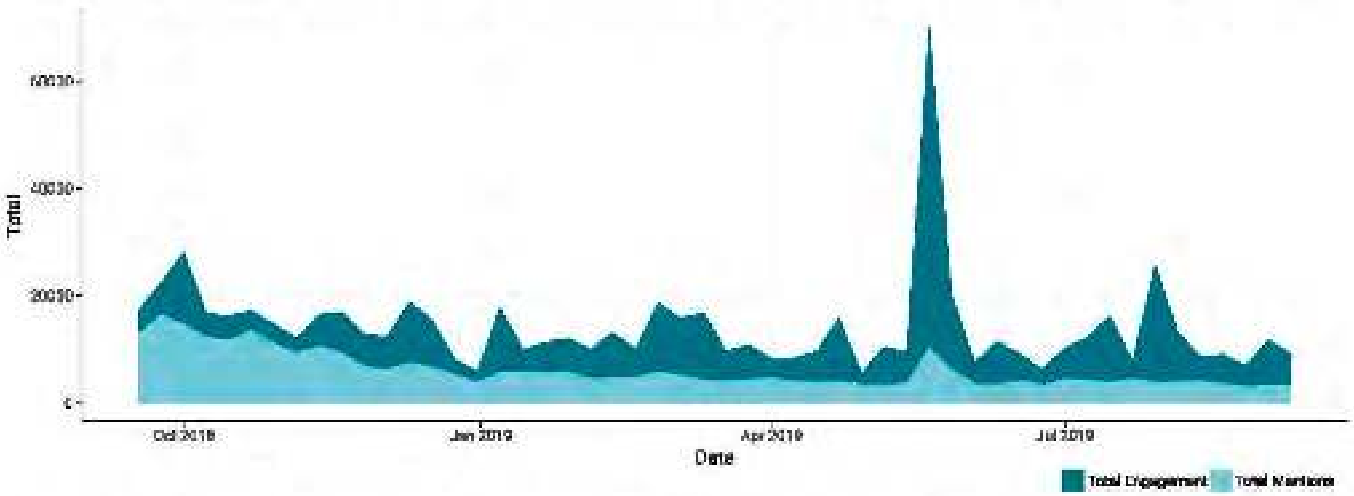


Technological awareness

80.9 percent of Russia's population has access to the internet, with a mean download speed of 14.9 Mbps.

Between mid-September 2018 and mid-September 2019, there were 82,556 unique authors contributing to total content generation. The volume of online activity in Russia within the four technology fields chosen displays an average of 24,787.8 mentions and 31,449.2 instances of engagement per month. Online activity concerning technological fields displays a degree of concentration of 0.00064. In comparative terms, 2019 presents a higher concentration than the previous sampling period, which produced a value of 0.000097.

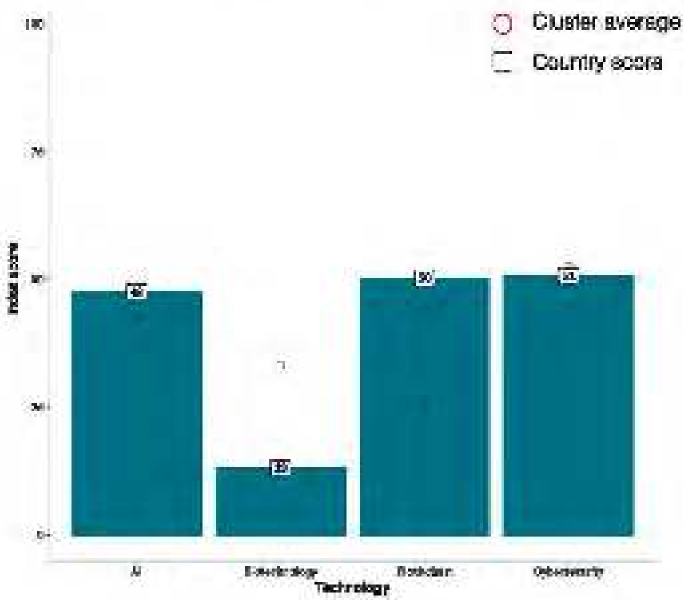
Volume of discussions and engagement level associated with the four key technologies for the future in Russia



The trend in online activity over time for Russia shows a major peak in engagement and mentions, accompanied by a number of less expressed instances. The peaks mostly pertained to blockchain (economy), cybersecurity (enabling environment) and AI (RDI and science). The peak in mentions from September 2018 pertained to online activity on blockchain, a topic of interest due to the introduction of a new regulation on the use of cryptocurrencies in Russia.[1] Specifically, mentions were linked to cryptocurrency rate updates on social media.[2] In the same period, an announcement by the UK Ministry of Defence concerning the establishment of a British intelligence agency specialised in cybersecurity contributed to the peak.[3] A further peak in mentions also related to blockchain, referring to an international blockchain event held in Moscow in May 2019, "Way Summit: Blockchain Technology Invest Day 2019".[4] The major peak in engagement from May 2019 mainly pertained to an algorithm produced by the Samsung AI lab – referring to the research of a group of scientists in computer vision and pattern recognition[5] – enabling a system that is able to animate images of a human face to produce videos, while only using a few shots of the face.[6]

Global Technology Awareness Index: Russia

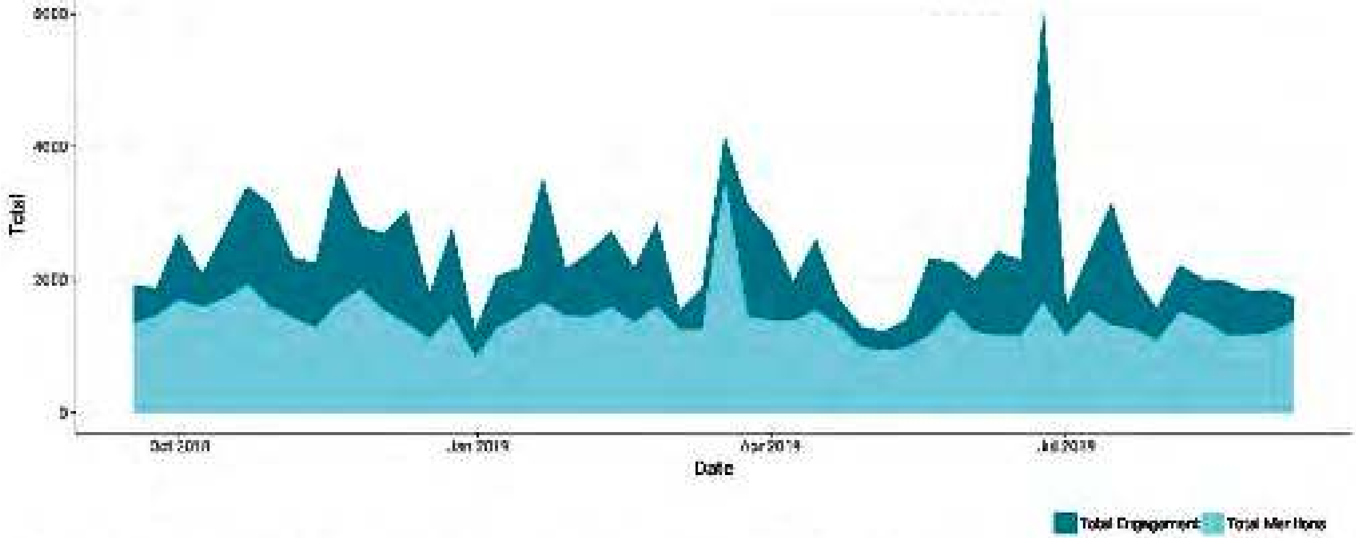
Russia outperforms the online activity cluster average in two out of the four technology fields. In terms of activity distribution within the country, Russia performs above the average for blockchain and AI, and close to the cluster average for cybersecurity.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average of 5,663.1 mentions and 3,825.2 instances of engagement per month. Total online activity in this area in Russia is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Russia



The trend in online activity over time for Russia shows a number of peaks in engagement and mentions, mainly pertaining to education. Results associated with a larger peak in engagement pertain to local news. The event, 'Leaders of Russia' – a competition for ordinary citizens with some managerial experience to win personal mentors and a monetary award – received a record number of applications from 68 countries for its 2019 edition. The finalists were evaluated by criteria such as results-orientation and strategic thinking, teamwork, innovation and social responsibility. The winners of the competition also won grants for continuous vocational training to raise their qualifications profile.[7] A further peak in activity was linked to the news of inspections at the Higher Education School of Economics, where teachers will have to provide certificates detailing criminal records and medical examinations.[8]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Russia exhibits moderate performance in terms of its knowledge infrastructure, technology and future skills awareness, with an average-to-high score across most dimensions.

Overview of Russia's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★☆☆	★★★★☆	★★★★★	★★★★☆	★★☆☆☆	★★★★☆	★★★★☆
Technology awareness	★★★☆☆	★★★☆☆			★★☆☆☆	★★☆☆☆	★★☆☆☆
Future skills awareness	★★☆☆☆	★★★☆☆			★★★☆☆	★★☆☆☆	★★☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The relatively moderate awareness scores in the technology and RDI, and science dimensions indicate that Russia relies on its legacy infrastructure and is now starting its transition to new technologies, especially in AI and blockchain. However, limited discussion shows that improvement is required in the field of biotechnology.

There is active online discussion of education. Throughout the observation period, Russia has witnessed improvement in the ranking of its universities within the top 400 universities worldwide. As a result of its 'Project 5-100' to develop major Russian universities, nine of the project's universities are now ranked amongst the top 400 universities globally.[9] Recently, President Vladimir Putin decided to split Russia's Education and Science Ministry into two federal departments – the Ministry of Education and the Ministry of Higher Education and Science – in order to improve the monitoring of the quality of secondary and higher education.[10] Online activity on the topic of education was also sparked by the WorldSkills Conference 2019, 'Skills for Change: Building Blocks for Impact', which took place in Russia.[11]

Endnotes

1 *Global Legal Insights, 2019.*
2 *DBitRU, 2018.*
3 *Machon, 2018.*
4 *Bits Online, 2019.*
5 *DmitryUlyanovML, 2019.*
6 *Zakharov et al., 2019.*
7 *Tass, 2019.*
8 *Mukhametshina and Didkovskaya, 2019.*
9 *Quinn, 2018.*
10 *Frolovskiy, 2019.*
11 *See: https://worldskillsconference.com/2019/.*

CLUSTER
02

SAUDI ARABIA

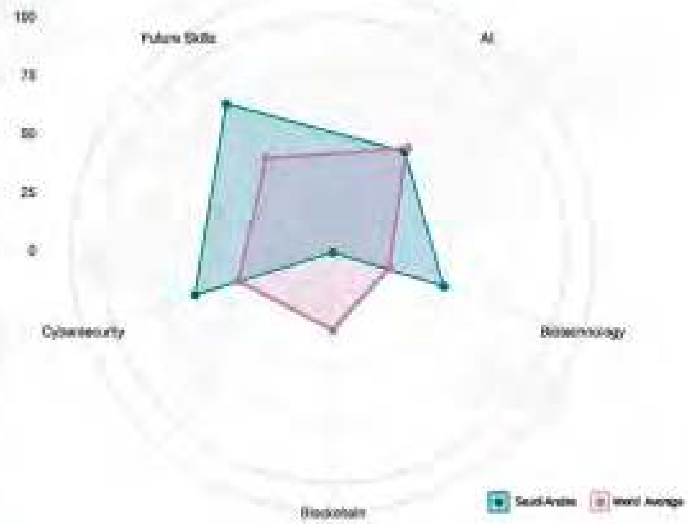
GDP per capita
$ 23,219
2018

HDI
0.853
2017

GKI
52/136
2019

1178
unique authors per million Internet users

Future field awareness indices

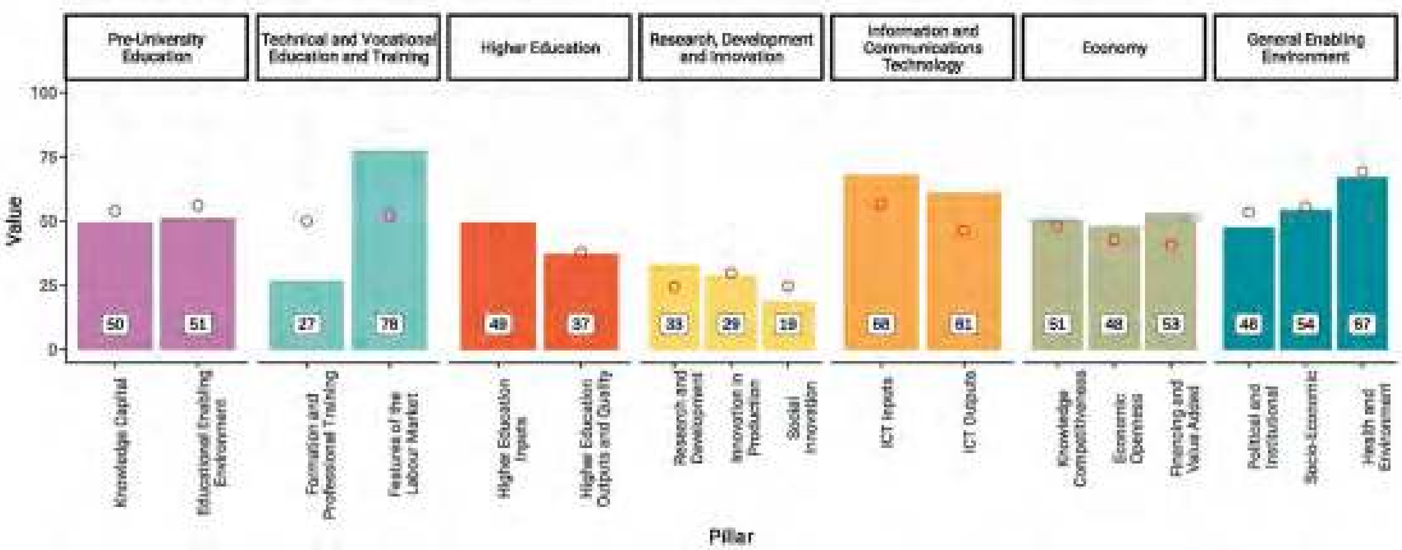


Knowledge infrastructure

Saudi Arabia has strong knowledge infrastructure to support technological uptake and stands alongside Malaysia and Brazil.

Saudi Arabia is ranked 52nd on the Global Knowledge Index, scoring above the world average. Saud Arabia performs above the world average in four out of seven sectoral indices. It performs strongly in areas related to the features of the labour market – ranking seventh globally. Conversely, Saudi Arabia faces challenges related to formation and professional training which may be attributed to the structure of the technical and vocational education and training sector.

Global Knowledge Index – Saudi Arabia

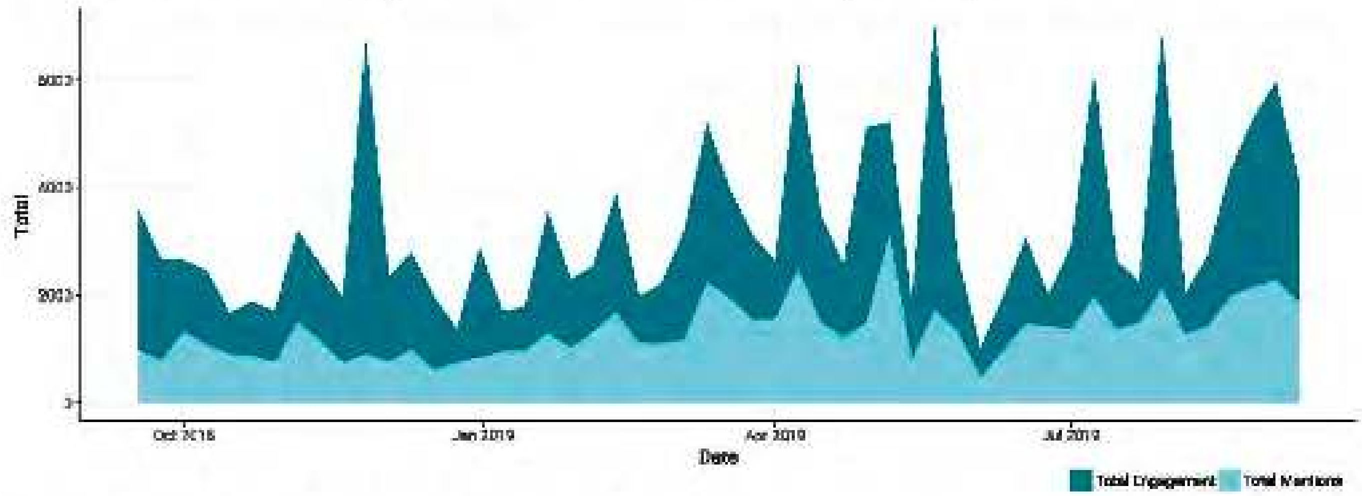


Technological awareness

93.3 percent of the population in Saudi Arabia has access to the Internet, with a mean download speed of 5.3 Mbps.

Between mid-September 2018 and mid-September 2019, there were 37,057 unique authors contributing to total content generation. The volume of online activity in Saudi Arabia within the four technology fields chosen displays an average of 5,377.1 mentions and 7,488.5 instances of engagement per month. Online activity concerning technological fields displays a degree of concentration of 0.002. In comparative terms, 2019 presents a higher concentration than the previous sampling period, which produced a value of 0.0012.

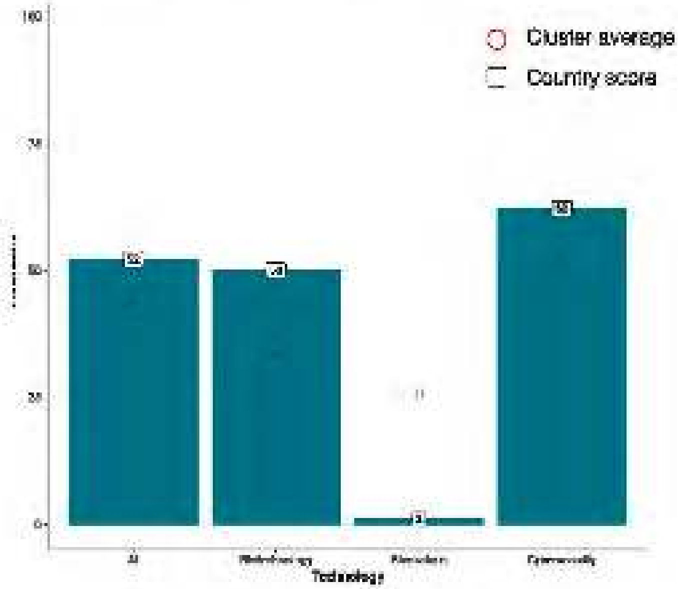
Volume of discussions and engagement level associated with the four key technologies for the future in Saudi Arabia



The trend in online activity over time for Saudi Arabia shows two relevant peaks in engagement relating to biotechnology (education, and RDI and science). One of the largest peaks in engagement pertained to international news concerning genetic engineering in human embryos. A Chinese scientist achieved the controversial DNA modification of two children, leading to discussions on the ethics and safety of such procedures on humans.[1] Another peak in engagement referred to the launch of a number of programmes and projects in the areas of education, health and community services at the King Abdulaziz University.[2] In terms of mentions, there are several peaks, one related to news items concerning AI, and another relating to articles on the best way to trade cryptocurrencies. Another peak in mentions related to cybersecurity (enabling environment and technology) and more specifically to the Managing Director of the Commercial International Bank – Egypt (CIB), Hisham Ezz Al-Arab, stressing the importance of data protection and cybersecurity for ensuring the reliability of digital services at the World Economic Forum on Africa.[3]

Global Technology Awareness Index: Saudi Arabia

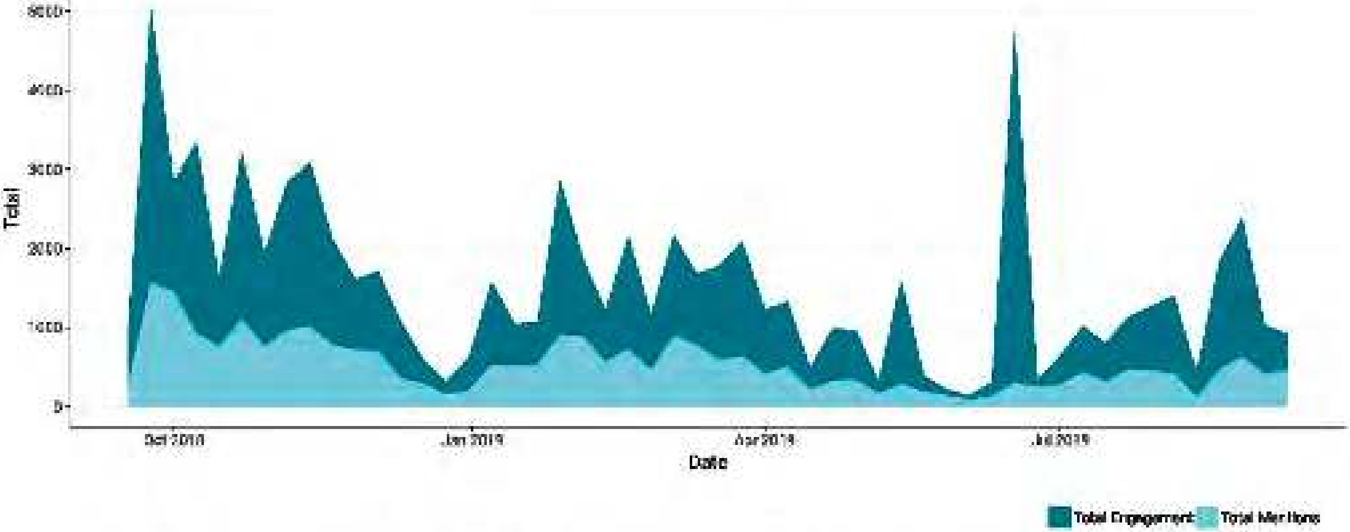
Saudi Arabia outperforms the online activity cluster average in three out of the four technology fields. In terms of online activity distribution within the country, Saudi Arabia witnesses relatively balanced levels of discussion across AI, biotechnology and cybersecurity, with blockchain being the least prominent.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average of 2,143.1 mentions and 3,953.2 instances of engagement per month. Total online activity in this area in Saudi Arabia is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Saudi Arabia



The trend in online activity over time for Saudi Arabia shows two relevant peaks in engagement and one in mentions relating to education. The results associated with these peaks pertain mainly to local news and initiatives. The Minister of Education in Saudi Arabia inaugurated a programme for school clubs, designed to offer various activities for pupils during the summer vacation, including technology courses.[4] The other relevant peak both in terms of engagement and mentions pertains to the promotion of courses for teachers, enhancing classroom management skills and active learning strategies.[5]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Saudi Arabia exhibits average performance in terms of its knowledge infrastructure, technology and future skills awareness, with a moderate score across most dimensions.

Overview of Saudi Arabia's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★☆	★★★☆☆	★★☆☆☆	★★☆☆☆	★★★☆☆	★★★★☆	★★★★☆
Technology awareness	★★☆☆☆	★★★☆☆			★☆☆☆☆	★★☆☆☆	★★☆☆☆
Future skills awareness	★★☆☆☆	★★★☆☆			★★☆☆☆	★★★★★	★★☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Across the results relating to future skills (RDI and science) in Saudi Arabia, Twitter dominates as the form of media used to discuss this topic (over 70 percent of the relevant results come from Saudi Arabian Twitter accounts and pages). As discussed in the future skills awareness section, these discussions on Twitter pertain mainly to the promotion of courses, workshops and materials for teachers to enhance classroom management skills and acquire active learning strategies.[6,7,8] This type of community and sharing online is a driving force behind Saudi Arabia's strong future skills, RDI and science awareness scores.

Endnotes

[1] *Yong, 2018.*
[2] *Saudi Arabia Ministry of Education, 2019a.*
[3] *Mounir, 2019.*
[4] *Saudi Arabia Ministry of Education, 2019b.*
[5] *Tekouati, 2018.*
[6] *Sois551, 2019.*
[7] *Edu_Le, 2018.*
[8] *Smallpox6666, 2018.*

VIET NAM

GDP per capita
$ 2,564 2018

HDI
0.694 2017

GKI
65/136 2019

516 unique authors per million Internet users

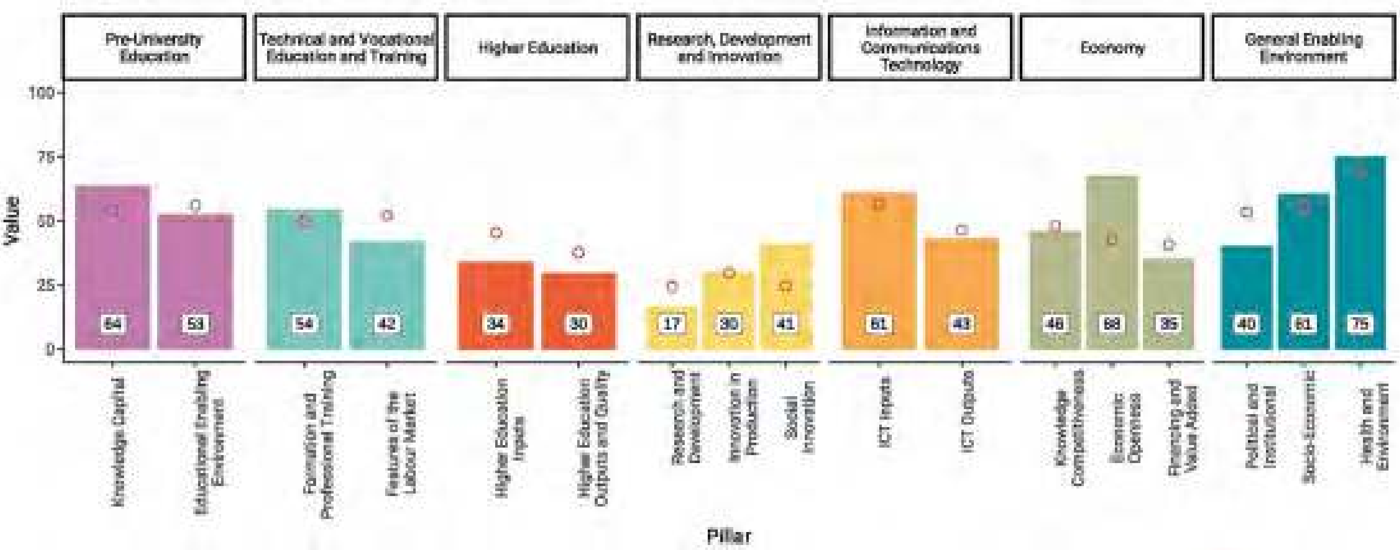
Future field awareness indices

Knowledge infrastructure

Viet Nam is amongst the strongest countries in terms of its knowledge infrastructure to support technological uptake, standing alongside Kuwait and Malaysia.

Viet Nam is ranked 65th on the Global Knowledge Index, scoring slightly below the world average. Viet Nam performs above the world average in two sectoral indices, namely pre-university education and economy. It performs strongly in areas related to economic openness – where it ranks sixth globally – and particularly relating to trade in creative and high-technology goods. Viet Nam faces challenges related to higher education inputs and outputs and the political and institutional environment, which may be attributed to a lack of press freedom and low government expenditure and enrolment in tertiary education.

Global Knowledge Index – Viet Nam

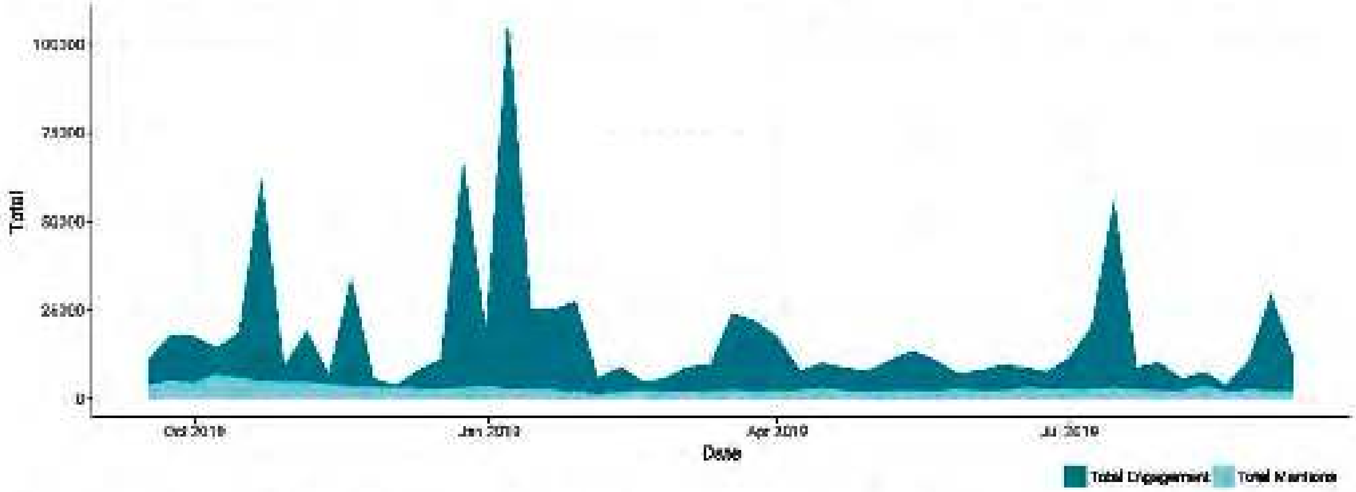


Technological awareness

70.3 percent of the population in Viet Nam has access to the Internet, with a mean download speed of 7 Mbps.

Between mid-September 2018 and mid-September 2019, there were 34,671 unique authors contributing to total content generation. The volume of online activity in Viet Nam within the four technology fields chosen displays an average of 11,799.8 mentions and 57,309.5 instances of engagement per month. Online activity concerning technological fields displays a degree of concentration of 0.00099. In comparative terms, 2019 presents a higher concentration than the previous sampling period, which produced a value of 0.00083.

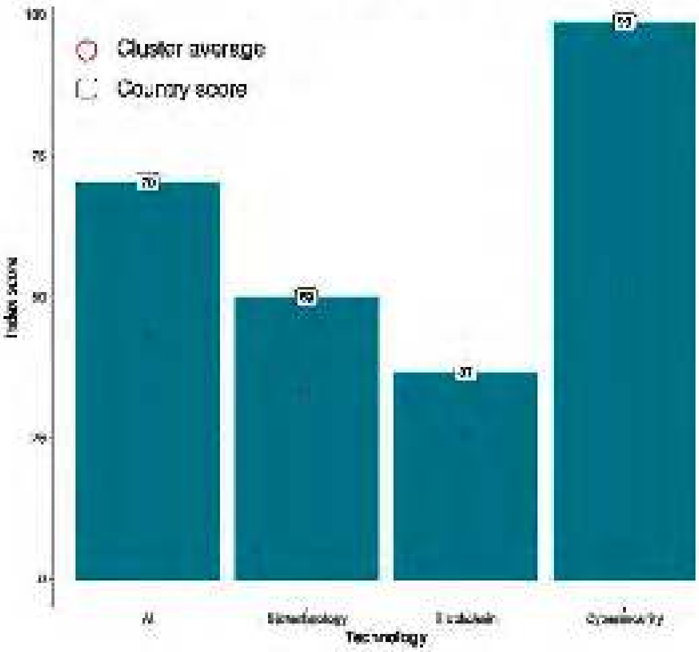
Volume of discussions and engagement level associated with the four key technologies for the future in Viet Nam



The trend of online activity over time for Viet Nam shows two relevant peaks, one of which is in mentions related to cybersecurity (enabling environment) and the other in engagement pertaining to AI (RDI and science). The peak in mentions mostly pertained to the first steps of the implementation of the law on cybersecurity, which began in early October 2018 in Viet Nam.[1] The first in engagement mainly pertains to an article on the Vingroup, a Vietnamese conglomerate.[2] The group announced in November 2018 a 10-year plan to become a major high-tech company, including the setup of VinAI – a research institute focusing on artificial intelligence. The second important peak in online engagement in January 2019 related to Facebook allegedly violating Viet Nam's new cybersecurity law by allowing users to post anti-government comments on the platform, as reported by state media days after the controversial legislation took effect in the communist-ruled country.[3] Another important peak in July related to biotechnology, and more specifically to the Vinmec Healthcare System's research group revealing the initial results of its Vietnamese genome decoding project, after more than two years of research.[4]

Global Technology Awareness Index: Viet Nam

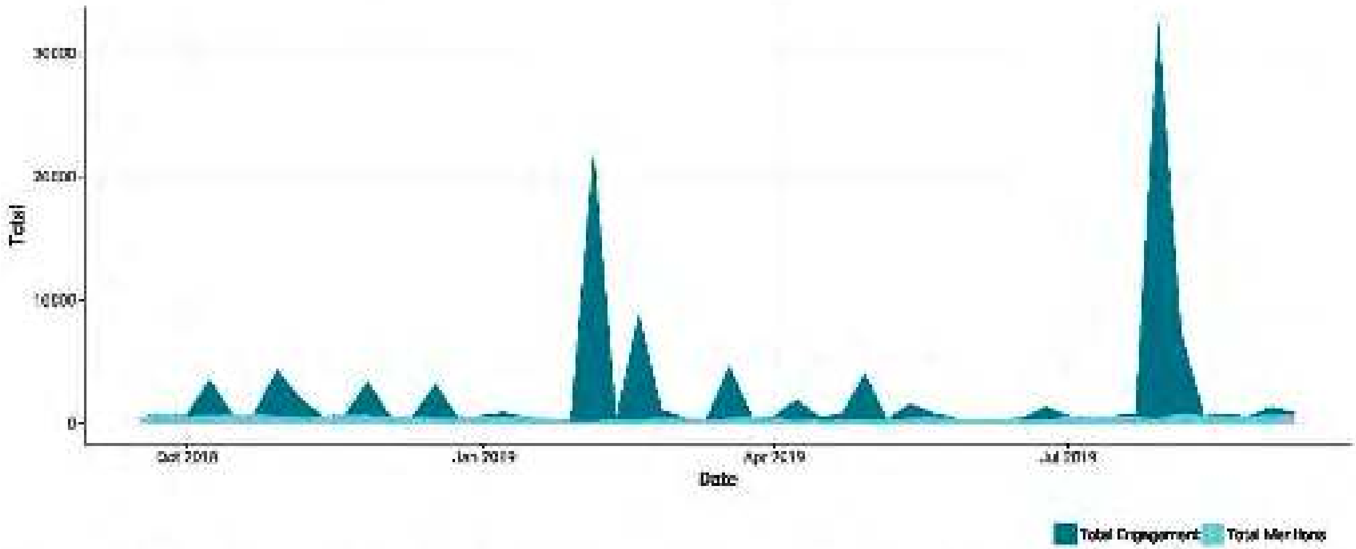
Viet Nam outperforms the online activity cluster average in all four technology fields. In terms of activity distribution within the country, discussion in Viet Nam concentrates on cybersecurity followed by AI, with significant activity concerning biotechnology and blockchain.



Future skills awareness

The online community presents an average level of online activity relating to future skills, with an average of 1,962.6 mentions and 7,527 instances of engagement per month. Total online activity in this area in Viet Nam is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Viet Nam



The trend in online activity over time for Viet Nam shows significant online activity relating to education at the beginning and the end of the observation period, inspired by the lack of teachers for the upcoming school year.[5] In August 2018, the raid of a teacher's house for illegally organising extra classes raised the attention of the online community.[6] Online activity was also particularly significant in February 2019, when a teacher from a village was selected as one of 50 global teachers from more than 10,000 candidates.[7] This annual award honours teachers who have made an outstanding contribution to the cause of education.

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Viet Nam displays average performance in terms of its knowledge infrastructure, technology and future skills awareness, with moderate-to-high scores across most dimensions.

Overview of Viet Nam's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★☆	★★☆☆☆	★★★☆☆	★★★☆☆	★★★☆☆	★★★☆☆	★★★☆☆
Technology awareness	★★☆☆☆	★★★★☆			★★★★★	★★★★☆	★★★☆☆
Future skills awareness	★★★★☆	★★★☆☆			★★★★☆	★★★☆☆	★☆☆☆☆

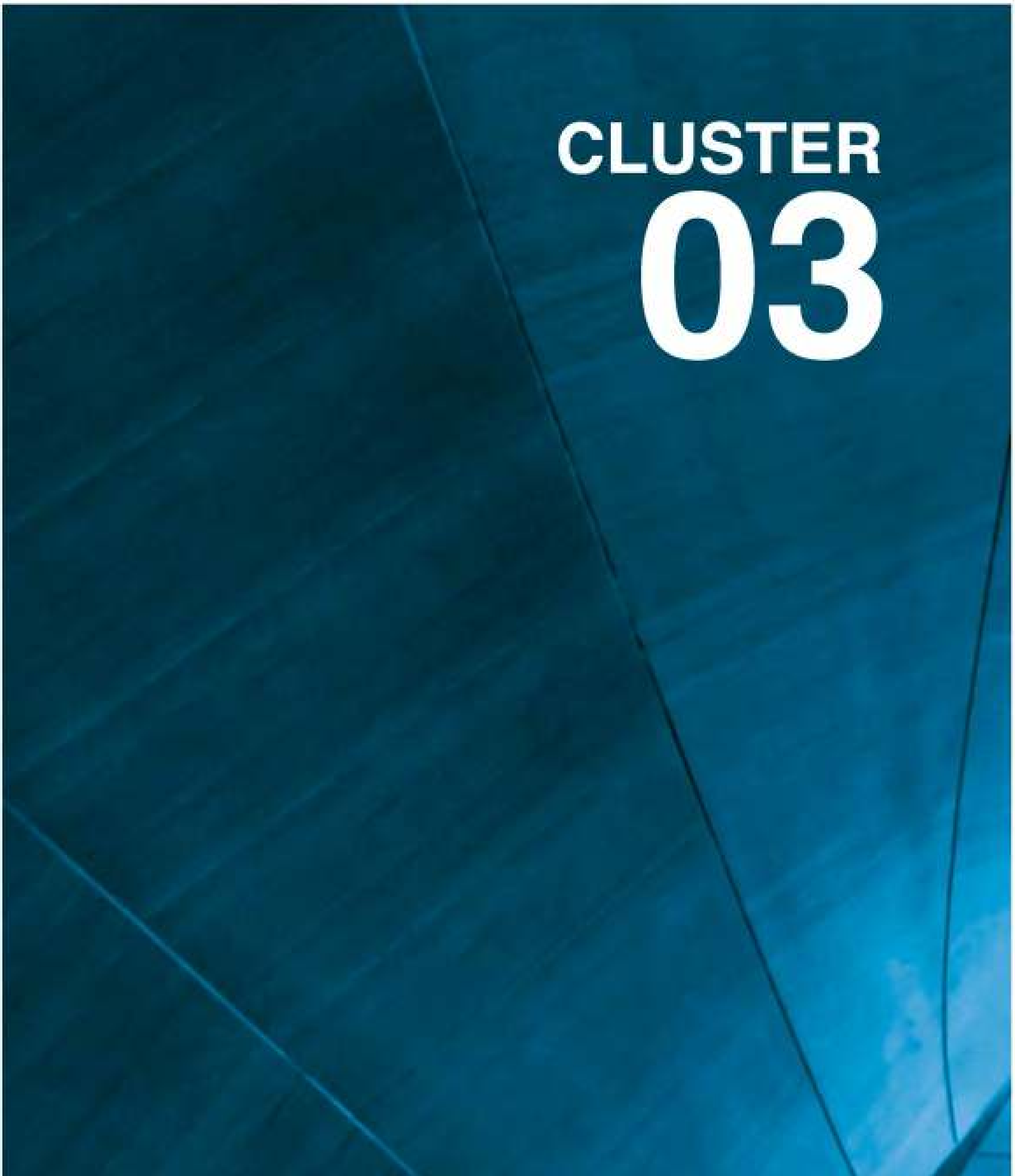
Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval): 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Looking at technology awareness in RDI and science, we notice a focus on local developments in the various technology fields – be it the establishment of a research institute for AI in Viet Nam[8] or the publication of local biotechnology research.[9] The national media coverage of local issues such as the shortage of IT workers in the field of AI and blockchain,[10] and the Prime Minister's speech to create favourable policies to support innovation in technology.[11]

At the international level, a conference on network safety within the Internet of Things (IoT)[12] and a Vietnamese start-up that won a challenge in the US[13] received significant engagement online, thus contributing to the strong technology awareness relating to RDI and science for Viet Nam.

Endnotes

[1] *An-Vos, 2018; and Hai, 2018.*
[2] *Mega Story, 2019.*
[3] *Vu, 2019.*
[4] *Việt Nam News, 2019.*
[5] *Việt Nam News, 2018.*
[6] *Tuyết, 2019.*
[7] *Ontics, 2019.*
[8] *Mega Story, 2019.*
[9] *Tuổi Trẻ, 2019.*
[10] *Nguyễn, 2019.*
[11] *ICT News, 2018.*
[12] *ICT News, 2018.*
[13] *Kien Thuc Kinh Te, 2019.*



CLUSTER 03

Moderate knowledge infrastructure cluster

40 moderate knowledge infrastructure countries

- Algeria
- Armenia
- Belize
- Bhutan
- Bolivia (Plurinational State of)
- Botswana
- Cabo Verde
- Cambodia
- Dominican Republic
- Ecuador
- Egypt
- El Salvador
- Ghana
- Guatemala
- Guyana
- Honduras
- India
- Indonesia
- Iran (Islamic Republic of)
- Jordan
- Kenya
- Kyrgyzstan
- Lao People's Democratic Republic
- Lebanon
- Moldova (Republic of)
- Mongolia
- Morocco
- Namibia
- Nepal
- North Macedonia
- Panama
- Paraguay
- Peru
- Rwanda
- South Africa
- Sri Lanka
- Tanzania (United Republic of)
- Tunisia
- Turkey
- Zimbabwe

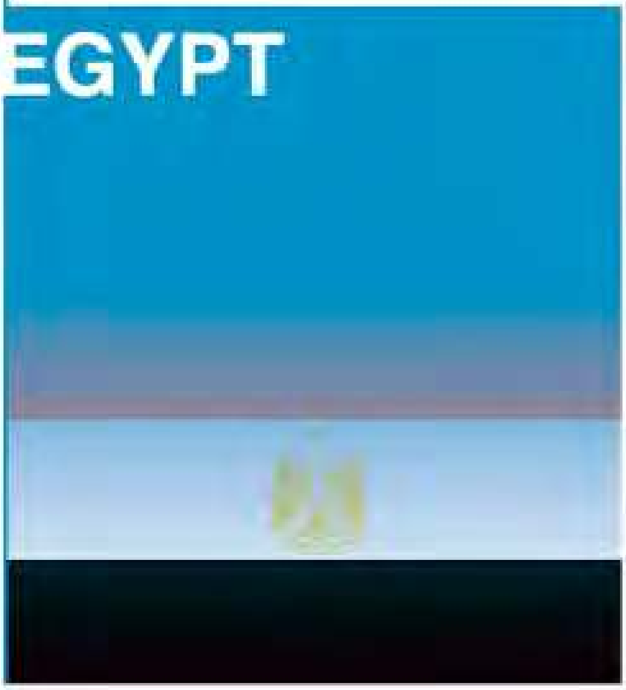
The countries in this cluster are characterized by average GKI scores of between 36 and 44.5, with world rankings ranging from 70 to 109. Within the cluster, country performances are weakest in RDI, with only three countries scoring above the global average, and a high variation in scores is evident in relation to technical and vocational education and training, and ICT.

