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

THE FUTURE OF KNOWLEDGE:
A FORESIGHT REPORT

Knowledge 4All

The Future of Knowledge:

A Foresight Report

2018

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This report has been produced through a partnership between Mohammed Bin Rashid Al Maktoum Knowledge Foundation (MBRF) and United Nations Development Programme/ Regional Bureau for Arab States (UNDP/RBAS)

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Foreword
Mohammed Bin Rashid Al Maktoum Knowledge Foundation

In a rapidly changing world, knowledge is currency. It is with knowledge, science and research that we can forecast the future and set sail towards our objectives of building sustainable knowledge economies and ensuring the wellbeing of communities. This has been a mantra guiding our efforts across public and private entities here in the UAE, echoing the forethought and directives of our wise leadership. "The pen and knowledge are mightier than all other powers," said His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE, Ruler of Dubai.

As the foundation bears His Highness's name, and is dedicated to the production, dissemination and localisation of knowledge in the UAE, we, at the Mohammed Bin Rashid Al Maktoum Knowledge Foundation, have committed ourselves to consistently innovating and upgrading initiatives, projects and programs to achieve these objectives. Our journey has brought us together with various partners over the years, most notably among them is the United Nations Development Program (UNDP), with whom we are honoured to be celebrating the 10th year of collaboration on the Knowledge Project.

Last year, our partnership saw us launch a ground-breaking new initiative to drive forward a knowledge movement on a global scale. The Global Knowledge Index was introduced as an international knowledge platform that tracks the realities
and conditions of this sector in 140 countries around the world, highlighting challenges and proposing solutions for the sustainable development of societies. The launch truly established the Foundation as a global institution spreading knowledge and science to all corners of the globe.

This year, we are excited to be announcing three specialized reports, once again in close cooperation with our partners at the UNDP. The first is the much-anticipated "Results of the Global Knowledge Index 2018", which reveals the findings of the Index in 2018. The second – titled "The Future of Knowledge: A Foresight Report" – is the first of its kind and will see the Foundation go beyond tracking knowledge in the present to place equal attention on the future of the sector, resonating with the UAE's general direction of focusing on the future. As our world develops, knowledge evolves with it; we must update our instruments to maintain our capability to capitalise on the knowledge opportunities these transformations bring – especially the advancements of the Fourth Industrial Revolution.

The third report bears the title "Knowledge and the Fourth Industrial Revolution". Created following great demand from numerous academics and researchers, the report takes a deeper look at the findings of last year's edition of the Index, offering analysis and greater insight into the main takeaways.It is with great enthusiasm that we launch these reports, as we look forward to hosting the fifth annual Knowledge Summit here in the UAE. We are honoured to be playing our part in promoting our country as a centre for cultural dialogue, and a source of ambitious, future-oriented visions and strategies foronce again with the vision of H.H. Sheikh Mohammed bin Rashid Al Maktoum, who repeatedly asserted that "the preservation of leadership, excellence, sustainable growth and prosperity requires us to embrace the age of the knowledge economy as soon as possible."

Sheikh Ahmed bin Mohammed bin Rashid Al Maktoum
Chairman of MBRF

Foreword
United Nations Development Programme

The release of this report coincides with the tenth anniversary of the Knowledge for All project which, since its inception, has been focusing on the correlation and interaction between knowledge and development, taking into consideration the unique context of the Arab States. Such work would not have been possible without the precious and longstanding partnership between the United Nations Development Programme and the Mohammed bin Rashid Al Maktoum Knowledge Foundation. With knowledge as its cornerstone, this collaboration fully embraced 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, who said, “the race for excellence has no finish line.”

The project has moved from an initial stage of theoretical studies on the status of knowledge to quantitative monitoring and analysis of countries’ knowledge profile, and finally to forecasting the future of knowledge around the world. This has allowed various stakeholders in the political, academic, research, industrial, and economic circles to develop informed policies based on data and scientific evidence, and to assess any improvement or decline in 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 the general enabling environment.The project introduces various publications this year. First, the Global Knowledge Index 2018, with updated data and reviewed indicators that can better capture the various and complex dimensions of the knowledge landscape at the global level. The second publication is an analysis of the results of the Global Knowledge Index 2017, which shows that the achievement ‘knowledge societies’ is linked primarily to revolutions in the field of information and communications technology, led by the capacity of human capital in terms of creativity, innovation, and use of technology for innovation and development. Therefore, the success of countries in embracing these revolutions, especially the Fourth Industrial Revolution, depends on their willingness to investin the fields of knowledge and technology, and their ability to take the necessary decisions to address obstacles in their way.

While the Global Knowledge Index measures the current levels of knowledge, this year’s third publication focuses on the importance of anticipating the future of knowledge. Leveraging the potential of big data, a new model was built to measure countries’ readiness for further knowledge development, taking into account the rapid technological transformations and their impact on various knowledge sectors.The Knowledge for All project is a unique initiative that seeks to shape a new and innovative vision for the realisation of the 2030 Agenda within and outside the Arab States. Despite the difficult challenges and sharp changes in the region in recent years, the project has not lost momentum. Rather, today at the Knowledge Summit, we are eager and proud to present yet another milestone achievement and express our appreciation to all those who contributed to its completion, particularly the expert teams, the Mohammed bin Rashid Al Maktoum Knowledge Foundation and its leaders, and the Knowledge Project team. Strongly committed to continuing supporting policy-makers in their strive for sustainable development, we look forward to producing more quantitative and qualitative data and analysis to enrich the global knowledge landscape in the years to come.