Hence, this cluster includes countries that display a below average performance in most sectors, with cluster averages falling short of the world average. This cluster faces major challenges in RDI and ICT.

The following section presents the country profiles of the 11 countries of this cluster: Egypt, Ghana, India, Indonesia, Jordan, Lebanon, Morocco, Rwanda, South Africa, Tanzania and Turkey.

Egypt
Ghana
India
Indonesia
Jordan
Lebanon
Morocco
Rwanda
South Africa
Tanzania
Turkey

EGYPT



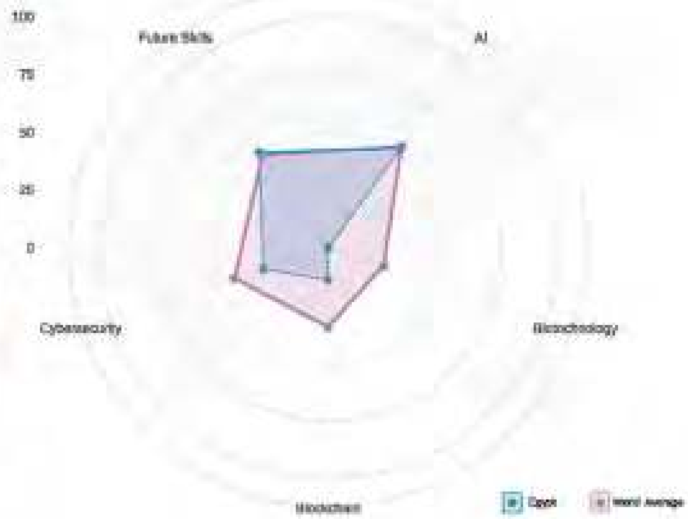
GDP per capita
$ 2,549 2018

HDI
0.696 2017

GKI
82/136 2019

97
unique authors
per million
Internet users

Future field awareness indices

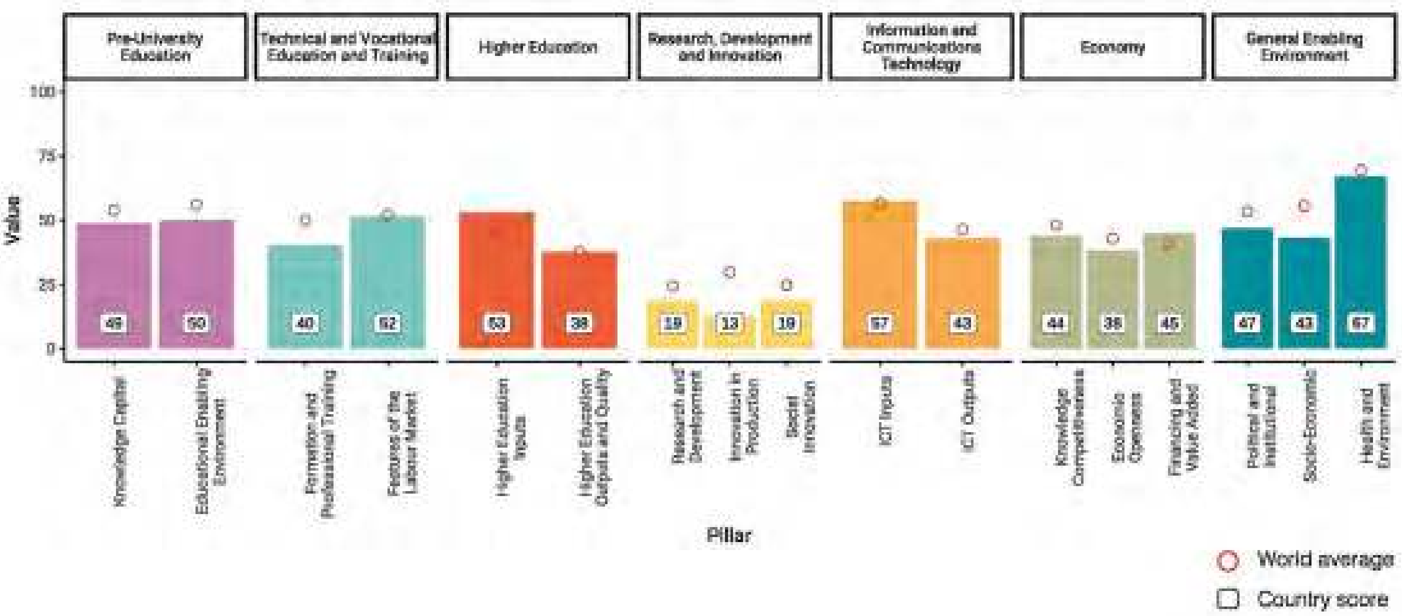


Knowledge infrastructure

Egypt displays a moderate level of knowledge infrastructure to support technological uptake, standing alongside Indonesia and Ghana.

Egypt is ranked 82nd on the Global Knowledge Index, scoring below the world average. Egypt performs above the world average in only one out of the seven sectoral indices, namely higher education. It performs strongest in areas relating to enrolment and competency of higher education students. Conversely, it faces challenges relating to gender equality, empowerment opportunities, ICT sector competitiveness – which may be attributed to the high price of the ICT basket and the laws relating to ICT – unemployment and the limited participation of women in the labour force.

Global Knowledge Index – Egypt

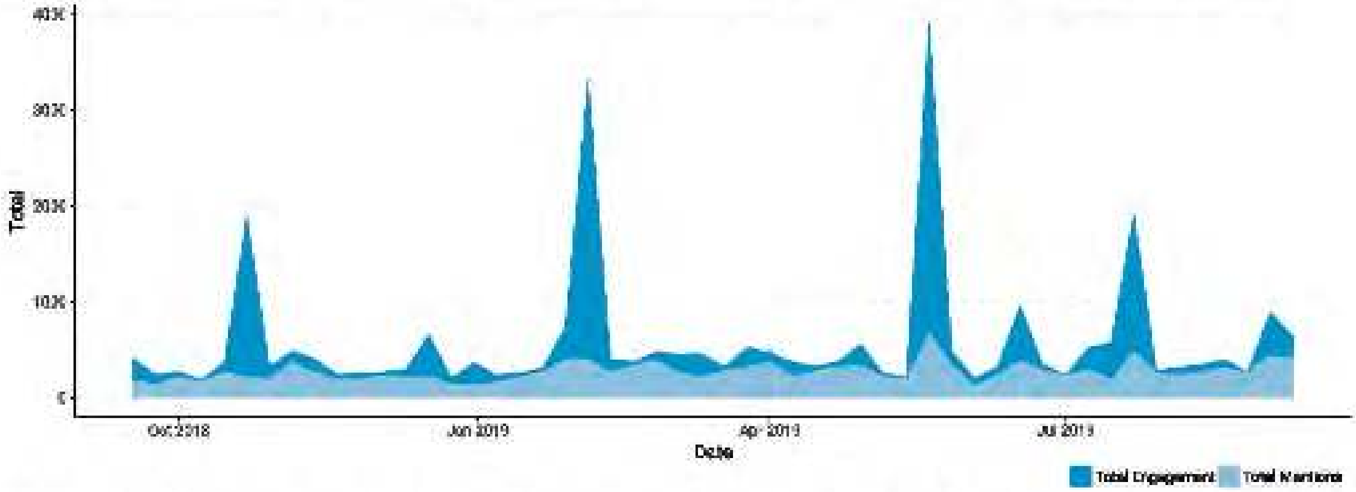


Technological awareness

46.9 percent of Egypt's population have access to the Internet, with a mean download speed of 1.6 Mbps.

Between mid-September 2018 and mid-September 2019, there were 4,468 unique authors contributing to total content generation. The volume of online activity in Egypt within the four technology fields chosen displays an average of 1,100.6 mentions and 1,211.5 instances of engagement per month. Online activity within the technology fields displays a degree of concentration 0.00064. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.00025.

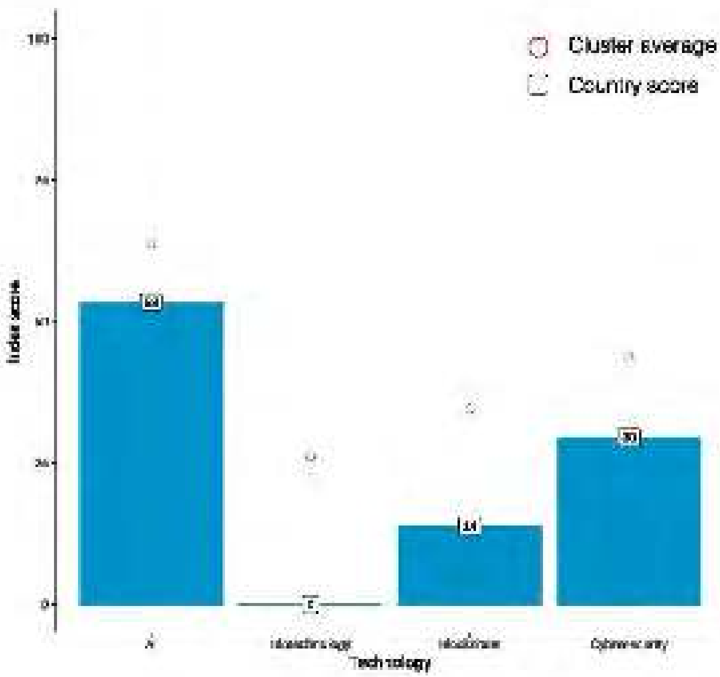
Volume of discussions and engagement level associated with the four key technologies for the future in Egypt



The online activity trend over time for Egypt shows a number of relevant peaks in both engagement and mentions relating to AI (enabling environment and education). The results associated with these peaks pertain mainly to: (i) a new national strategy for AI – the country is seeking global partnerships for the implementation of this strategy within the next five years;[1] (ii) the 'Benhat Seshat' initiative empowering young female orphans through the provision of digital literacy courses;[2] (iii) a new AI tool focused on forecasting the results of soccer matches in the Champions League or any other regional or local league;[3] and (iv) the Central Bank of Egypt allowing the establishment of licensed cryptocurrency companies.[4]

Global Technology Awareness Index: Egypt

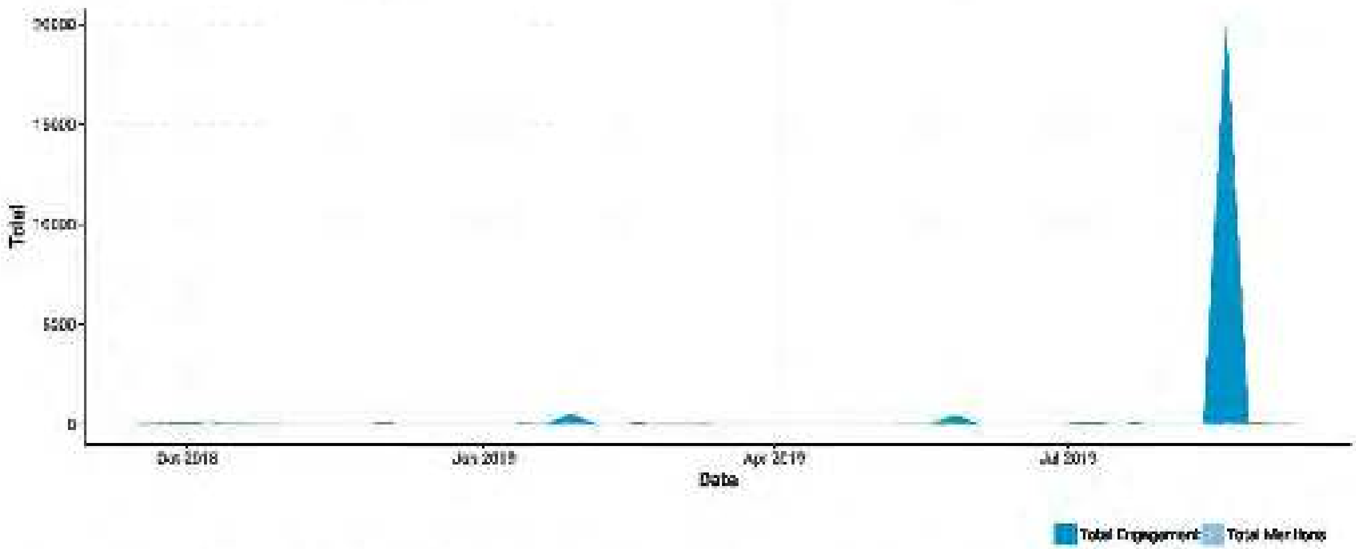
Egypt performs below the online activity cluster average in all technology fields. In terms of in-country activity distribution, discussions in Egypt are generally oriented towards AI, followed by cybersecurity.



Future skills awareness

The online community exhibits a low level of activity relating to this topic, with an average of 134.9 mentions and 1,625.5 instances of engagement per month. Total online activity in this area in Egypt is lower in terms of mentions and higher in terms of instances of engagement than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Egypt



The online activity trend over time for Egypt shows a peak in engagement relating to education. The results associated with this peak pertained mainly to local news on Egyptian President Abdel Fattah el-Sisi announcing that the 'New Egypt' is prioritizing science and advancing the country's education system, and explaining that special importance must be devoted particularly to Egypt's scientists and researchers.[5]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Egypt exhibits moderate performance in terms of its knowledge infrastructure, with a balanced score across most dimensions. In terms of awareness, Egypt exhibits weak performance in terms of technology and future skills awareness.

Overview of Egypt's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★☆☆	★★★★☆	★★☆☆☆	★★☆☆☆	★★☆☆☆	★★☆☆☆	★★★☆☆
Technology awareness	★☆☆☆☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★☆☆☆☆
Future skills awareness	★☆☆☆☆	★☆☆☆☆			★☆☆☆☆	★★★★★	★☆☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country has room for improvement in terms of infrastructure but also needs to prepare for the future in skills and technologies.

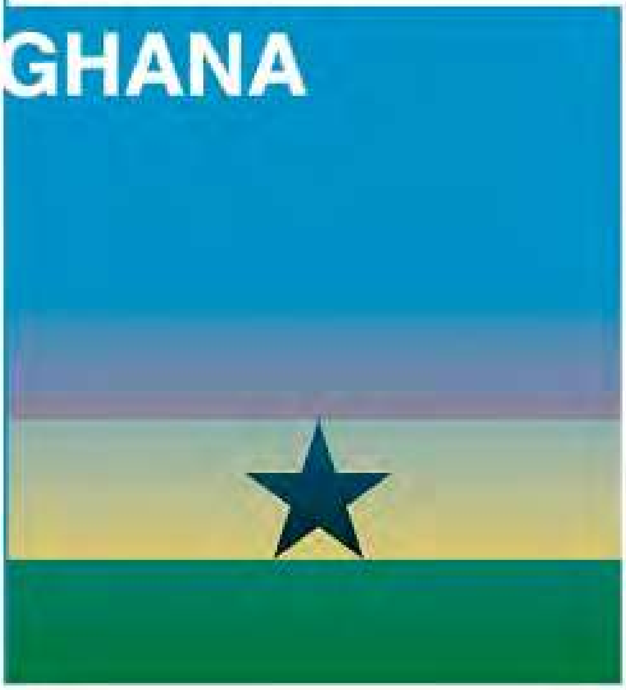
Egypt's future skills awareness score in RDI and science is particularly prominent. The awareness score in this case is driven by discussions around local policies concerning education reform and a new education system, university practices and student performances.[6,7,8]

We also see a significant amount of online news reporting on training teachers in active learning strategies – delivered by the Quality Department of Luxor Azhar[9] and by Alexandria University[10] – as well as Egypt's first entrepreneurial hub to accelerate learning.[11] These articles and coverage by the media highlight ongoing reform in education within the country.

Endnotes

[1] *Al-Masry Al-Youm, 2019.*
[2] *Khalaf, 2019.*
[3] *Ashraf, 2019.*
[4] *Biggs, 2019.*
[5] *Asharq Al-Awsat, 2019.*
[6] *Hussein, 2109.*
[7] *Mansour, 2019.*
[8] *Ramadan, 2018.*
[9] *Merhi, 2019.*
[10] *Saati, 2019.*
[11] *Eltigani, 2018.*

GHANA



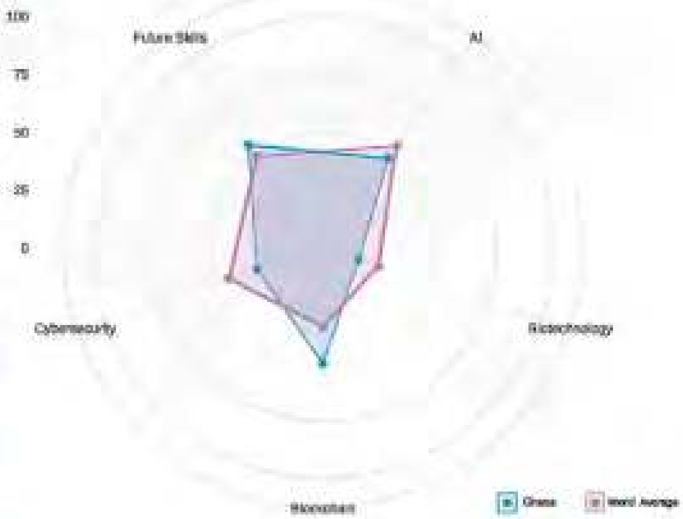
GDP per capita
$ 2,202
2018

HDI
0.592
2017

GKI
99/136
2019

709
unique authors
per million
Internet users

Future field awareness indices

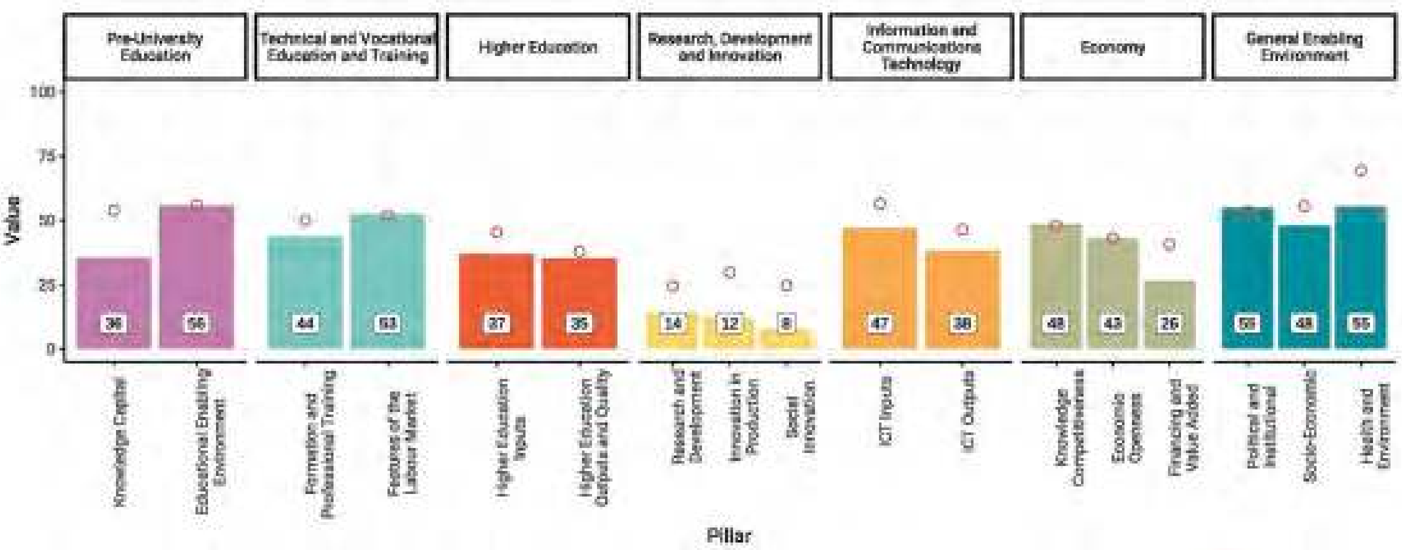


Knowledge infrastructure

Ghana has a moderate level of knowledge infrastructure to support technological uptake, standing alongside Lebanon and Rwanda.

Ghana is ranked 99th on the Global Knowledge Index, scoring below the world average overall as well as on all sectoral indices. It performs strongest in terms of competitiveness drivers – namely high investments in telecommunications. Conversely, Ghana faces challenges related to R&D, innovation in production, social innovation, and financing and value added, which may be attributed to low domestic credits to the private sector and minimal financing to research and development.

Global Knowledge Index – Ghana

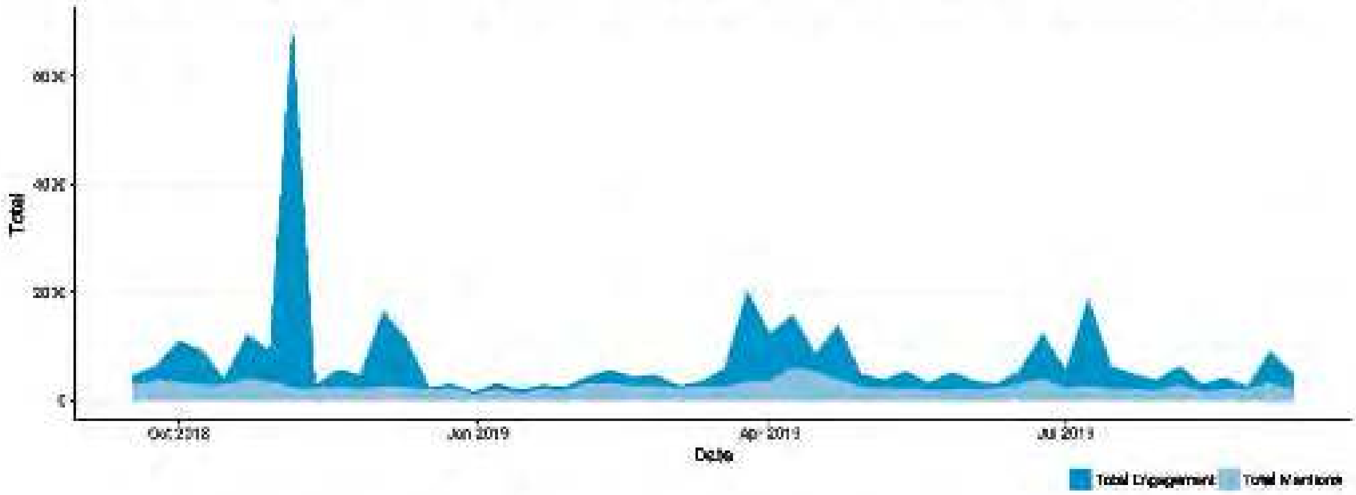


Technological awareness

39 percent of the population in Ghana has access to the Internet, with a mean download speed of 3.2 Mbps.

Between mid-September 2018 and mid-September 2019, there were 4,270 unique authors contributing to total content generation. The volume of online activity in Ghana within the four technology fields chosen displays an average of 1,071.9 mentions and 2,036.9 instances of engagement per month. Online activity within technological fields displays a degree of concentration of 0.015. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.006.

Volume of discussions and engagement level associated with the four key technologies for the future in Ghana

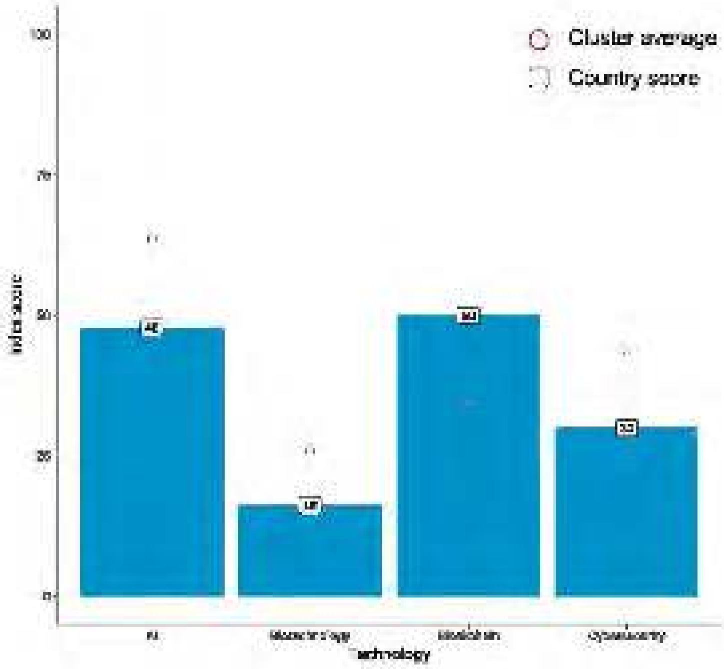


The trend in online activity over time for Ghana shows a major peak at the beginning of the observation period, corresponding to the second edition of the Ghana Blockchain conference.[1] The release of the Doing Business 2019 report at around the same time also generated online activity as Ghana has made progress in terms of 'ease of doing business', as it now ranks 114th out of 190 countries – an improvement given that it is up six places from its position in the 2018 edition of the report.[2] This is mostly due to the various measures set up by the government to digitalize and formalize the economy to accelerate growth and improve the mobilization of revenue. The report highlights the ongoing implementation of the digital address system with area codes, and the introduction of the national identity card – the Ghana Card – as well as the launch of mobile interoperability within the banking and financial sectors. Ghana also has a paperless port clearing operation and e-registration of businesses at the Registrar-General's Department.

In that same period, online activity was also sparked by the National Cyber Security Awareness Month, organized by the National Cyber Security Centre and the Ministry of Communications.[3] The second peak in online activity related to AI (RDI and science), and specifically the opening of Google's first Africa AI Lab in Ghana in April 2019.[4] The lab will address the economic, political and environmental issues faced by Africa for which the use of AI could be beneficial, notably by developing solutions in healthcare, education and agriculture. The rise in online activity in June and July 2019 in terms of cybersecurity was related to the organisation of the first Africa Data Protection and Privacy conference,[5] as well as the Africa Blockchain Conference 2019 that took place in Uganda.[6]

Global Technology Awareness Index: Ghana

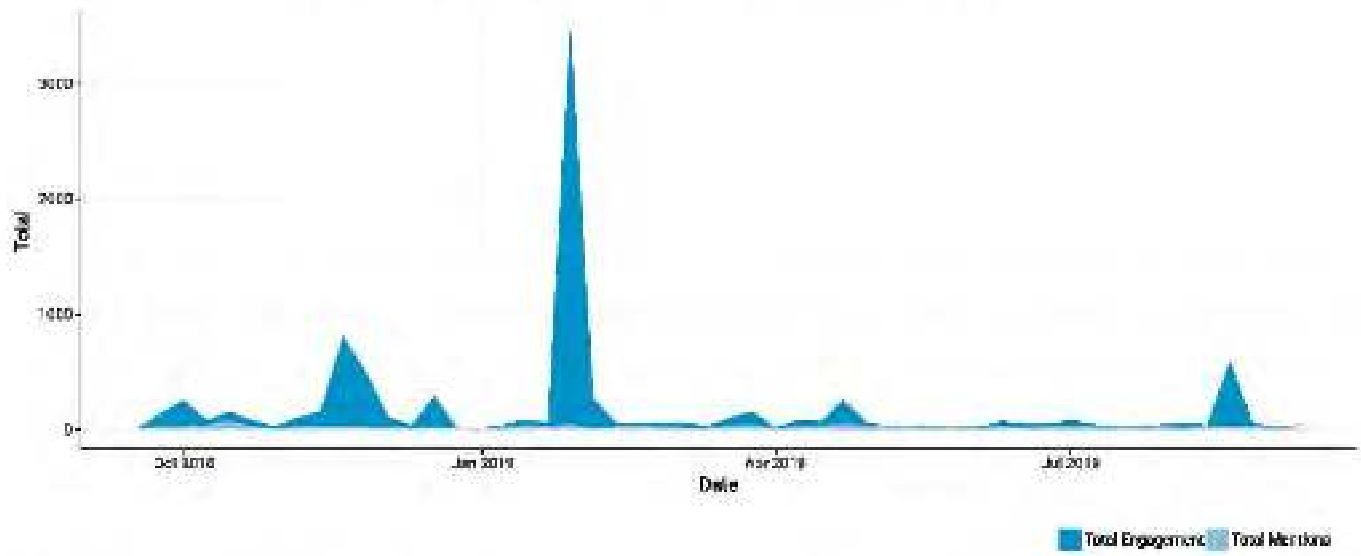
Ghana outperforms the online activity cluster average in one out of the four technology fields. In terms of activity distribution within the country, Ghana's activity is mainly concentrated around AI and blockchain.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average of 89.8 mentions and 586.4 instances of engagement per month. Total online activity in this area in Ghana is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Ghana



The online activity trend over time for Ghana shows a peak in February 2019 relating to education as the government of Ghana has announced that teachers will enjoy a 10 percent increase in their basic salaries this year.[7] The online activity has also been sparked through the whole observation period due to issues of retention of the teachers and the need of training for them as well as the necessity to increase teacher efficiency and satisfaction in their job. The 2018 Africa Summit on Women and Girls in Technology with the theme 'Unlocking Africa's Digital Future' and convened by the African Development Bank in collaboration with the World Wide Web Foundation in October 2018 also sparked the attention of the online community.[8]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Ghana exhibits rather weak performance in terms of its knowledge infrastructure, technology and future skills awareness, with a weak-to-average score across most dimensions.

Overview of Ghana's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★☆☆	★★☆☆☆	★☆☆☆☆	★★☆☆☆	★★☆☆☆	★☆☆☆☆	★★☆☆☆
Technology awareness	★★★☆☆	★★☆☆☆			★★☆☆☆	★★★☆☆	★★☆☆☆
Future skills awareness	★★★☆☆	★★★☆☆			★★☆☆☆	★★☆☆☆	★★★★☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country has room for improvement in terms of infrastructure but also needs to prepare for the future in skills and technologies. Blockchain is where signs of progress can be expected in the coming years. This is indicated by the Blockchain Academy and its recently updated course offering including blockchain usage, encryption and programming. The aim is to provide specialized knowledge of blockchain and to introduce participants to the technology in a meaningful way.[9]

Ghana is performing relatively well in the economy dimension; this can be explained by its repeated recognition as 'one of Africa's leading tech innovation hubs'. It encompasses a strong network of tech support hubs, such as Mest Accra – an incubator for African tech start-ups – and the iSpace Foundation, a co-working space that offers tools for entrepreneurs and start-ups to implement their business ideas.[10]

Moreover, the scores relating to technology under future skills awareness are high, pertaining to the recent announcement that Ghana will join the WorldSkills Family. WoldSkills is a global hub for skills excellence and development that supports the development of skills within industry and public institutions through the promotion of international cooperation and development initiatives. In this context, Ghana hosted its first National Skills Competition in Accra in November 2018.[11]

Endnotes

[1] *Kuuire, 2018.*
[2] *Christian, 2018.*
[3] *Delegation of the European Union to Ghana, 2018.*
[4] *Adeoye, 2019 and Mensah, 2019.*
[5] *MyJoyOnline, 2019.*
[6] *Boddy, 2019.*
[7] *Nunoo, 2019.*
[8] *African Development Bank Group, 2018.*
[9] *See: https://www.ghana.com/blockchain/.*
[10] *Zenzo, 2018.*
[11] *Ghana Skills, 2019.*

INDIA

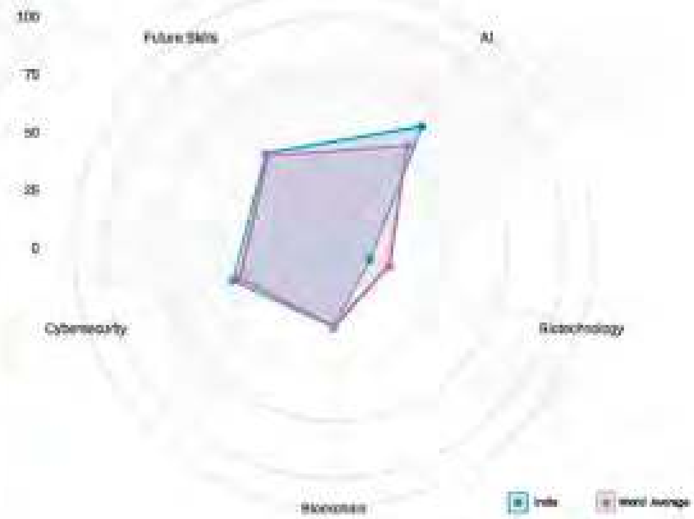
GDP per capita
$ 2,016 2018

HDI
0.640 2017

GKI
75/136 2019

182 unique authors per million Internet users

Future field awareness indices

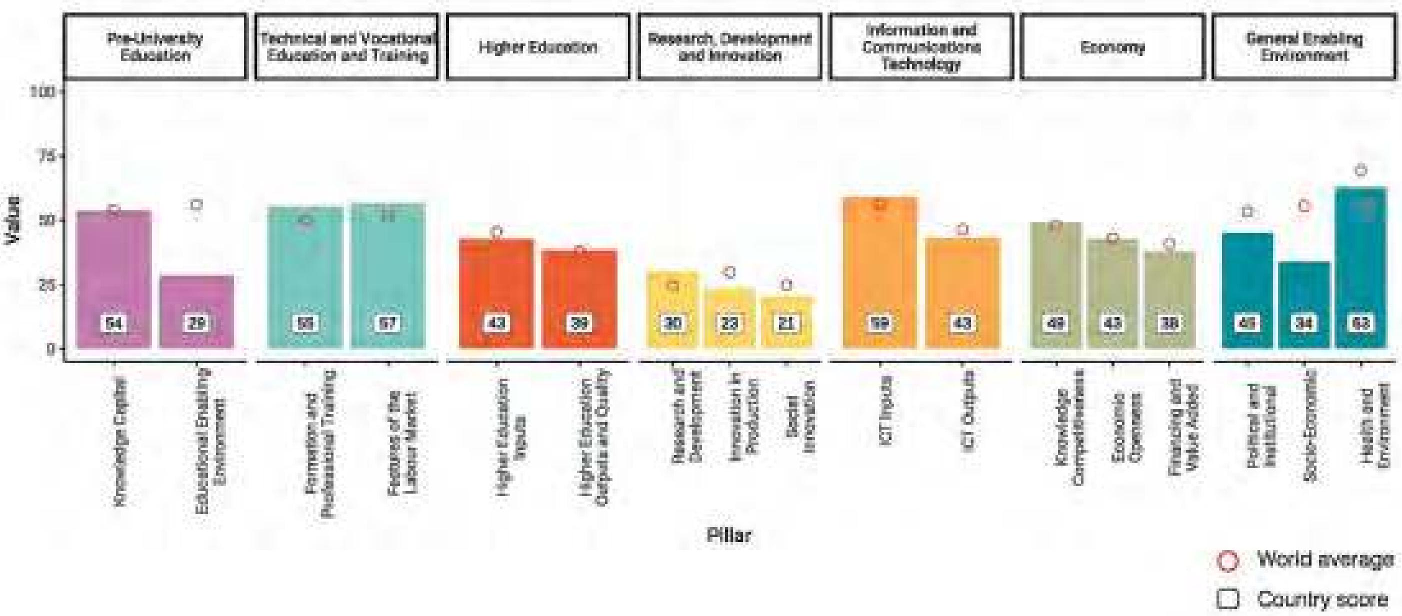


Knowledge infrastructure

India displays a moderate level of knowledge infrastructure to support technological uptake, standing alongside South Africa and Turkey.

India is ranked 75th on the Global Knowledge Index and scores slightly below the world average. India performs above the world average in two out of the seven sectoral indices, namely RDI and technical and vocational education and training. It performs strongly in areas related to research and development, qualifications of human capital and creative economy. Conversely, India faces challenges related to the enabling environment of pre-university education, with low levels of government expenditure on primary education, high pupil–teacher ratios and low enrolment ratios in early childhood education.

Global Knowledge Index – India

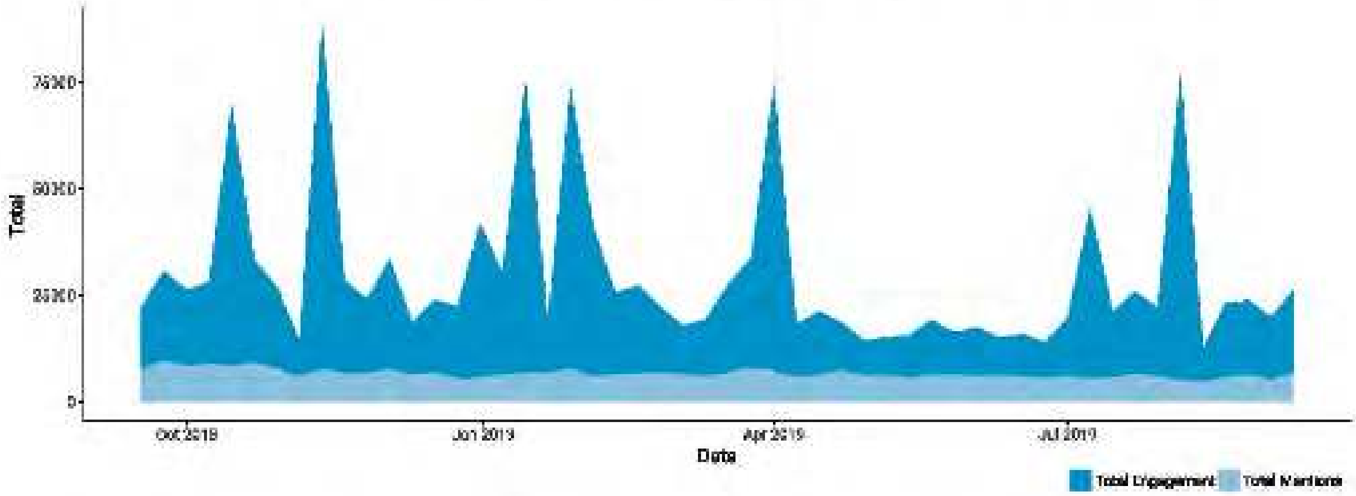


Technological awareness

34.5 percent of the population in India have access to the Internet, with a mean download speed of 8.7 Mbps.

Between mid-September 2018 and mid-September 2019, there were 83,790 unique authors contributing to total content generation. The volume of online activity in India within the four technology fields chosen displays an average of 26,328.4 mentions and 91,740.7 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0023. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.003.

Volume of discussions and engagement level associated with the four key technologies for the future in India

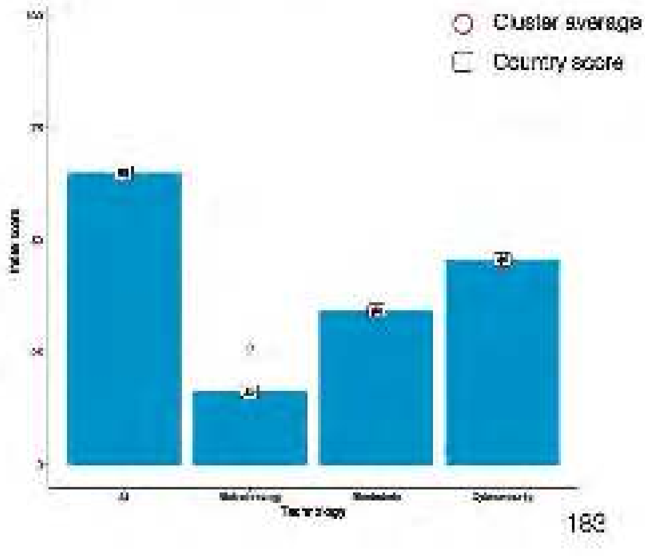


The online activity trend over time for India shows a number of peaks in engagement and mentions relating to cybersecurity (enabling environment) and biotechnology (economy). The results associated with the peaks in engagement pertained mainly to a crackdown on fake news on Facebook and an Indian student team's win of an award at the Genetically Engineered Machines competition.[1] The former topic rose to prominence, as Facebook removed 687 pages and accounts just days before voting in the general elections began.[2]

The third peak was a result of national news on Lynked. World announcing its strategic partnership with the leading blockchain investment firm Pecunio.[3] The fourth peak in engagement was due to the announcement that the Indian start-up Pixxel, which is seeking to launch microsatellites to beam data for AI analytics, has been selected as the only Asian start-up in the US' Techstars Starbust Space Accelerator.[4] In terms of peaks in mentions, the most significant concerned the national scandal of pharmaceutical biotech company STERLING Biotech Ltd. in June of 2019, when the company was exposed for scamming Indian banks for over Rs 14,500 crore;[5] and the international news on Facebook being fined GBP 500,000 for allowing political consultancy firm Cambridge Analytica to improperly gather and misuse the data of 87 million users.[6]

Global Technology Awareness Index: India

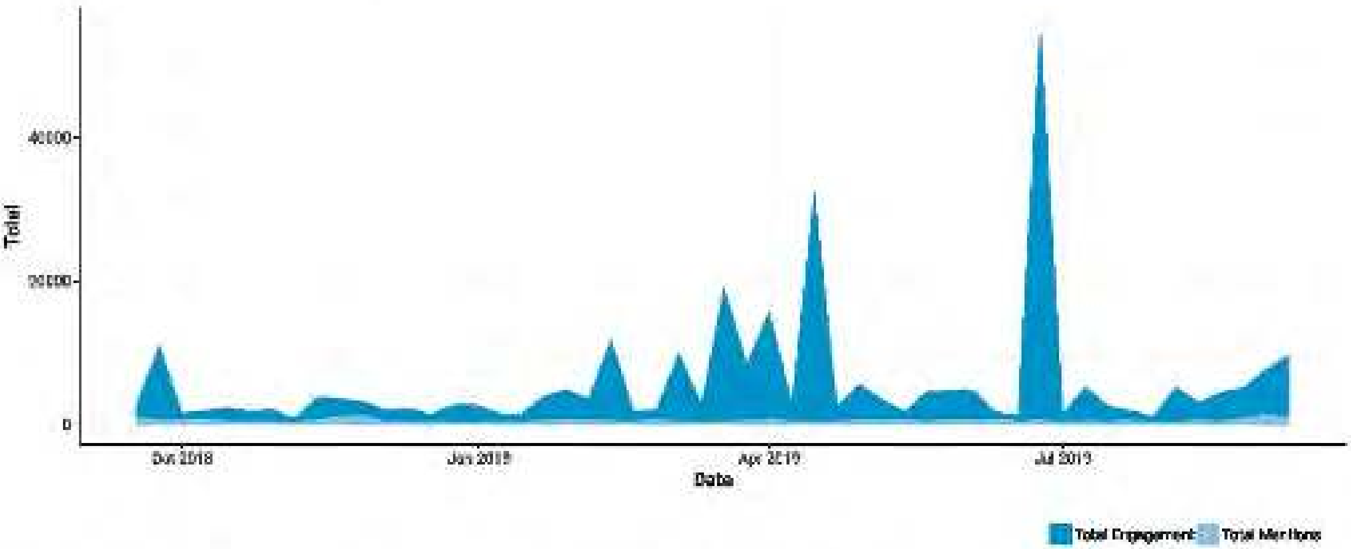
India outperforms the online cluster average in one out of the four technology fields. In terms of activity distribution within the country, India's discussions mainly focus on AI and cybersecurity.



Future skills awareness

The online community presents a high level of online activity relating to future skills, with an average value of 2,448.4 mentions and 20,840.3 instances of engagement per month. Total online activity in the area of future skills in India is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in India



The online activity trend over time for India shows a number of peaks in engagement relating to education and RDI and science, and noteworthy peaks in mentions in relation to economy and education. The results associated with the first peak in engagement pertain to the national announcement that for India's 75th anniversary, 75 student satellites may fly to space, built by students of Indian universities between 2020 and 2022.[7]

The second engagement peak resulted from the announcement that the national curriculum's social science syllabus will be amended to decrease the burden on students – the chapters on democracy, popular movements and challenges to democracy will no longer be evaluated in the board examination in 2020.[8]

In terms of mentions, the first peak is due to a national article on R.S. Shanbhag, the co-founder of Valuepoint Group, a leading IT infrastructure service company in South Asia, which survived three recessions and is now worth Rs 600 Cr.[9] The second peak in mentions relates to national news on the announcement by Minister of Education Satish Dwivedi of the need to transfer teachers into the rural communities of India (this transfer will be facilitated by the Prerna App making the leave request and relocation simpler and providing the necessary overview).[10]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

India exhibits average performance in terms of its knowledge infrastructure, with strong performance in TVET and RDI. In terms of awareness, India exhibits moderate performance in terms of technology awareness and future skills awareness.

Overview of India's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★☆☆	★★★☆☆	★☆☆☆☆	★★★★☆	★☆☆☆☆	★★★★☆	★★★☆☆
Technology awareness	★★☆☆☆	★★★☆☆			★★★☆☆	★★☆☆☆	★★★☆☆
Future skills awareness	★★☆☆☆	★★☆☆☆			★★★☆☆	★★★★★	★★★☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is reasonably positioned for the future with moderate infrastructure and showing an average level of awareness on both future skills and technologies, with room for improvement in biotechnology.

The high score relating to future skills (RDI and science) is mainly due to engagement with local and regional news within the country on topics such as 'educational development', 'accelerated learning' and 'learning methodology'.

A majority of articles referring to the target topics discuss changes in the education system of India as declared by the State Council of Educational Research and Training in order to boost academic awareness and learning, e.g. "Government Introduces a four-year Integrated Teacher Education Programme,"[11] "Kejrial wants government school kids to become entrepreneurs".[12]

Another factor driving future skills awareness is a local interest in university-level education and research. Particularly engaging topics related to articles and discussion around Indian universities not being ranked in the top 300 worldwide ("Not a single Indian University in top 300 world university rankings for first time since 2012"[13]) and the launch of Infosys' digital learning platform, offering e-courses for engineering students.[14]

From the online activity in India, there also appears to be a strong interest in integrating AI and machine learning in education. Indeed, India's Central Board of Secondary Education (CBSE), in order to adapt their education system to make students well-versed in today's fast growing and highly-demanding technologies, has decided to include artificial intelligence in their syllabi.[15] In partnership with Microsoft India, these programmes aim to conduct capacity building for high school teachers by providing them with better access to the latest ICT tools and helping them integrate technology into teaching.[16]

Endnotes

[1] *Son, 2018.*
[2] *Times of India, 2019.*
[3] *Bitcoinist, 2018.*
[4] *Chakraborty, 2019.*
[5] *Asian News International, 2019.*
[6] *Khandelwal, 2018.*
[7] *The Brainfeed Magazine, 2019.*
[8] *Jaswal, 2019.*
[9] *Mansur, 2019.*
[10] *Pradesh, 2019.*
[11] *India Today, 2019.*
[12] *Bedi, 2019.*
[13] *Awasthi, 2019.*
[14] *Das and Phadnis, 2019.*
[15] *Mittal, 2019.*
[16] *Mathur, 2019.*

CLUSTER
03

INDONESIA

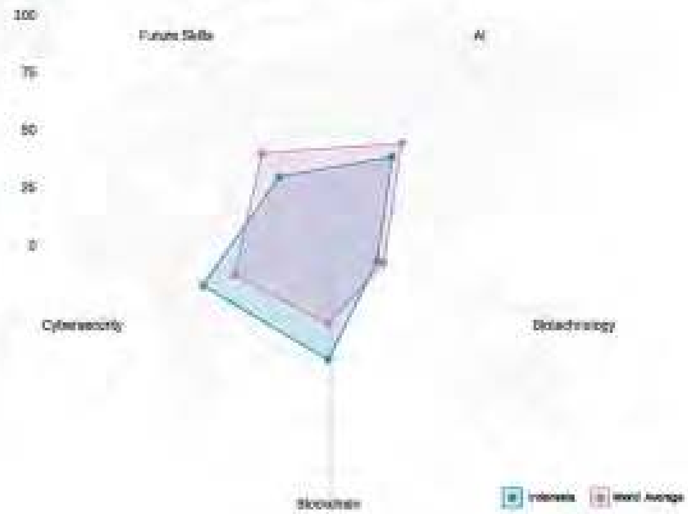
GDP per capita
$ 3,894 2018

HDI
0.694 2017

GKI
85/136 2019

449
unique authors
per million
Internet users

Future field awareness indices

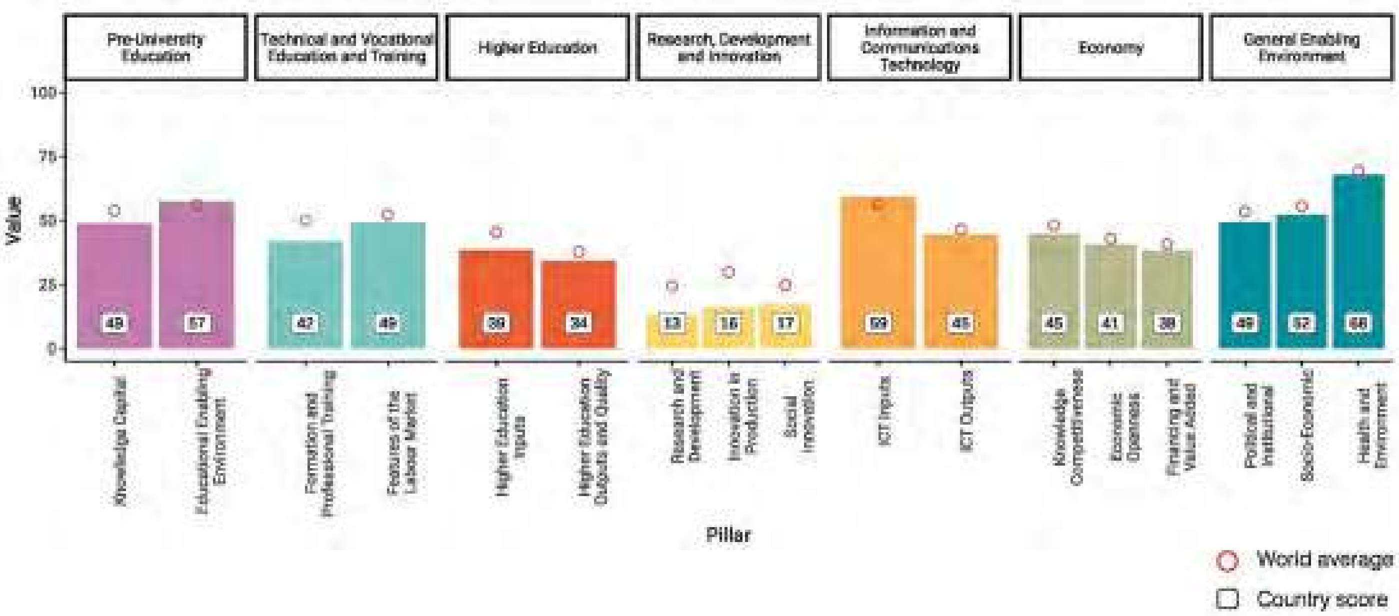


Knowledge infrastructure

Indonesia is amongst those countries with moderate knowledge infrastructure to support technological uptake, standing alongside Rwanda and Turkey.

Indonesia is ranked 85th on the Global Knowledge Index, scoring below the world average. Indonesia also performs below the world average on all seven sectoral indices. Indonesia faces challenges in its education system, especially the technical and vocational education and training sector, which may be attributed to formation and professional training. Also, socio-economic conditions and gender disparities hinder efforts towards the development of an inclusive economy.

Global Knowledge Index – Indonesia

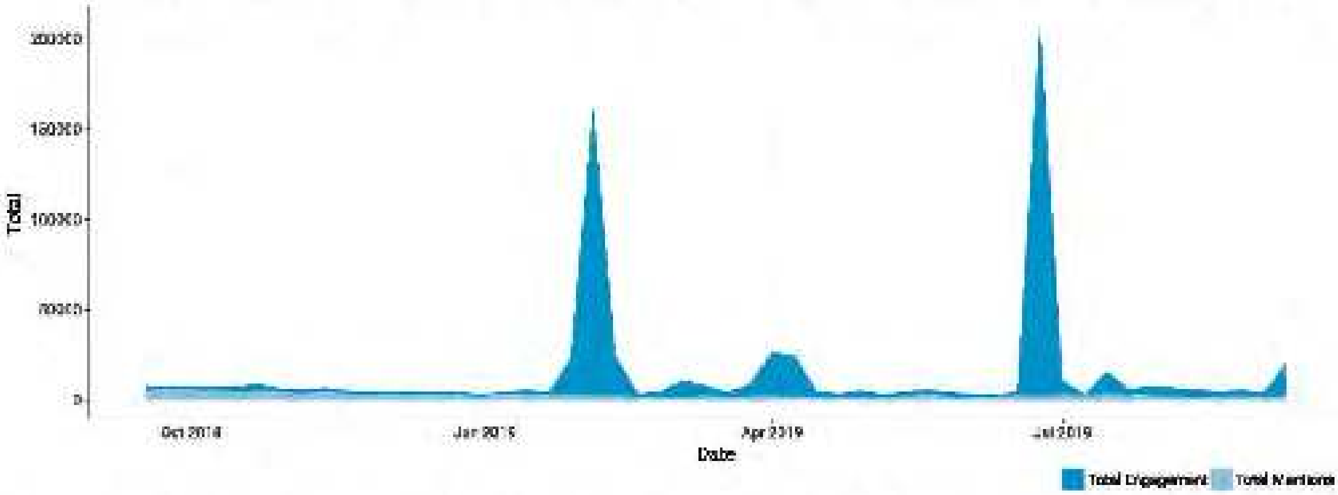


Technological awareness

39.8 percent of Indonesia's population have access to the Internet, with a mean download speed of 6.6 Mbps.

Between mid-September 2018 and mid-September 2019, there were 47,774 unique authors contributing to total content generation. The volume of online activity in Indonesia within the four technology fields chosen displays an average of 10,205.3 mentions and 46,828.9 instances of engagement per month. Online activity relating to technological fields displays a degree concentration of 0.00033. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of $3e^{04}$.

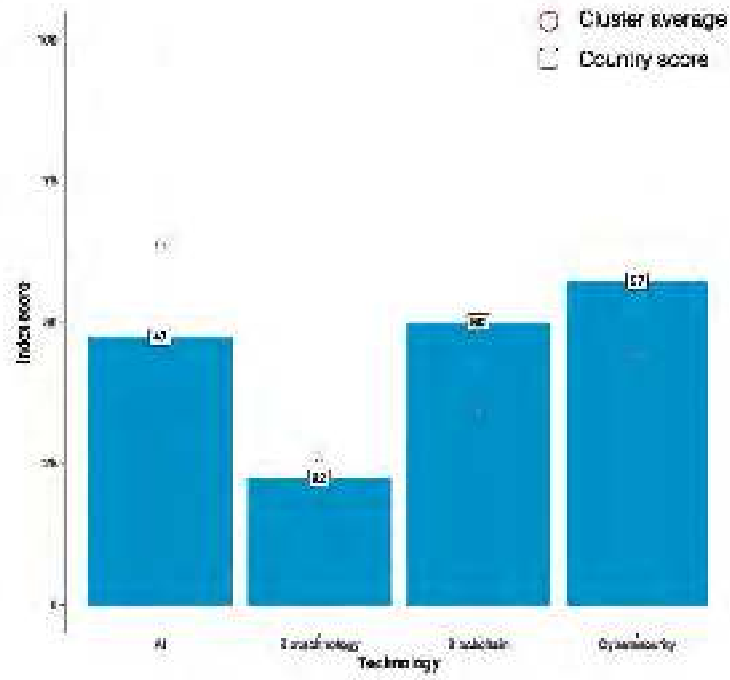
Volume of discussions and engagement level associated with the four key technologies for the future in Indonesia



The trend in online activity over time for Indonesia shows a relevant peak in engagement, pertaining to cybersecurity (enabling environment). Specifically, this is linked to Facebook's removal of hundreds of Indonesian accounts, pages and groups from its social network, after discovering they were linked to online group Saracen, which is accused of spreading hate speech and fake news.[1] This is part of Facebook's efforts to fight allegations that the network is used to spread misinformation. In terms of mentions, the results associated with the main peak pertained to blockchain, which generated significant online activity in September due to the Asia Blockchain Summit 2018 that took place in Jakarta.[2]

Global Technology Awareness Index: Indonesia

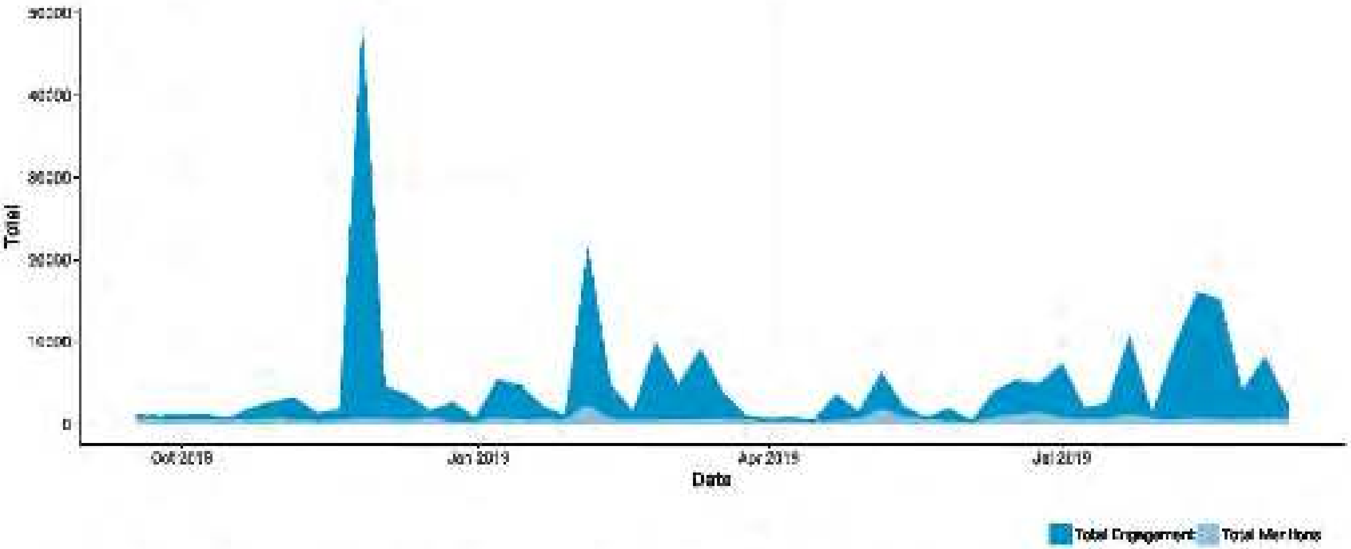
Indonesia outperforms the online activity cluster average in two out of the four technology fields. In terms of activity distribution within the country, Indonesia's online activity is relatively balanced, except for biotechnology, which is the exception.



Future skills awareness

The online community presents an average level of online activity related to future skills, with an average value of 2,671.7 mentions and 17,353.4 instances of engagement per month. Total online activity in this area in Indonesia is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Indonesia



The online activity trend over time for Indonesia shows two relevant peaks in engagement and two peaks in mentions relating to education. The top results associated with the first peak pertained to Indonesia winning six gold and three silver medals at the 2018 WorldSkills Asia competition in Abu Dhabi, with the country's representatives demonstrating their outstanding vocational skills.[3] The second peak referred mainly to a new Government Employee Scheme with Work Agreement (PPPK) to address the shortage of productive teachers in schools.[4] In terms of mentions, the first peak is associated with the current lack of teachers and a new recruitment plan.[5] The second peak in mentions is also related to the teacher shortage in Indonesia. The Coordinating Minister for Human Development and Cultural Affairs said he would invite teachers from abroad to become teaching staff in Indonesia.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Indonesia displays a moderate performance in terms of its knowledge infrastructure, technology and future skills awareness, with a weak-to-average score across all dimensions.

Overview of Indonesia's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★☆☆	★★☆☆☆	★★☆☆☆	★★☆☆☆	★★★☆☆	★★☆☆☆	★★★☆☆
Technology awareness	★★★☆☆	★☆☆☆☆			★★★★★	★★★☆☆	★★★☆☆
Future skills awareness	★☆☆☆☆	★★★☆☆			★☆☆☆☆	★★☆☆☆	★☆☆☆☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country is reasonably well positioned for the future with moderate infrastructure and showing an average level of awareness on both future skills and technologies, although with room for improvement.

There is an active discussion related to future skills and education conducted by the International Labour Organization in order to bridge Indonesia's skills gap through partnership between industry and vocational education and training. The skills mismatch is one of the reasons for unemployment in Indonesia; hence, engaging industry in the design and delivery of vocational education and training is key to enhancing skills development and improving youth employment.[7]

From the online activity of Indonesia, there also appears to be a strong interest in cybersecurity, as the Indonesian National Police and the United States Attorney General's Office have agreed to strengthen bilateral cooperation against transnational cyber and financial crime.[8] The pact with the US Attorney General's Office will involve law enforcement-related training programmes for Indonesian police delivered by their American counterparts.

Endnotes

[1] *Birnbaum, 2019.*
[2] *Blockaster, 2018.*
[3] *The Jakarta Post, 2018.*
[4] *Viva, 2019.*
[5] *Wahyuni, 2019.*
[6] *Abdi, 2019.*
[7] *Sudono, 2019.*
[8] *Chen, 2018.*

JORDAN

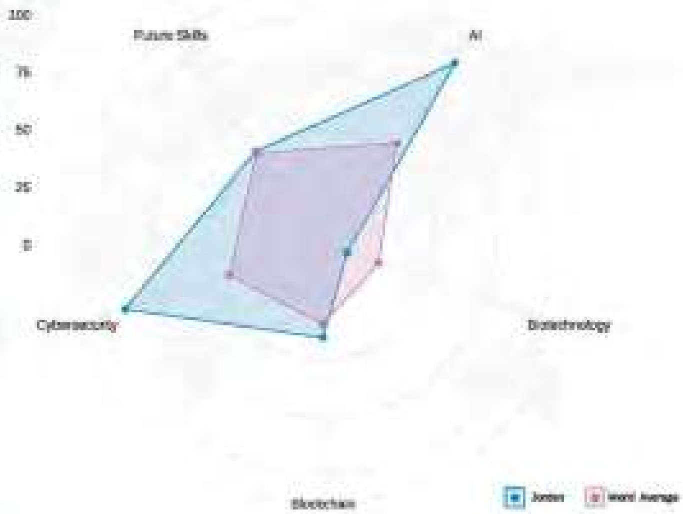
GDP per capita
$ 4,248
2018

HDI
0.735
2017

GKI
70/136
2019

215
unique authors
per million
Internet users

Future field awareness indices

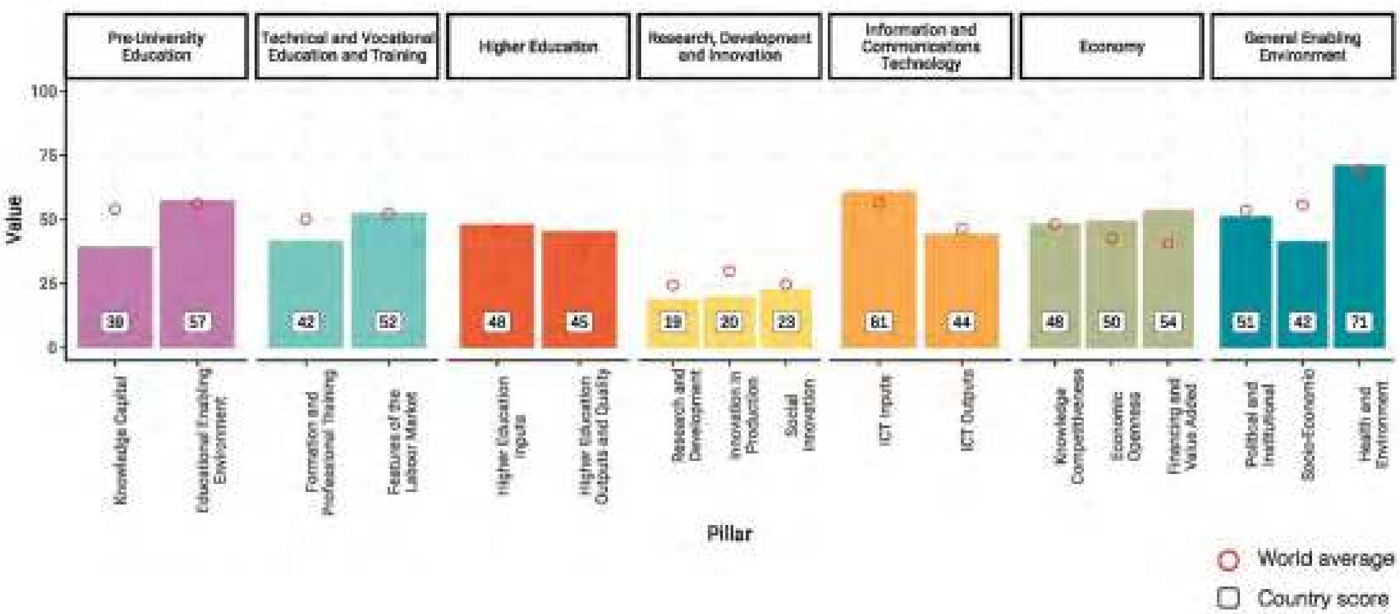


Knowledge infrastructure

Jordan is classified amongst those countries with moderate knowledge infrastructure to support technological uptake, standing alongside countries such as Turkey and Rwanda.

In terms of the Global Knowledge Index, Jordan is ranked 70th, scoring slightly below the world average. Jordan performs above the world average in two out of seven sectors; higher education and economy. Jordan performs strongest in terms of financing and value added, but faces challenges in terms of innovation in production, knowledge capital and socio-economic environment.

Global Knowledge Index – Jordan

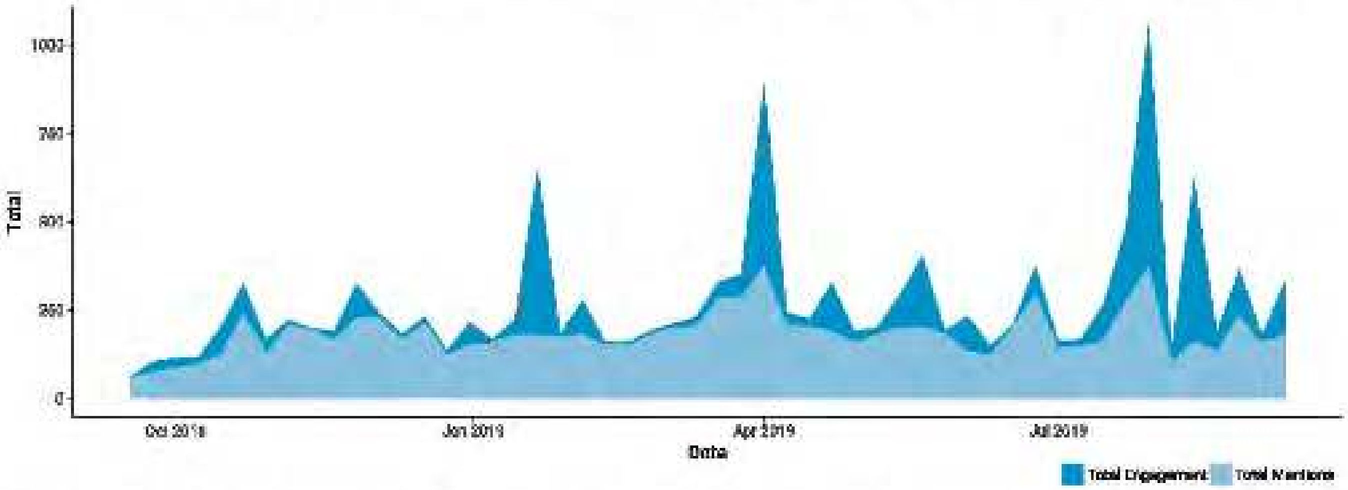


Technological awareness

66.8 percent of Jordan's population has access to the Internet, with a mean download speed of approximately 5.2 Mbps.

Between mid-September 2018 and mid-September 2019, there were 1,407 unique authors contributing to total content generation. The volume of online activity in Jordan within the four technology fields chosen displays an average of 733 mentions and 345.7 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.13. In comparative terms, 2019 presents a higher concentration over the previous sampling period, which produced a value of 0.00091.

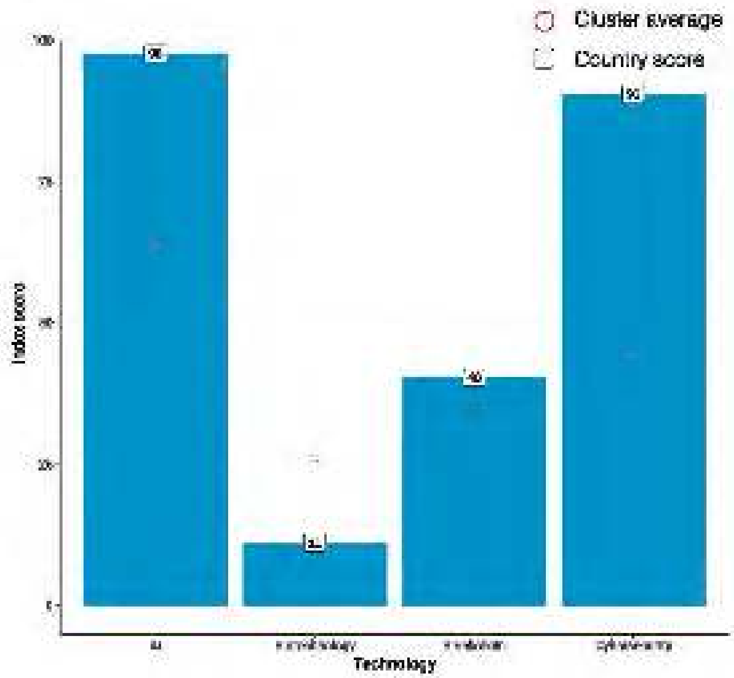
Volume of discussions and engagement level associated with the four key technologies for the future in Jordan



The online activity trend over time for Jordan shows three relevant peaks in engagement and three relevant peaks in mentions in the cybersecurity-enabling environment and education dimensions. The top results associated with these peaks pertained mainly to local news and events. A cybersecurity hackathon competition was held to promote cybersecurity ethics and practices at Al-Hussein Technical University in April 2019.[1] The theme remained relevant with the adoption of a national cybersecurity strategy for Jordan. This included the endorsement of the 2019 cybersecurity law which specifies the formation of a national council for cybersecurity.[2] Indeed, a significant peak in engagement resulted from Acting Prime Minister Rajai Muasher's announcement of the need for a cybersecurity law to end the cyberattacks Jordan faces.[3]

Global Technology Awareness Index: Jordan

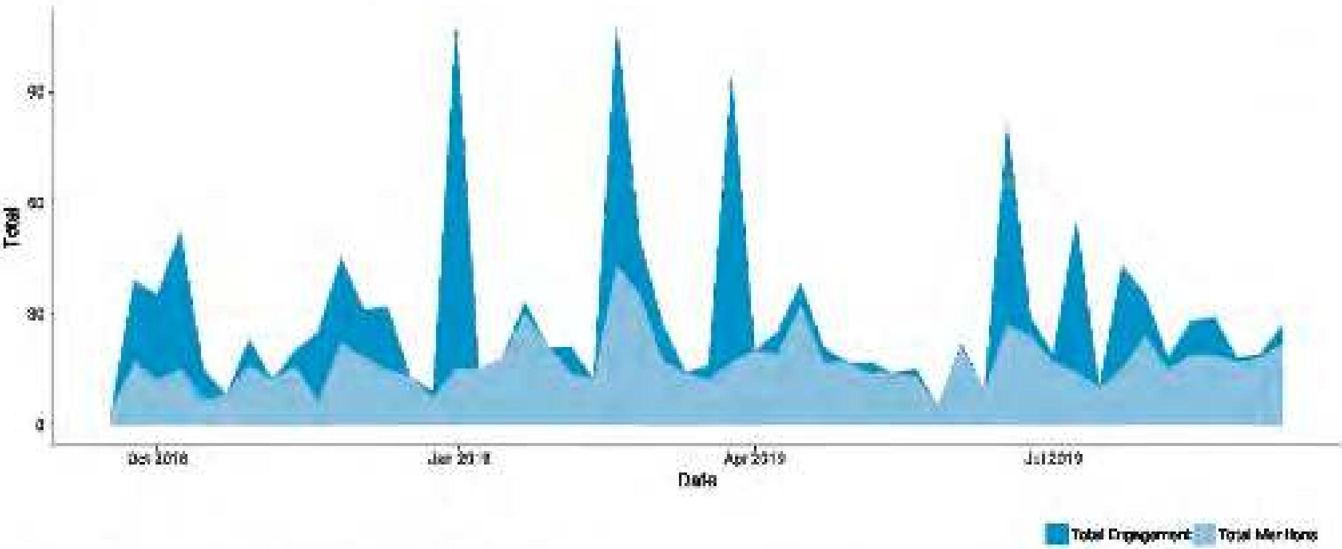
Jordan outperforms the online activity cluster average in three out of the four technology fields. In terms of activity distribution within the country, Jordan displays a less balanced overall performance than the cluster average, where online activity is mainly focused on AI and cybersecurity.



Future skills awareness

The volume of online activity relating to future skills displays a low level of online activity on the topic, with an average value of 67.1 mentions and 49.1 instances of engagement per month. Total online activity in this area in Jordan is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Jordan



The online activity trend over time for Jordan shows four relevant peaks in engagement relating to education and two relevant peaks in mentions relating to technology and RDI and science. The results associated with the peaks in engagement pertain mainly to local news of Queen Rania joining a group of young women and men at a bookshop in Madaba to promote a culture of reading and encouraging youth innovation.[4]

The second peak in engagement was a result of a national article offering helpful tips on how to achieve an efficient balance between technology and learning within the classroom – the article provides helpful tips for students and teachers on how to take advantage of technology within the education system.[5]

The third peak in engagement was another article published in the national news, stating that students needed to develop buoyancy to better cope with academic setbacks. Academic buoyancy is defined as building student resilience and the ability of students to rebound from daily setbacks, which are part of normal school life.[6]

Finally, the fourth peak in engagement was triggered by international news on the region's largest entrepreneurship programme, the Arab Innovation Academy (AIA), which was launched by the Qatar Science & Technology Park (QSTP) and the European Innovation Academy (EIA).[7]

The peaks in mentions result from an international announcement made by the Dubai Future Academy introducing a new set of knowledge initiatives – the Ramadan Pioneer Series – that took place during the month of Ramadan. The initiative aims to share knowledge and expertise in the field of innovative and futuristic ideas.[8] The second peak in mentions was due to national news concerning the inauguration of Queen Rania Al Abdullah's new Queen Rania Teacher Academy (QRTA) at The University of Jordan. The academy aims to improve the quality of education in Jordan and the region as a whole.[9]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Jordan displays a moderate performance in terms of its knowledge infrastructure and a weak performance in terms of technology and future awareness, with a weak-to-average score across all dimensions.

Overview of Jordan's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★☆	★★★★☆	★★☆☆☆	★★☆☆☆	★★☆☆☆	★★★☆☆	★★★☆☆
Technology awareness	★★☆☆☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★★☆☆☆
Future skills awareness	★☆☆☆☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★★★☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval): 1 star (0-20%), 2 stars (20-40%), 3 stars (40-60%), 4 stars (60-80%), 5 stars (80-100%).

There is room for improvement on infrastructure, but Jordan also needs to prepare for the future in terms of skills and technologies. AI is where sign of progress can be expected in the coming years. An indicator of this is the unprecedented, recently-introduced undergraduate and graduate degrees in data science and artificial intelligence at the Princess Sumaya University for Technology (PSUT).[10] Another example is the Arab Artificial Intelligence Summit (AAIC'19) that took place for the first time in Jordan at the end of October 2019.[11]

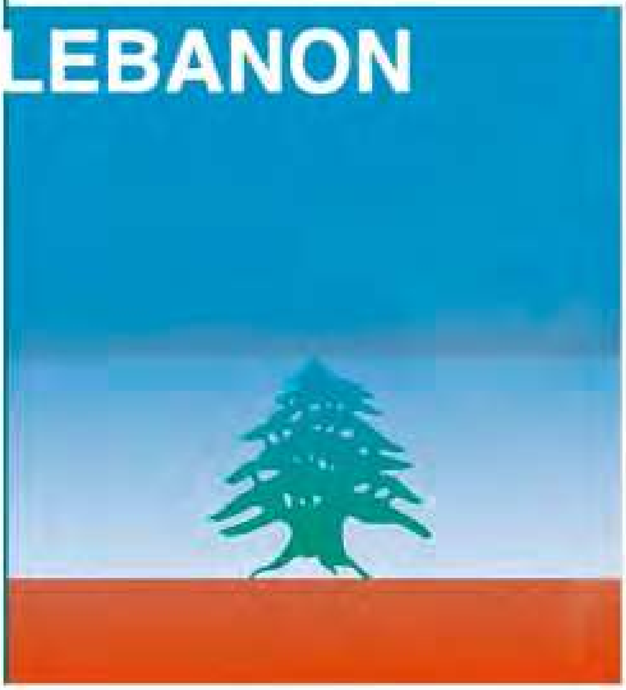
The relatively strong score in technology under future skills awareness is a key area to be capitalised upon, especially with the announcement by the World Bank of the provision of financial resources of up to $1 billion for Lebanon, Jordan and Iraq. These financial resources are for supporting the development of the digital economy, but also for actively engaging in building the requisite skills, which will allow youth in particular to engage in the digital economy. As a result, the government of Jordan pledged to increase its broadband access to 100% across the country, promote e-payments and develop digitalised government services.[12]

Endnotes

[1] *Jordan News Agency, Petra, 2019.*
[2] *The Jordan Times, 2019a.*
[3] *Ammon News, 2019.*
[4] *The Jordan Times, 2019b.*
[5] *MENA FN, 2019b.*
[6] *MENA FN, 2019c.*
[7] *PR Newswire, 2019.*
[8] *MENA FN, 2019a.*
[9] *Queen Rania Media Center, 2019.*
[10] *Princess Sumaya University for Technology, 2019.*
[11] *EU Neighbors South, 2019.*
[12] *Luck, 2019.*

CLUSTER
03

LEBANON



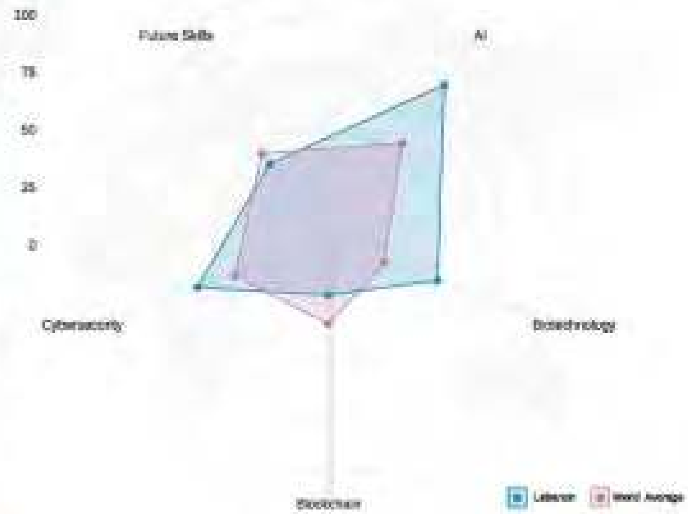
GDP per capita
$ 8,270
2018

HDI
0.757
2017

GKI
81/136
2019

238
unique authors
per million
Internet users

Future field awareness indices

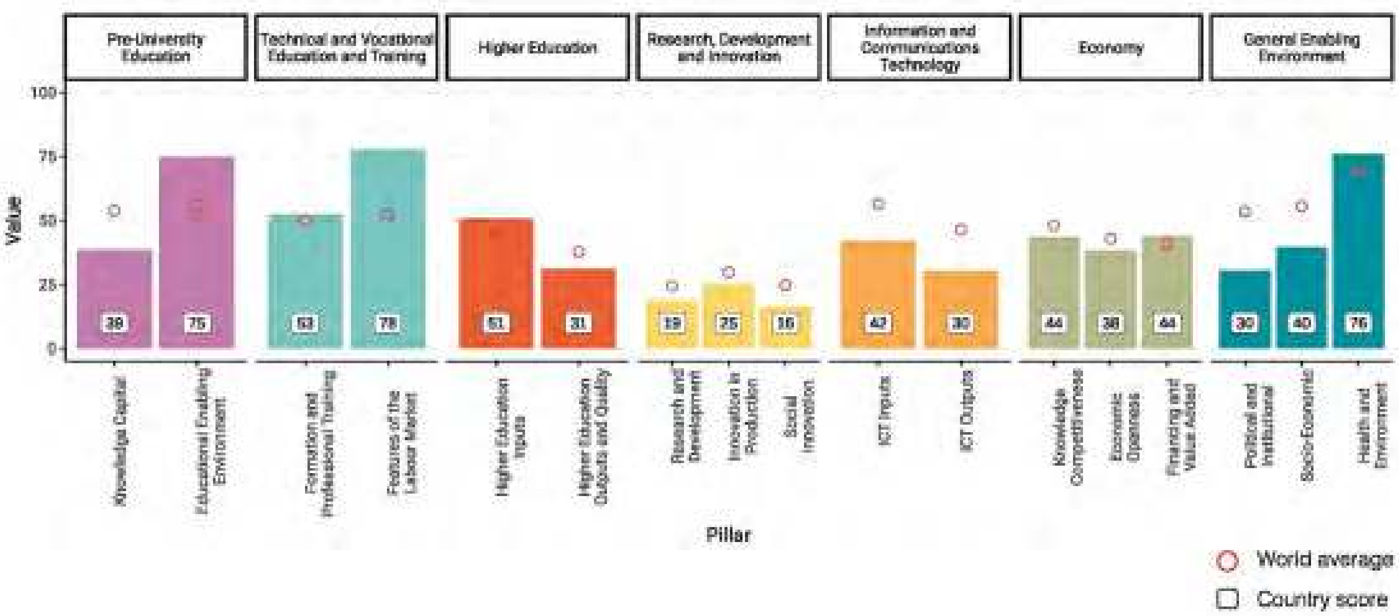


Knowledge infrastructure

Lebanon is amongst those countries with moderate knowledge infrastructure to support technological uptake, such as Rwanda and Turkey.

Lebanon is ranked 81st on the Global Knowledge Index and scores below the world average. Lebanon performs above the world average in only one out of the seven sectoral indices – technical and vocational education and training. It performs strongly in areas related to the features of the labour market, and was ranked fifth globally on the quality of human capital. Conversely, Lebanon faces challenges related to political instability, government ineffectiveness, weak regulatory quality, low levels of societal innovation and poor ICT infrastructure.

Global Knowledge Index – Lebanon

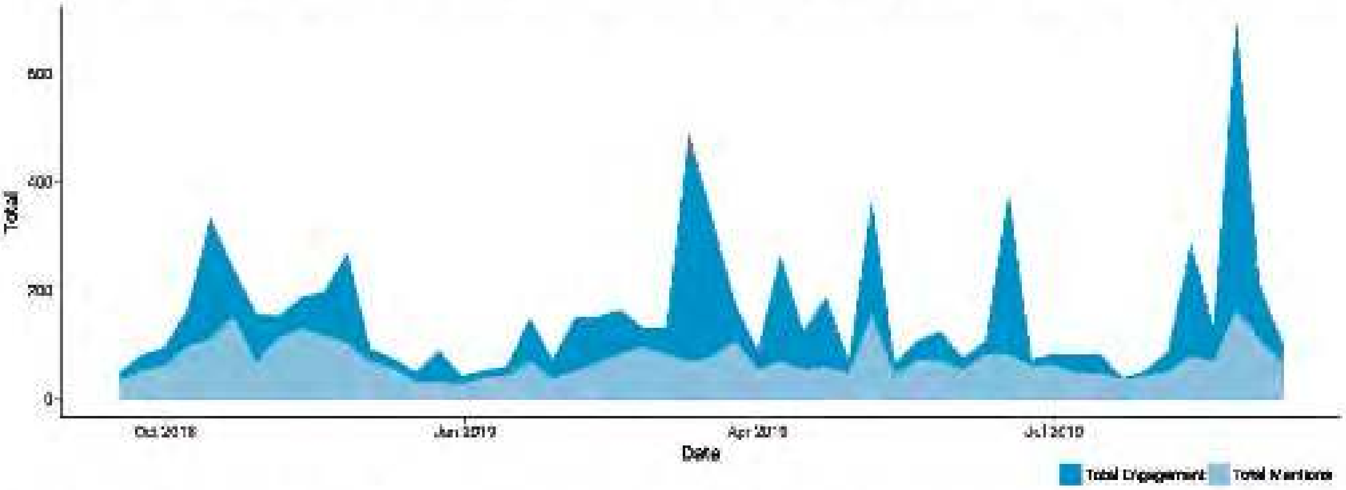


Technological awareness

78.2 percent of the Lebanese population has access to the Internet, with a mean download speed of 1.8 Mbps.