Mourad Wahba
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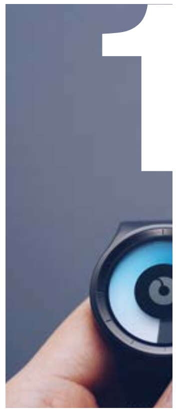
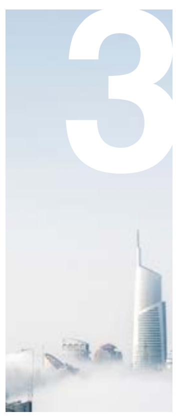


INTRODUCTION

METHODOLOGY



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1 INTRODUCTION

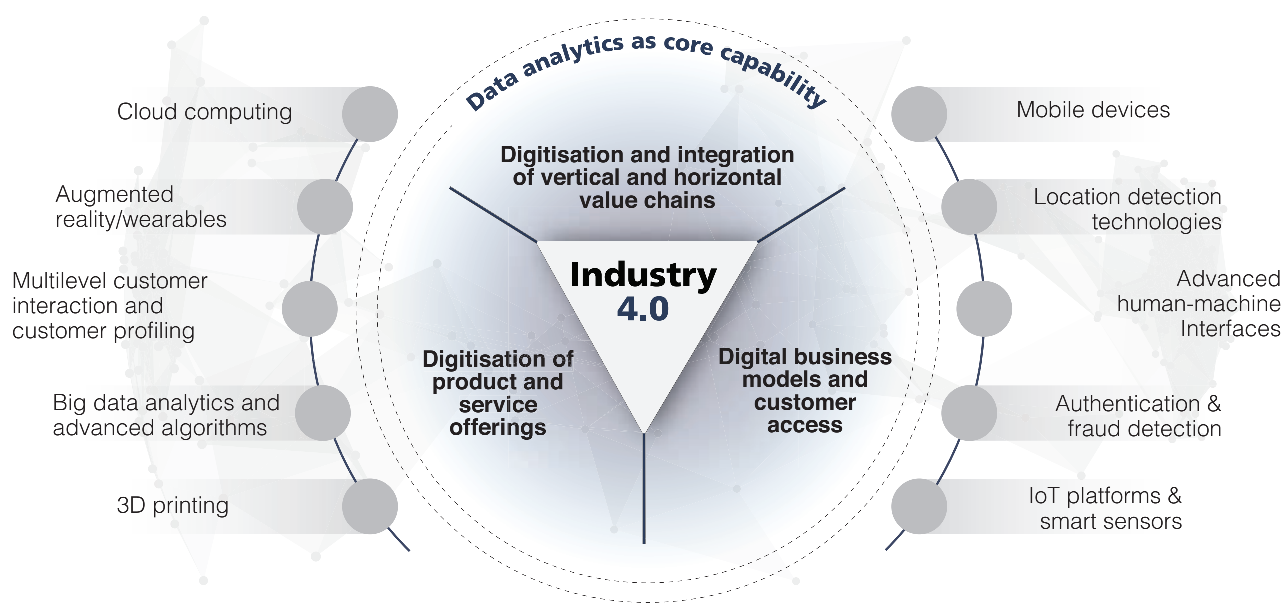
1 INTRODUCTION

1.1. Setting the scene

Since the emergence of the Internet and the rise of electronic and information technology at the dawn of the third millennium, **societies have been changing rapidly and drastically**. The increasing importance of knowledge, combined with globalization and the disruptiveness of technological change that characterized the Fourth Industrial Revolution, has created a fundamentally different type of world.

The Fourth Industrial Revolution (also called Industry 4.0) is unfolding before our eyes. It is the era of creative convergence, where a myriad of technologies that span themes such as the Internet of Things (IoT), cloud computing, big data analytics and artificial intelligence (AI) begin to connect,[1] creating an ecosystem in which each technology both exploits and fosters the development of the others.[2] This revolution **creates unprecedented opportunities and challenges** for businesses and societies alike. It is distinct from prior revolutions, given its intensity, complexity and scope, and it is rooted in a new technological phenomenon – digitalization, i.e. the integration of digital technologies – that is penetrating the infrastructure of every business, organization and government with unprecedented speed.[3]

Figure 1: Digital technologies contributing to Industry 4.0 (PwC, 2016)