Between mid-September 2018 and mid-September 2019, there were 1,268 unique authors contributing to total content generation. The volume of online activity in Lebanon within the four technology fields chosen displays an average of 286.5 mentions and 341.7 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.015. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.029.

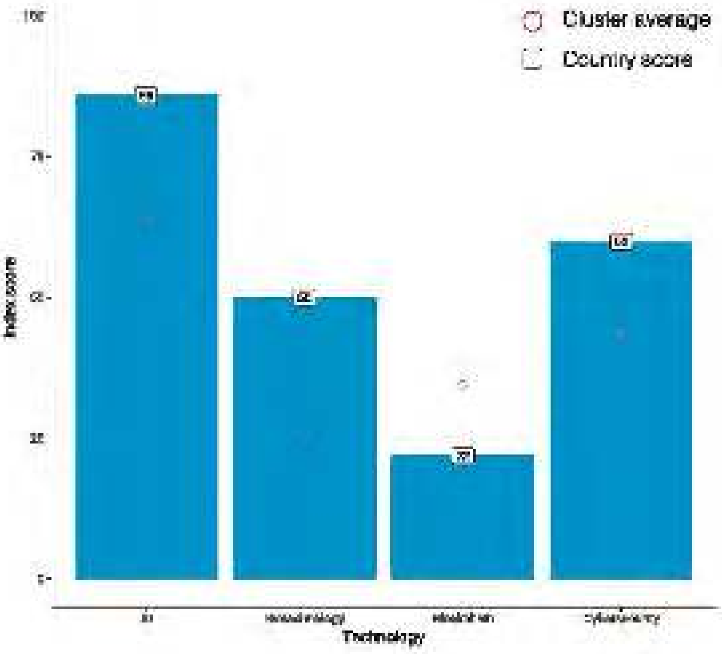
Volume of discussions and engagement level associated with the four key technologies for the future in Lebanon



The trend in online activity over time for Lebanon shows relevant peaks in engagement related to cybersecurity (enabling environment). The first peak refers to the 1st Lebanese Internet Governance Forum (IGF) that took place in the American University of Beirut (AUB).[1] The second peak relates to the adoption by the Cabinet of a cybersecurity strategy that aims to protect the government, ministries and telecommunications sector.[2] In terms of mentions, the results associated with the main peak pertain to the area of AI (RDI and science), and specifically to Google awarding $1 million to the AUB for an Artificial Intelligence project that will address some of the pressing issues related to water in the region's agricultural sector.[3]

Global Technology Awareness Index: Lebanon

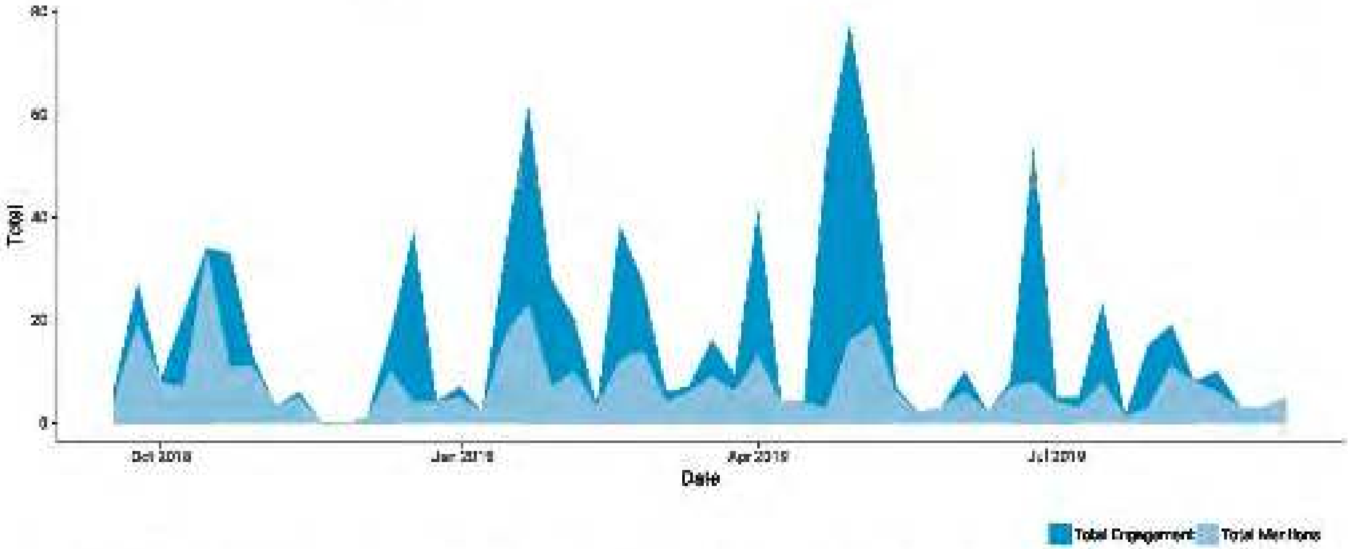
Lebanon outperforms the online activity cluster average in three out of the four technology fields. In terms of activity distribution within the country, Lebanon performs below the cluster average for blockchain while its online activity is balanced and concentrated on AI, biotechnology and cybersecurity.



Future skills awareness

Total online activity in the area of future skills in Lebanon is lower than that relating to the technologies of the future. The online community presents a low level of online activity in the topic, with an average value of 29.8 mentions and 37.8 instances of engagement per month.

Volume of discussions and engagement level associated with future skills in Lebanon



The trend in online activity over time for Lebanon shows a major relevant peak in engagement and a number of low-scale peaks in mentions related to education and technology. The results associated with these peaks pertain mainly to national and international news on issues of public education. Namely, in terms of engagement, activity in one of the peaks was concentrated on upgrading technology education in Lebanese schools.[4] In terms of mentions, the trend online shows a relevant peak related to education that refers to the graduation of 500 students from German funded digital skills courses at AUB Lebanon – a programme organised by the World Food Programme.[5]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Lebanon exhibits moderate performance in terms of its knowledge infrastructure, across all sectors. In terms of awareness, Lebanon exhibits weak performance in terms of technology awareness and future skills awareness.

Overview of Lebanon's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★☆☆	★★★☆☆	★★★☆☆	★★★★★	★★☆☆☆	★★★☆☆	★★☆☆☆
Technology awareness	★☆☆☆☆	★★☆☆☆			★☆☆☆☆	★☆☆☆☆	★☆☆☆☆
Future skills awareness	★☆☆☆☆	★☆☆☆☆			★★★☆☆	★☆☆☆☆	★☆☆☆☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval); five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

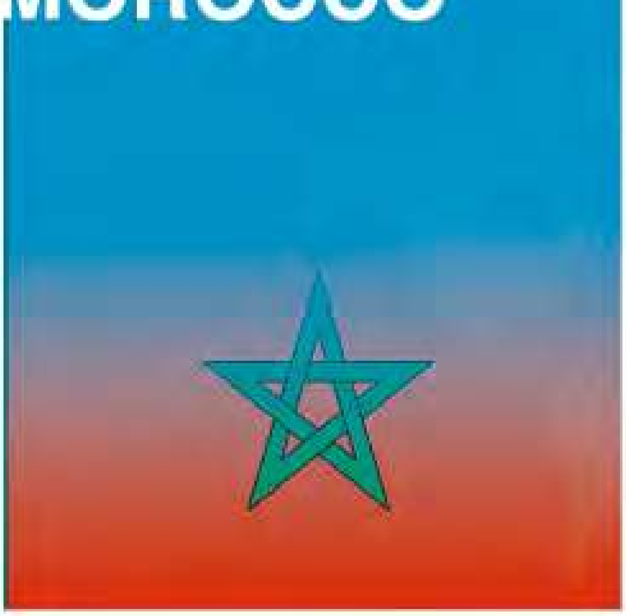
The country has room for improvement in terms of infrastructure, but also needs to prepare for the future in terms of relevant skills and technologies. AI is an area in which signs of progress can be expected in the coming years. This is suggested by events such as the 'Artificial Intelligence Digital Revolution Impact on the Economy' conference, which took place in Beirut. The aim of this conference was to develop an understanding of the latest trends and developments in innovation and the application of AI in industry, computing and customer devices.[6]

The relatively strong score on enabling environment in future skills awareness, results from the World Bank's recent announcement to provide financial resources of up to $1 billion for Lebanon, Jordan and Iraq. These financial resources are aimed to boost and support the development of the digital economy but also actively engage in building the requisite skills, which will allow to engage in the digital economy. As a result, the government of Lebanon pledges to increase its broadband access to 100 per cent across the country, promote e-payments and develop digitalized government services.[7]

Endnotes

[1] *See: https://igflebanon.org/.*
[2] *Council of Europe, 2019.*
[3] *Sewell, 2019.*
[4] *Herzog, 2018.*
[5] *WFPLebanon, 2019.*
[6] *See: https://www.lebtivity.com/event/artificial-intelligence-digital-revolution-impact-on-the-economy.*
[7] *Luck, 2019.*

MOROCCO



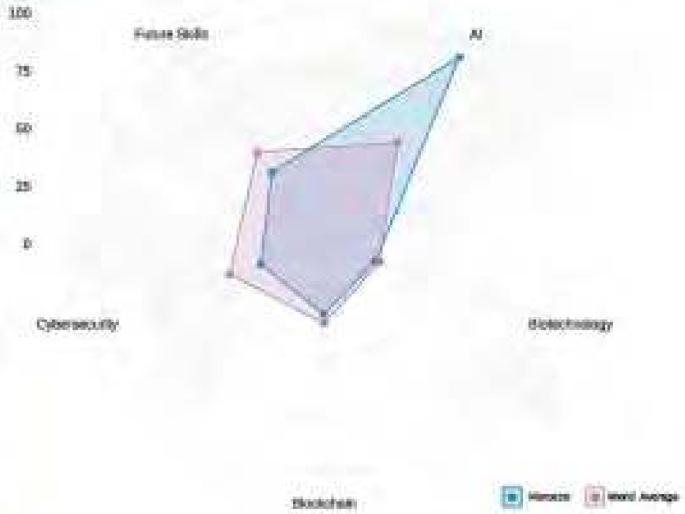
GDP per capita
$ 3,238
2018

HDI
0.667
2017

GKI
92/136
2019

148
unique authors
per million
Internet users

Future field awareness indices

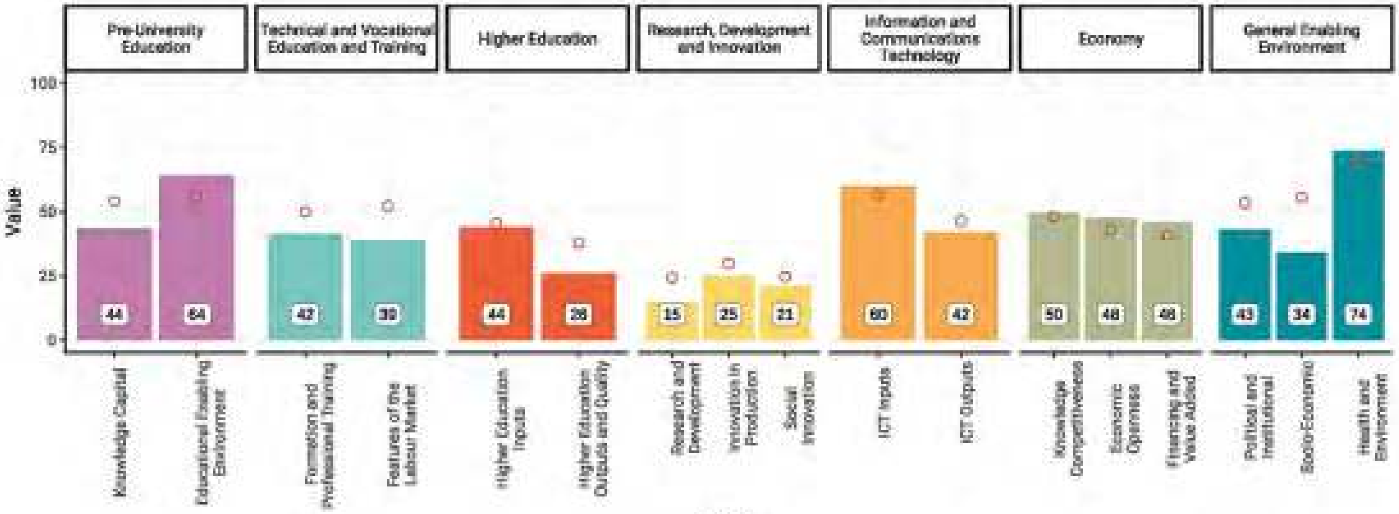


Knowledge infrastructure

Morocco is amongst those countries with moderate levels of knowledge infrastructure to support technological uptake, alongside Lebanon and Indonesia.

Morocco is ranked 92nd on the Global Knowledge Index, scoring below the world average. Morocco performs above the world average in only one out of seven sectoral indices; economy. It performs strongly in areas related to trade and financing. Conversely, Morocco faces challenges related to gender disparities, empowerment opportunities, and in the outputs and quality of higher education.

Global Knowledge Index – Morocco

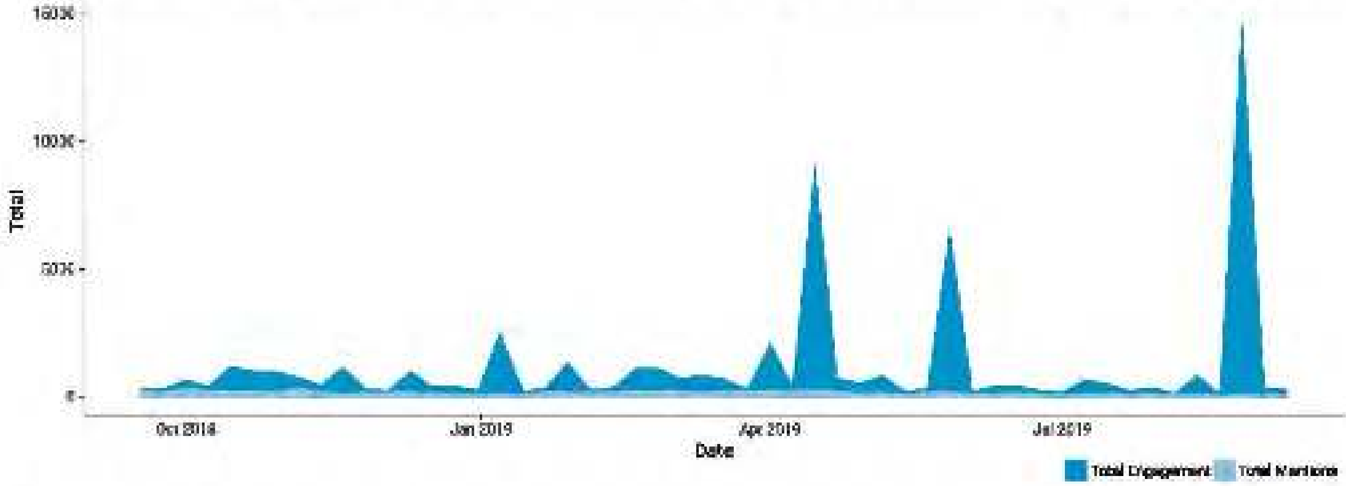


Technological awareness

64.8 percent of Morocco's population has access to the Internet, with a mean download speed of 5.5 Mbps.

Between mid-September 2018 and mid-September 2019, there were 3,446 unique authors contributing to total content generation. The volume of online activity in Morocco within the four technology fields chosen displays an average of 722.2 mentions and 3,897.3 instances of engagement per month. Online activity within technological fields displays a degree of concentration of 0.0028. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.0029.

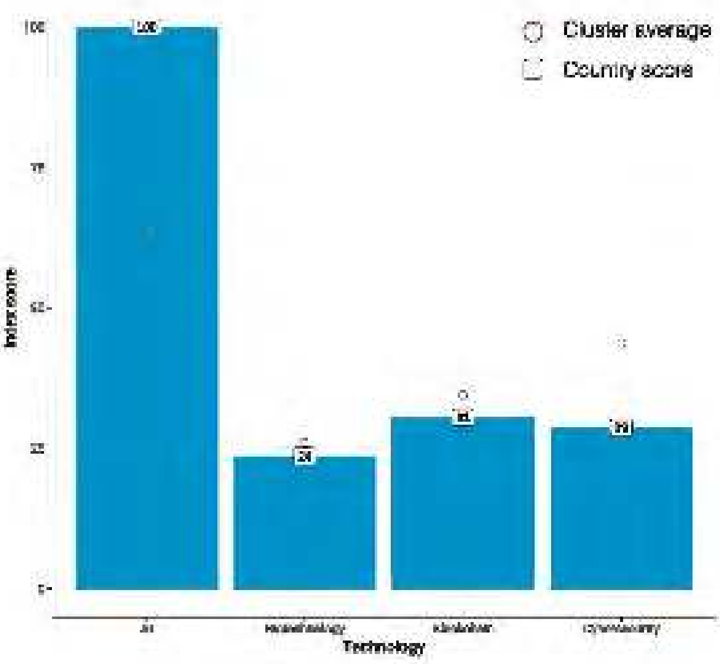
Volume of discussions and engagement level associated with the four key technologies for the future in Morocco



The online activity trend over time for Morocco shows peaks in engagement relating to AI (education, economy and RDI and science). The results associated with this first peak in engagement pertained mainly to a 23-year-old Moroccan student enrolled at the University of Stanford who was put in charge of teaching AI at the university's AI Laboratory.[1] The second peak in engagement mainly related to support to a declaration of the French president, Emmanuel Macron, which emphasised the importance for economies of investment in innovation, new technologies and AI.[2] The third, and largest, peak in engagement pertained to the World Artificial Intelligence Conference (WAIC) that was held in Shanghai in August 2019.[3]

Global Technology Awareness Index: Morocco

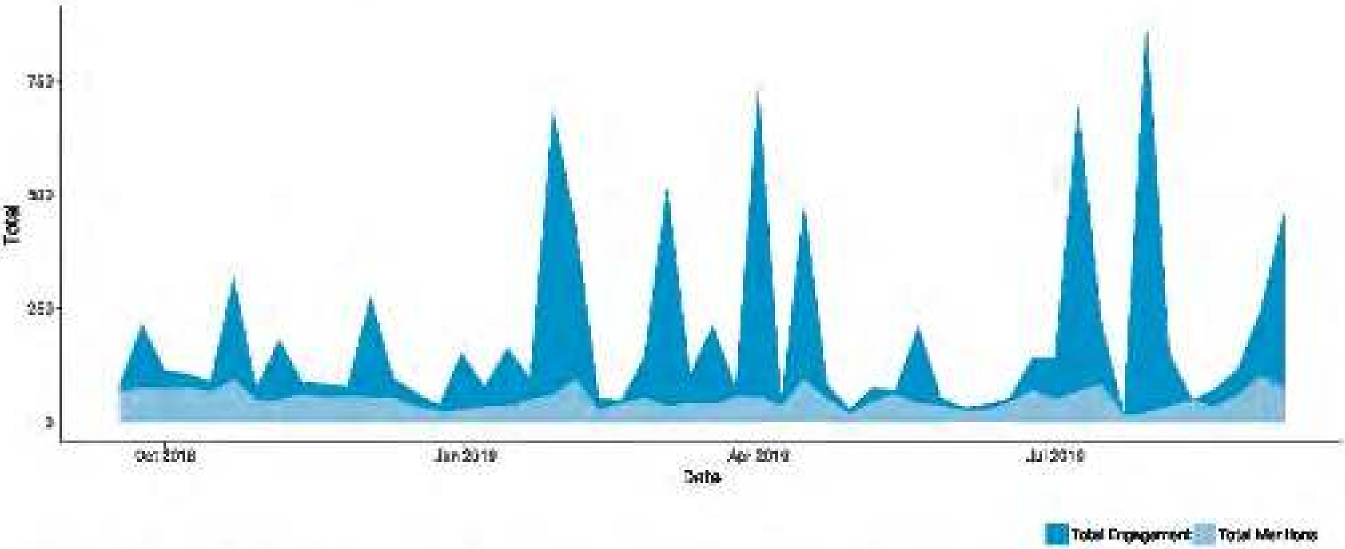
Morocco outperforms the online activity cluster average in one out of the four technology dimensions. In terms of activity distribution within the country, Morocco's discussions mainly focus on AI, with other activity spread evenly across the remaining dimensions.



Future skills awareness

Total online activity in the area of future skills in Morocco is lower than that relating to the technologies of the future. The online community presents a low level of activity regarding this topic, with an average value of 204 mentions and 543 instances of engagement per month.

Volume of discussions and engagement level associated with future skills in Morocco



The trend in online activity over time for Morocco shows several peaks in engagement relating to education. The results associated with these peaks are mainly sparked by discussions on the national education system – and, more specifically, the debate on whether the language of instruction should (or should not) be Arabic.[4,5] Regarding mentions, the peaks in October were driven by the World Investment Forum organised by the United Nations Conference on Trade and Development (UNCTAD) that brought together several heads of states and government.[6] The remaining peaks in mentions also pertained to sustainable development and the national education system; two topics that seem of high importance for the country.

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Morocco exhibits weak-to-moderate performance in terms of its knowledge infrastructure, technology awareness and future skills awareness, with performance varying across dimensions.

Overview of Morocco's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★★★☆	★★☆☆☆	★★☆☆☆	★☆☆☆☆	★★☆☆☆	★★★☆☆	★★★☆☆
Technology awareness	★★★☆☆	★★★☆☆			★☆☆☆☆	★★★★☆	★★★★☆
Future skills awareness	★★★☆☆	★★☆☆☆			★★★☆☆	★★☆☆☆	★☆☆☆☆

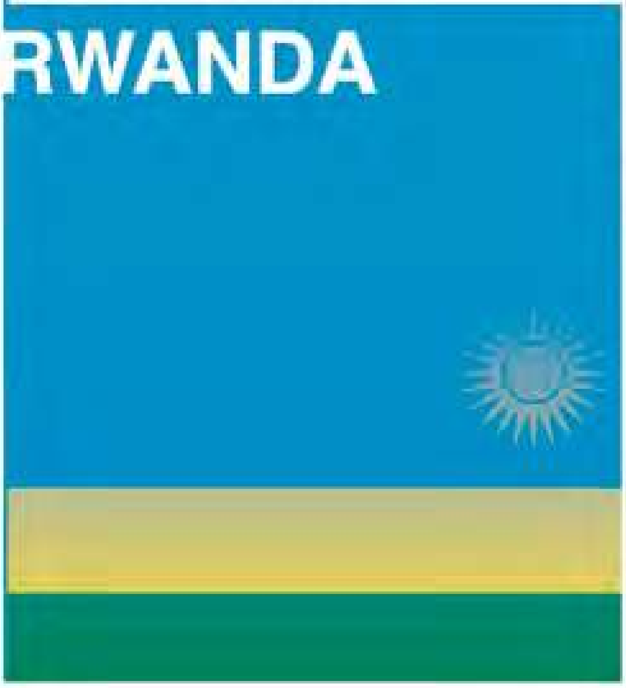
Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Strong technology awareness scores in RDI are driven by discussions on AI. The inauguration of the first anti-cancer unit in Africa[7] and talks about the promotion of digital to empower African women[8] generated remarkable results in online activity. The results are also driven by sources within the country reporting on local developments such as the opening of an AI school in Fez[9], plans by SAS to invest in artificial intelligence in Casablanca[10] and the achievements of individuals in the region, e.g. two Tunisian women recognized for their scientific contributions to medicine and biotechnology.[11]

Endnotes

[1] *Choukri, 2019.*
[2] *Emmanuel Macron, 2019.*
[3] *See: https://www.shine.cn/World-Artificial-Intelligence-Conference/.*
[4] *El Ouardighi, 2019.*
[5] *Sail, 2019.*
[6] *Panora Post, 2018.*
[7] *Huffpost Maghreb, 2019b.*
[8] *Remy-Boutang, 2019.*
[9] *Lystad, 2019.*
[10] *Le 360, 2019.*
[11] *Samoud, 2019.*

RWANDA



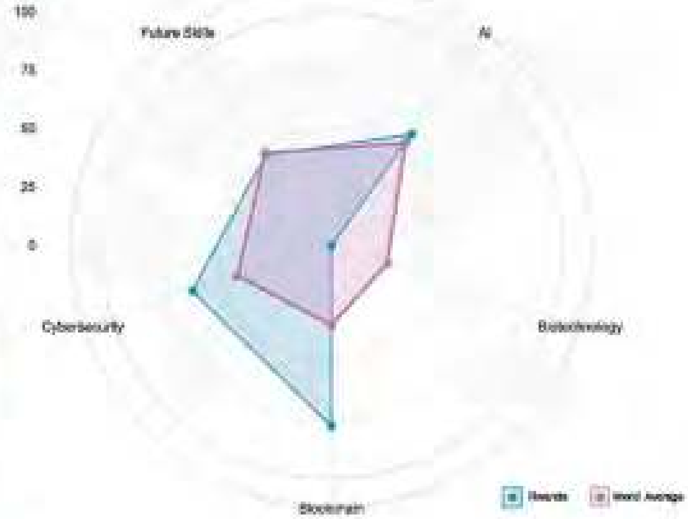
GDP per capita
$ 773
2018

HDI
0.524
2017

GKI
96/136
2019

345
unique authors
per million
Internet users

Future field awareness indices

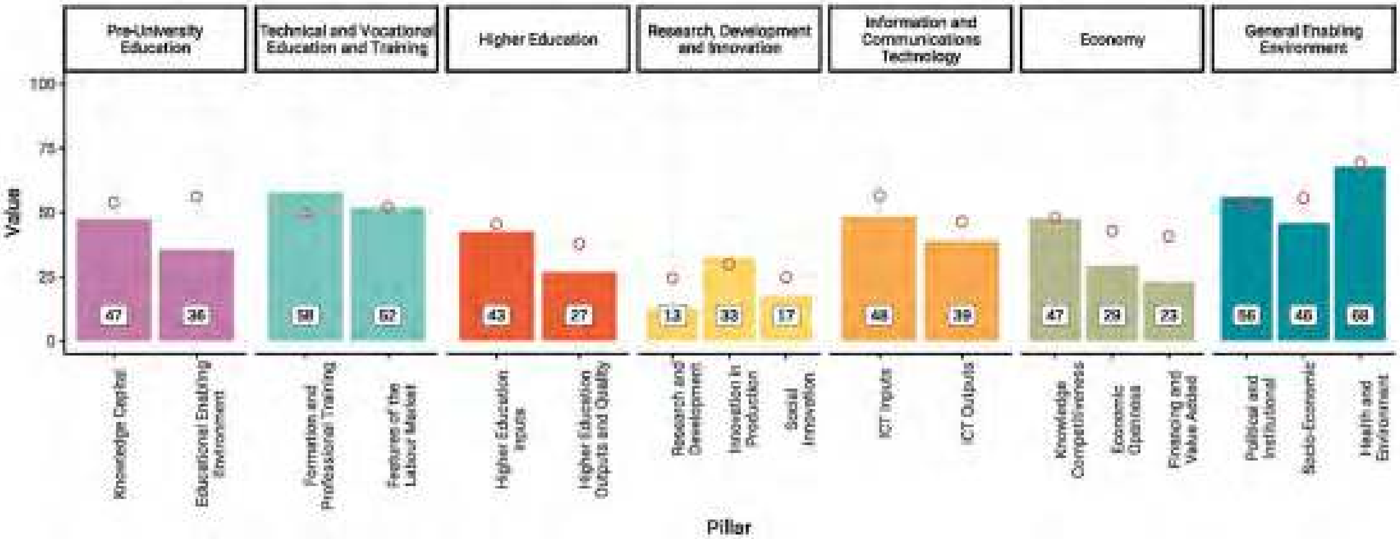


Knowledge infrastructure

Rwanda is amongst those countries with moderate levels of knowledge infrastructure to support technological uptake, standing alongside countries such as Egypt and Indonesia.

Rwanda is ranked 96th on the Global Knowledge Index, scoring below the world average. Rwanda performs above the world average in only one out of the seven sectoral indices; technical and vocational education and training. It performs strongly in areas related to formation and professional training, especially in terms of firms offering formal training. Conversely, it faces challenges related to pre-university and higher education, and economic openness, financing and value added, which may be attributed to minimal trade in creative services and goods and the low contribution of manufacturing to its GDP.

Global Knowledge Index – Rwanda

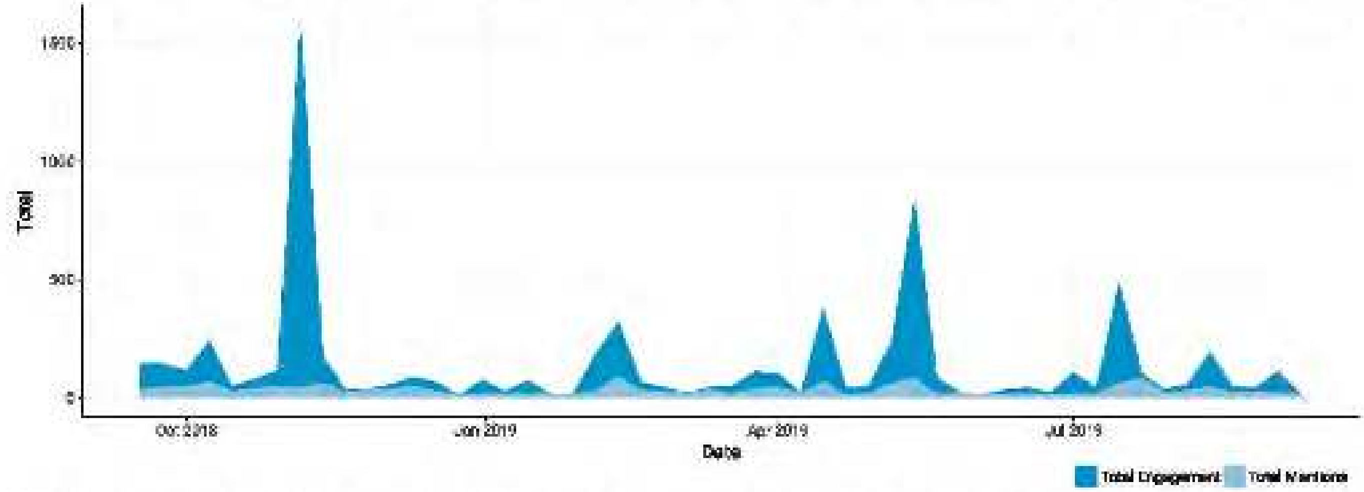


Technological awareness

21.8 percent of the population in Rwanda have access to the Internet, with an average download speed of 3.3 Mbps.

Between mid-September 2018 and mid-September 2019, there were 900 unique authors contributing to total content generation. The volume of online activity in Rwanda within the four technology fields chosen displays an average of 134.9 mentions and 411.1 instances of engagement per month. Online activity concerning technological fields displays a degree of concentration of 0.0052. In comparative terms, 2019 presents a lower concentration than the previous sampling period, which produced a value of 0.0078.

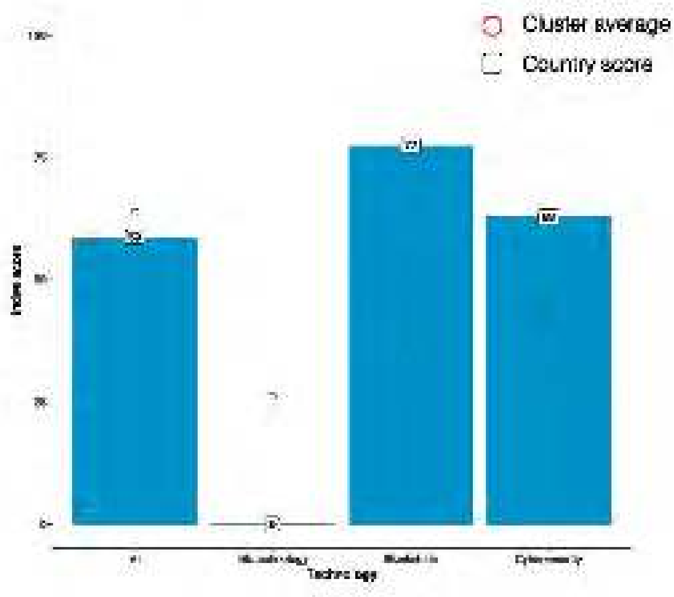
Volume of discussions and engagement level associated with the four key technologies for the future in Rwanda



The trend in online activity over time for Rwanda shows a number of peaks in engagement. The highest peak related to blockchain (education) and more specifically to the upcoming registration deadline of a course – the 'Oxford Blockchain Strategy Programme' – given by the Saïd Business School of the University of Oxford.[1] The second peak relates to cybersecurity (RDI and science), and specifically to Eugene Kaspersky, founder of the global cybersecurity firm Kaspersky Lab, who paid tribute to victims of the genocide against the Tutsis.[2] In terms of mentions, the results associated with the main peak pertained to AI (RDI and science), and specifically to the announcement of 10 fully-funded Masters' scholarships in Artificial Intelligence, quantum computing and Internet of Things at selected Universities in Quebec, Canada.[3] The online activity trend over time also displays smaller peaks of engagement and mentions. These peaks are mainly connected to local news and events, such as the Transform Africa Summit that took place in Kigali, Rwanda in May 2019 under the theme 'Boosting Africa's Digital Economy'.[4] Also, Pundi X, a Singapore-based company, released a new blockchain phone at the GSMA Mobile 360 Africa event in Kigali in July 2019.[5]

Global Technology Awareness Index: Rwanda

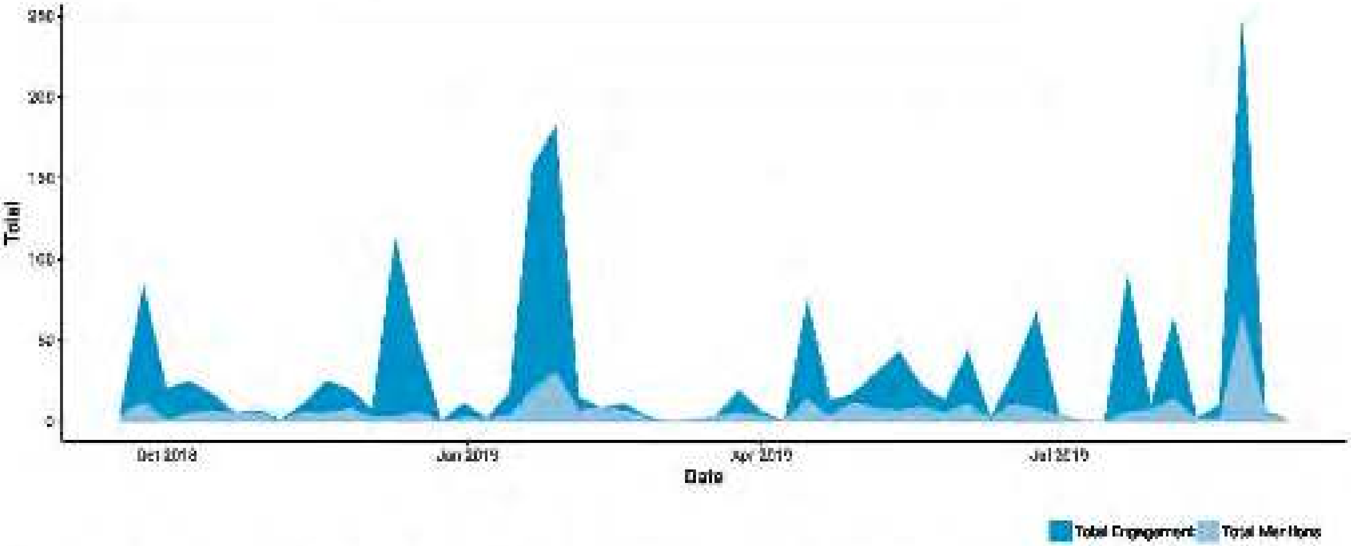
Rwanda outperforms the online activity cluster average in two out of the four technology fields. In terms of activity distribution within the country, Rwanda performs close to the cluster average for AI, while it performs above the average for blockchain and cybersecurity and activity is non-existent concerning biotechnology.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average of 28.2 mentions and 95.9 instances of engagement per month. Total online activity in this area in Rwanda is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Rwanda



The online activity trend over time for Rwanda shows a number of relevant peaks in engagement and mentions relating to education and economy. The results are associated with peaks pertaining mainly to local and international news and events. The largest peak referred to the Tokyo International Conference on African Development (TICAD), attended by Rwanda's President, Paul Kagame, and his speech emphasizing the role of the private sector in development. TICAD is a high-level policy event facilitating dialogue between African and Japanese leaders.[6] The other peak referred to education reforms amid teacher shortages. The Rwandan government announced new incentives for university graduates to join the teaching profession, waiving their student loans should they choose to teach for three years after graduation.[7] The smaller peaks in engagement and mentions mainly pertain to the promotion of events, such as the Next Einstein Forum[8] – a science and innovation conference – and an interview with a World Bank expert emphasizing the role of technology and innovation in sustainable development in Rwanda.[9]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Rwanda exhibits a weak performance in terms of its knowledge infrastructure, technology and future skills awareness, with a weak-to-average score across most thematic dimensions.

Overview of Rwanda's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★☆☆☆	★★☆☆☆	★☆☆☆☆	★★★★☆	★★☆☆☆	★★☆☆☆	★★☆☆☆
Technology awareness	★★☆☆☆	★★☆☆☆			★★★☆☆	★★☆☆☆	★★★★☆
Future skills awareness	★★★★☆	★★☆☆☆			★★★☆☆	★★☆☆☆	★★★☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval): 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country has room for improvement in terms of infrastructure but also needs to prepare for the future in skills and technologies. Blockchain is where signs of progress can be expected in the coming years. This is indicated by Rwanda's recent announcement of the world's first blockchain project to track tantalum from the pit-face to the refinery, enabling a conflict-free mining.[10]

An explanation for the high score in technical and vocational education and training (TVET) under knowledge infrastructure could be the recent announcement made by the Rwandan president of focusing on TVET, in which he mentioned that he aimed to increase the number of students in TVET schools from 31 percent to 60 percent by 2024. The Prime Minister also stated that technical and vocational skills are the most powerful tools in decreasing poverty and overcoming the skills gap. A particular focus appears to be on TVET skills in the technology field, which could also explain the high score in the technology dimension.[11]

Endnotes

[1] *Get Smarter, 2019.*
[2] *Hope Magazine, 2019.*
[3] *Rwanda_Edu, 2019.*
[4] *See: https://transformafricasummit.org/web/.*
[5] *Mbogo, 2019.*
[6] *Bizimungu, 2019.*
[7] *Bishumba, 2019.*
[8] *See: https://nef.org/about/.*
[9] *Mwai, 2019.*
[10] *Uwiringiyimana and Lewis, 2018.*
[11] *CNBC Africa, 2019.*

CLUSTER
03

SOUTH AFRICA

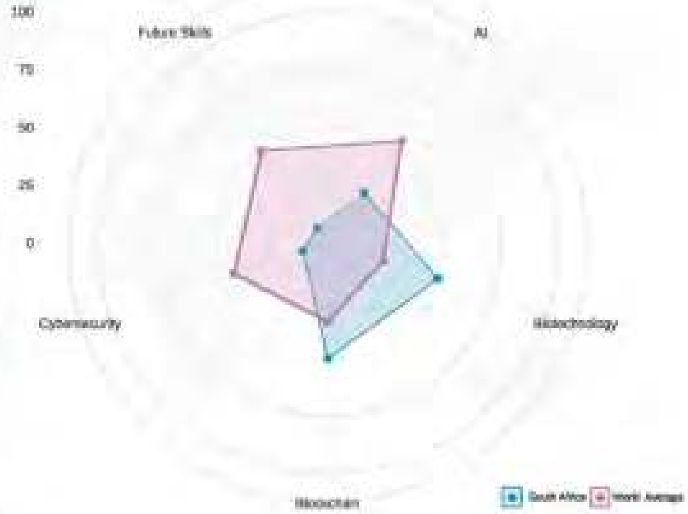
GDP per capita
$ 6,340
2018

HDI
0.699
2017

GKI
73/136
2019

528
unique authors
per million
Internet users

Future field awareness indices

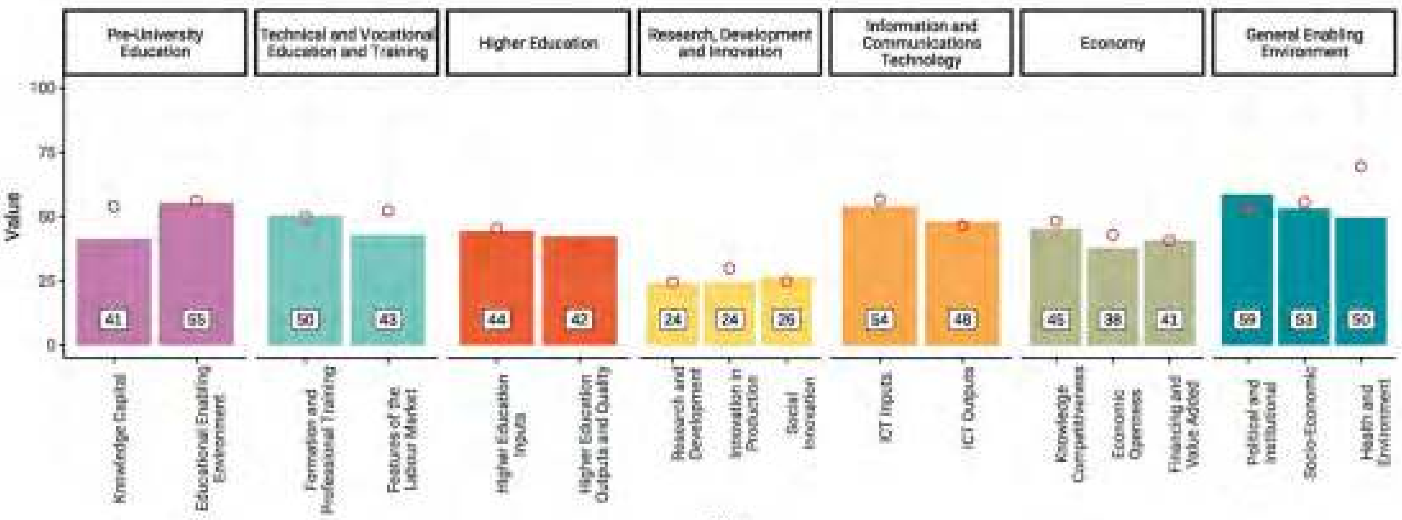


Knowledge infrastructure

South Africa is amongst those countries with moderate levels of knowledge infrastructure to support technological uptake, standing alongside Lebanon and Turkey.