The present technological revolution is having a tremendous impact on knowledge societies by triggering the production of massive amounts of new data, improving the transfer of information and knowledge, enhancing knowledge creation, and facilitating innovation. Knowledge societies "are identified as societies based on the creation, dissemination and utilization of information and knowledge. They are societies with economies in which knowledge is acquired, created, disseminated and applied to enhance economic and social development."[4] The rise of ICT and its wide adoption by every economic sector has improved knowledge sharing and knowledge creation by lowering temporal and spatial barriers between people and improving access to information. AI and other advanced analytics technologies decrease information processing costs. The newest algorithms, built on machine learning, big data and cloud computing, are now enabling organizations to collect in seconds huge amounts of data that are being produced by the myriad of low-cost, digital sensors present in industrial equipment, vehicles and production systems worldwide. The same algorithms help analyse these data to produce granular insights about processes and behaviours, which in turn can generate innovation that can create fundamental shifts in productivity, growth, customer value and competitiveness.[5] The increase of open digital platforms also contributes to both speed up and decrease the cost of innovation, by helping organizations and individuals to connect with each other and empowering them to combine technologies and practices more rapidly.[6]

The amount of **data** being captured **increases by a staggering** **40%** **each year**[7]

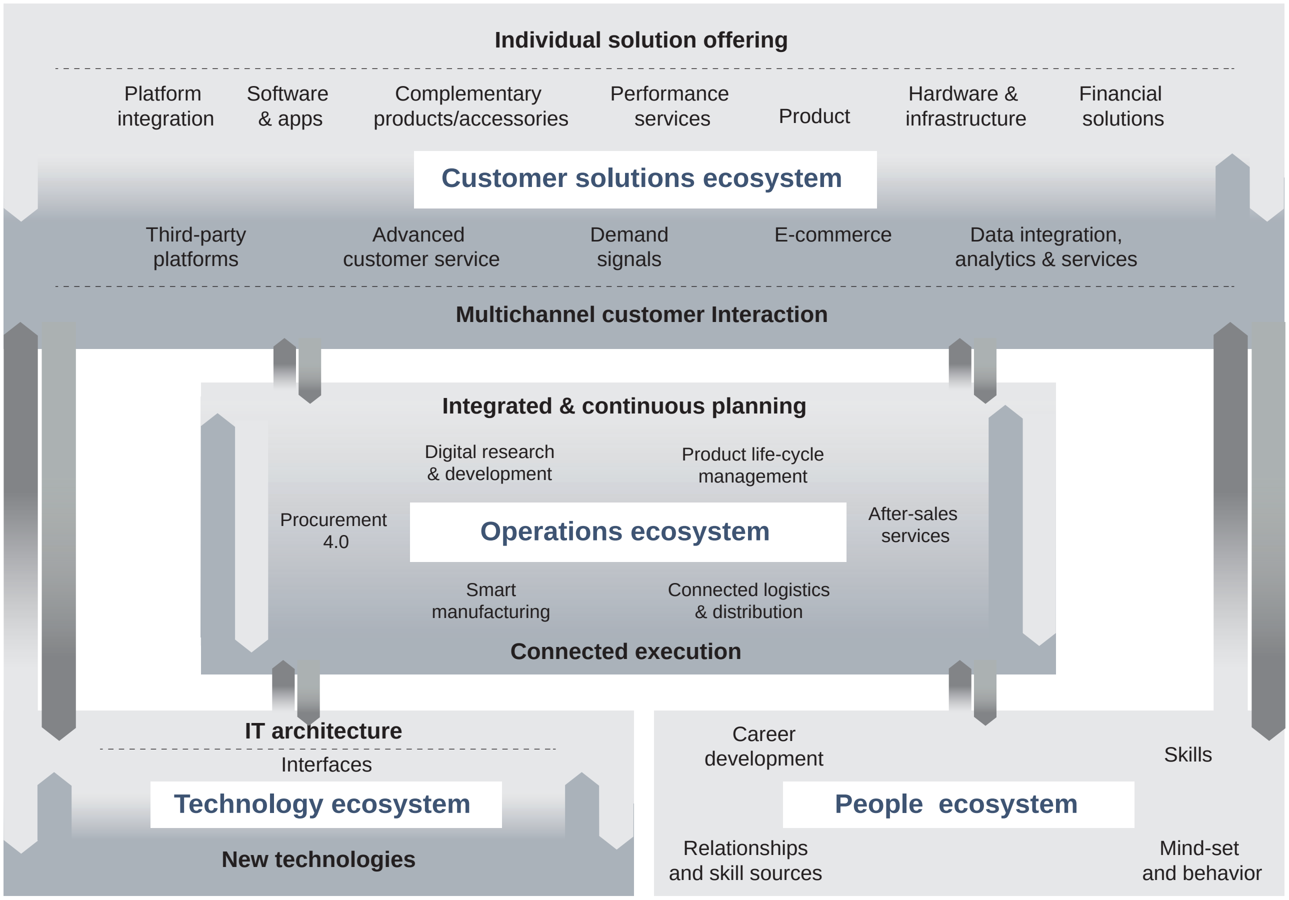
In 2025 the **"digital universe"** will reach **180 Zettabytes**[8]
"180,000,000,000, 000,000 000,000"

In light of these changes, **the process of knowledge creation and innovation is being reshaped**. The assumption that information, knowledge and innovation are costly to generate and can be easily protected (e.g. patents) no longer applies. As knowledge grows at an exponential rate and is ubiquitously available, companies can no longer build their competitive advantage on the uniqueness of their knowledge capital. Instead, they must learn to use information in the moment to make decisions, meet demand and respond to customers, as knowledge now has true competitive value only at the moment it is created.[9]

By 2020 knowledge will likely be **doubling** every **11- 12 hours**[10]

Companies that ignore this shift will likely struggle to survive. Entrants from the digital economy are now encroaching on the field of incumbent companies that have been on the top for decades, altering profit pools, redesigning existing value chains and blurring the boundaries of traditional industries. Existing players will need to be strategic about maintaining their market positions in a fast-changing environment by becoming 'digital champions', able to master the four critical ecosystem layers needed to embrace digitalization successfully.[11]

Figure 2: The four critical business ecosystem layers mastered by Digital Champions (PwC, 2018)



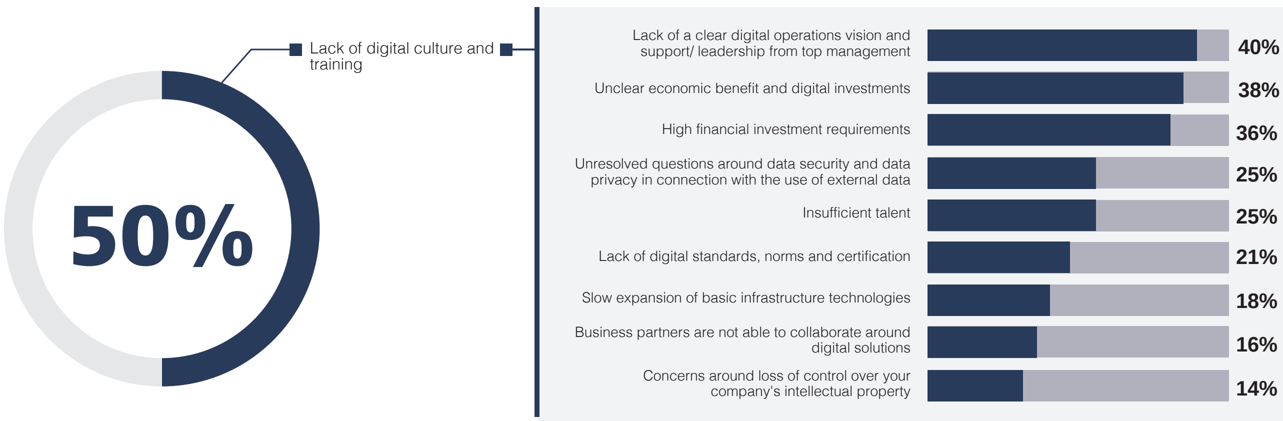
If companies fail to have the requisite strategies to cope with this radical change, they will not only precipitate their own decline, but also that of their entire sub-industries. **It is therefore also key that government leaders worldwide adequately support companies in their digital transformation** if they want to maintain the competitiveness of their industry, thereby sustaining growth and ensuring prosperity. In order to support the adoption and dissemination of new technologies, government leaders and policymakers will need to set the appropriate policies, regulations and national strategies for digital transformation, as well as collaborate both nationally and internationally.[12]

One specific knotty policy problem companies will likely face relates to antitrust regulation, as many industries are becoming more concentrated, with profits increasingly falling into the hand of fewer firms. In particular, they will need to better understand how the use of sophisticated computer algorithms by "super-platforms" can manipulate the markets and distort the perceived competitive environment.[13,14]

Another challenge for both government and business leaders is how to address the changing nature of work caused by the fourth revolution. Research has shown that (digital) technology contributes to labour market polarization that in turn causes a similarly polarized distribution of wages that is more unequal than in the past: employment in high- and low-skilled positions has grown substantially while the number of middle-skilled jobs has dropped dramatically.[15] In addition, disruptive technological changes accelerate the obsolescence of workers' skills. According to most research, half of workers' skills will be outdated within two to five years, depending on the industry.[16]

Companies will therefore need to be reorganized around learning if they want to remain relevant. Committing to executive education and upskilling employees will be essential.[17] To help both employers and individuals facing these disruptions, **government leaders, as well as other stakeholders such as education leaders and social partners, must deliver their part**. Government support is crucial for digitalization to become positive for all. With access to funding and a forward-looking posture that embraces change as an opportunity rather than an obstacle, national employment agencies can put together innovative training programmes to tackle the conundrum the job market is trying to solve.[18]