South Africa is ranked 73rd on the Global Knowledge Index, scoring slightly below the world average. South Africa performs above the world average in only two out seven sectoral indices; higher education and ICT. It performs strongly in areas related to social innovation, which may be attributed to new business density, protection of minority investors and the relatively high imports of ICT goods. Conversely, South Africa faces challenges in its education system, mainly at the pre-university level, which relates to low levels of enrolment and high dropout rates. The health and environment pillar require major improvements addressing the high rates of under-five mortality and CO2 emissions per capita.

Global Knowledge Index – South Africa

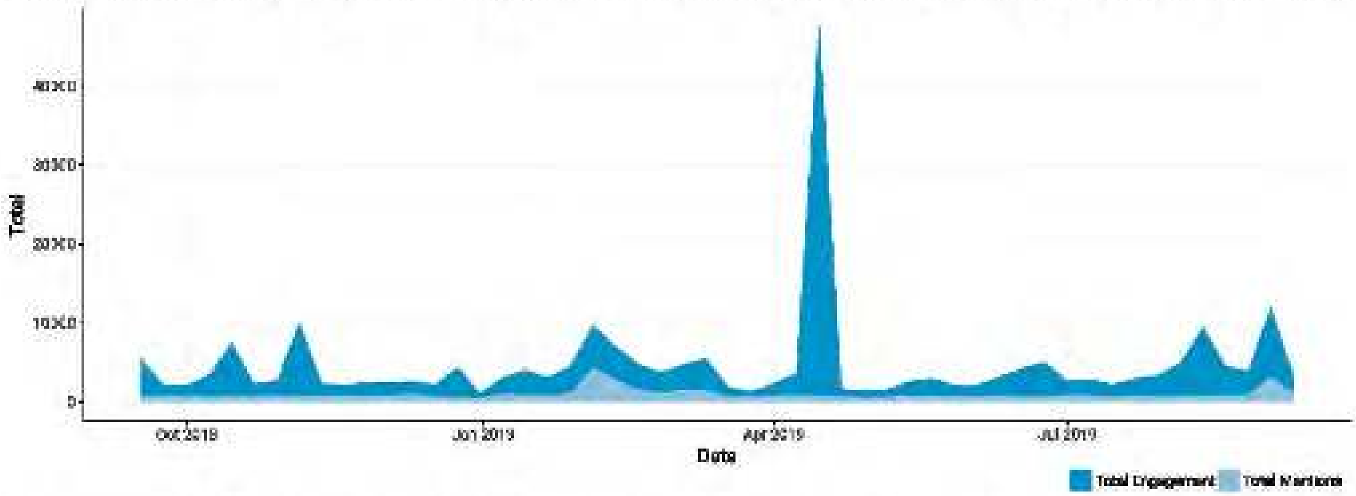


Technological awareness

56.2 percent of the South African population have access to the Internet, with a mean download speed of 8.4 Mbps.

Between mid-September 2018 and mid-September 2019, there were 16,913 unique authors contributing to total content generation. The volume of online activity in South Africa within the four technology fields chosen displays an average of 3,938.2 mentions and 14,493.4 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0034. In comparative terms, 2019 presents a lower concentration than the previous sampling period, which produced a value of 0.0066.

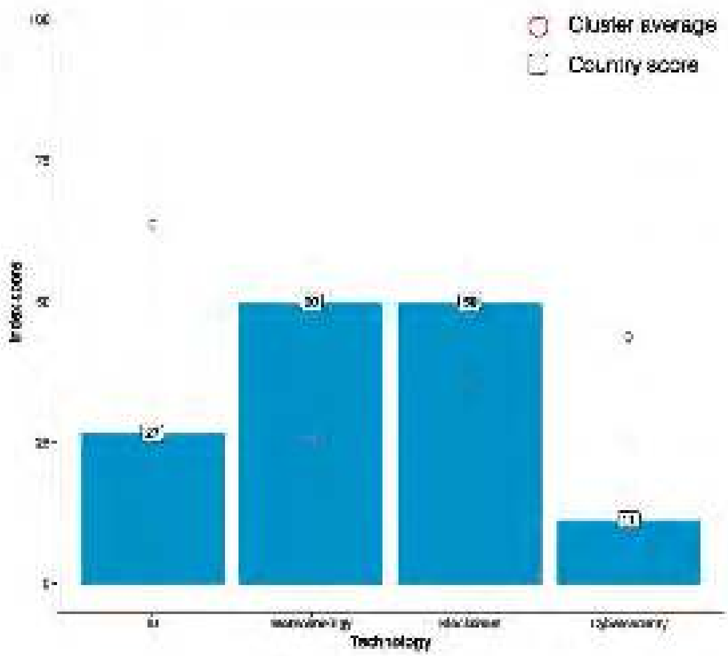
Volume of discussions and engagement level associated with the four key technologies for the future in South Africa



The online activity trend over time for South Africa shows a major relevant peak in engagement related to biotechnology (RDI and science) triggered by the world's first 3D printed heart with blood vessels, ventricles and chambers using human tissue.[1] As for the trend in online activity over time, it does not reflect any relevant peak in terms of mentions.

Global Technology Awareness Index: South Africa

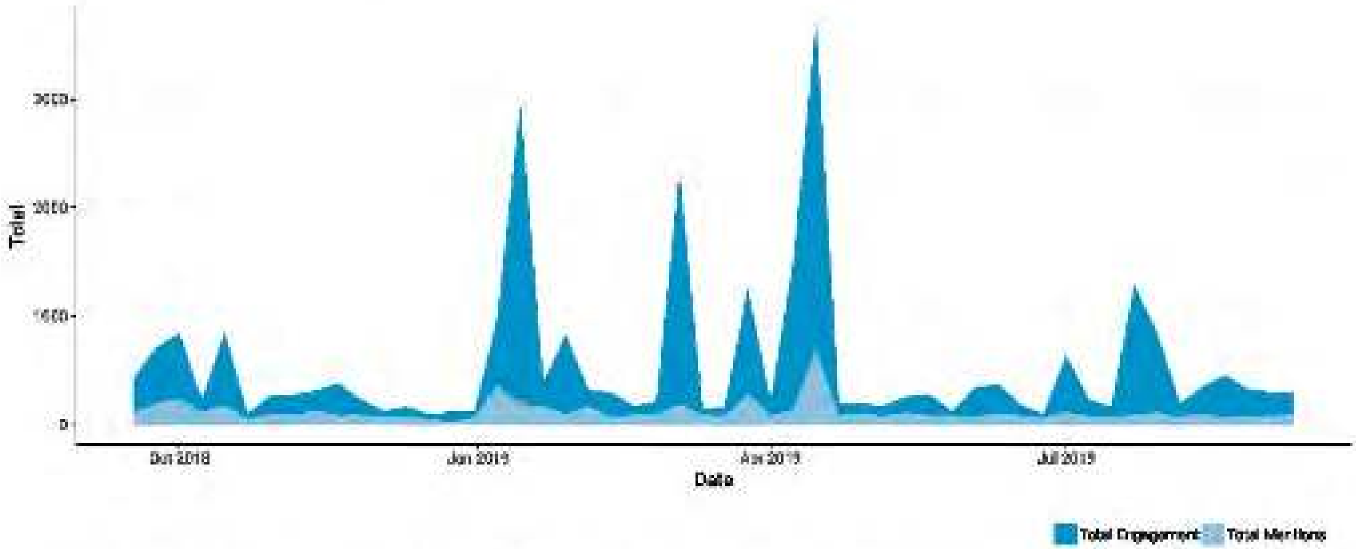
South Africa outperforms the online activity cluster average in two out of four technology fields. In terms of activity distribution within the country, South Africa displays a level of online activity above the cluster average in terms of biotechnology and blockchain, while it performs below the cluster average for AI and cybersecurity.



Future skills awareness

Total online activity in the area of future skills in South Africa is lower than that relating to the technologies of the future. The online community presents a low level of online activity in this area, with an average of 466.4 mentions and 1,657.5 instances of engagement per month.

Volume of discussions and engagement level associated with future skills in South Africa



The trend in online activity over time for South Africa shows a number of relevant peaks in engagements and mentions mainly related to education. The results associated with these peaks are mainly attributed to national and international news on issues of public education. Namely, in terms of engagement, activity in one of the peaks was concentrated on the Africa Code Week 2018 that exceeded all expectations by empowering 2.3 million young people across 37 African countries with digital and coding skills.[4] The second peak in activity, which matched the peak in mentions, mostly concerned a tweet by Panyaza Lesufi, a South African politician, presenting the launch of a "skills school to teach and train learners so that they can be technicians and artisans".[5]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

South Africa exhibits average performance in terms of its knowledge infrastructure, technology and future skills awareness, with a weak-to-average score across most dimensions.

Overview of South Africa's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★★☆☆☆	★★★☆☆	★★☆☆☆	★★☆☆☆	★★☆☆☆	★★★☆☆	★★★☆☆
Technology awareness	★★☆☆☆	★★☆☆☆			★★★☆☆	★★★★☆	★★★☆☆
Future skills awareness	★★★★☆	★★☆☆☆			★★☆☆☆	★★☆☆☆	★★★★☆

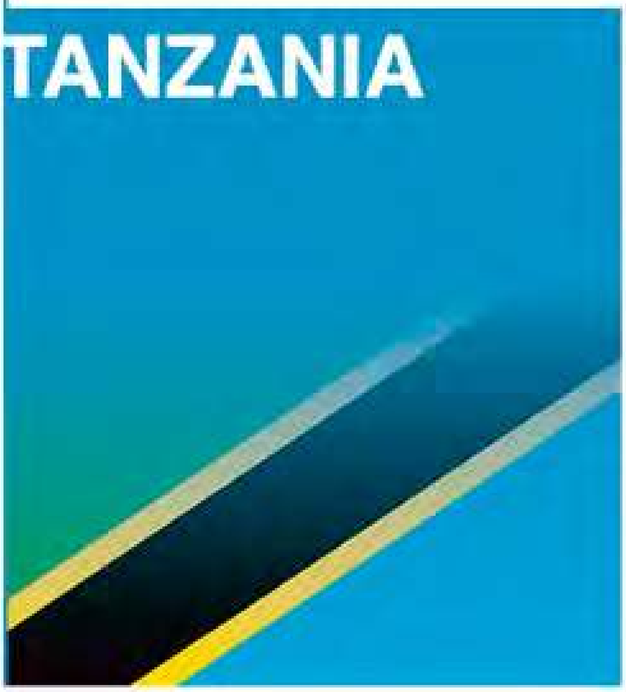
Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval): 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

South Africa's high technology awareness score in RDI and science is driven by international and regional research in AI, a keen interest locally in digital currencies, and especially high engagement triggered by two key biotechnology breakthroughs (the 3D printing of a human heart[4] and a solution to beetles killing South Africa's trees[5]). Larger news sources within the country reporting on major international news and developments (e.g. the Pentagon admitting that "it will lose to China on AI if it doesn't make some big changes"[6]) as well as a general regional focus across the continent of Africa (e.g. Google taking on 'Africa's challenges' with first AI centre in Ghana[7]). As for blockchain, there appears to be significant local interest, as evidenced from articles such as "Why South Africans are obsessed with Bitcoin",[8] events and conferences such as the Blockchain and AI Conference held in South Africa,[9] as well as the creation of Safcoin, an exclusive African cryptocurrency.[10,11]

Endnotes

[1] *Tangermann, 2019.*
[2] *Africa.com, 2019.*
[3] *Losuli, 2019.*
[4] *Tangermann, 2019.*
[5] *Grobler, 2019.*
[6] *Pickrell, 2019.*
[7] *Eyewitness News, 2019.*
[8] *McKane, 2019.*
[9] *BlockchainZA, 2019.*
[10] *Opportunity, 2018.*
[11] *SAFCOIN1, 2018.*

TANZANIA



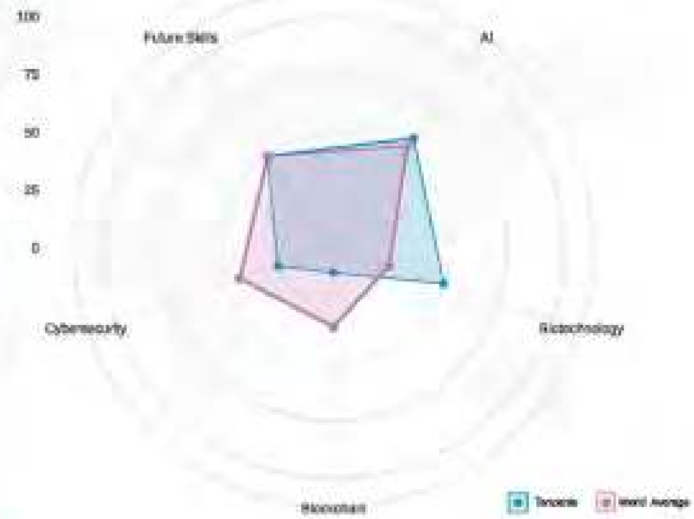
GDP per capita
$ 1,051
2018

HDI
0.538
2017

GKI
103/136
2019

215
unique authors
per million
Internet users

Future field awareness indices

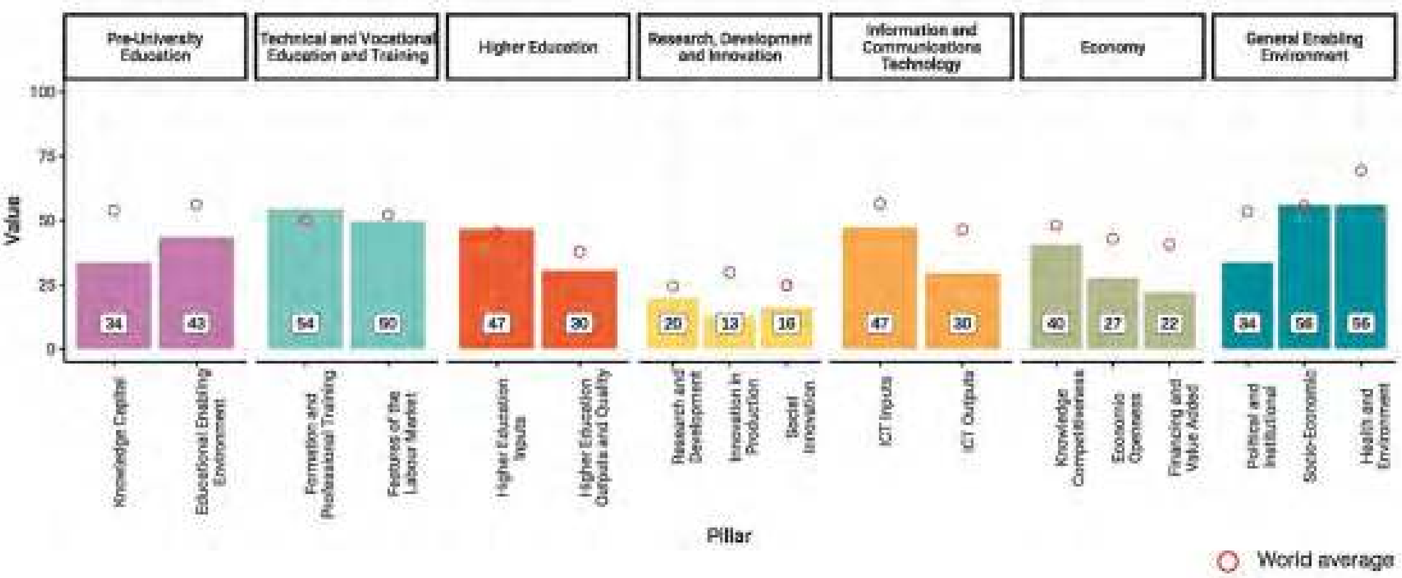


Knowledge infrastructure

Tanzania displays a moderate level of knowledge infrastructure to support technological uptake, standing alongside Lebanon and Indonesia.

Tanzania is ranked 103rd on the Global Knowledge Index, scoring below the world average. Tanzania performs above the world average in only one out of the seven sectoral indices – technical and vocational education and training. It performs strongest in terms of the structure of the labour market. Conversely, Tanzania faces challenges related to knowledge competitiveness, economic openness and politics and institutions, which may be attributed to government ineffectiveness, absence of regulatory quality, limited trade and low enrolment ratios in pre-university education.

Global Knowledge Index – Tanzania

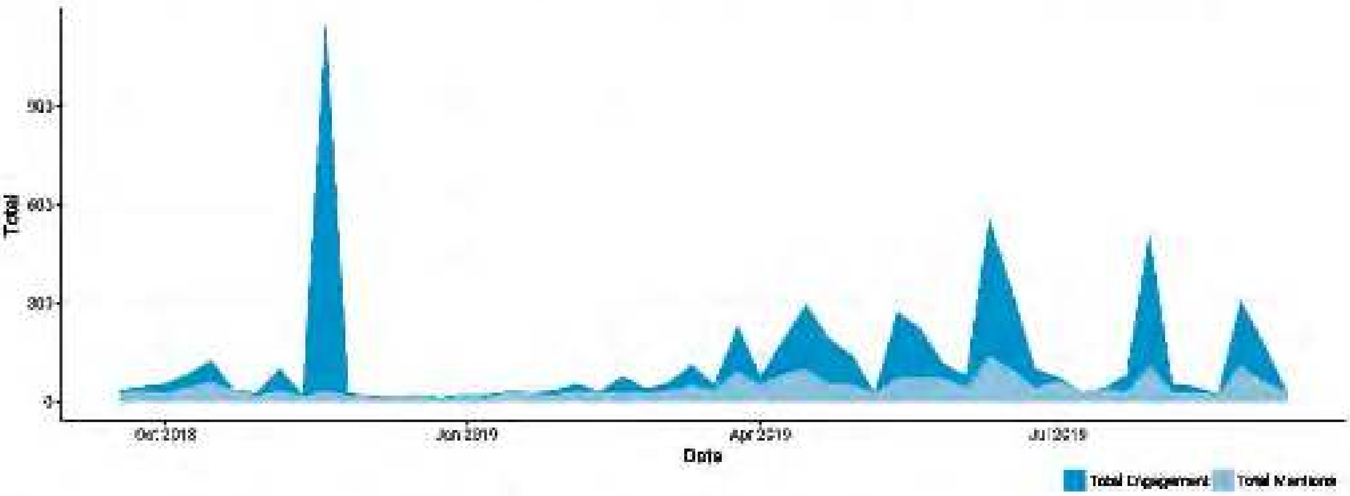


Technological awareness

25 percent of the population in Tanzania has access to the Internet, with a mean download speed of 2.3 Mbps.

Between mid-September 2018 and mid-September 2019, there were 1,356 unique authors contributing to total content generation. The volume of online activity in Tanzania within the four technology fields chosen displays an average of 175.5 mentions and 325 instances of engagement per month. Online activity within technological fields displays a degree of concentration of 0.0065. In comparative terms, 2019 presents a lower concentration than the previous sampling period, which produced a value of 0.0097.

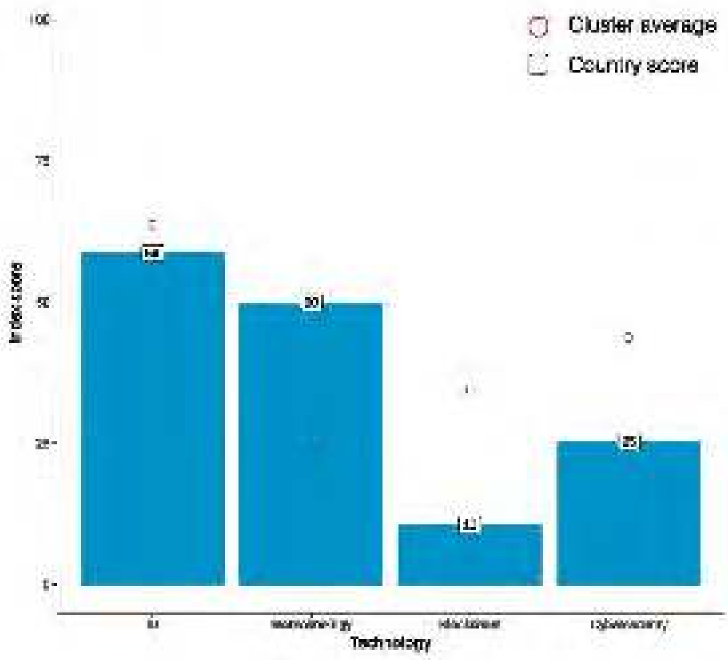
Volume of discussions and engagement level associated with the four key technologies for the future in Tanzania



The trend in online activity over time for Tanzania shows a generally low level of engagement, with one peak relating to biotechnology (enabling environment). This pertained to the Tanzanian government ordering the Tanzania Agriculture Research Institute to stop all genetically modified organism trials and destroy all test remnants.[1] A further peak in engagement and mentions from June 2019 related to AI (education) and specifically to the promotion across social media of the first hackathon on AI and machine learning to solve health challenges in Tanzania.[2]

Global Technology Awareness Index: Tanzania

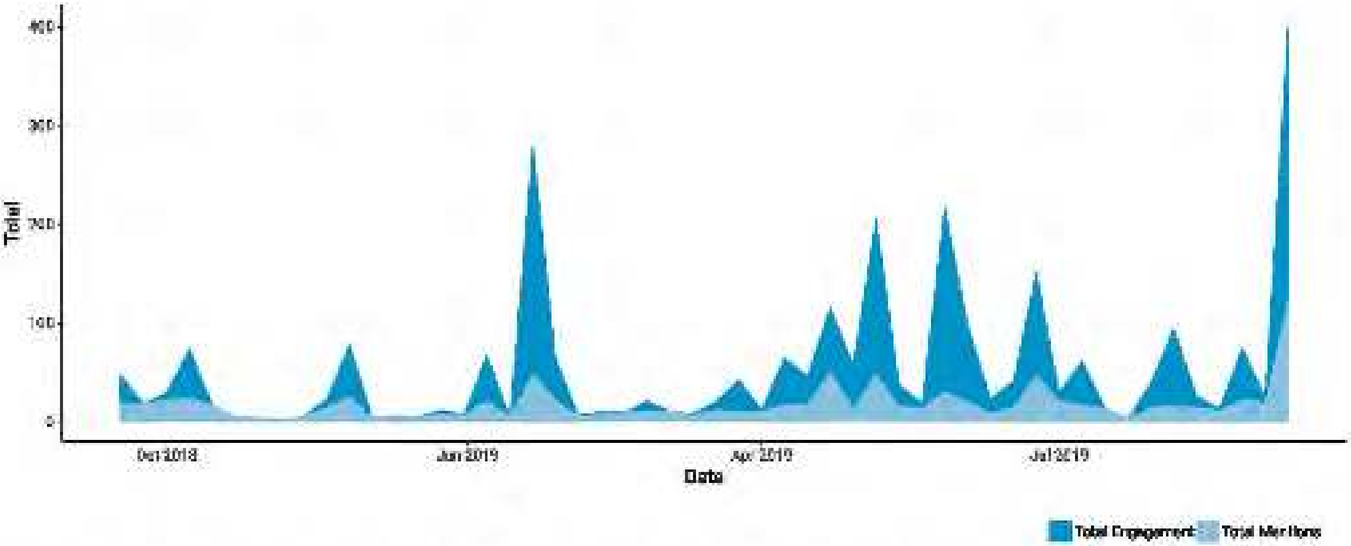
Tanzania outperforms the online activity cluster average in one out of four technology fields. In terms of activity distribution within the country, Tanzania's activity is concentrated on AI and biotechnology.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average value of 70.8 mentions and 140.8 instances of engagement per month. Total online activity in this area in Tanzania is lower than that relating to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Tanzania



The trend in online activity over time for Tanzania shows a number of relevant peaks in engagement related to education. The results associated with the largest peak pertain mainly to local news concerning the creation of 6,000 new jobs for teachers in science and mathematics and a restructuring of the tasks of teachers already in employment in response to teacher shortages.[3] A further peak is associated with the 2nd ATE Annual Leadership Conference, organized by the Association of Tanzania Employers in collaboration with UN Global Compact Network Tanzania and the Confederation of Norwegian Enterprises. The conference took place in September 2019, bringing together private sector, academia and government to develop innovative approaches to achieving gender equality in the workplace.[4]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Tanzania exhibits a rather weak performance in terms of knowledge infrastructure, technology and future skills awareness, with weak scores across most dimensions.

Overview of Tanzania's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★☆☆☆☆	★★☆☆☆	★☆☆☆☆	★★★★☆	★★☆☆☆	★★☆☆☆	★★☆☆☆
Technology awareness	★☆☆☆☆	★★☆☆☆			★★☆☆☆	★☆☆☆☆	★☆☆☆☆
Future skills awareness	★★★☆☆	★★☆☆☆			★★☆☆☆	★★☆☆☆	★★☆☆☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country has room for improvement in terms of infrastructure but also needs to prepare for the future in skills and technologies. Biotechnology is an area in which signs of progress can be expected in the coming years – as indicated by the World Health Organization's recent announcement that Tanzania is the first African country to achieve a well-functioning regulatory system for medical products. This analysis is a result of a global benchmarking tool that uses more than 200 indicators, such as market surveillance and adverse event reporting.[5]

While the scores relating to RDI and science, and economy, under technology awareness are low, there are signs of progress. An example is the discussion around the Tanzan AI Lab, which opened its doors in May 2019. The organization aims to facilitate collaborations and "build a strong AI community and ecosystem in Tanzania."[6] The Lab plans to provide a series of workshops to deliver necessary AI skills.

Online activity also relates to the Z-Roads project – an AI solution for automating road condition analysis via deep learning. It provides a solution for monitoring the road conditions in a fast-growing country such as Tanzania, where this is otherwise challenging and expensive, especially in rural areas. "The project is a collaboration between DFID [the UK Department of International Development] and consultants based at the University of Nottingham, that investigates application of state-of-the-art machine learning techniques to automatically classify road conditions" with the help of drone imagery.[7] The programme aims to build connections with the tech innovation ecosystem in Dar Es Salaam in order to best support the integration of new technological solutions locally, organizing sessions in June 2019 with 'skills in the future workforce' being the main topic of discussion.[8]

Endnotes

[1] *Mirondo, 2018.*
[2] *DrMgute, 2019.*
[3] *Udaku Special, 2019.*
[4] *Association of Tanzania Employers, 2019.*
[5] *The Pharma Letter, 2018.*
[6] *See: https://ailab.co.tz/index.html.*
[7] *Goulding, 2018.*
[8] *Jones, 2019.*

CLUSTER
03

TURKEY

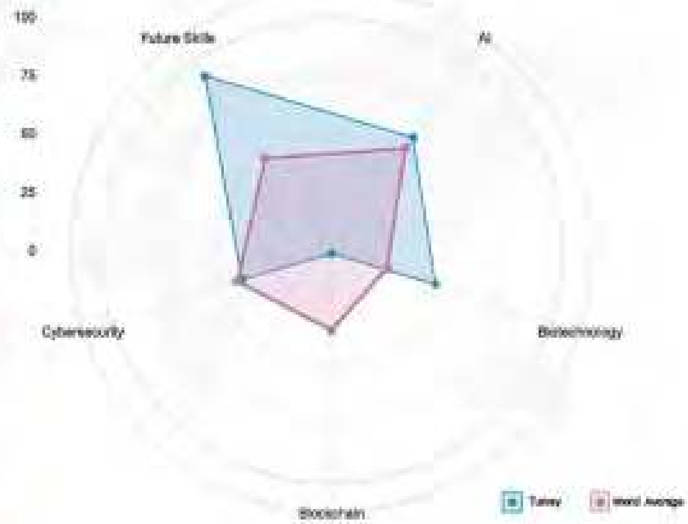
GDP per capita
$ 9,311
2016

HDI
0.791
2017

GKI
72/136
2019

2080
unique authors
per million
Internet users

Future field awareness indices

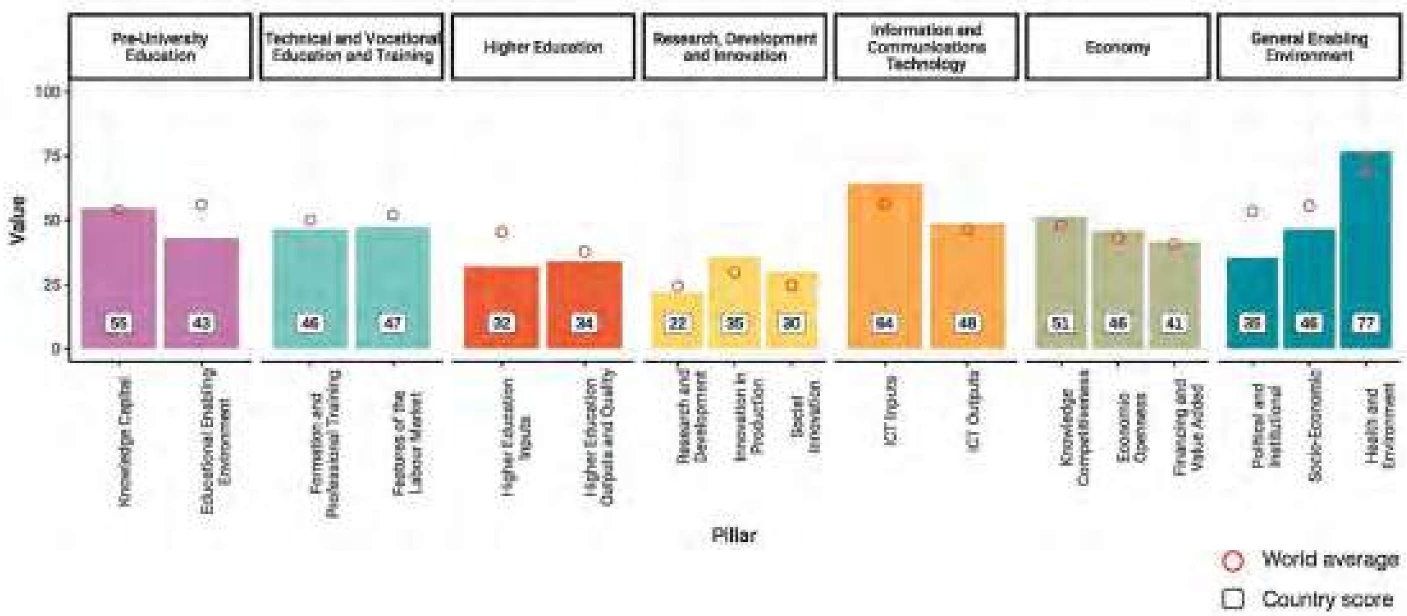


Knowledge infrastructure

Turkey is amongst those countries with moderate knowledge infrastructure to support technological uptake, standing alongside India and Jordan.

Turkey is ranked 72nd on the Global Knowledge Index and scores slightly below the world average. Turkey performs above the world average in three out of the seven sectoral indices, namely economy, ICT and RDI. It performs strongly in areas related to innovation in production and economic infrastructure and competition. Conversely, Turkey faces challenges related to poor higher education inputs, weak institutions and gender disparities.

Global Knowledge Index – Turkey

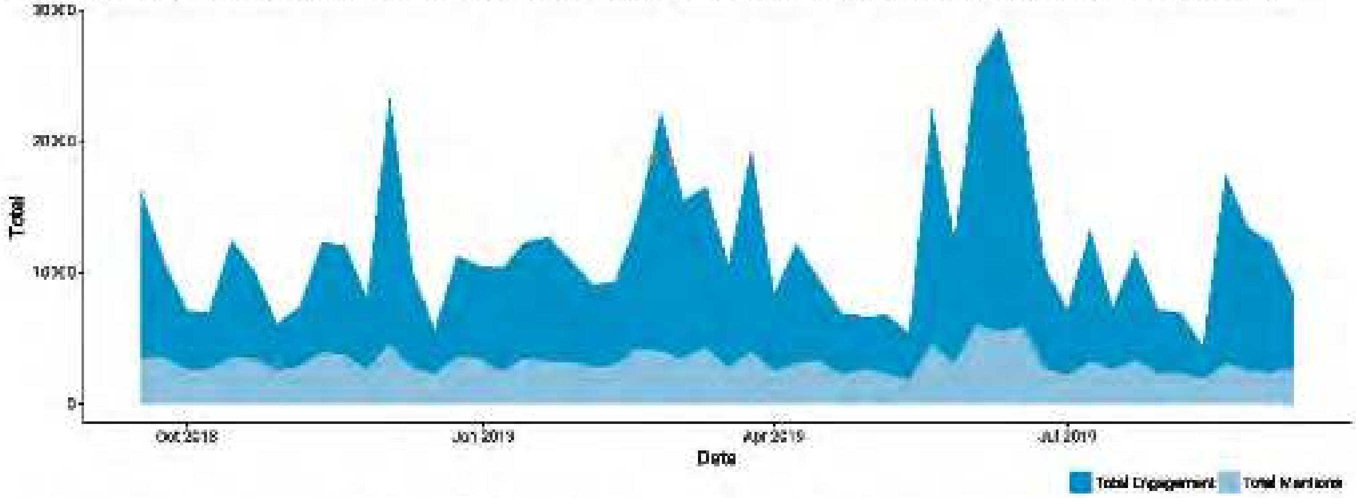


Technological awareness

71 percent of the Turkish population has access to the Internet, with a mean download speed of 5.3 Mbps.

Between mid-September 2018 and mid-September 2019, there were 121,683 unique authors contributing to total content generation. The volume of online activity in Turkey within the four technology fields chosen displays an average of 12,611.6 mentions and 34,893.8 instances of engagement per month. Online activity within technological fields displays a degree of concentration of 0.00022. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.00035.

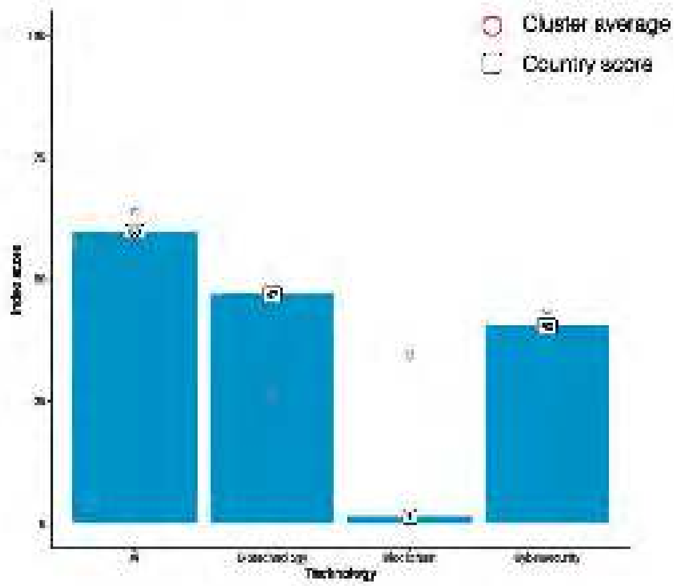
Volume of discussions and engagement level associated with the four key technologies for the future in Turkey



The online activity trend over time for Turkey shows several peaks in engagement and mentions, mainly concerning biotechnology (economy) and AI (enabling environment and education). The results related to these peaks mostly concern local and national events and news, such as the announcement of the establishment of a biotechnology valley in Tuzla and a technology development centre in Pendik.[1] One of the larger peaks in engagement and mentions from December 2018 pertained to the promotion of the 13th International MEB Robot Competition, organised by the Directorate of Vocational and Technical Education of the Ministry of Education. The event took place in April 2019 in Samsun, Turkey, under the theme of Artificial Intelligence, with 198 participants competing in several different categories, including Industrial Robotic Arms, Mini Drones, Humanoid Robots and more.[2] Further developments in terms of research facilitation were reported in June 2019, with the Turkish Council of Higher Education launching artificial intelligence departments at different universities. This includes the opening of new doctoral programmes for nanotechnology and big data.[3] A less expressed peak in mentions from August 2019 concerned the head of the defence industry's visit to Turkey's largest Cyber Security Summer Camp in Ankara.[4]

Global Technology Awareness Index: Turkey

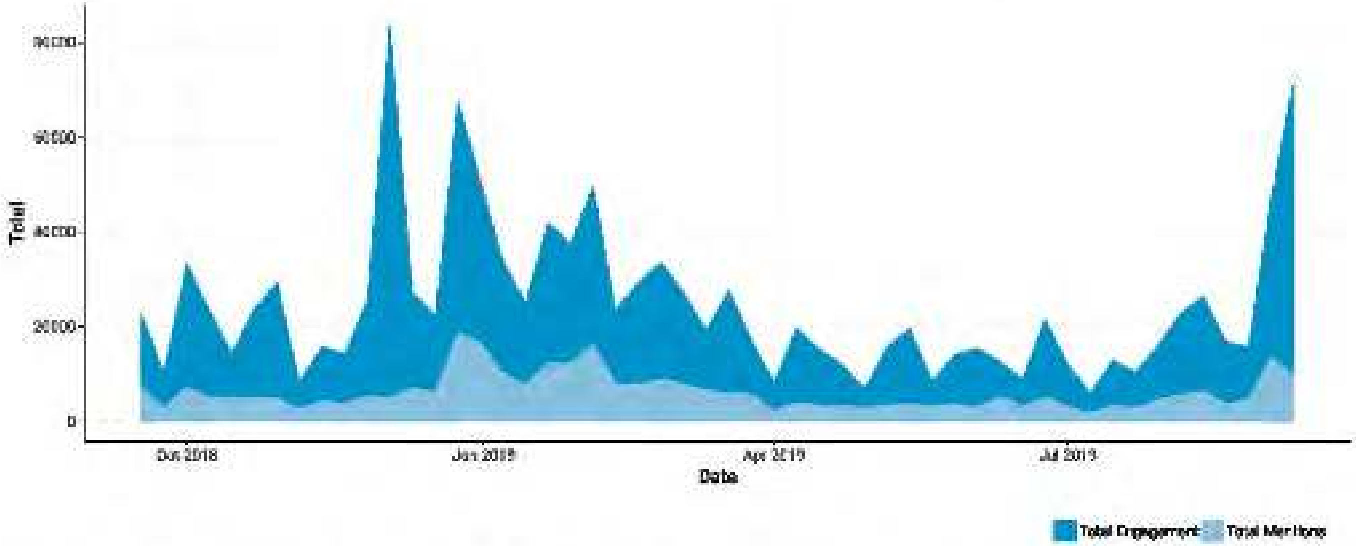
Turkey outperforms the online activity cluster average in one out of the four technology fields. In terms of activity distribution within the country, discussion in Turkey was balanced across AI, biotechnology and cybersecurity, with blockchain being the least prominent.



Future skills awareness

Total online activity for future skills in the area of future skills in Turkey is higher than that relating to technology awareness. The volume of online activity relating to this area displays an average value of 24,914.2 mentions and 73,373.8 instances of engagement per month.

Volume of discussions and engagement level associated with future skills in Turkey



The online activity trend over time for Turkey shows several peaks in engagement and mentions, relating to education, and RDI and science. The results concerning the major peaks in engagement and mentions from December 2018 and January 2019 pertained to local and international news. A group of Turkish students participated in the 2018 World Robot Competition, held in Shanghai, China, demonstrating their skills in robotics coding.[5] In terms of local news, the national budget negotiations concerning public education and funding for universities were linked to a spike in online activity.[6] A number of peaks in engagement and mentions over the course of 2019 were related to the topic of teacher shortages. A major peak from September 2019 pertains to social media posts concerning the discrepancy between the teacher shortage and a large number of teachers awaiting employment. The online discussions intensified in the context of national news of the appointment of only 20,000 teachers during the 2017–2018 academic year, amid an estimated shortage of 100,000.[7]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Turkey exhibits a rather moderate performance in terms of its knowledge infrastructure, across most sectors, with poor performance on the higher education, and technical and vocational education and training sectoral indices. In terms of awareness, Turkey displays an average performance, with education being the strongest dimension.

Overview of Turkey's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★★★★☆	★★☆☆☆	★★☆☆☆	★★☆☆☆	★★☆☆☆	★★★★☆	★★★☆☆
Technology awareness	★★★☆☆	★★★★★			★★☆☆☆	★★☆☆☆	★★★☆☆
Future skills awareness	★☆☆☆☆	★★★★★			★☆☆☆☆	★★★★★	★★☆☆☆

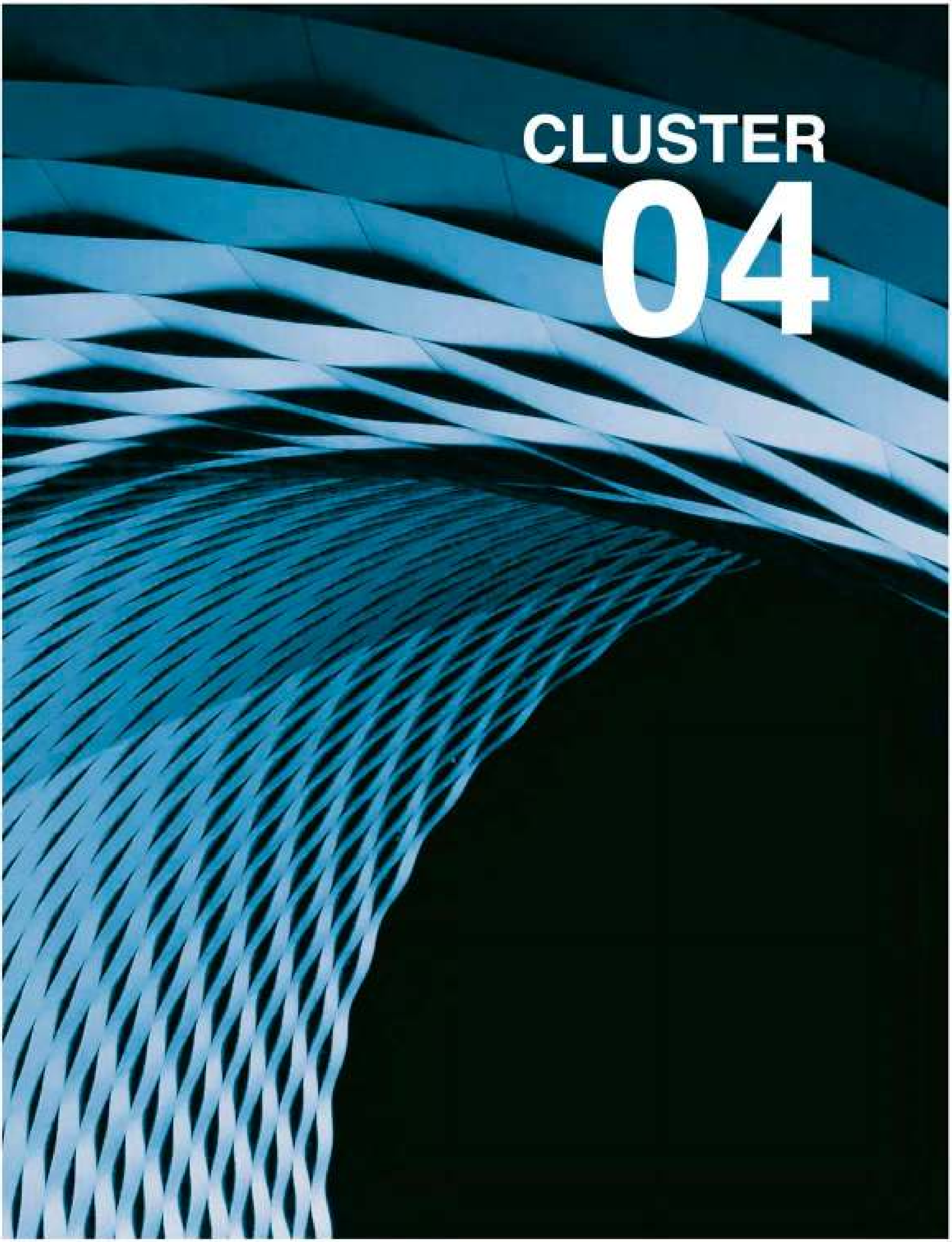
Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval); five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Future skills awareness is particularly high for RDI and science due to three factors driving the conversation and engagement online in Turkey: statements from the Minister of National Education, Ziya Selçuk; news on university rankings (based on learning environment and research environment); and news about research undertaken by the Ministry of National Education in Turkey – the ABİDE study.[8]

In general, there are multiple discussions and debates surrounding Turkey's performance in education. The ABİDE study highlighted the low performance of Turkish students, especially in mathematics and Turkish.[9] Likewise, various articles discussed the performance of Turkish universities, mainly concerning the ranking by Times Higher Education in which only two Turkish universities were featured in the top 500 (Sabancı University and Koç University).[10] Lastly, was a peak caused by a plethora of articles relating to Selçuk and the statements/commitments he has made (education is not only important; it is extremely valuable to society,[11] 2023 Education Vision,[12] need for individualized/personalized learning[13]). Overall in the Turkish media, we see high awareness around the need for research, development and innovation in future skills and in pedagogy in general.