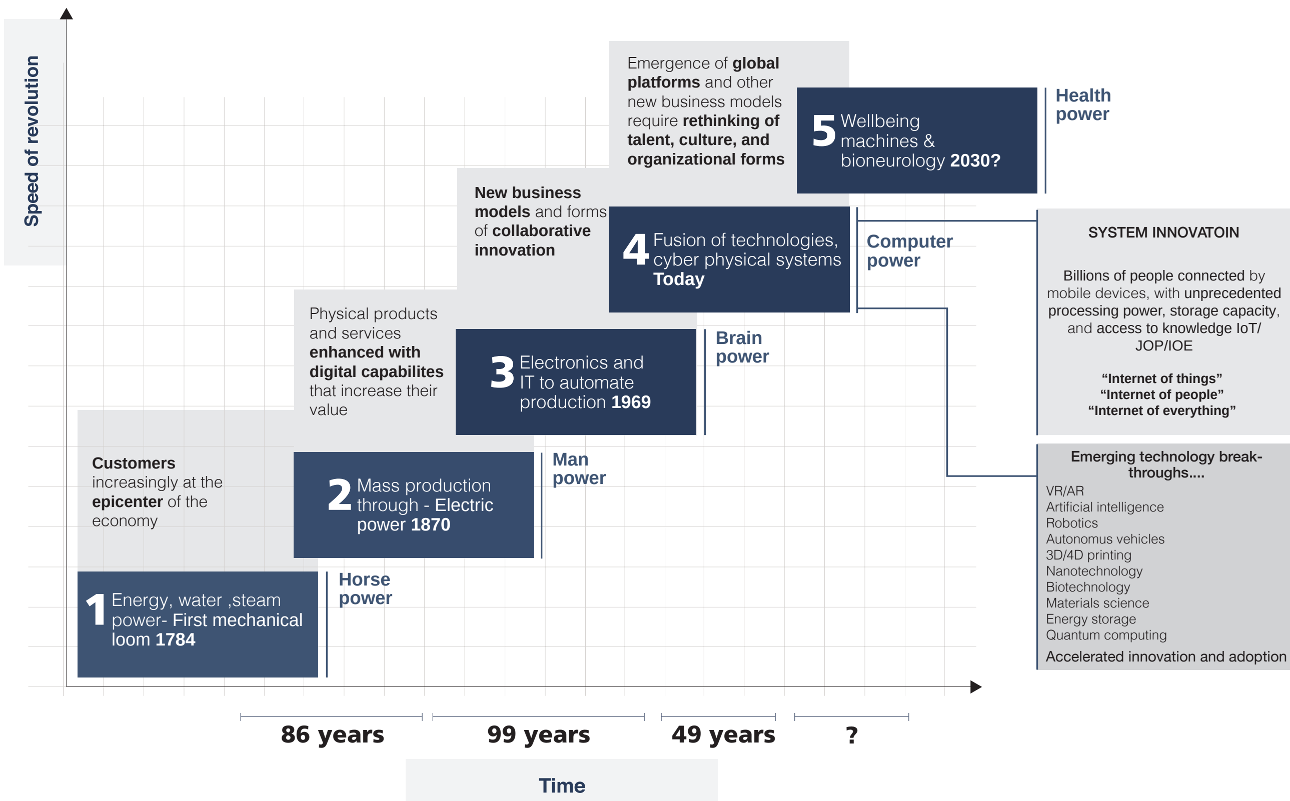
Figure 3: Biggest challenges facing companies for building their digital operation capabilities (PwC, 2016)



New types of training are essential, not only to teach employees and individuals the skills to harness technology and team up with the machines, but also to help them face the coming knowledge explosion associated with new technologies. With the boom of knowledge characterizing the digital economy, companies will increasingly need to cooperate with different types of partners to acquire ideas and resources from the external environment in order to stay abreast of competition.[19,20] Therefore, workers best prepared for the future will be the ones trained to be comfortable and conversant in disciplines outside their own, as well as in skills that support collaboration, such as empathy, active listening and open mindedness.

As of today, we have barely seen the tip of the iceberg when it comes to the implications of the Fourth Industrial Revolution for a country's competitiveness, its citizens and the nature of its industries and companies. It is a fact: new technologies are changing the world as we know it, but the direction they will take remains uncertain. Will they contribute to the creation of a more inclusive and sustainable society, or on the contrary, deliver a society characterized by more inequalities, exacerbated social fragmentation and increased polarization of ideas? Both paths are possible, and the course of transformation will greatly depend on actions taken today. Many government leaders, companies and individuals are attempting to stay on top of the wave by addressing surface disruptions of technologies in the short-term, but more lasting value can come from understanding and exploiting the forces underlying them. Awareness is therefore key. All of us – leaders and citizens – should strive to detect and better anticipate the upcoming shifts in the industry and emergence of new technologies if we want to build the kind of future in which we would like to work and live. In particular, in view of the accelerating speed at which each new industrial revolution appears, those who will know how to anticipate the next big change will be the ones holding the future in their hands.

Figure 4: The speed at which industrial revolutions appear is accelerating [21]



This report is in line with the goal of detecting and better anticipating the next big change. For us, knowing where we are today is half of the battle. By proposing a new method for measuring where countries stand in terms of future fields of knowledge using real-time data, we offer government leaders and supporting stakeholders a tool for anticipating what may come next.

1.2. Purpose and objective

After years of measuring the current state of knowledge based on data from national statistical and data systems, and given the exponential growth of knowledge creation, a new knowledge measurement tool using big data is being designed to better understand the future of knowledge societies. This report will present a pilot study, covering 20 countries, on the future fields of knowledge that will shape the future of knowledge societies.

To achieve the goal of the study, the report was divided into four chapters. A detailed methodology is presented in Chapter 2, followed by a detailed analysis of the main findings in Chapter 3, then discussions on key knowledge issues, perspectives and trends in Chapter 4. The chapters are interlinked with one another in order to give the reader a holistic approach to the future of knowledge societies.

The purpose of this report is twofold:

- To have a better understanding of today's strong and weak signals in the next wave of (technology) disruption by testing a new way to capture and analyse real-time data associated with five key future fields of knowledge: Artificial Intelligence (AI), Cybersecurity, Blockchain, Biotechnology, and Future Skills;
- To accelerate knowledge development by helping country leaders to benchmark their performance against that of front-runners.

Our objectives are to:

- Conceptualize the future of knowledge creation and development as a multidimensional phenomenon;
- Move from primary statistics collected through surveys to real-time statistics collected through digital platforms;
- Evaluate the performance of 20 selected countries – including the top five performing countries on the Global Knowledge Index 2017 i.e. Switzerland, Singapore, Finland, Sweden and the Netherlands – in terms of readiness for the future;
- Encourage policymakers, business leaders, researchers and civil society to combine their efforts to develop those technologies that will likely shape the near and long-term future.

1.3. Future fields of knowledge

In this section, we explain our 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

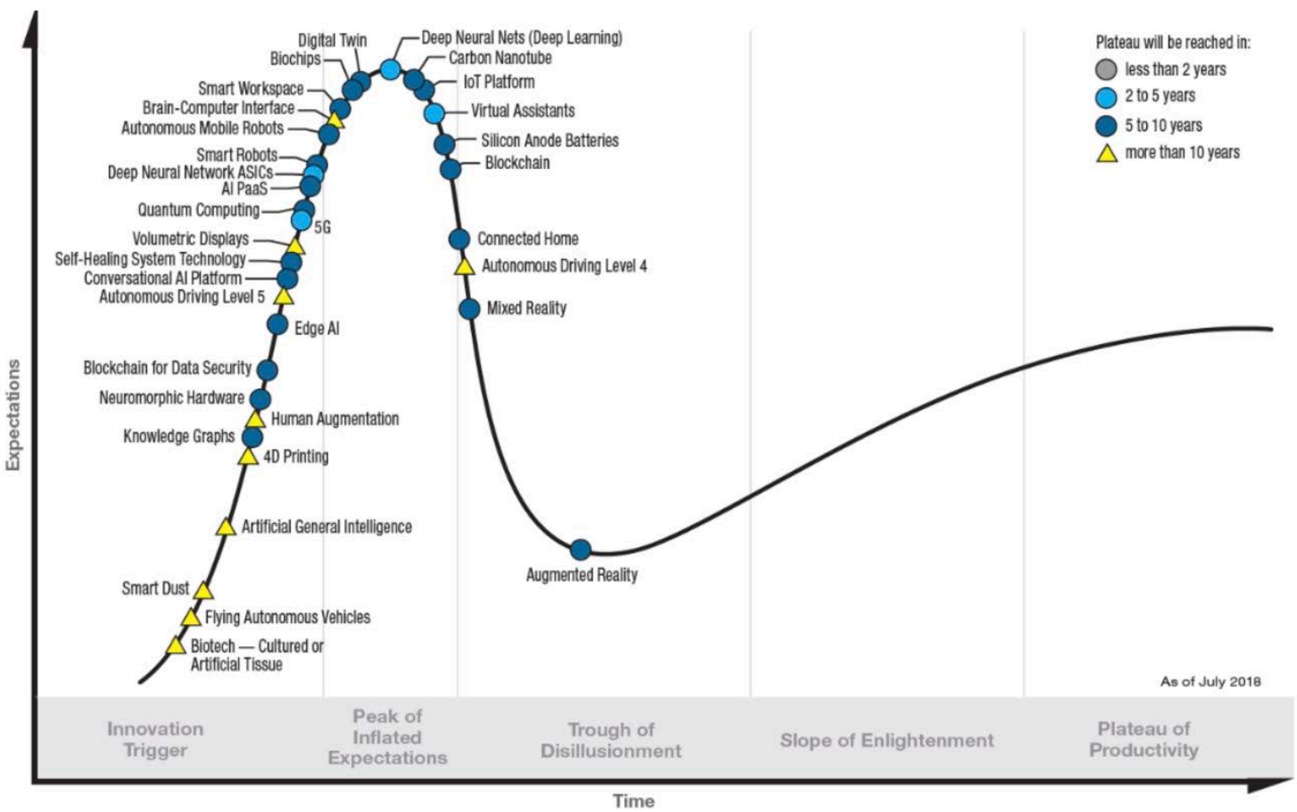
When we talk about the future of societies, technological change cannot be considered in isolation. Other forces – or trends –, such as globalization, sustainability, demographic shifts and urbanization, will also affect the future state of the economy and the future of work. Therefore, if we want to understand how the future will be shaped, we need to acknowledge the interactions embedded in these trends as they often reinforce each other.

We believe that certain types of technologies can help overcome most of the challenges associated with these trends, such as the ageing population, increasing scarcity of resources (including food shortage in developing economies) and growing inequalities. The European Commission calls these technologies "Key Enabling Technologies" (KETs),[22] and they are also commonly referred to as "Exponential technologies."[23] In this report, we refer to them as "key technologies for the future."