Endnotes

[1] *BA_Yildrim, 2019.*
[2] *See: http://robot.meb.gov.tr/home.*
[3] *Çakmakcı, 2019.*
[4] *My Net, 2019.*
[5] *Ahaber, 2018.*
[6] *Turkey Haber, 2018.*
[7] *Akyüz, 2019.*
[8] *Karakas and Bellut, 2019.*
[9] *Time Turk, 2019.*
[10] *Akdif Haber, 2018.*
[11] *My Net, 2018.*
[12] *Bir Gun, 2018.*
[13] *@NazmiAvci11, 2018.*



CLUSTER 04

Modest knowledge infrastructure cluster

27 modest knowledge infrastructure countries

- Angola
- Bangladesh
- Benin
- Burkina Faso
- Burundi
- Cameroon
- Chad
- Congo (Democratic Republic of the)
- Côte d'Ivoire
- Eswatini (Kingdom of)
- Ethiopia
- Gambia
- Guinea
- Lesotho
- Madagascar
- Malawi
- Mali
- Mauritania
- Mozambique
- Myanmar
- Pakistan
- Senegal
- Syrian Arab Republic
- Tajikistan
- Togo
- Uganda
- Venezuela (Bolivarian Republic of)

The countries in this cluster are characterized by average GKI scores of between 19.1 and 35.3, with world rankings ranging from 110 to 136. Within this cluster, country performances are similar in RDI with all countries scoring below the world average and with high variation in scores relating to pre-university education.

Hence, this cluster includes countries that display a lower average performance in all sectors examined and especially in terms of ICT and general enabling environment. This cluster faces major challenges in the general enabling environment, with none of the countries scoring above the world average.

The following section presents the country profiles of the five countries of this cluster: Bangladesh, Cameroon, Ethiopia, Senegal and Tajikistan

Bangladesh

Cameroon

Ethiopia

Senegal

Tajikistan

CLUSTER
04

BANGLADESH

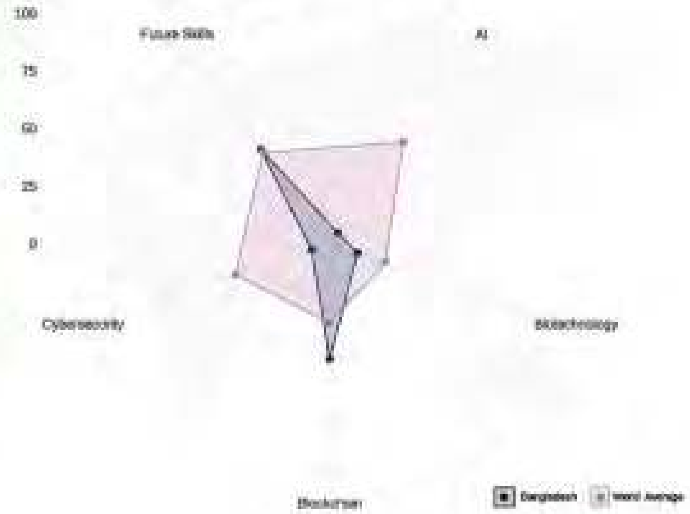
GDP per capita
$ 1,698
2018

HDI
0.608
2017

GKI
112/136
2019

350
unique authors
per million
Internet users

Future field awareness indices

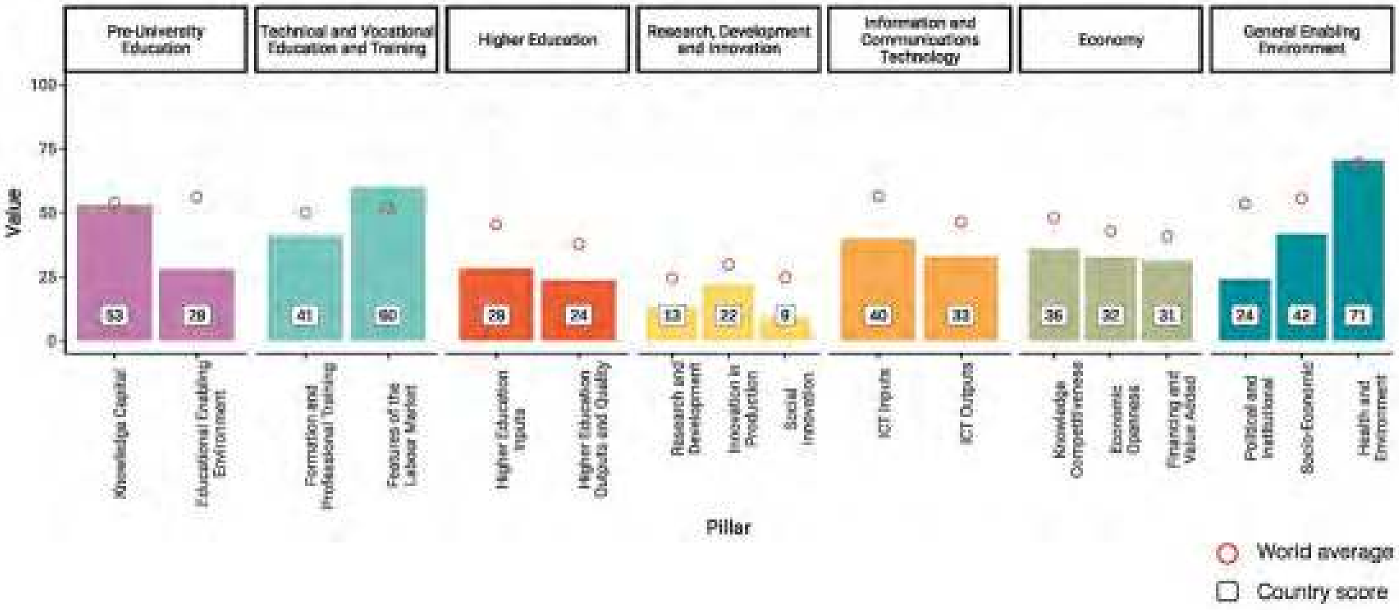


Knowledge infrastructure

Bangladesh is amongst those countries with modest knowledge infrastructure to support technological uptake, such as Cameroon and Ethiopia.

Bangladesh is ranked 112th on the Global Knowledge Index, scoring below the world average on all sectoral indices. The challenges it faces are mainly related to political unrest, weak regulatory quality and rigid technological infrastructure. Furthermore, the education system is unable to create, localize and disseminate knowledge – a result of the poor enabling environment for education. Despite all these challenges, the structure of the labour market is a promising area for investment in Bangladesh.

Global Knowledge Index – Bangladesh

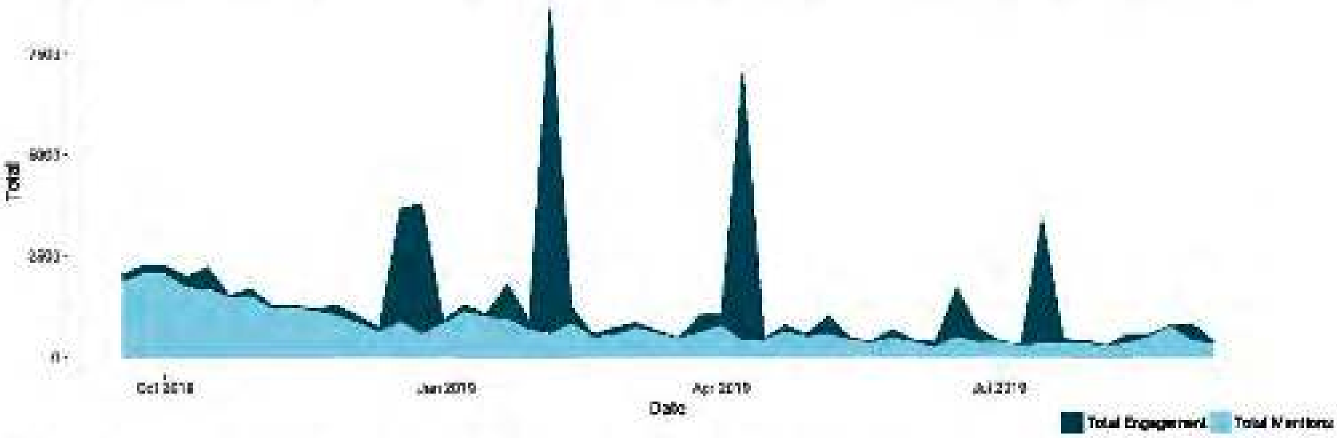


Technological awareness

15 percent of the Bangladeshi population have access to the Internet, with a mean download speed of 2.7 Mbps.

Between mid-September 2018 and mid-September 2019, there were 5,301 unique authors contributing to total content generation. The volume of online activity in Bangladesh within the four technology fields chosen displays an average of 3,031.8 mentions and 2,576.8 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0015. In comparative terms, 2019 presents a similar degree of concentration to the previous sampling period.

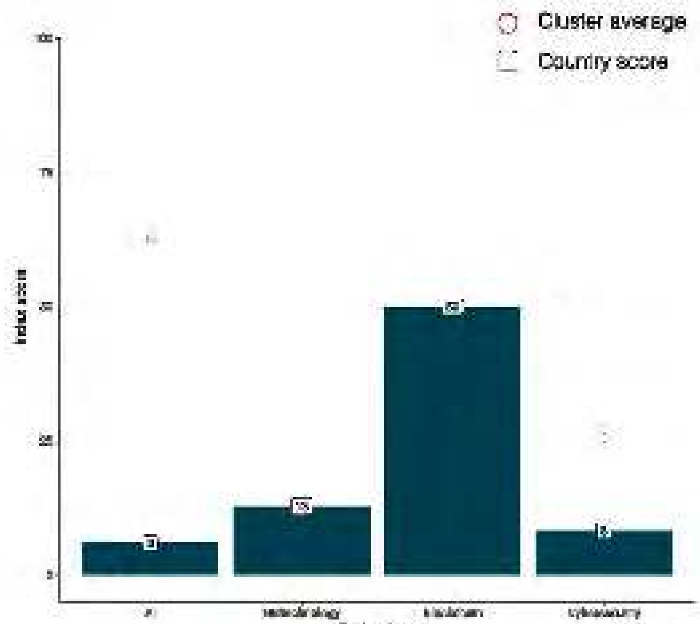
Volume of discussions and engagement level associated with the four key technologies for the future in Bangladesh



The trend in online activity over time for Bangladesh shows several peaks in engagement. The first peak pertains to biotechnology (RDI and science) and more specifically to the publication by BioMed Central – a UK-based journal – of the work of a team of Bangladeshi researchers who decoded the genome sequence of the hilsa fish in September 2018, enabling new insight into previously unknown aspects of its life, including its ability to survive in both salt and fresh water.[1] The second peak was related to the field of cybersecurity (enabling environment), and concerned a study that ranks the country as one of the least safe in terms of cybersecurity.[2] The third peak in engagement partially relates to the first image taken of a black hole.[3] The last peaks relate to Posts, Telecommunications and Information Technology Minister Mostafa Jabbar, who said that the Bangladesh Post Office aims to become an exemplary institution in South Asia by integrating new technologies in its services and training staff.[4] The peak in mentions at the beginning of the observation period relates to various discussions around blockchain and cryptocurrencies, especially those inspired by conferences on these topics taking place in the region (e.g. Blockchain Solutions Asia,[5] Blocfest 2018[6] and Southeast Asia Blockchain Summit[7]).

Global Technology Awareness Index: Bangladesh

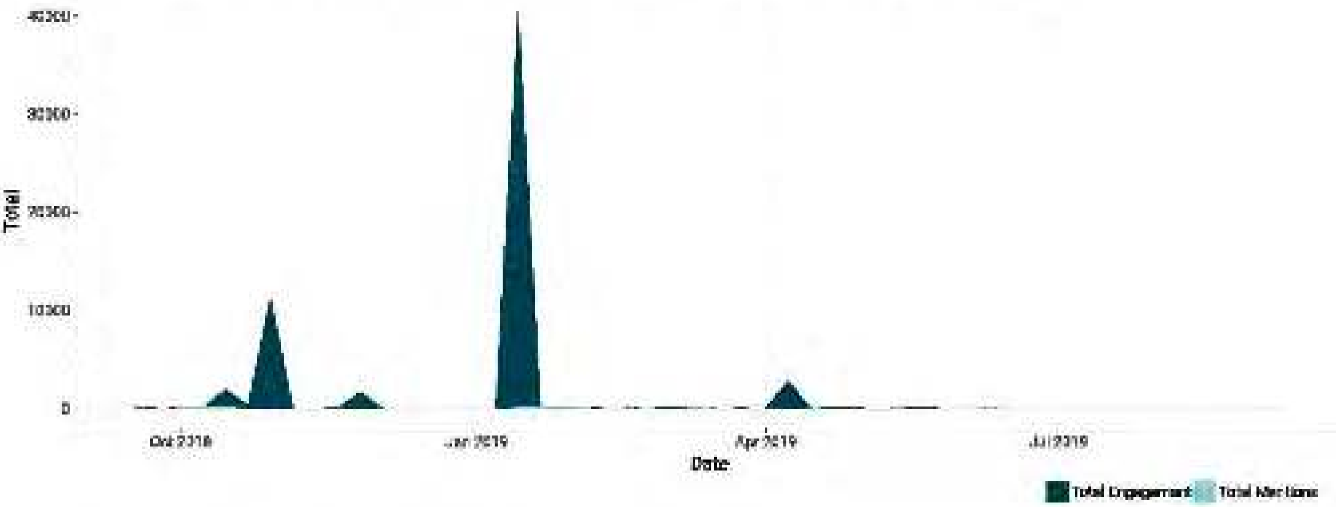
Bangladesh outperforms the online activity cluster average in two out of the four technology fields. In terms of in-country activity distribution, Bangladesh's discussions are mainly oriented towards blockchain, while online activity related to AI, cybersecurity and biotechnology is less prominent.



Future skills awareness

Total online activity in the area of future skills in Bangladesh is lower in terms of mentions and higher in terms of instances of engagement than that relating to technologies of the future. The online community presents a moderate level of online activity on the topic, with an average value of 77.8 mentions and 4,520.5 instances of engagement per month.

Volume of discussions and engagement level associated with future skills in Bangladesh



The trend in online activity over time for Bangladesh shows important online activity relating to education, inspired by the lack of properly trained teachers in the country. While there has been significant investment allocated to improve education, the country faces challenges in implementing many reforms, and progress is being hampered by funding problems and inadequate school infrastructure. As a result, classrooms are overcrowded and teachers are often poorly trained.[8] The major peak in online activity at the beginning of 2019 relates also to the strict warning issued by the Prime Minister, Sheikh Hasina Wazed, to government physicians and nurses to do their duties properly or quit their jobs. This statement followed allegations that doctors were not fulfilling their duties in government hospitals across the country. Wazed proposed a series of measures to address this issue and, notably, instructed the Ministry of Health to enhance its oversight of private medical colleges to ensure that students receive instruction of sufficient quality to become capable physicians.[9]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Bangladesh performs well in terms of its future skills awareness, while performance in its knowledge infrastructure and technology awareness is rather weak, with low to average scores across most dimensions.

Overview of Bangladesh's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆	★★☆☆☆	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆
Technology awareness	★★★★☆	★★☆☆☆			★★★☆☆	★★☆☆☆	★★☆☆☆
Future skills awareness	★★★★★	★★★★★			★★★★★	★★★★☆	★☆☆☆☆

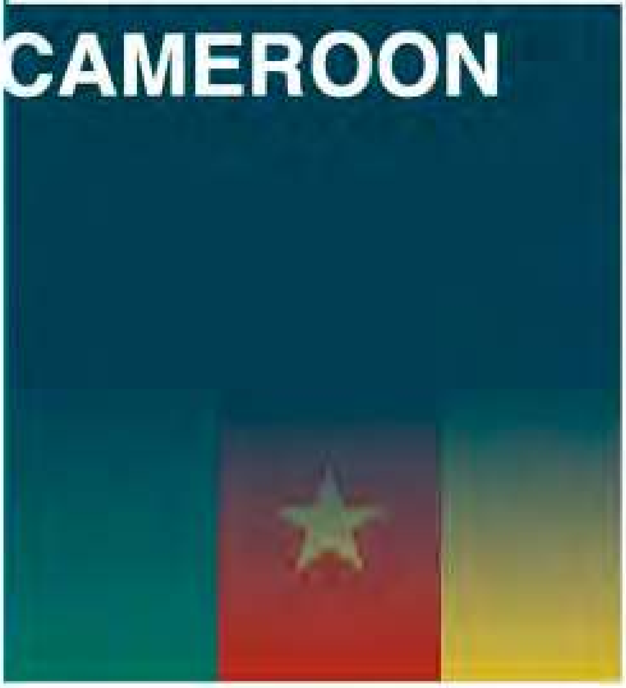
Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Bangladesh's strong scores in future skills awareness is a result of media coverage concerning key issues in education in Bangladesh and the need to address them with research, funding and skilled educators in order to develop in the future.[10,11,12] Particularly important discussions related to the lack of skilled teachers, especially in higher education, which accounts for a majority of the mentions and engagement.[13,14,15,16] Other problems are also discussed, such as socioeconomic[17] issues and lack of funds.[18] While Bangladesh may face infrastructural deficits in education, online awareness around the need for research, reform and innovation is strong.

Endnotes

[1] *The Daily Star, 2019b.*
[2] *Prothom Alo, 2019.*
[3] *BBC News, 2019b.*
[4] *Bangla News 24, 2019a.*
[5] *See: http://www.blockchainsolutionsasia.com.*
[6] *See: https://www.blocfest.asia/.*
[7] *See: https://southeastasiablockchain.com/.*
[8] *Alamgir, 2018; and Islam, 2019.*
[9] *The Daily Star, 2019a.*
[10] *Bangladesh Sangbad Sangstha, 2019.*
[11] *Jugantor, 2019a.*
[12] *United News of Bangladesh, 2019.*
[13] *Salman, 2019.*
[14] *Bangla News 24, 2019b.*
[15] *Jugantor, 2019b.*
[16] *Bangla Tribune, 2019.*
[17] *New Age Bangladesh, 2019.*
[18] *The Financial Express, 2019.*

CAMEROON



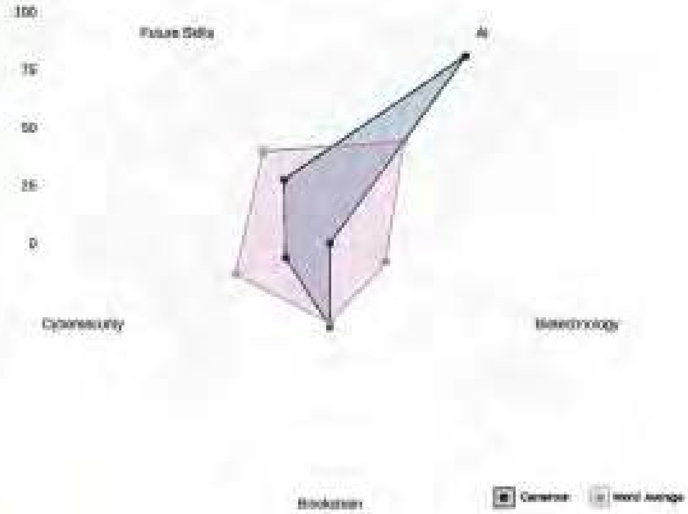
GDP per capita
$ 1,527
2018

HDI
0.556
2017

GKI
117/136
2019

184
unique authors
per million
Internet users

Future field awareness indices

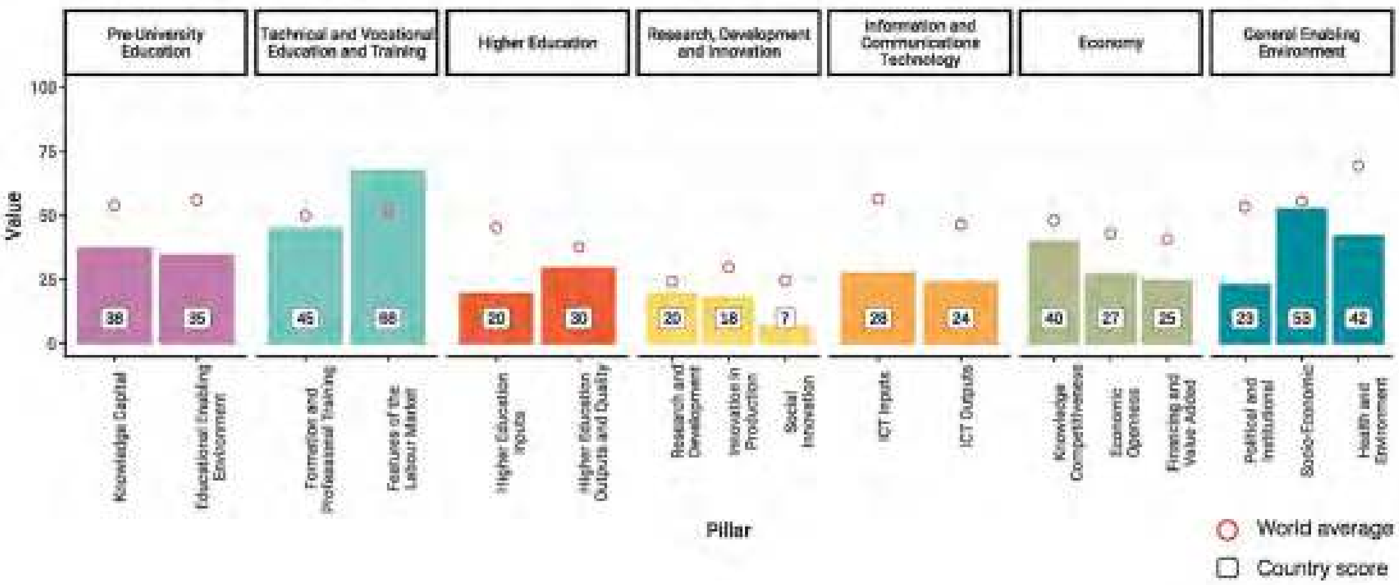


Knowledge infrastructure

Cameroon is amongst those countries with modest knowledge infrastructure to support technological uptake, such as Bangladesh and Tanzania.

Cameroon is ranked 117th on the Global Knowledge Index and scores below the world average. Cameroon performs above the world average in only one sectoral index (out of seven) – technical and vocational education and training. The challenges it faces are mainly related to political instability, the ineffectiveness of the government, and low health and environmental standards. Furthermore, the educational system in Cameroon is unable to create, localize and disseminate knowledge, as inferred by the pre-university and higher education results.

Global Knowledge Index – Cameroon

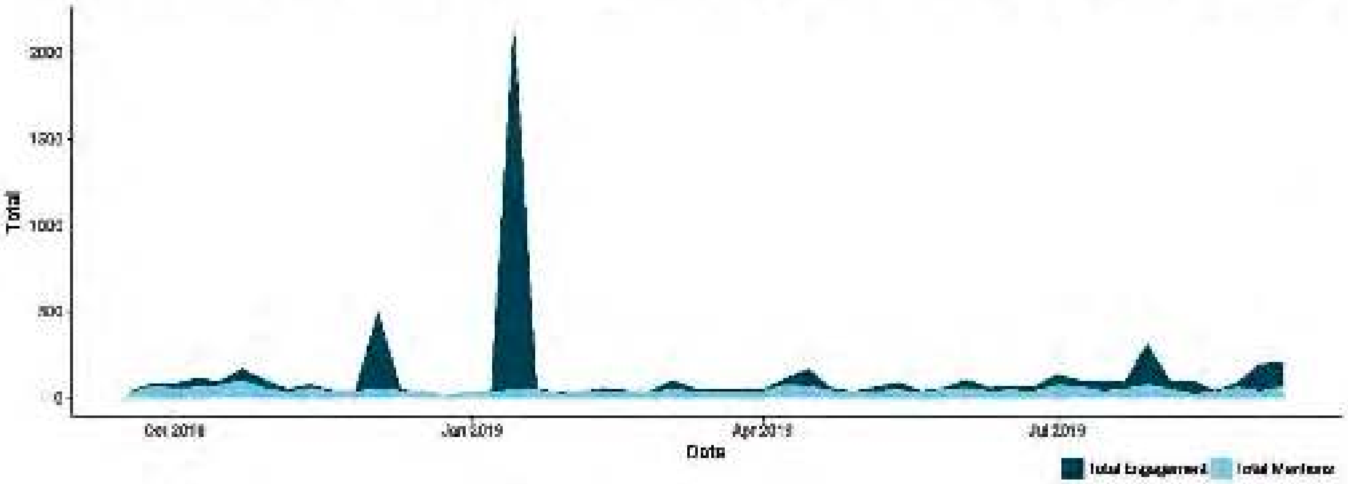


Technological awareness

23.2 percent of Cameroon's population have access to the Internet, with a mean download speed of 1 Mbps.

Between mid-September 2018 and mid-September 2019, there were 1,046 unique authors contributing to total content generation. The volume of online activity in Cameroon within the four technology fields chosen displays an average of 187.9 mentions and 325.9 instances of engagement per month. Online activity within technological fields displays a degree of concentration of 0.0051. In comparative terms, 2019 presents a lower degree of concentration than the previous sampling period, which produced a value of 0.046.

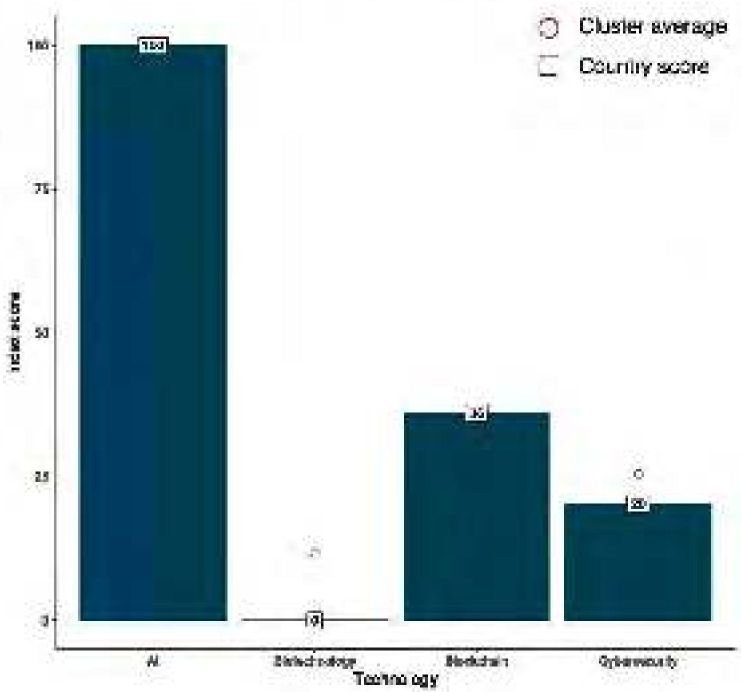
Volume of discussions and engagement level associated with the four key technologies for the future in Cameroon



The online activity trend over time for Cameroon shows two relevant peaks, one in mentions in the field of cybersecurity (RDI and science) and one in engagement in the field of AI (economy). The peak in mentions mainly pertains to the Africa Cyber Security Conference[1] that was held in October 2018 in Abidjan. The results associated with the peak in engagement relate to a young entrepreneur who launched Algo Drone – having successfully closed his fundraising operation, announced in early 2018, upon reaching 1.3 billion CFA francs (around EUR 2 million) – in order to supply the international market with the Cyclop algorithm-powered drone 'made in Cameroon'.[2]

Global Technology Awareness Index: Cameroon

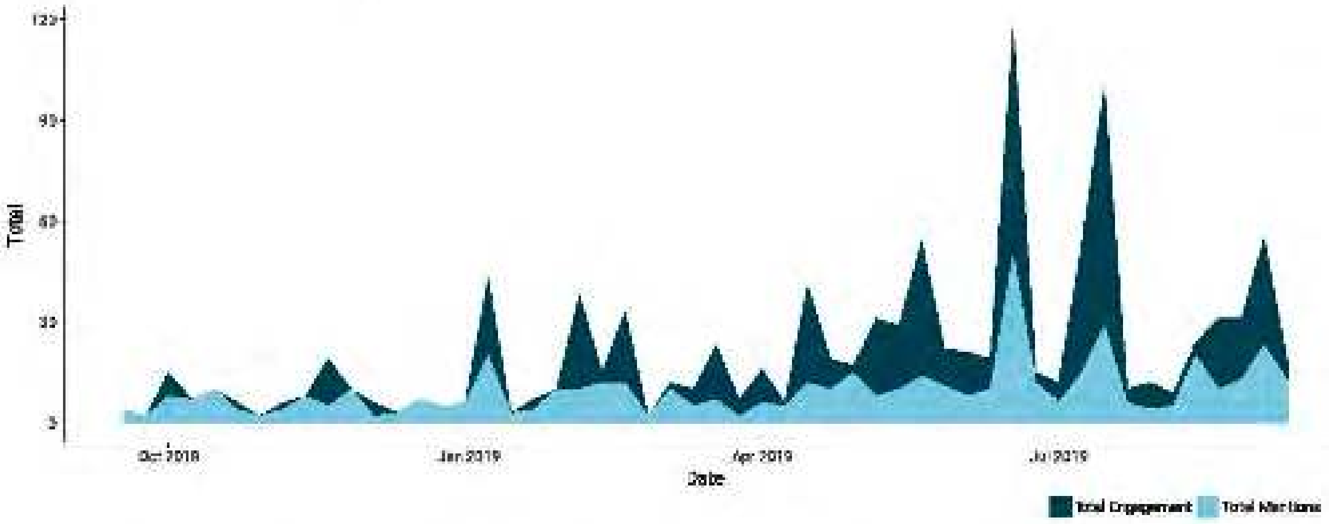
Cameroon outperforms the online activity cluster average in two out of four technology fields in terms of online activity. Regarding activity distribution within the country, Cameroon displays strong online activity results for topics in the area of AI. Blockchain and cybersecurity are also discussed, but to a lesser degree, with biotechnology being the least prominent.



Future skills awareness

Total online activity in the area of future skills in Cameroon is lower than that relating to the technologies of the future. The online community exhibits a low level of online activity concerning this topic, with an average value of 38.4 mentions and 44.9 instances of engagement per month.

Volume of discussions and engagement level associated with future skills in Cameroon



The online activity trend over time for Cameroon shows several peaks in engagement and mentions; the results associated with those occurring in the end of June 2019 mainly pertain to discussions around an online platform, EduClick, where teachers can publish lessons in an audio-visual format to help educate children who cannot follow a conventional learning process due to poverty or conflict.[3] Overall, online activity in Cameroon was mostly sparked by national and international African news and articles on conferences and workshops such as the WordPress Development Bootcamp[4] in ActivSpaces.[5]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Cameroon exhibits weak performance, especially in terms of its knowledge infrastructure, with weak-to-average scores across most dimensions.

Overview of Cameroon's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆	★★★★☆	★☆☆☆☆	★★☆☆☆	★☆☆☆☆
Technology awareness	★★★★☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★★☆☆☆
Future skills awareness	★★★☆☆	★☆☆☆☆			★★☆☆☆	★☆☆☆☆	★★★☆☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval): 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

An examination of the results of the economy dimension across the four technologies reveals two main drivers boosting the score of the country. Firstly, as previously discussed, there was significantly high engagement around the progress of William Elong, a young Cameroonian entrepreneur who founded Will & Brothers, a technology consulting company, and Algo Drone Holding, an artificial intelligence and drone solutions company. Especially high engagement was triggered when Elong announced that he had raised around EUR 2 million for his operations.[6,7]

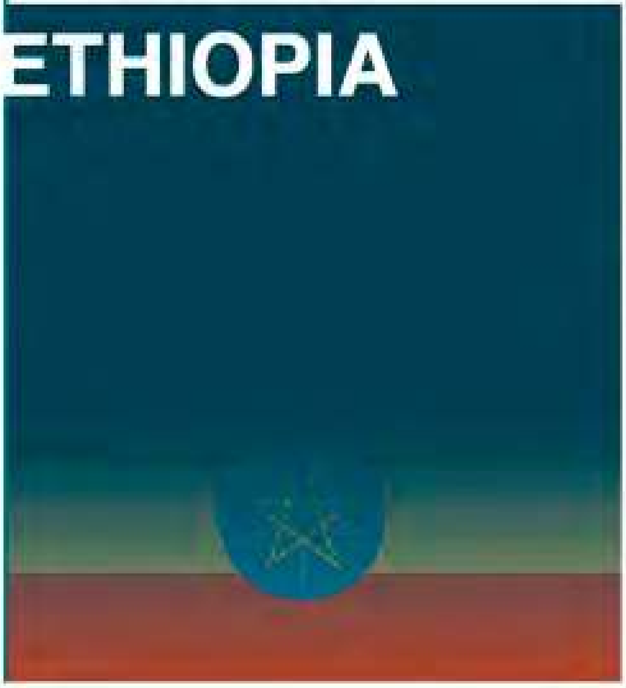
Aside from this instance of news directly related to Cameroon, we see mainly a focus on regional news and events related to investments and funding occurring throughout Africa. Reports and articles from sites such as Africa News Hub, Disrupt Africa and Agence Ecofin make up a majority of the conversations in the economy dimension in Cameroon.[8,9,10]

Endnotes

[1] *See: https://afrika-news.com/africa-cyber-security-conference-2018-in-abidjan/.*
[2] *Mbodiam, 2019.*
[3] *Messa, 2019.*
[4] *Colong, 2019.*
[5] *See: https://www.activspaces.com/.*
[6] *Djene, 2019.*
[7] *Mbodiam, 2019.*
[8] *Jackson, 2019.*
[9] *Agence Ecofin, 2019b.*
[10] *Agence Ecofin, 2019a.*

CLUSTER
04

ETHIOPIA



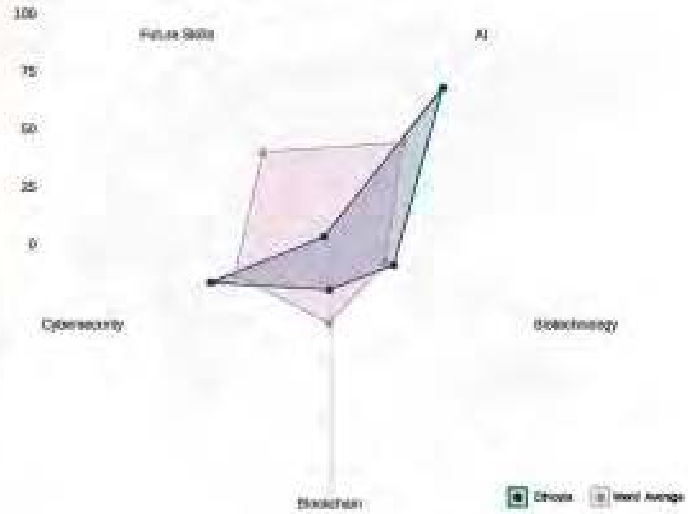
GDP per capita
$ 772
2018

HDI
0.463
2017

GKI
129/136
2019

33
unique authors
per million
Internet users

Future field awareness indices

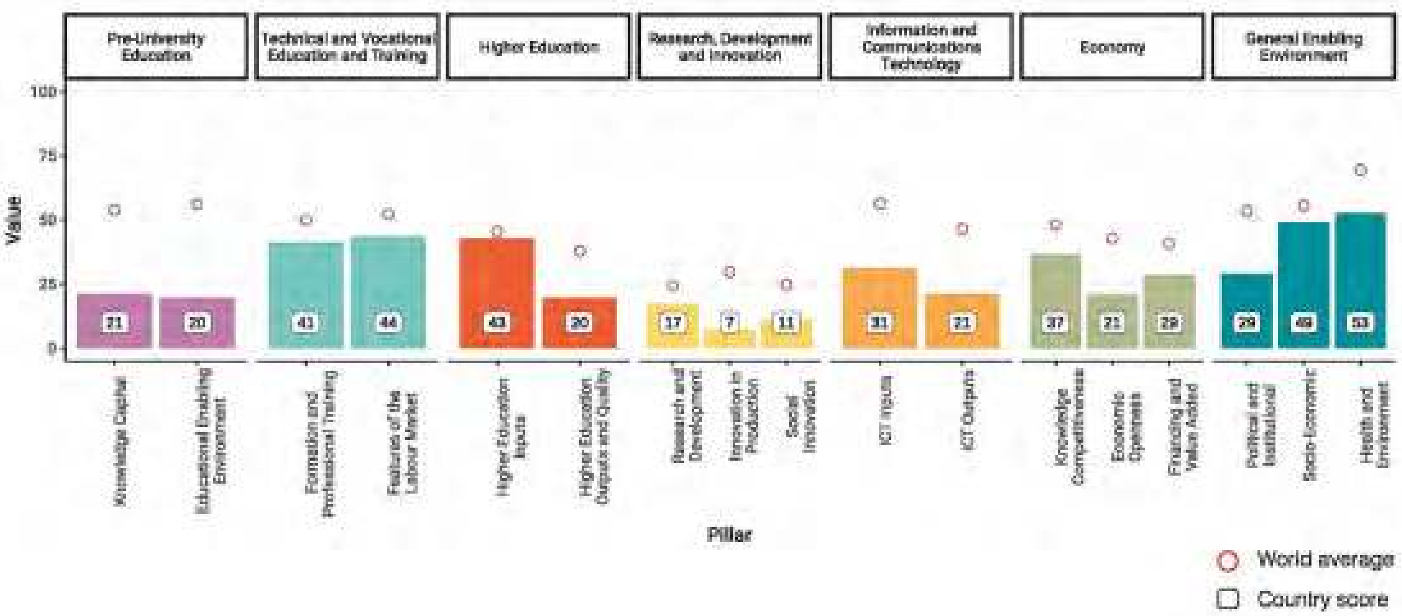


Knowledge infrastructure

Ethiopia is amongst those countries with modest knowledge infrastructure to support technological uptake, such as Senegal and Tajikistan.

Ethiopia is ranked 129th on the Global Knowledge Index, positioned in the bottom 5 percent. Ethiopia performs below the world average in all sectoral indices. Key challenges in Ethiopia are mainly related to political instability and violence, gender disparities and low health and environment standards. Furthermore, the education system is unable to create, localise and disseminate knowledge owing to a weak enabling environment. A key area for Ethiopia to develop is the features of its labour market.

Global Knowledge Index – Ethiopia

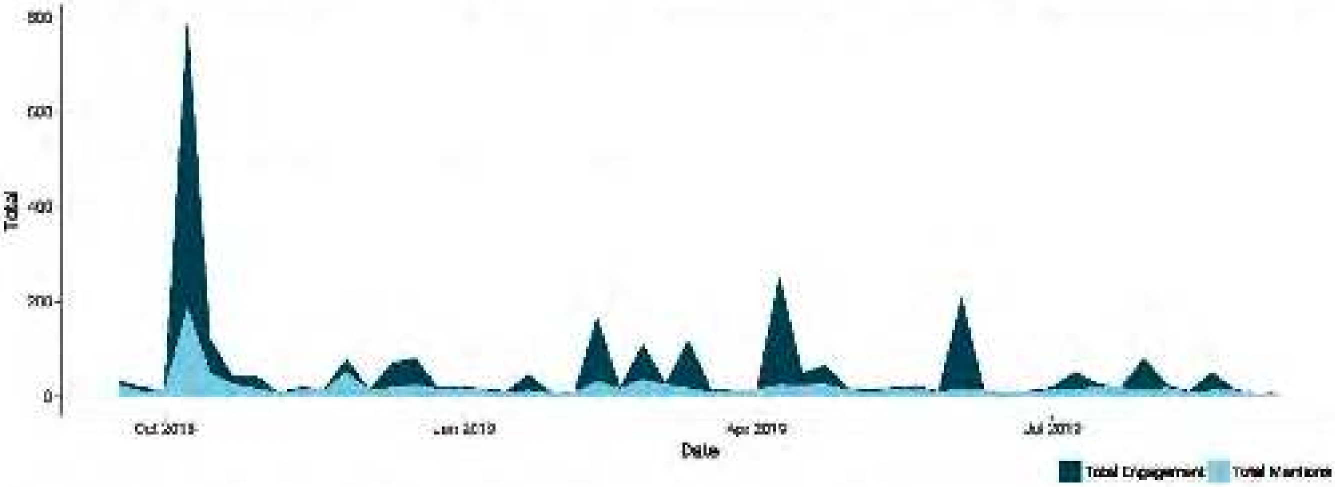


Technological awareness

18.6 percent of the Ethiopian population have access to the Internet, with a mean download speed of 0.8 Mbps.

Between mid-September 2018 and mid-September 2019, there were 654 unique authors contributing to total content generation. The volume of online activity in Ethiopia within the four technology fields chosen displays an average of 78.2 mentions and 146.5 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0037. In comparative terms, 2019 presents a lower concentration over the previous sampling period, which produced a value of 0.0088.