All key technologies for the future present two principal common features. First, they form together an ecosystem in which each technology both exploits and fosters the development of the others. In other words, the novel technologies that are being grafted on existing and more mature technologies amplify the performance of the latter, and *vice versa*.[24] Second, they enable the exponential acceleration of innovation, as each technological improvement leads to innovation, which in turn functions as a platform for further technological improvement and innovation. These technologies therefore help developing multiple novel applications in a wide range of sectors and industries.[25,26]

As highlighted in the "Technology Profiles", **AI, Cybersecurity, Blockchain and Biotechnology** possess these two features. In addition, they are all still at an early stage of development as exemplified by their position in the latest Gartner Hype Cycle (see Figure 5). For each of them, many avenues for future research, experimentation and innovation remain, which could lead to unexpected results. We therefore believe that these four technologies **are good options to bet on and invest in for the future, as together they could be used to build solutions to the world's most pressing environmental, economic and social challenges with greater speed and accuracy**, thereby helping to realize the 17 Sustainable Development Goals (SDGs).

Figure 5: Gartner's Hype Cycle for Emerging Technologies (2018)



ARTIFICIAL INTELLIGENCE
Technology Profile

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.[27]

Progress in AI is accelerating thanks to advances made in key other technologies

Since its initial conception in the 1940s, AI has reached a historical moment because of six converging factors, four of which are technological:[28]

Big data

Today, the availability of greater volumes and sources of data (both structured and unstructured) is enabling capabilities in AI that were not possible in the past due to lack of data availability and limited sample sizes.[29]

Cloud computing

Breakthroughs in cloud computing technologies have made it cheaper and faster to handle large volumes of data with complex AI-empowered systems through parallel processing.

Social media platforms

Advances in several aspects of AI such as deep learning and reinforcement have been facilitated by the existence of open-source communities who are developing and sharing AI tools and applications.

Open-source software and data

Similarly, open-source software and data are also accelerating the uptake of AI as they allow spending less time on routine coding and industry standardization.

AI equips other technologies with tremendous power

Recent advances in AI presage a new age for many other technologies. For example, AI could improve cloud technology just as cloud technology has improved AI development. Their combination has the potential to change the way the data are stored and processed across various geographies.[30] AI has also taken root in biotech, where for instance, machine learning shows great promise to make drug discovery cheaper and quicker.[31]

AI as an answer to most pressing challenges faced by societies

Today, AI is already used to forecast crop yields from space, automate microscopes to diagnose malaria and make customer support multilingual. These are only a few examples of how different sectors can benefit from the technology. More than 60 percent of consumers and business decision makers believe that AI can help provide solutions to the most important issues facing modern society ranging from clean energy to cancer and disease.[32]

By tailoring drugs and treatments, the technology could deliver savings of up to EUR 8.45 trillion in the healthcare sector. In the energy sector, AI has the potential to cut 10 percent in national electricity usage by using deep learning to match energy generation and demand in real-time, increasing efficiency, use and storage of available energy. Machine learning could also yield 12 percent fuel savings for manufacturers, customers and airlines by optimizing flight routes.[33] AI techniques are also opening up various new approaches to protect and sustainably manage oceans. In order to protect endangered marine species, new systems could use image analytics and machine learning to track the numbers and locations of invasive species. AI-powered robots could also be used to monitor ocean conditions by detecting pollution levels and tracking changes in temperature and pH of the oceans due to climate change.[34]

BLOCKCHAIN

Technology Profile

Definition

Blockchain is the technological heart of the cryptocurrency known as Bitcoin. It 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."[35] By providing a high level of security, Blockchain can be an important piece of the digital infrastructure, where trusted digital applications can be used.

Blockchain helps resolve key technologies weaknesses

As Joe Kaeser, CEO of Siemens pointed out, "Data is the oil, some say the gold, of the 21st century."[36] Technologies developed at the beginning of the twenty-first century fostered the development and creation of millions of pieces of data, as well as their online storage and exchange between individuals, companies and organizations. Nevertheless, whereas simplification in data exchange brought numerous advantages, it also raised reliability problems, to which Blockchain provided as a solution:[37]

Secure, shared information storage. The main and most important feature of Blockchain is to act as a neutral infrastructure, over which no one has complete control. Blockchain allows the exchange of data with third parties in which trust is limited.

A registry for any type of data. In addition to features such as immutability and authentication, Blockchain allows to directly and quickly access all information needed.

Automated transactions via "smart contracts." The "contract" is defined in software and stored in the Blockchain. It is executed automatically under the precondition that the predefined conditions are met.

Blockchain as a milestone in the development of other technologies

As Blockchain offers a mean to securely share and store digital information, and provides solutions to execute contracts, the technology is likely to be integrated into AI applications. For example, it could be used to track and/or understand the rules followed by AI algorithms when making decisions.[38] Similarly, Blockchain could also be used to keep track of who has accessed data, an important, well-sought-after feature in the current data economy.[39]

Blockchain as an answer to the "Grand Challenges"

Through the advantages it creates, Blockchain technology could come as an answer to the various "grand challenges" facing society. For instance, in the medical area, Blockchain could allow doctors to access all the records of a patient securely and easily at any time. This would minimize the risk of error and reduce inequalities in access to health care. The technology could also help in checking students' transcripts and educational records across the world. This would permit different education institutes to enroll students easily, without having to undertake checks on individual records. Large institutions and governments could also both benefit from the technology in order to reduce inequalities, risk of fraud and waste.[40]

Overall, the uptake of Blockchain could help to reach SDG 3 (ensure healthy lives and promote well-being for all at all ages), SDG 9 (build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation) and SDG 10 (reduce inequality within and among countries).