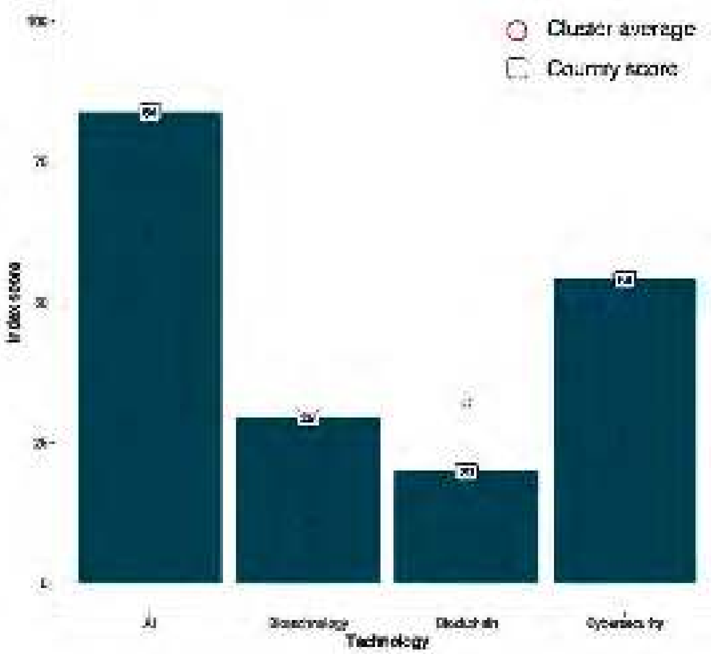
Volume of discussions and engagement level associated with the four key technologies for the future in Ethiopia



The trend in online activity over time for Ethiopia shows peaks in both engagement and mentions related to AI (RDI and science). The peaks are associated mainly with national and international news. One of the major peaks in activity, both in terms of mentions and engagement, pertains to social media posts about Ethiopia's first AI lab – iCog. A 19-year-old coder, Betelhem Dessie, rose to prominence as the youngest pioneer in the Ethiopian tech scene, having four software programmes copyrighted solely in her name. Dessie developed an app for the government to map rivers used for irrigation.[1] A further peak in engagement related to the opening of Google's AI lab in Accra, Ghana.[2] This research centre is the company's first in Africa and will focus on building products that have the potential to be applied to real world problems in sectors such as agriculture, health and education.[3]

Global Technology Awareness Index: Ethiopia

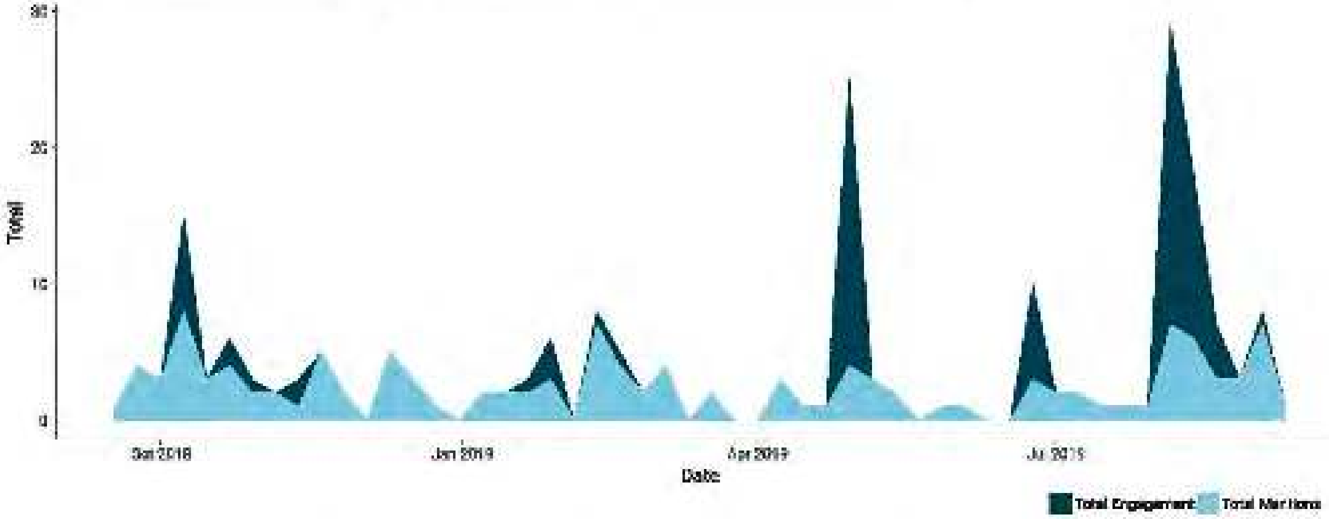
Ethiopia outperforms the cluster average in three out of the four technology dimensions in terms of online activity. Concerning activity distribution within the country, Ethiopia displays strong results of online activity around AI and cybersecurity and a lower performance for biotechnology and blockchain.



Future skills awareness

The online community presents a low level of online activity relating to future skills, with an average value of 9.8 mentions and 6.5 instances of engagement per month. Total online activity in the area of future skills in Ethiopia is lower than that related to the technologies of the future.

Volume of discussions and engagement level associated with future skills in Ethiopia



The trend in online activity over time for Ethiopia shows a generally low level of both engagement and mentions, with peaks on a low scale. The peaks are mainly associated with education and pertain to both local and national news. An interview with a public health nurse representing the YALI (Young African Leaders Initiative Network) Alumni Chapter of Ethiopia caused the largest peak in engagement. The representative, Rahel Getachew, shared her experiences of being a mentor and empowering young people in the country to inspire entrepreneurship. She called for active support from the financial sector and international organisations for small enterprises.[4] The second largest peak in engagement was also connected to the same theme, with the promotion of the Adama Coding Camp on social media.[5] With the support of UN Women, the African Union and International Telecommunication Union, and in collaboration with the Ethiopian Ministry of Education, the camp aims to train 150 girls in robotics, gaming, animation and other skill areas. Similar coding initiatives were held across several different cities, including in the capital, Addis Ababa, bringing together a total of 450 participants.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Ethiopia exhibits weak performance in terms of its knowledge infrastructure, technology awareness and future skills awareness, with low scores across all dimensions.

Overview of Ethiopia's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆	★★☆☆☆	★☆☆☆☆
Technology awareness	★☆☆☆☆	★☆☆☆☆			★★☆☆☆	★☆☆☆☆	★☆☆☆☆
Future skills awareness	★☆☆☆☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★★☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country has room for improvement on the infrastructure front but must also prepare for the future both in terms of future skills and technologies. Cybersecurity is a dimension where signs of progress can be expected in the coming years; at the 32nd African Union summit, which was held in Addis Ababa, leaders repeatedly called on regional organisations and the private sector to prepare youth for engagement with the technologies that are currently reshaping global commerce – particularly cybersecurity.[7] Another area where progress is expected for Ethiopia is future skills awareness in the technology domain. Indeed, the country is part of the SKILL UP Programme, a joint effort of the International Labour Organization and the Norwegian Ministry of Foreign Affairs that aims to help countries take advantage of contemporary technological changes, amongst other objectives.[8]

Endnotes

[1] *McCool and Lewton, 2018.*
[2] *JNkengasong, 2019.*
[3] *Adeoye, 2019.*
[4] *Getachew, 2019.*
[5] *NWbet, 2019.*
[6] *Chiwara, 2019.*
[7] *Roby, 2019.*
[8] *International Labour Organization, 2019.*

CLUSTER

04

SENEGAL

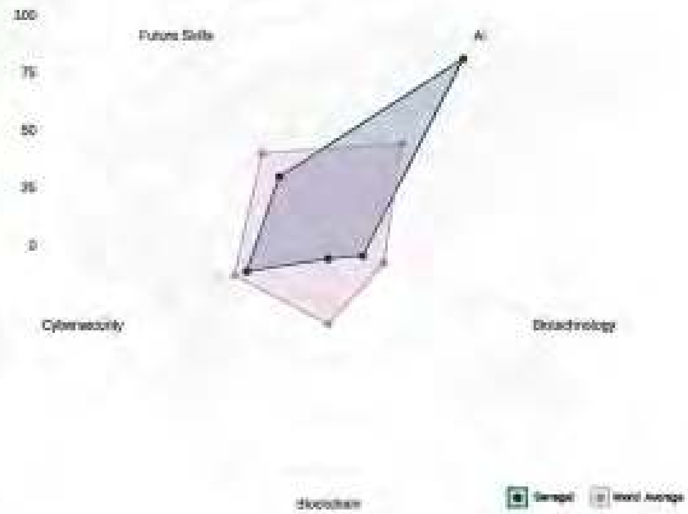
GDP per capita
$ 1,522
2018

HDI
0.505
2017

GKI
110/136
2019

482
unique authors
per million
Internet users

Future field awareness indices

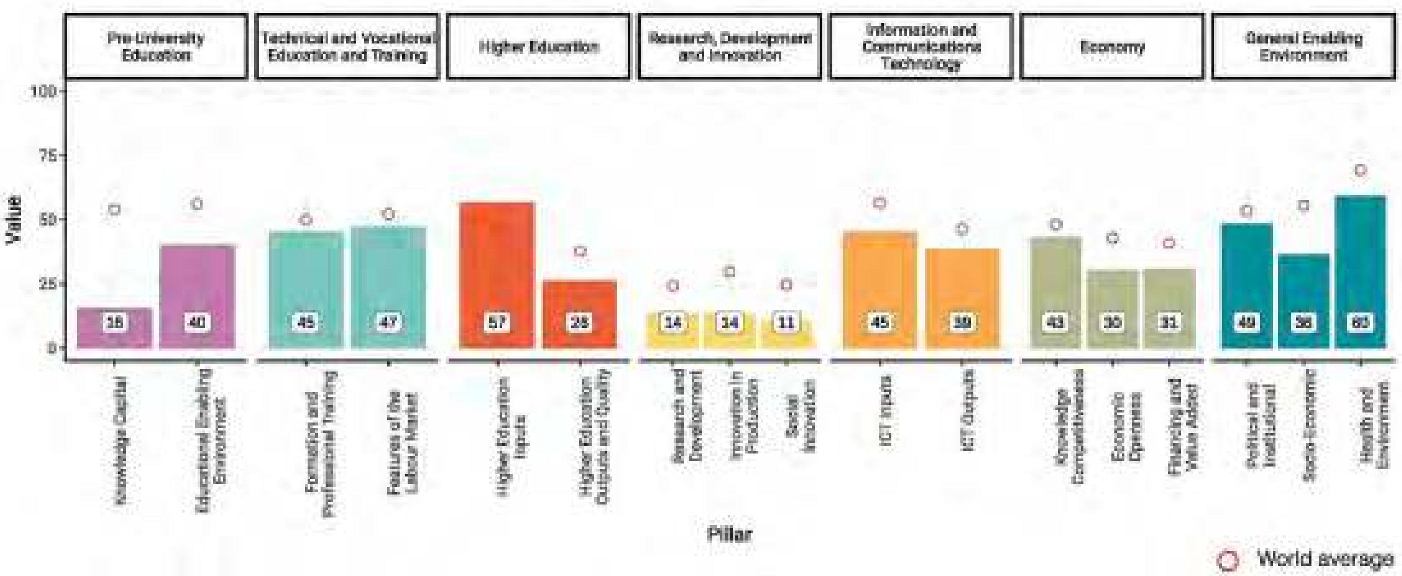


Knowledge infrastructure

Senegal is amongst those countries with modest knowledge infrastructure to support technological uptake, such as Ethiopia and Tajikistan.

Senegal is ranked 110th on the Global Knowledge Index and is positioned in the bottom 20 percent. Senegal performs below the world average in all sectoral indices. The challenges it faces are mainly related to areas of empowerment, gender parity, health and competitiveness drivers. Despite these challenges, government expenditure enrolment ratios in tertiary education are high.

Global Knowledge Index – Senegal

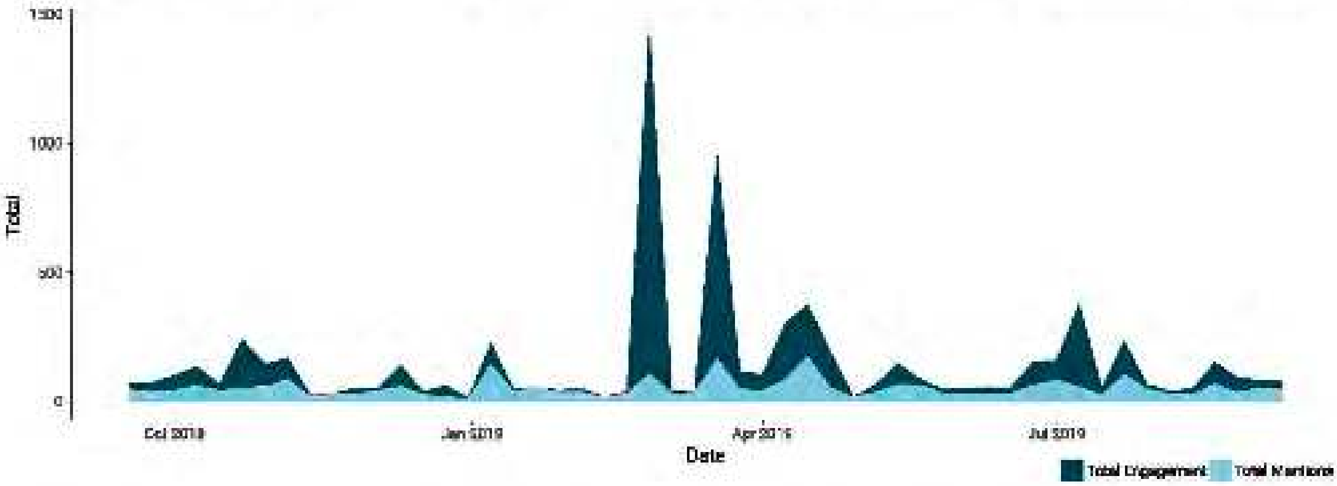


Technological awareness

46 percent of Senegal's population have access to the Internet, with a mean download speed of 2.2 Mbps.

Between mid-September 2018 and mid-September 2019, there were 1,614 unique authors contributing to total content generation. The volume of online activity in Senegal within the four technology fields chosen displays an average of 207 mentions and 370.2 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.0044. In comparative terms, 2019 presents a lower concentration over the previous sampling, which produced a value of 0.0078.

Volume of discussions and engagement level associated with the four key technologies for the future in Senegal

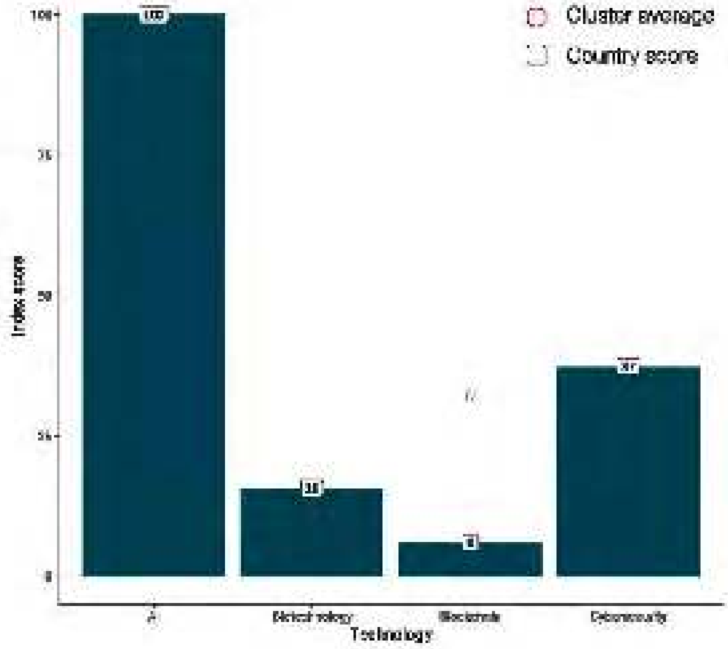


The online activity trend over time for Senegal shows a number of relevant peaks in mentions in the fields of cybersecurity (education) and AI (enabling environment as well as RDI and science). The first peak in mentions pertained to local news on Senegal's Personal Data Protection Commission (CDP), announcing that it will initiate a hackathon on mobile technologies for better protection of personal data.[1] A second peak in mentions concerned local news discussing the risks and opportunities offered by technology – particularly within the context of journalism.[2] The third peak in mentions resulted from national news on the first conference on Artificial Intelligence in Dakar organized by Indaba X, with the aim to strengthen the community of practitioners, researchers and machine learning enthusiasts.[3]

In terms of engagement, peaks in the fields of AI (enabling environment, and RDI and science) are expressed. The first pertains to local news during the presidential elections, and specifically on how the political party Benno Bokk Yakaar (BBY) used big data to target uncertain voters in rural areas.[4] The final peak in engagement was caused by international news on Betelhem Dessie, who at the age of 19 became the project manager of iCog Labs, the first AI laboratory in Ethiopia.[5]

Global Technology Awareness Index: Senegal

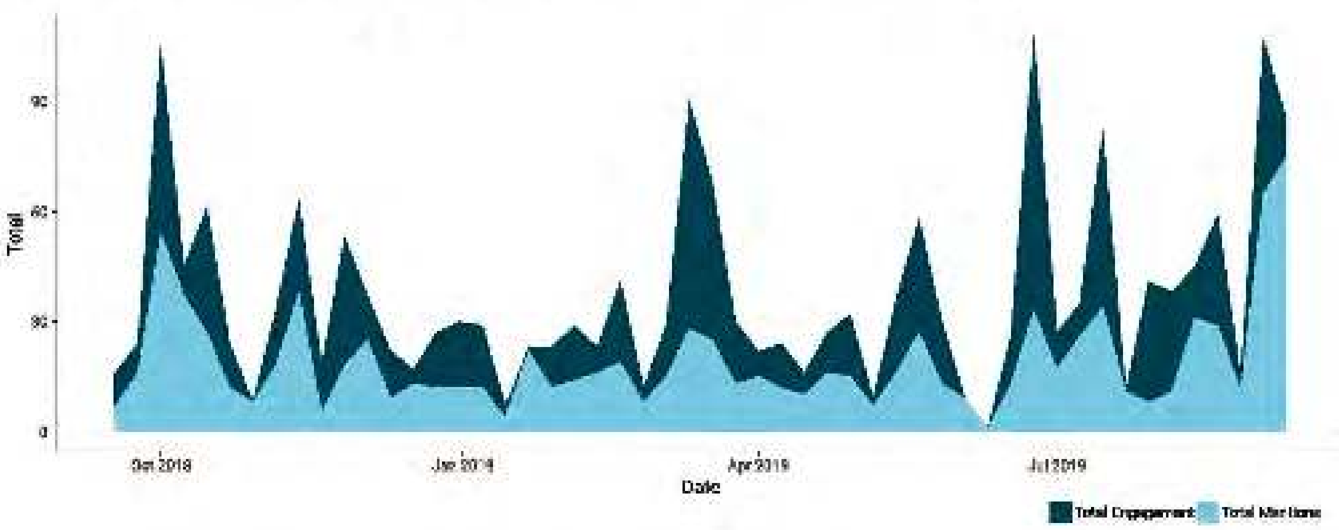
Senegal outperforms the online activity cluster average in three out of four technology fields. In terms of activity distribution within the country, Senegal displays a very high score for online activity around AI, performing above the cluster average. Cybersecurity and biotechnology also appear to raise interest online in Senegal, but to a lesser degree.



Future skills awareness

The volume of online activity relating to future skills displays an average value of 77.2 mentions and 71.2 instances of engagement per month. Total online activity in the area of future skills in Senegal is lower than that relating to technologies of the future.

Volume of discussions and engagement level associated with future skills in Senegal



The online activity trend over time for Senegal shows multiple relevant peaks in both engagement and mentions related to education, enabling environment, and RDI and science. The top results associated with the peaks in mentions pertain mainly to international news related to World Teacher Day[6] and the publishing of the 'Global Outlook on Financing for Sustainable Development' by the OECD in 2019 addressing the 12 percent decline in financing for Sustainable Development Goals.[7] The peaks in engagement pertain to national news on Senegal ranking amongst the top five African countries with a low risk of credit default; and the Senegalese President's announcement that Senegal will make sustainable development and the green economy national priorities during a national dialogue on sustainable development.[8]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Senegal exhibits weak performance in terms of its knowledge infrastructure, technology awareness and future skills awareness, with a weak to average scores across most dimensions.

Overview of Senegal's readiness for technological uptake

	Economy	Education			General enabling environment	RDI and science	Technology (ICT)
		Higher education	Pre-university education	Technical and vocational education and training			
Knowledge infrastructure (GKI)	★☆☆☆☆	★★☆☆☆	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆	★☆☆☆☆
Technology awareness	★☆☆☆☆	★★☆☆☆			★★☆☆☆	★★☆☆☆	★☆☆☆☆
Future skills awareness	★★★★☆	★★☆☆☆			★★★★☆	★☆☆☆☆	★★★☆☆

Notes: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

Looking at future skills related to the economy, we see a focus in Senegal on sustainable development and investment/financing from international public sector organizations, such as the FAO, UNESCO, OECD, UNCDF and UN Senegal. Local events such as a workshop in Senegal on financing the Sustainable Development Goals,[9] the first Galien Forum Africa in Dakar,[10] as well as larger regional projects such as the work of the FAO and G5 Sahel[11] and the Conference of Ministers of the ECA (Economic Committee for Africa)[12] were often tweeted on and written about in Senegal – however, mainly by those directly involved in the work. Nonetheless, we see very little discussion around local economic programmes or funding related to future skills outside the international public sector.

Endnotes

[1] *Observatory on Information Systems, Networks and Road Information in Senegal, 2019.*
[2] *Borschardt, 2019.*
[3] *B. A., 2019.*
[4] *Sissoko, 2019.*
[5] *McCool and Lewton, 2018.*
[6] *Ndiaye, 2018.*
[7] *Toure, 2018.*
[8] *Mamadou, 2019.*
[9] *NedeyeDiopNiang1, 2019.*
[10] *Pajraj1, 2018.*
[11] *FAOWestAfrica, 2019.*
[12] *Toure, 2019.*

CLUSTER
04

TAJIKISTAN

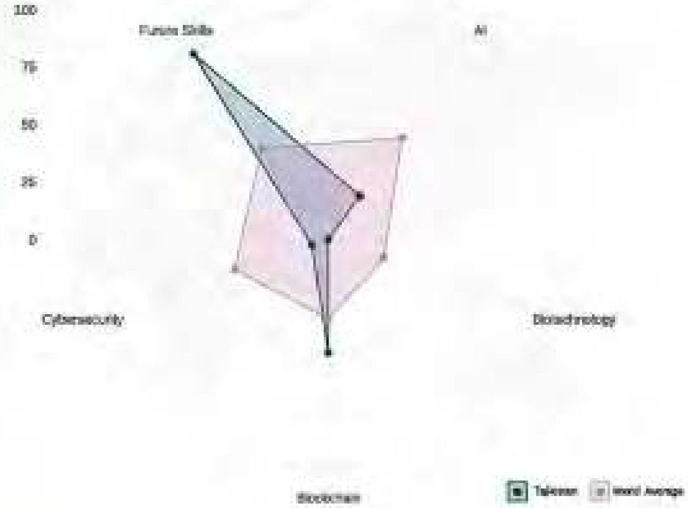
GDP per capita
$ 827
2018

HDI
0.650
2017

GKI
114/136
2019

57
unique authors
per million
Internet users

Future field awareness indices

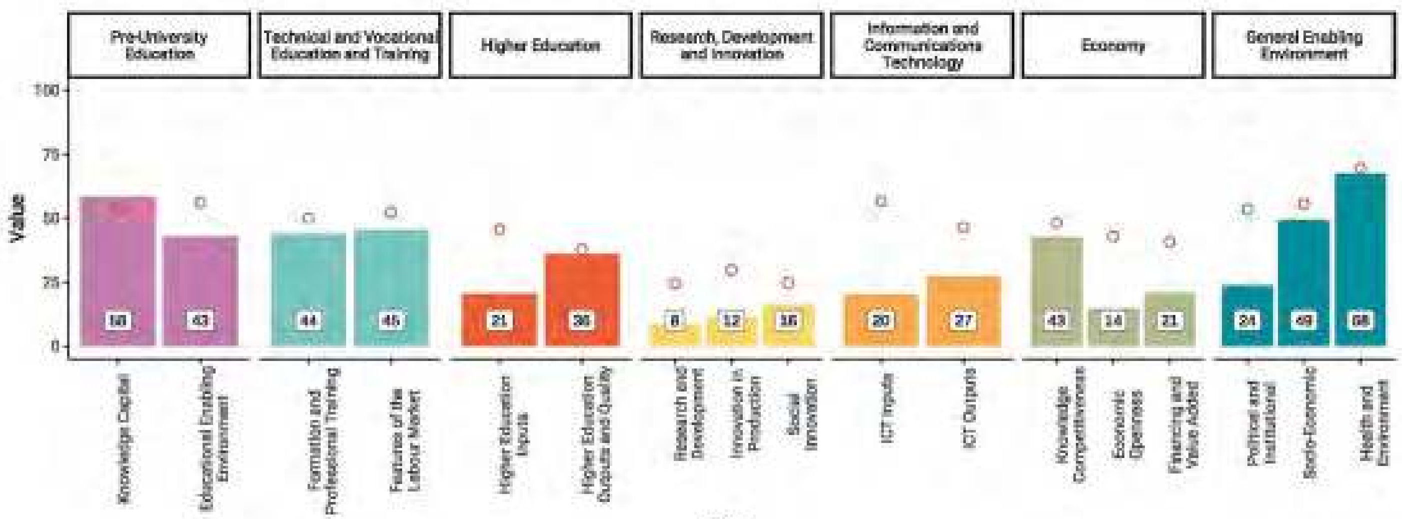


Knowledge infrastructure

Tajikistan is amongst those countries with modest knowledge infrastructure to support technological uptake, such as Ethiopia and Bangladesh.

Tajikistan is ranked 114th on the Global Knowledge Index and is positioned in the bottom 20 percent. Tajikistan performs below the world average in all sectoral indices. The challenges faced are mainly related to ICT inputs, R&D, gender parity, inefficient institutions and political instability. Further, the educational system in Tajikistan is unable to create, localize and disseminate knowledge, as inferred by the pre-university and higher education results.

Global Knowledge Index – Tajikistan

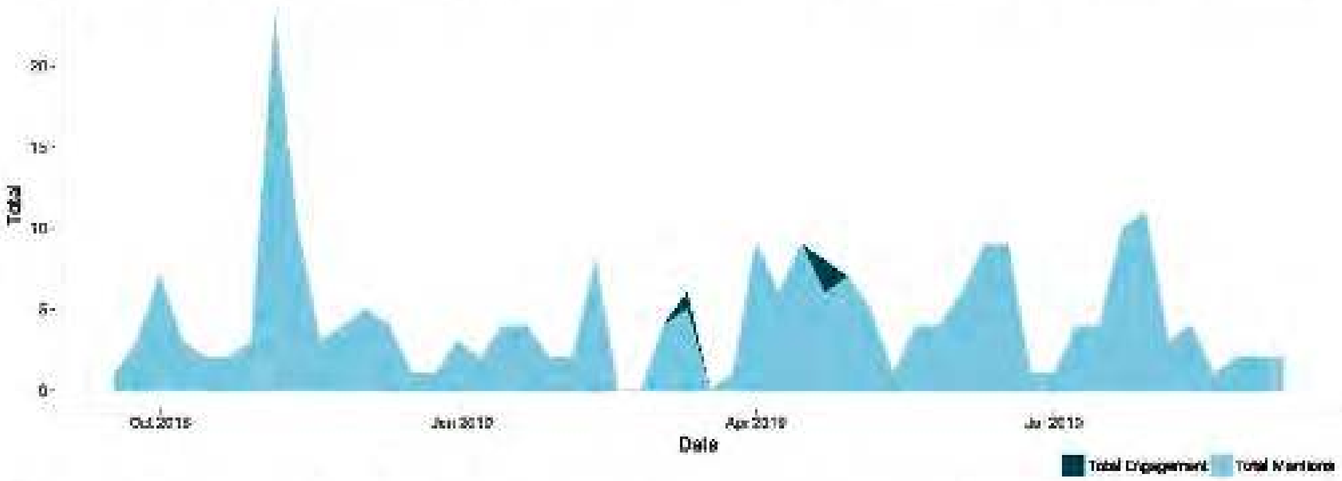


Technological awareness

22 percent of Tajikistan's population have access to the Internet, with a mean download speed of 1 Mbps.

Between mid-September 2018 and mid-September 2019, there were 112 unique authors contributing to total content generation. The volume of online activity in Tajikistan within the four technology fields chosen displays an average of 17.5 mentions and 0.2 instances of engagement per month. Online activity within the technology fields displays a degree of concentration of 0.05. In comparative terms, 2019 presents a lower degree of concentration over the previous sampling period, which produced a value of 0.2.

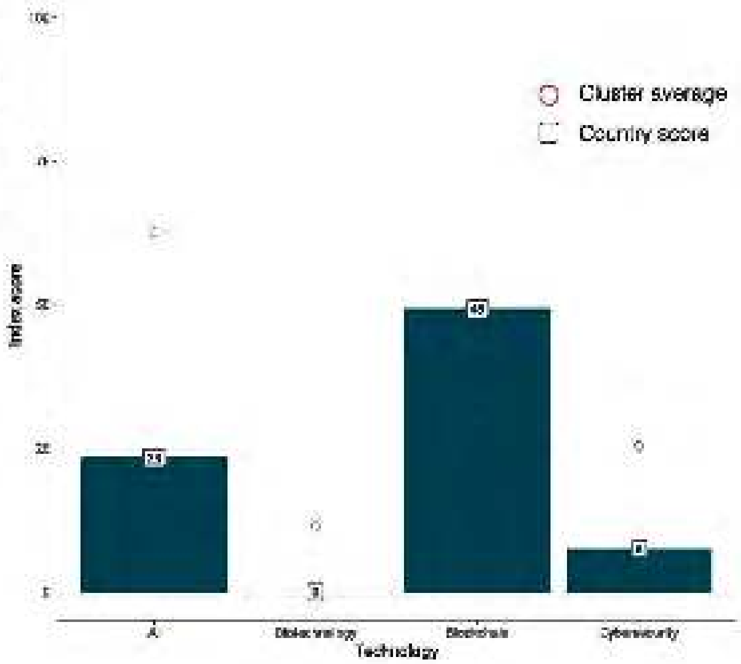
Volume of discussions and engagement level associated with the four key technologies for the future in Tajikistan



The trend in online activity over time for Tajikistan shows a generally low level of engagement and mentions, with peaks on a low scale. There are two instances of engagement expressed in the graph, both of which pertain to blockchain (economy). Both are linked to international news around a fintech platform used to raise funds for a blockchain-related enterprise and an article about the benefits of blockchain.[1,2] The results associated with a peak in mentions mainly pertain to the Malta AI and Blockchain Summit[3,4] held in November 2018, which is considered a major blockchain event, especially because of the diversity of professionals from different fields who attend.

Global Technology Awareness Index: Tajikistan

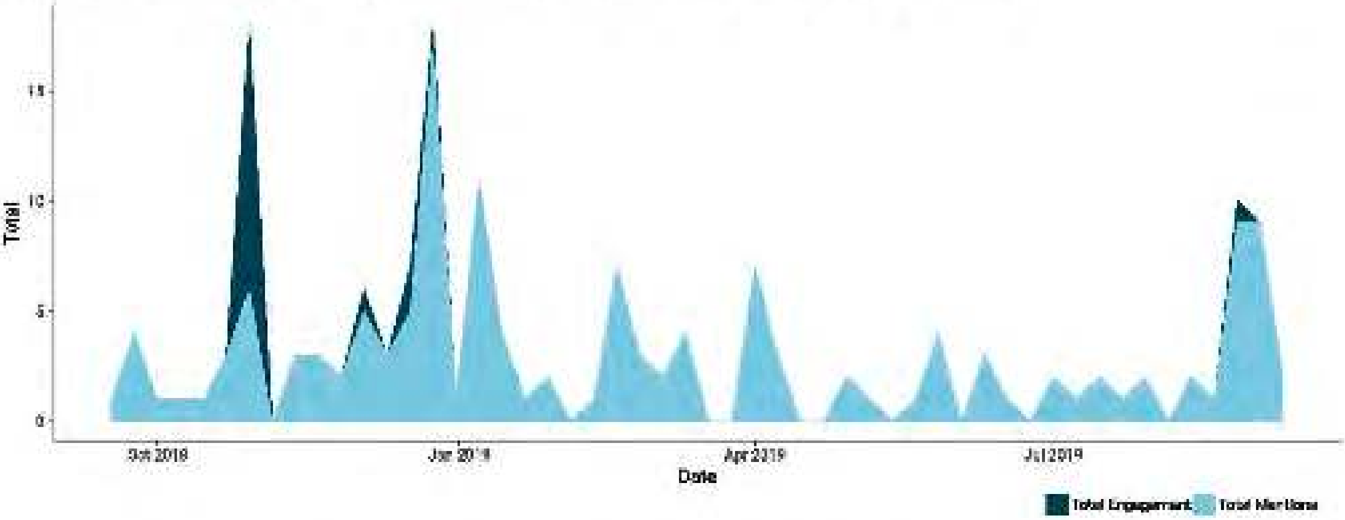
Tajikistan outperforms the online activity cluster average in one out of four technology fields. In terms of activity distribution within the country, Tajikistan displays strong results for online activity on topics related to blockchain and, to a lesser degree, AI and cybersecurity, with biotechnology being the least prominent.



Future skills awareness

Total online activity in the area of future skills in Tajikistan is lower in terms of mentions and higher in terms of instances of engagement than that relating to the technologies of the future. The online community presents a low level of online activity in the topic, with an average value of 11.1 mentions and 1.3 instances of engagement per month.

Volume of discussions and engagement level associated with future skills in Tajikistan



The trend of online activity over time for Tajikistan shows a general low level of both engagements and mentions, with peaks on a low scale. The results associated with the peaks pertain mainly to technology and are linked to international news, such as a social media post about an innovation centre in Yerevan, Armenia, that provides digital skills for 10,000 students.[5] A peak in mentions from December 2018 was due to news reports on the annual address of the Tajik president, who highlighted the importance of strengthening opportunities for teachers to enrol in training courses.[6]

Readiness for technological uptake

To conceptualize the readiness of the country for technological uptake, we compare two key determinants of variation in the quality of the technological uptake environment at the country level: knowledge infrastructure and awareness.

Tajikistan exhibits weak performance in terms of its knowledge infrastructure, technology awareness and future skills awareness, with weak scores across all dimensions.

Overview of Tajikistan's readiness for technological uptake

	Economy	Education: Higher education	Education: Pre-university education	Education: Technical and vocational education and training	General enabling environment	RDI and science	Technology (ICT)
Knowledge infrastructure (GKI)	★☆☆☆☆	★☆☆☆☆	★★☆☆☆	★★☆☆☆	★★☆☆☆	★☆☆☆☆	★☆☆☆☆
Technology awareness	★☆☆☆☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★☆☆☆☆
Future skills awareness	★☆☆☆☆	★☆☆☆☆			★☆☆☆☆	★☆☆☆☆	★★☆☆☆

Note: A star system was used to rank countries' performance: one star represents the 'least welcoming environment' (i.e. in the lowest quintile interval), five stars the 'most welcoming environment' (i.e. in the highest quintile interval); 1 star (0–20%), 2 stars (20–40%), 3 stars (40–60%), 4 stars (60–80%), 5 stars (80–100%).

The country has room for improvement on the infrastructure front, but also needs to prepare for the future in terms of skills and technologies. Blockchain is where signs of progress can be expected in the coming years. This is indicated by a recent announcement by China UnionPay that it will be expanding, issuing cards and enabling blockchain in Tajikistan.[7] This news comes after research on the potential use of blockchain for remittances was conducted by a Hong Kong based start-up with the support of UNDP.[8] It seems, however, that attitudes towards the technology need to change first, as blockchain is widely viewed in the context of illegal activity and the financing of organized crime.

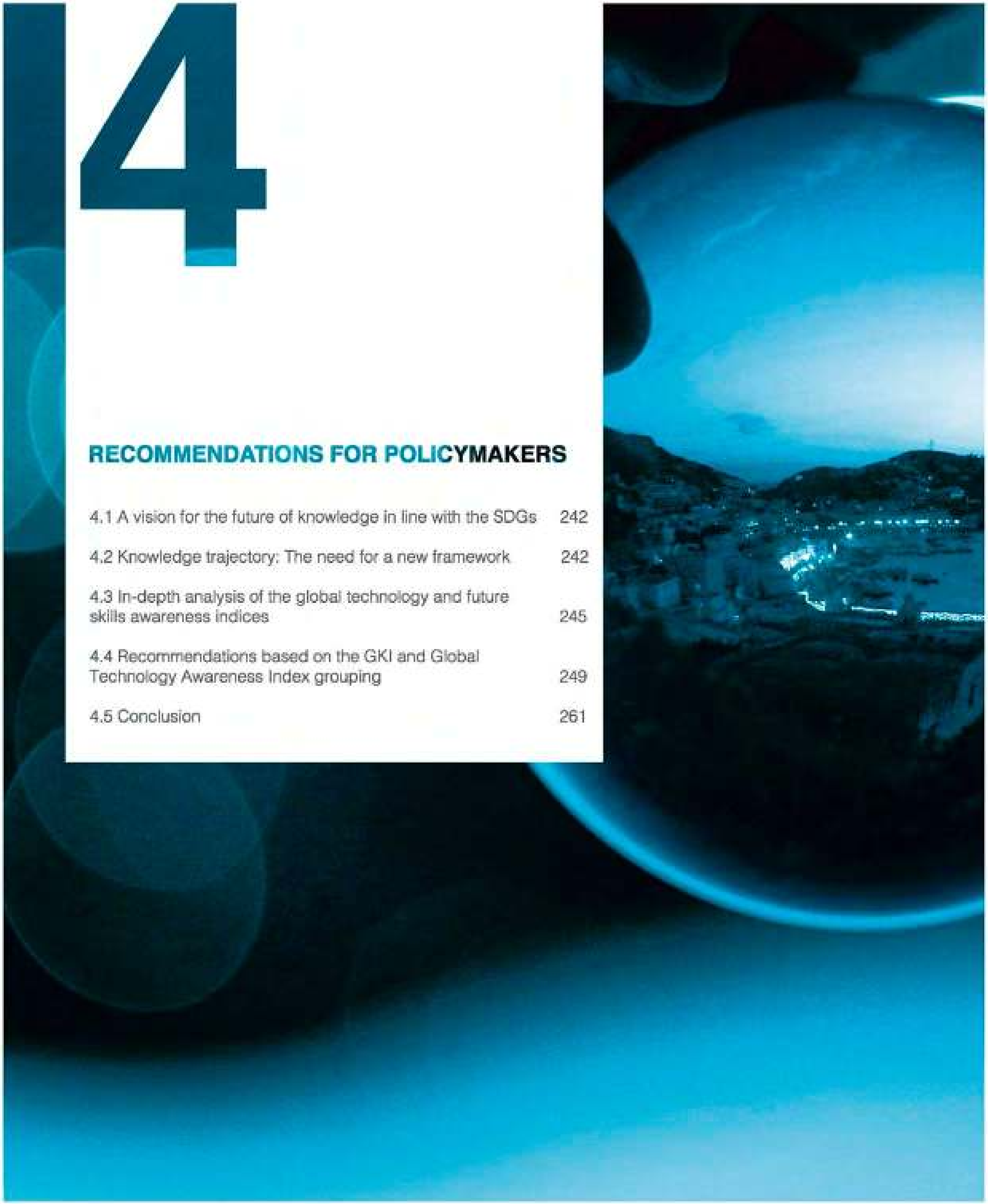
A high-level conference on the international and regional cooperation on countering terrorism and its financing through illicit drug trafficking and organised crime was held in Dushanbe, Tajikistan in May 2019. Amongst the main topics discussed during the event was the abuse of cryptocurrencies for terrorism financing.[9]

Generally, however, the ICT domain in Tajikistan is developing positively, with state efforts underway to encourage entrepreneurship and research. A field visit by Tajik government officials to Armenia took place in April 2019 to observe best practices in innovation. Representatives also toured Armenian IT campuses and techno parks, such as the Microsoft Innovation Centre for Armenia and the Enterprise Incubator Foundation, looking to establish collaborations.[10]

Endnotes

[1] *Emirates News Gazette, 2019b.*
[2] *Emirates News Gazette, 2019a.*
[3] *See: https://maltablockchainsummit.com.*
[4] *Trafficante, 2018.*
[5] *MubinRustamov, 2018.*
[6] *Presidency of Tajikistan, 2018.*
[7] *China UnionPay, 2019.*
[8] *Zhao, 2017.*
[9] *See: http://www.dushanbeconf2019.tj/about-conference.*
[10] *Organization for Security and Co-operation in Europe (OSCE), 2019.*

4



RECOMMENDATIONS FOR POLICYMAKERS

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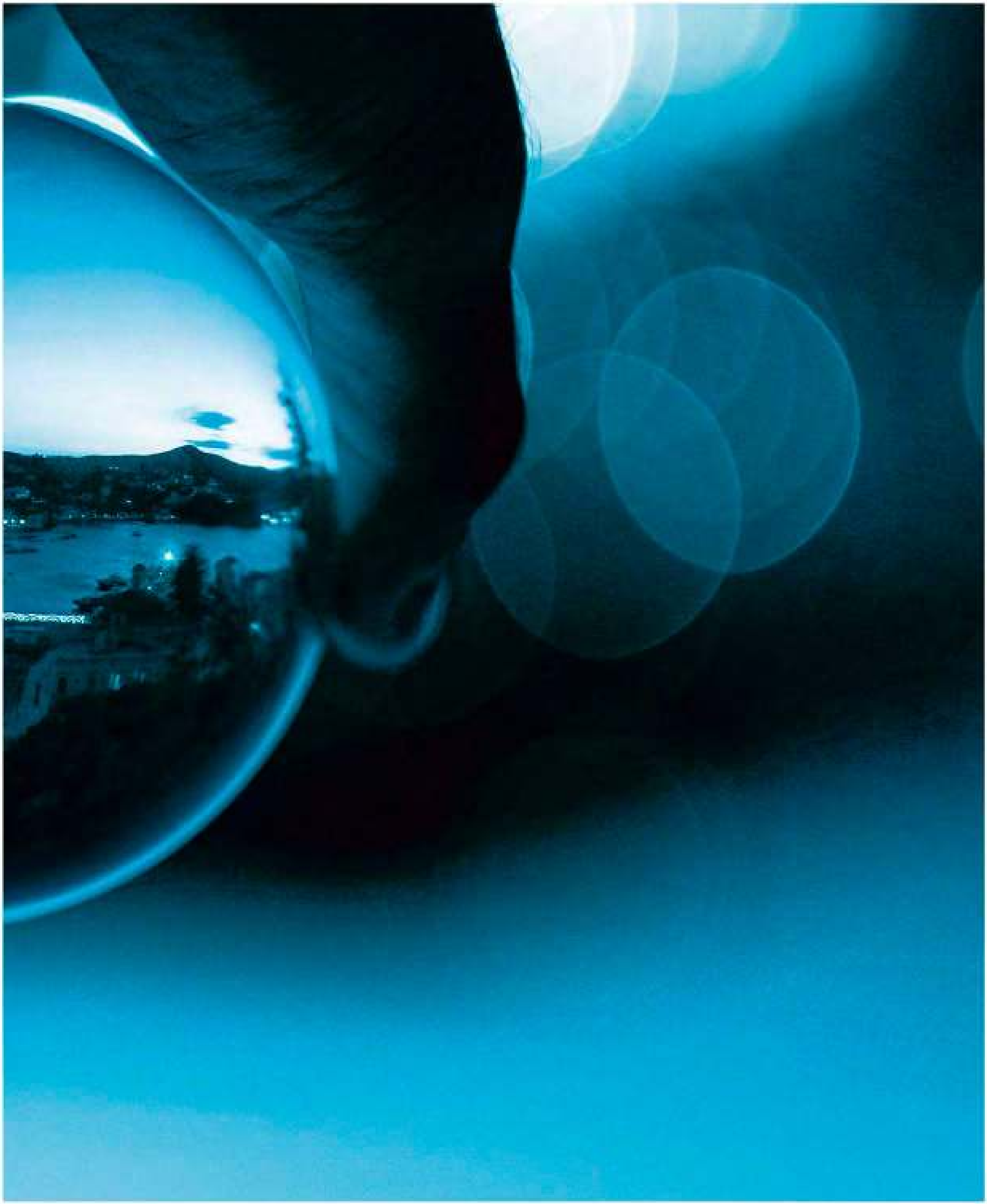


4 RECOMMENDATIONS FOR POLICYMAKERS

The objective of this chapter is twofold:

- to provide a grouping analysis of countries based both on their GKI performance and their global technology and future skills awareness; and to
- to propose a first iteration of a 'toolbox' of recommendations for decision makers to assist them in accelerating the development of new technologies and future skills readiness in line with the 2030 Agenda for Sustainable Development.

4.1 A vision for the future of knowledge in line with the SDGs

Our vision is to propose recommendations that inspire, drive and unite all countries in the need for an inclusive, sustainable and forward-looking skills and knowledge development ecosystem. All of the recommendations below encourage the development of partnerships, initiatives and programmes that support the achievement of the SDGs and strengthen overall awareness of sustainable technologies/ products.

This report aims to generate widespread momentum by inspiring all key stakeholders to take part in the collective design and implementation of innovative programmes that will drive awareness of future skills and technologies in their respective countries, while simultaneously securing a resilient knowledge infrastructure and supporting the realization of the SDGs.

The recommendations are supported by global best practices and success stories, and aim to encourage wider collaboration both between and within countries. Public and private leaders should be encouraged to exchange sustainable solutions, within their territories as well as with other countries, and to join forces to drive knowledge capital creation, innovation and technological advancement. At the same time, all future initiatives should be realistic, feasible, inclusive, inspiring, responsive, anticipatory and sustainable.

4.2 Knowledge trajectory: The need for a new framework

In order to facilitate this vision, leaders require a comprehensive framework that will support them in the development and implementation of national knowledge and innovation strategies. This new framework aims to monitor how a country, with its current knowledge capital, develops its awareness and capacity for future technologies and skills.

The GKI assesses knowledge infrastructure, while the Global Technology Awareness Index and Future Skills Awareness Index capture the 'future knowledge trajectory' of a country. This allows leaders to determine their countries' current positioning in terms of their existing knowledge foundations, as well as to initiate planning to transition to the desired position in the future.

Figure 4.1: Introducing the future knowledge trajectory concept

Figure 4.1 presents the future knowledge trajectory. As can be observed, a state's knowledge infrastructure is key to absorbing new knowledge, represented herby the Global Technology Awareness Index. The stronger the knowledge infrastructure, the higher the public's technology awareness. Country leaders therefore need to invest in both the knowledge infrastructure of their state and raise awareness regarding the skills and technologies of the future.

The subsequent recommendations will support countries in simultaneously improving their knowledge capital as well as anticipating the future strategic domains in which to develop new knowledge and skills. To facilitate this process, six key enablers have been identified that significantly influence future knowledge trajectory and inform the future actions of policymakers.

Figure 4.2: Presenting the six key enablers that determine the future knowledge trajectory

General enabling environment	**Information and communications technology**	**Education**
Research, development and innovation	**Economy**	**Funding**

The six key enablers of the future knowledge trajectory differ from the dimensions of the GKI – namely in terms of funding and education. The funding dimension has been added and describes the availability of capital within a country to finance investments and provide the required financial resources to its economy. The education dimension, on the other hand, regroups all education-related categories into a single key enabling category.

The key enabling categories reflect the governance structure of most states and thus encourage clear ownership in the implementation process. They allow for an easier overview of the areas in which policymakers and political leaders should invest to strengthen the position of their country as knowledge leaders.

Furthermore, to give policymakers a deeper understanding of the aim of each of the key enablers identified, a dedicated mission statement has been developed for each category. The mission statement presents the optimal state that all knowledge countries should aspire to achieve. It helps the design of national programmes and initiatives with a clear and sustainable aim.

Key enabler 1: General enabling environment

The development of strong national knowledge creation requires a general enabling environment with a defined leadership and governance structure, and an accompanying enabling regulatory framework. Public and private actors require the right environment to envision and introduce long-term innovative development strategies with appropriate incentives and end-to-end policies. They also need high-quality governance, country strategic foresight, strong institutions, a robust socio-economic environment and enforced health and environment standards in which to evolve. A strong general enabling environment will create trust amongst country stakeholders. Many of the leading countries of the GKI maintain a very strong enabling environment that supports innovation, knowledge and value creation.

Key enabler 2: ICT

At the heart of our digital societies lie emerging technologies that will impact our daily lives. Policymakers will need to ensure the comprehensive uptake of cutting-edge technologies across society and the economy to safeguard the competitiveness and resilience of their national economies and protect the safety and well-being of their people. Innovation requires new, complex and costly digital infrastructures (providing high connectivity, access to cybersecurity and computing power), an expansive talent pool and investments in advanced technologies to build digital societies.

Key enabler 3: Education

The current education system seeks to meet the standardized needs of the fourth industrial revolution, but can no longer meet the flexibility and diversity required by today's labour market. How do we harness technological and educational innovation to give access to education to an increasing share of youth that do not possess a high school diploma or basic foundations? How do we reform the education system to remain relevant in our ever-evolving society? How will education enable a country to absorb new knowledge and skills created elsewhere?

Education will clearly remain a major enabling pillar in our societies but will require significant transformation. The review and modernization of the national education and training system requires investments in existing training infrastructures, as well as the curricula offered. International partnerships and public-private initiatives should be considered within this framework to increase the performance and relevance of the education system.

Key enabler 4: RDI

The continued invention and review of technologies require a strong support system for research, development and innovation (RDI). RDI represents a major asset to countries that want to build effective knowledge infrastructure in an emerging field. Applied research supported by international open collaboration is the easiest way to start the journey, as part of a 10-year cycle. Existing RDI institutions must absorb and engage with collaborative projects, new technologies and science to increase the knowledge stock of a country.

Key enabler 5: Economy

The economy represents both value and the source of job creation for a country. It provides local and international market visions and interconnections. With today's accelerated pace of technological evolution, the economy must transform itself with a high level of risk, given the complexity of business models, human resources and operational and organizational transformation. The engagement of the economic community in the country's transformation, mobilizing economic and entrepreneurship resources as well as political, digital and technological knowledge assets, is a critical success factor in this regard. The alignment of the different socio-economic stakeholders with political and education leaders will further create a strong favourable ecosystem for the development of national future skill sets.

Key enabler 6: Funding

In line with a strong enabling environment and economic framework, the availability of funding is crucial to national knowledge and technology improvements. On one hand, country leaders should consider existing funding sources from international donors and benefit from the technical assistance provided and funding programmes made available to support their territory's future sustainability. On the other, they should also implement the most efficient funding and guarantee project quality and governance mechanisms to allow local private investments to fully exploit these resources for the welfare of society. In a societal paradigm shift, obtaining and unlocking private and public funds to invest in the skills of a population – as the most valuable strategic resource of a country – represents a sustainable strategy that positions human beings at the core of integrated policymaking.

4.3 In-depth analysis of the global technology and future skills awareness indices

Before presenting a detailed set of recommendations aligned with these key enablers, this section will offer the reader a deep exploration of the global technology and future skills awareness indices.

A closer comparison of the 40 countries under study between their GKI performance (representing knowledge infrastructure) and their Global Technological Awareness Index scores (from mid-September 2018 to mid-September 2019) provides a clearer image of these states' respective readiness for technological uptake. This allows policymakers to gain a deeper understanding of the factors influencing their state's future knowledge trajectory and will facilitate the implementation of targeted actions. Similarly, the mapping of the Future Skills Awareness Index with respect to the GKI provides a basis for the partitioning of the countries assessed into four groups of similar behaviour.

To partition countries into groups of similar readiness for technological uptake, in terms of technology or future skills, respectively, we use K-means, which is an unsupervised machine-learning algorithm used for clustering observations.

Given a fixed K, the K-means algorithm partitions n observations (one for each country) into K groups minimizing within-cluster variances (squared Euclidean distances). The choice K=4 is determined using the Elbow method and provides the best balance in terms of minimized distance between observations within a cluster, and minimum number of groups as well.

4.3.1 Country grouping based on the GKI and the Global Technology Awareness Index

Figure 4.3 maps the 40 countries included in this study by their respective GKI scores and Global Technology Awareness Index results. The GTAI assesses a state's awareness of the following key future technologies: artificial intelligence, biotechnology, cybersecurity and blockchain.

Figure 4.3: Country grouping based on GKI and Global Technology Awareness Index

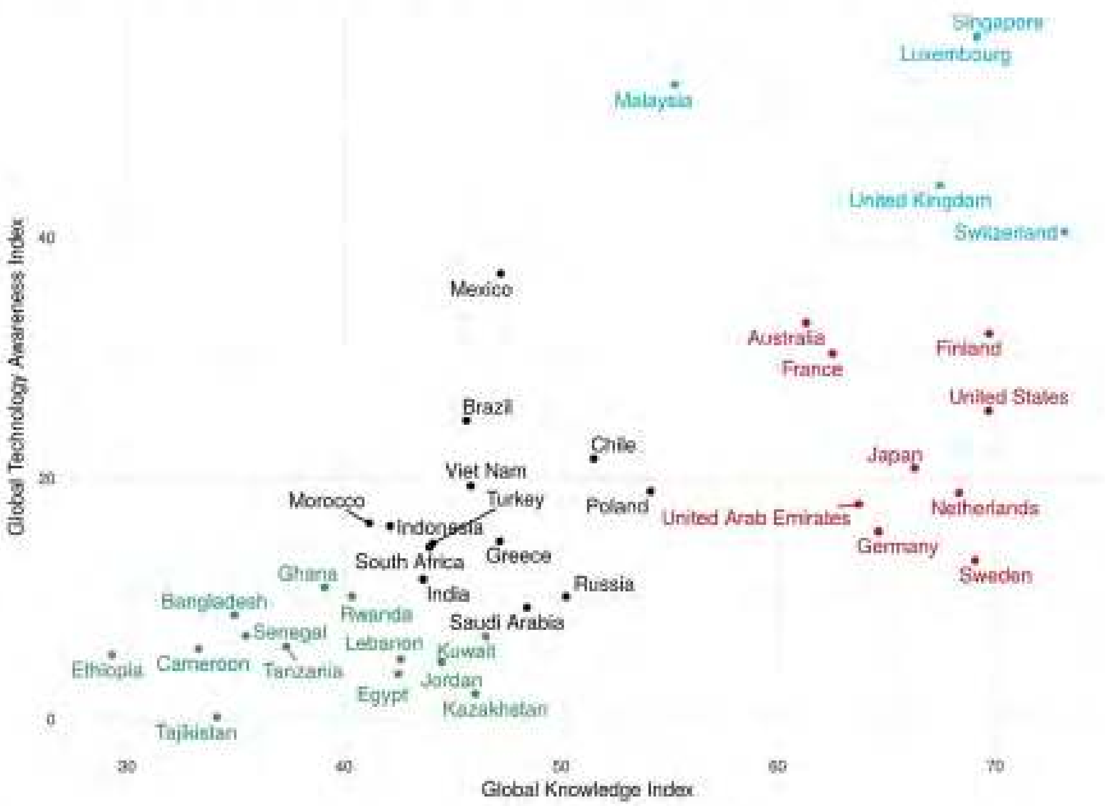


Table 4.1: Countries per group

Green group	Black group	Red group	Blue group
Ethiopia	Mexico	Finland	Malaysia
Cameroon	Brazil	France	United Kingdom
Senegal	Viet Nam	Australia	Singapore
Bangladesh	Chile	United States	Luxembourg
Tanzania	Poland	Japan	Switzerland
Rwanda	Indonesia	Netherlands	
Ghana	Morocco	United Arab Emirates	
Lebanon	Turkey	Germany	
Egypt	Greece	Sweden	
Jordan	South Africa		
Kuwait	Saudi Arabia		
Kazakhstan	India		
Tajikistan	Russia		

When analysing the mapping of the groupings, clear distinctions can be made between the possible future knowledge trajectories.

The countries in the Green grouping present limited knowledge infrastructure that will prevent them from creating new knowledge and absorbing new technologies. These countries must invest significantly across all sectors to develop a better future knowledge trajectory.

Countries in the Black grouping display a good knowledge infrastructure and some absorption capacity regarding new technologies. At the same time, they must address some weaker dimensions that currently hinder their development and growth. Countries in the Black grouping could rapidly improve their future knowledge trajectories with a strong action plan to implement knowledge development policies, and a more insightful understanding of the impact of technologies and future of skills on their societies.

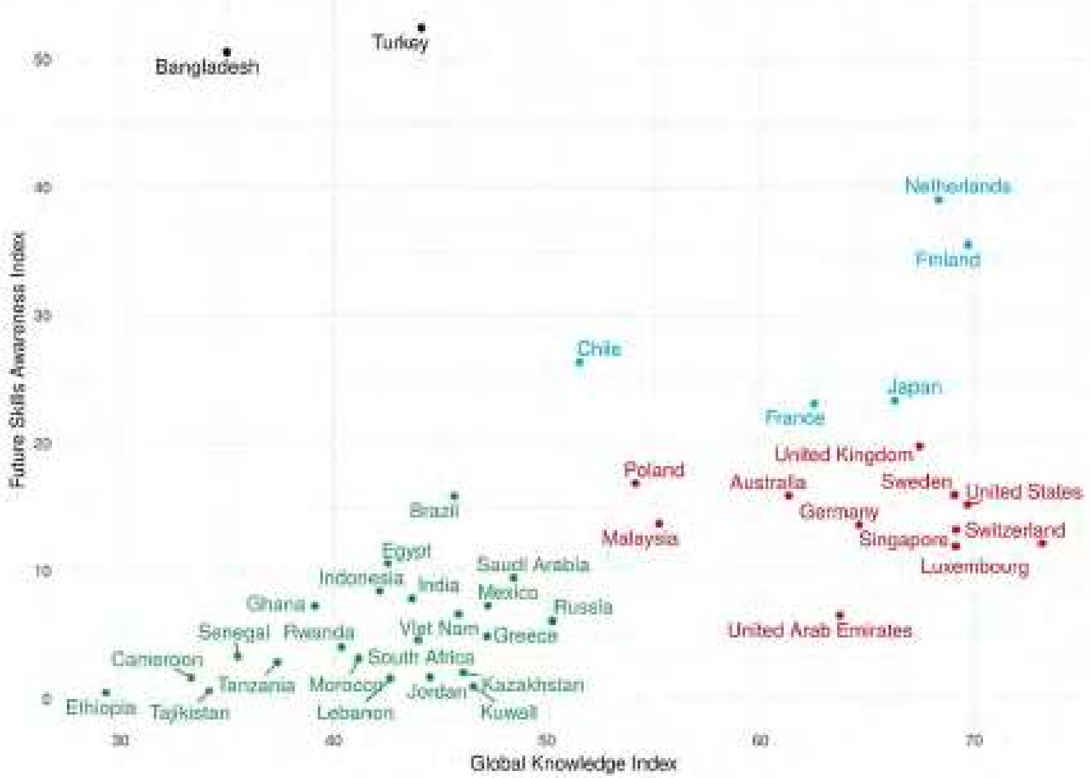
The Red grouping is composed of some of the most developed economies of the world (i.e. Sweden, the United Arab Emirates, the United States, etc.). The members of this group have developed a very solid knowledge infrastructure in all dimensions but show limited capacity concerning new technology awareness. It is worth mentioning in this respect the great progress the United Arab Emirates has made in recent times, positioning itself amongst the most developed knowledge countries. Policymakers in the countries within the Red grouping will need to strengthen both the foundations of their existing knowledge infrastructures and launch awareness raising campaigns on the skills and technologies of the future. Collaborations with higher-performing countries from the Blue grouping are highly encouraged and could greatly facilitate the necessary investments.

The economies of the Blue grouping actively share strategies and projects in the field of new technologies. Collaborations within this group, as well as with other groups, might be particularly enriching and could inspire the development of sustainable solutions. Therefore, members of this group should be encouraged to establish close collaborations with those of the Green, Black and Red groups to share knowledge and co-design a sustainable future for our societies.

4.3.2 Country grouping based on the GKI and the Future Skills Awareness Index

The clustering exhibited in Figure 4.4. maps the 40 countries included in the scope of this study by their respective GKI scores and Future Skills Awareness Index results.

Figure 4.4: Country grouping based on the GKI and the Future Skills Awareness Index



This grouping is closely aligned with the preceding figure, with two notable exceptions:

- *A first group of outliers composed of Bangladesh and Turkey.*

  The common point between these countries is the national discussion around the education system and teacher status. The debate in these countries was more intense and conflictual than in other territories. This explains their elevated results on the Future Skills Awareness Index. For further information please refer to Chapter 3.

- *A second group of outliers composed of the Netherlands and Finland.*

  In the Netherlands, awareness of, and debate on, future skills is concentrated on the shortage of teachers, which creates a significant problem for the education system. In Finland, the debate was focused on excellence and innovation within the Finnish education model, as evidenced by several international reports. In both cases, national debates led to a rise in the Future Skills Awareness Index. For a more detailed overview of the described trends, please refer to Chapter 3.

Table 4.2: Countries per group

Green group	Black group	Red group	Blue group
Ethiopia	Bangladesh	Malaysia	Chile
Cameroon	Turkey	United Kingdom	France
Senegal		Singapore	Japan
Indonesia		Luxembourg	Netherlands
Tanzania		Switzerland	Finland
Rwanda		Poland	
Ghana		Australia	
Lebanon		Germany	
Egypt		United States	
Jordan		United Arab Emirates	
Kuwait		Sweden	
Kazakhstan			
Tajikistan			
Morocco			
South Africa			
Greece			
Russia			
Saudi Arabia			
Brazil			
India			
Viet Nam			
Mexico			

4.4 Recommendations based on the GKI and Global Technology Awareness Index grouping

The recommendations described will be primarily based on the GKI and Global Technology Awareness Index groupings as outlined in table 4.1. Most recommendations integrating future skills indices will be proposed under the different enablers.

The following section addresses each group individually to present impactful recommendations that meet the needs of each state included in the Future of Knowledge Model. The groupings identified are those gleaned from deep analysis of the GKI and Global Technology Awareness Index. We believe that this visualization provides country leaders and policymakers with the most impactful assessment. Nevertheless, the Future Skills Awareness Index directly influences the following recommendations and has been included in every aspect of the suggestions.

4.4.1 Group 1: The Green grouping

Countries in the Green grouping demonstrate a low GKI and a low Global Technology Awareness Index score.

General enabling environment

Policymakers should concentrate their efforts on strengthening the foundations of their national political, economic, entrepreneurial, technological and environmental ecosystems. In the first instance, a transparent and participative governance framework should be introduced involving various stakeholder groups to prevent corruption and build trust, supported by international partnerships and best practices.

The digitalization of e-government services, with technologies and user experiences adapted to the local context, will be a major driver for building an enabling environment.

In parallel, the display of ethical technological solutions should be envisioned to foster the deployment of tech solutions for both learning and training, as well as for solving public and environmental health issues. This will raise awareness of future skills and technologies.

Box 4.1: CoST global infrastructure transparency initiative in public infrastructure

CoST Infrastructure Transparency Initiative

As a global Infrastructure Transparency Initiative, the CoST works in 15 countries across four continents, including five fragile and conflict-affected states.

The aim of CoST is to improve transparency and accountability in public infrastructures in order to boost trust in government.

CoST works with government, industry and civil society to promote the disclosure, validation and interpretation of data from infrastructure projects.

This helps to inform and empower citizens and enables them to hold decision makers to account for their actions. This also drives reforms that reduce mismanagement, inefficiency, corruption and the risks posed to the public from poor quality infrastructure.

Source: CoST, 2019.

ICT

Concerning the strengthening of national ICT uptake, policymakers should develop comprehensive and sustainable national technology strategies with clear targets. The digital strategies developed should embrace sectoral and thematic application areas and align with national education, funding, RDI and SDG strategies. At the heart of these efforts should lie the development of digital access and literacy for all citizens, as well as a robust digital infrastructure and connectivity.

Education

The countries grouped in this cluster often struggle with weak educational systems that do not sufficiently integrate the skills and technologies of the future into their curricula. Therefore, policymakers should review the entire national education system and define a comprehensive national skills strategy. The skills strategy defined will subsequently inform all upcoming re/upskilling activities.

National skills strategies should be closely aligned with the country's investment strategy, its technological strengths as well as its areas of specialization. These directly influence the skills and knowledge needs of the state in question.

Particular attention should be paid to fostering gender equality, be it through boosting female participation in STEM education or the provision of child-care services to facilitate the active participation of female talent in the workforce. Furthermore, the skills strategies to be developed should set clear, measurable and achievable objectives with strict deadlines to allow for timely implementation and support the wider realization of the SDGs.

Box 4.2: Cisco Networking Academy

Over the course of the past 20 years, the Cisco Networking Academy has changed the lives of 10.9 million students in 180 countries by providing education, technical training and career mentorship.

The programme represents a pillar of Cisco's corporate social responsibility policy and delivers classroom instruction, online teaching materials, interactive tools and hands-on learning to students from all socioeconomic backgrounds. The main themes covered by the courses are networking, programming, IoT, cybersecurity, operating systems and IT, and packet tracer.

Established in 1997, the academy has now developed into an organization that creates a community of all relevant stakeholders – other companies (e.g. IBM and Verizon), universities, government agencies and educators – and has set ambitious targets; for example, to bring the benefits of digitization to one billion people by 2025.

Through partnerships with countries and ministries of education, Cisco courses can be offered free of charge and delivered by certified trainers. This represents a great resource for a country to build national competencies in new digital technologies.

Source: Cisco, 2019.

RDI

Members of this cluster currently lack the infrastructure and talent necessary to drive RDI as a national talent and wealth engine creator. To address this gap, policymakers should be encouraged to develop applied research competencies and infrastructure in partnership with leading countries to benefit from the latest discoveries and knowledge transfers.

Lacking a strong foundation in RDI, they should focus their initial efforts on defining a comprehensive, forward-looking and sustainable national RDI strategy that takes into consideration the country's existing key assets and aims to expand them. The creation of a relevant RDI infrastructure could be further financed by leveraging international donations or collaborations.

Economy

In line with the efforts presented to define dedicated strategies and roadmaps for each key enabler, policymakers should be encouraged to develop comprehensive sustainable industrial strategies that define current and future key economic sectors and assess their skills and education needs (i.e. supply and demand analysis in the short, medium and long terms). Within these strategies, particular attention should be paid to the needs of SMEs along the key national value chains to ease their modernization and strengthen their entrepreneurial spirit. The strategies developed will build the foundations of the state's future activities in the knowledge economy. They will inform the digital infrastructure in which political leaders will invest, financial incentives to introduce, and the training/educational programmes to offer.

Funding

Funding represents one of the key challenges faced by the members of this cluster and may hinder the further development of their growing knowledge communities. In the first instance, policymakers should develop a comprehensive sustainable country strategy and related financial plan that will feed into their national development plan and will be earmarked for boosting knowledge and innovation capacity as well as capability development through education. The establishment of green investment platforms to support sustainable projects and entrepreneurs may be of particular interest in this regard.

Additionally, policymakers should aim to attract private and supranational funding to invest in the digital infrastructure of the country. The funding received could further facilitate the implementation of the skills and training strategy developed.

Finally, the set-up of climate resilience metrics may be useful to political leaders trying to assess the extent to which financing activities contribute to climate resilience. This would allow them to align their financing flows over time.

Box 4.3: Green fund and green politics in Rwanda

As one of the most vulnerable nations to climate change, Rwanda has established a green fund, known locally as FONERWA – a ground-breaking investment fund and the largest of its kind in Africa, established to achieve its vision of a low-carbon and climate-resilient economy by 2050.

The fund invests in the public and private projects that have the highest potential for transformative change and that align with Rwanda's commitment to building a strong green economy.

FONERWA

The fund also provides expert with technical assistance to ensure the success of its investments.

Thanks to Rwanda's efforts to put the environment and climate change at the heart of its development, the country's Ministry of Natural Resources was accredited by the International Green Climate Fund, which aims to attract sufficient climate finance to enable it to maintain rapid economic growth on a resource-efficient, low-carbon and climate-resilient path.

Rwanda also benefits from the Green Climate Fund for an off-grid solar project to drive solar use in East Africa through a new investment fund – KawiSafi – which provides equity to clean energy companies with expertise in household solar power, as well as recent $32.8 million grant to strengthen climate resilience in Gicumbi District.

Source: United Nations Framework Convention on Climate Change, 2019.

4.4.2 Group 2: The Black grouping

Countries in the Black grouping demonstrate moderate GKI and Global Technology Awareness Index results.

General enabling environment

Countries in this group could rapidly progress or regress due to the impact of their policies on the general enabling environment. Their policymakers should reinforce the foundations of their general enabling environments and address some key, specific national issues preventing innovation development or the expansion of entrepreneurial activities.

The development of a strong digitalization strategy for government services will help the country to progress on key international benchmarks while simultaneously transforming the private sector. The general environment should be the most compliant with international governance standards, in order to reassure foreign investors and donors.

ICT

ICT represents an area of major strength and opportunity for countries with a well-educated population. Policymakers should concentrate their efforts on modernizing existing ICT infrastructures and investing in state-of-the-art technologies (e.g. high speed and accessible Internet, 5G, high-performance computing [HPC], cloud computing, etc.). These technologies will act as enablers in the adoption of advanced technologies and will allow the country to build a strong ICT based economy and society.

Education

Policymakers in this grouping should develop or review their national skills strategies as well as their implementation. Keeping in mind the significant efforts needed to review an entire national education and training system, as well as vocational training, investments in new infrastructure and learning facilities could represent an important financial burden, highlighting the need for closer collaboration between states and centres of expertise.

To advance with the modernization of education and training infrastructure, a pilot programme targeting a key priority sector or technology of the respective state should be introduced. This will allow political leaders to focus their efforts on a specific target area and to improve the efficiency of processes in place.

Box 4.4: Turkey's Education Vision 2023

"The main purpose of the 2023 Education Vision is to raise science-loving, skilled and ethical individuals who take an interest in culture and are willing to use present and future skills for the well-being of humanity".

Ziya Selcuk –
Minister of National Education

Turkey's Ministry of National Education announced a comprehensive national education vision in 2018 that addresses a wide set of education priorities, from the creation of a data-based education management system, skills assessment and evaluation, to school funding, the introduction of revamped education programmes for students with special needs and increased efforts to increase the digital skills of the population.

Turkey's Education Vision 2023 might present food for thought for other policymakers and presents a good example of a comprehensive national skills strategy.

Source: MEB, 2018.

RDI

While good RDI foundations exist in the present countries, with some centres of excellence, they might not be in line with the latest trends and key enabling technologies. Political leaders should be encouraged to renew and strengthen RDI foundations in core domains to support the development of future knowledge.

The RDI strategies in place should be revised and key centres of excellence defined to support the advancement and integration of new key technologies. Private–public partnerships, as well as international collaboration agreements, might drive the creation of dedicated centres of expertise. Additionally, the intellectual property framework should be revised to facilitate the protection of newly-created intellectual property.

Box 4.5: İTÜNOVA Technology Transfer Office (TTO), Turkey

The İTÜNOVA Technology Transfer Office (TTO), established in 2013, offers academic studies and new technologies developed by the Istanbul Technical University (ITU) to national industry. This allows national industry leaders to meet their needs for innovative solutions and adds value to Turkey's economy.

The vision of İTÜNOVA TTO is to increase the scientific and technological knowledge production capacity of ITU on an international level and commercialize the knowledge generated for the benefit of society.

Its mission is to enhance scientific and technological knowledge production capability through academy–industry collaboration and to implement new technologies built on this knowledge. It further aspires to increase the radius of action for additional research by making use of national and international funds; to protect the resulting intellectual property rights; and provide suitable platforms for entrepreneurs that will create this new knowledge.

Source: İTÜNOVA, 2016.

Economy

For some countries in this grouping, the economy is driven and supported by the availability of natural resources. Economic diversification remains a major challenge for these states and the digitalization of their economies may not have been their top priority so far. For these countries, as for those without natural resources, population skills represent their most valuable strategic asset.

Key policies should concentrate on mobilizing the entrepreneurial potential of the country through the acceleration and up-scaling of existing organizations. Particular attention should be paid to SMEs in this regard.

Political leaders may also consider partnerships between RDI and education institutions and industry leaders to further drive innovation and the development of national wealth. Open innovation could be additionally strengthened through the establishment of innovation support institutions – such as Fab Labs and Living Labs – or through the organization of design thinking events to engage public participation and develop collective solutions to common national challenges.

Box 4.6: Biggest accelerator in Latin America: Start-up Chile (SUP)

Start-up Chile is a public start-up accelerator created by the Chilean Government for high-potential entrepreneurs to boost their start-ups and use Chile as a foundation for their growing businesses. Currently, Start-up Chile presents the leading accelerator in Latin America and scores amongst the top 10 globally.

Start-up Chile offers various funding opportunities to start-ups depending on their maturity level. Funding support aims to boost female entrepreneurship, internationalization and societal innovation, amongst others.

In addition to funding, Start-up Chile also provides training, access to an international network of mentors and investors for local companies, and offers soft landing and work visa support to encourage internationals to locate and establish their business in Chile.

Source: Start-Up Chile, 2019.

Funding

To drive the necessary advancements presented above, policymakers will need to increase their investments in reforming the capacity and capability of existing education, digital infrastructure and RDI institutions to facilitate the adoption of advanced technologies and unlock private sector investments.

Hand-in-hand with a general enabling environment that respects best international standards and will accelerate international investments, new green energy, industrial and digital strategies will create brand-new momentum in these countries.

4.4.3 Group 3: The Red grouping

This group of countries presents a very solid knowledge-based infrastructure and robust technology awareness maturity.

General enabling environment

Policymakers should consider modernizing and reinforcing their general enabling environment by addressing some of their specific national weaknesses. Overall, countries in this grouping already perform very well. Nevertheless, their foundations were created during the last industrial revolution and are no longer aligned with the requirements of a fully digitalized and sustainable society. The development of a general enabling environment that prioritizes the advancement of a sustainable digital society and an economy based on a human-centric approach represents a key priority for most of these states. Upskilling the workforce to softly transition to the sustainable digital societies of the 21st century will represent a major priority and challenge.

ICT

Policymakers should concentrate their efforts on further upgrading existing ICT infrastructure, skills bases and driving innovation. Awareness on new technology solutions and their potential opportunities and challenges amongst citizens, policymakers and industry leaders must be maintained and advanced. Without their buy-in, political leaders will struggle to advance the technological prowess of their constituencies. Public–private partnerships (PPPs) might be of tremendous value to policymakers with limited funds and/or experience in this field. Partnerships between industry, academia and RDI institutions at both the national and international levels should be considered.

Box 4.7: UAE AI Strategy

The National Artificial Intelligence Strategy 2031 aims to position the United Arab Emirates as a global leader in AI by 2031. It aspires to:

- position the UAE as a global hub for AI;
- increase the competitive edge of the AI sector in the UAE;
- establish an incubator for AI innovation;
- employ AI in the field of customer services to improve overall quality of life;
- attract and train talent for the jobs of the future;
- attract leading research capabilities;
- provide data-driven infrastructure to support AI experiments; and
- optimize AI governance and regulations.

The formation of the UAE AI Council	Workshops, programmes, initiatives and field visits to government bodies	Develop capabilities and skills of all staff operating in the field of technology and organise training courses for government officials	Provide all services via AI and the full integration of AI into medical and security services	Launch leadership strategy and issue a government law on the safe use of AI

The comprehensive nature of the strategy may present inspiration for country leaders facing similar conditions and aspirations.

Source: AI Everything, 2019.

Education

Overall, existing education systems show strong foundations but will require specific modernization to deliver a more personalized journey for students. The reform of the vocational training system will also provide a new framework that will allow for the continuous upskilling of the workforce in line with labour market demand.

Further efforts should focus on the introduction of innovation programmes and centres of expertise concentrating on dedicated technologies of interest to the state. Policymakers should drive the continued expansion and specialization of the talent pool of the country with regards to competition for international talent. Exchange programmes with other centres of expertise should be widely encouraged and financially supported to encourage knowledge and capability development.

RDI

The ratings of the countries in this grouping demonstrate a high level of performance in their RDI institutions. The challenge for these states lies in the integration of new key enabling technologies into existing frameworks and linking national capacities to market demands (e.g. blockchain, AI, photonics, etc.). The valorization of key RDI assets produced over the last 20 years, in combination with increased computing power, could represent a further opportunity for these states.

Economy

Political leaders should focus their efforts on awareness-raising activities that will valorize innovation. Public demonstrations of new technologies might present an opportunity in this regard. The aim of these activities is to raise awareness of technological solutions amongst industry players, policymakers, and sectoral and business associations that will tackle societal and industrial issues.

The combination of a new regulatory, technology and economic environment will further enable the creation of nationwide test beds that will facilitate the testing and validation of new innovations while simultaneously promoting the development of new skills.

Additional activities should establish strong connections between tech companies, sectoral companies, RDI institutions, training providers, higher education institutions (e.g. Industrial Masters & PhD programmes, dual track education combining education with industry experience, etc.) to stimulate knowledge creation and raise awareness of the technologies/skills of the future. SMEs should receive particular attention in this respect, in order to allow for the re/upskilling of their employees in line with the skills needs of emerging technologies.

Funding

For most of the countries in the Red grouping, the funding challenge lies in financing existing ongoing societal expenses and keeping reasonable debt levels, while simultaneously finding the resources needed to drive the generation of new infrastructure and upskill workforces. The development of new funding schemes such as green bonds or social bonds offers an opportunity for these countries to switch to more sustainable economies.

4.4.4 Group 4: The Blue grouping

The members of the Blue grouping present the strongest performances on the GKI and the Global Technology Awareness Index.

General enabling environment

Policymakers should concentrate their efforts on anticipating and co-developing their enabling ecosystems in light of global societal issues and opportunities. Their status as innovative and entrepreneurial nations will help them to conceive the best-trusted enabling environments for the future based on human-centric approaches. At the same time, these states should share their knowledge and educate less advanced countries through international collaborations.

Box 4.8: e-Estonia

Estonia is currently seen as one of the most advanced digital societies in the world due to its increased efforts in this field over the past 20 years.

Building e-Estonia as one of the most advanced e-societies in the world has involved continuous experimentation and learning from mistakes.
Currently, Estonia sees the natural next step in the evolution of the e-state as moving basic services into a fully digital mode with automatic e-services available 24/7.

Data, cybersecurity, cross-border data exchange, real-time economy, intelligent mobility, e-Health, Industry 4.0 and the transformation in education are amongst the key focus areas of Estonia.

Source: e-Estonia, 2019.

ICT

Members of the Blue grouping have established strong ICT foundations and their citizens are generally aware of future technology and skills trends, yet they continue to lack the skills necessary to drive innovation. To keep advancing as centres of excellence for dedicated technologies, policymakers should continue investing in the growth of their national talent pools in advanced technology domains and ensure they remain at the forefront of the latest developments and innovations. Here, particular attention should be paid to the development and/or implementation of global standards to facilitate international collaboration and exports.

Education

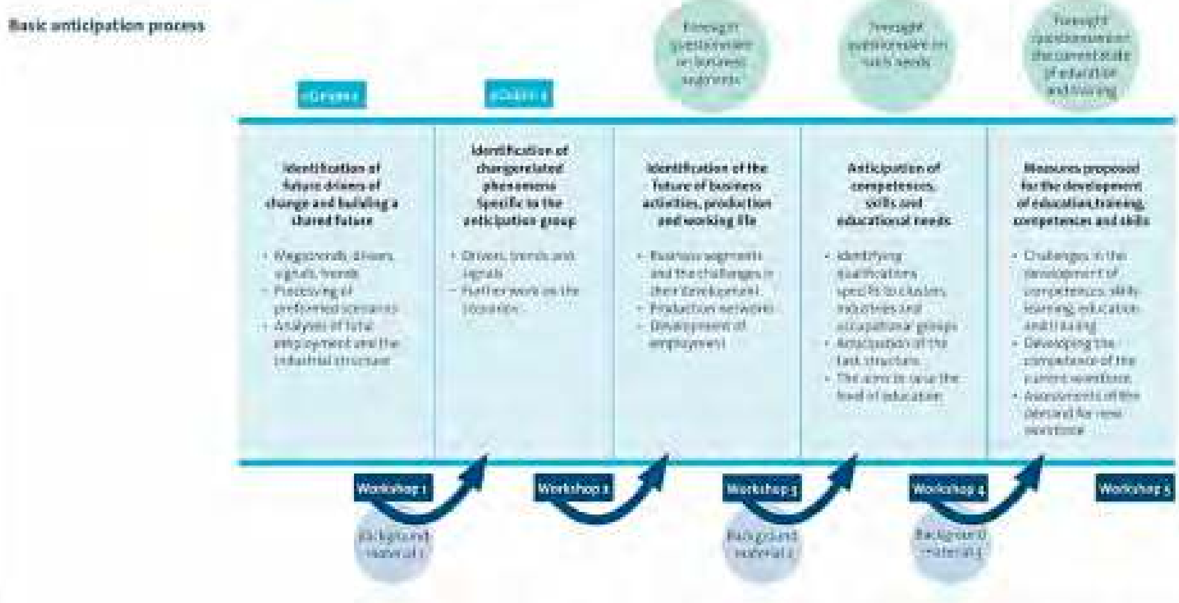
To maintain their strong education and skills ecosystems, policymakers in this grouping should introduce a national skills observatory that will collect real-time data on the latest national skills and technology trends to rapidly adapt their education and vocational training curricula frameworks. Partnerships with industry, as well as the creation of an enabling environment for learning, will accelerate the creation of new relevant knowledge and skills capital.

Box 4.9: Finland's National Forum for Skills Anticipation

The Finnish National Agency for Education (EDUFI) and the Ministry of Education and Culture founded a joint expert body – the National Forum for Skills Anticipation – with the aim of strengthening national educational anticipation.

The National Forum for Skills Anticipation aims to gain a better understanding of future skills trends and to align with training providers on how best to meet this demand. It has been appointed for a term of three years between 2017 and 2020 and consists of nine sectoral anticipation groups. The members included represent stakeholders from vocational education, training providers, higher education institutions and working life.

The National Forum for Skills Anticipation highlights the benefits of encouraging active stakeholder engagement in designing and implementing national skills strategies and underlines the need for forward-looking skills assessments.



Source: Ministry of Education and Culture, Finland, 2019.

RDI

Policymakers should further support the expansion of multi-disciplinary and cross-sectoral centres of excellence to drive RDI and the multimodal deployment of technologies with a specific focus on how they can be used to tackle societal challenges and support economic development. To complement these activities, test beds and large-scale demonstration projects should be envisioned to accelerate the commercialization of innovative solutions/technologies. Furthermore, national development aid programmes should be introduced to support high-potential partnerships with lower scoring territories. Specific efforts could focus on either the development of new RDI infrastructures or common participation in innovative RDI programmes.

Box 4.10: Luxembourg's Interdisciplinary Centre for Security, Reliability and Trust (SnT)

The Interdisciplinary Centre for Security, Reliability and Trust (SnT) conducts internationally competitive research in ICT and engages in multiple public–private projects. To continue expanding its demand-driven collaborative projects, the SnT introduced a dedicated partnership programme that includes over 40 members and targets strategic areas addressing challenges confronting industry and the public sector in ICT. The resulting concepts present a genuine, long-lasting competitive advantage for companies in Luxembourg and beyond. The SnT presents a great example of how public and private actors can drive innovation together and build a sustainable digital society.

Source: University of Luxembourg, 2019.

Economy

Policymakers should focus on strengthening existing frameworks to make the skills of their human capital their most effective strategic resources. At the same time, they should continue their efforts to attract and retain international talent. Collaboration programmes with other states should be encouraged and international business missions organized to help industry expand and localize knowledge. In parallel, international PPPs and collective initiatives can establish respective economies as centres of excellence and promote their standing as nations driving innovation and knowledge in key focus areas.

Funding

The members of this grouping present strong funding infrastructure and assets that could be further strengthened through the formation of PPPs at the national level on a thematic or key-sector basis. Substantial efforts should be devoted to supporting industries/sectors that will facilitate the implementation of technological solutions to address concrete national issues. As in the previous sections, international partnerships should be pursued to tackle broad societal challenges by pooling financial and human resources (i.e. for the realization of the SDGs).

4.5 Conclusion

This report has shown that all 40 countries within our sample have recognized the importance of embracing technological progress and supporting the development of modernized skill sets. Yet varying levels of advancement are noted. By separating the countries analysed into four groups, country leaders will be able to easily identify the recommendations applicable to their current state of advancement. The inclusion of best practices will further encourage the development of interstate partnership frameworks and drive sustainable innovation.

It is important to underline that none of the states analysed have reached their full future knowledge potential. The concept of the 'future knowledge trajectory' underlines the need for ongoing reform and reflection to enable the growth of continuously innovating, sustainable societies. In the same spirit, the toolbox presented above will require regular updates to remain aligned with the actual needs of the states assessed. This will allow country leaders to regularly review their knowledge infrastructures and ensure their citizens remain aware of the most vital skills and technologies of the future. At the same time, they will be able to track the progress they have made over time and to prioritize their efforts to those areas of the highest urgency.

Innovative societies require motivated and innovative leaders; the toolbox presented herein offers an initial enabler to those who are ready to drive the future development of their countries.

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