CYBERSECURITY

Technology Profile

Definition

Cybersecurity refers to the technologies, processes and controls that aim at safeguarding systems, networks and programs against digital attacks. Such attacks commonly involve attempts to access, alter or damage sensitive information. If successful, such an attack may result in extortion of money, infringement on intellectual property rights or disruption of service provision.

Cybersecurity builds on other key technologies

Tampering of data is a common threat to the delivery of financial services. Blockchain can be used to protect data from modification. By employing a digital signature (hash) before storage to a public or a private ledger, data can become immutable.

The exponential increase of devices linked to the Internet is putting stress on the workforce able to deliver cybersecurity services. In response to this, cybersecurity providers are turning towards AI and machine learning to develop algorithms that will aid in threat detection.

Other technologies used to enhance the strength of cybersecurity applications include quantum proofing, biometric security systems and lattice-based cryptography.

Progress in Cybersecurity is necessary for the delivery of other key technologies

The increasing reliance of computer systems on the Internet and wireless networks (Wi-Fi, Bluetooth, cloud computing) for storage and sharing of information, and the emergence of the Internet of Things, raise the importance of cybersecurity. Recent experience demonstrates that most technologies are vulnerable to hacking: instances include cars, alarm systems, implantable medical devices, aviation systems, public infrastructure, mobile banking applications and smart city technology.[41]
The use of appropriate safeguarding tools allows for accelerated delivery of services and the seamless implementation of processes.

Cybersecurity as a response to most pressing challenges faced by societies

Cybersecurity is at the core of addressing future challenges by functioning as a network management technology. Safer and seamless delivery of ICT services through effective Cybersecurity can aid in meeting a number of the Sustainable Development Goals (SDGs):

- Boost agricultural production, and broaden access to information relating to economic interaction between private and public entities (SDG 9);
- Enable universal secure and transparent access to information and communications technology (SDG 9). The spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies, as does scientific and technological innovation across areas as diverse as medicine and energy. However, building confidence and security in the use of information and communications technology for sustainable development should also be a priority, especially given growing challenges, including the abuse of such technologies for harmful activities from harassment to crime and terrorism.[42]

BIOTECHNOLOGY

Technology Profile

Definition

Biotechnology involves the manipulation of biological systems (living cells or cell components) for the efficient manufacturing of useful 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.[43]

Progress in Biotechnology is accelerating thanks to advances made in other key technologies

More than two decades ago, “prototype intelligent systems” based on AI were already used in different areas of biotechnology, such as for the exploration of new production routes for various bioproducts and the synthesis of downstream processing schemes for the separation and purification of proteins.[44]

Nevertheless, over the past ten years, progress in biotechnology has accelerated rapidly thanks to advances made in other technologies, in AI and Big Data in particular. New development of machine learning has, for example, accelerated the discovery and development of new drugs allowing to quickly identify relevant information from clinical trials, patient records and scientific articles. Other tedious tasks done in the lab, such as designing constructs for gene editing, are also slowly being handed over to AI programs.[45] Big Data is also enabling the rise of personalized medicine, based on genomic sequencing, electronic health records, and improved wearable technologies and medical sensors.

Biotechnology equips other technologies with tremendous power

Thanks to advances made in biotech, the robots of the future will likely be made of living materials. For example, the merging between tissue engineering and mechanical engineering – a very young field – has already produced a bio-hybrid robot able to swim around when controlled by the researcher.[46] The joint use of new biomaterials and nanoelectronics and photolithography could also help creating nanorobots that could be used in common medical applications, such as surgical instrumentation, diagnosis and drug delivery.[47] In the future, microbivores for instance – a type of nanorobots having similar functions as the biological phagocytes found in the human bloodstream – could help fight infections by destroying microbiological pathogens using a digest and discharge protocol.[48]

Biotechnology as an answer to most pressing challenges faced by societies

Today, biotechnology plays a key role in the field of sustainable development, the fight against poverty and disease prevention. In addition to the health and food sector, activities that greatly benefit from advances in biotechnology include energy production, waste management and pest control. Biotechnology is aiding in delivering on a great number of the SDGs, including:[49]

Ending poverty	Improving nutrition and promoting sustainable agriculture	Improving access to energy	Promoting sustainable use of marine resources
Support growth in sectors vital to the production of food such as farming, forestry and fishing. Biorefining is an activity that has the potential to contribute to economic activity via boosting employment. (SDG 1)	Biostimulants and biodegradable agricultural mulch films include some of the applications of this technology that significantly contribute to agricultural productivity. (SDG 2)	Use of bioethanol plays an important role in achieving the set of emission targets by reducing the emission of greenhouse gas emissions from fossil fuels. (SDG 7 and SDG 13)	Use of biopackaging and biolubricants contributes to the reduction of plastic products and overall pollution. (SDG 14)

1.3.2 Future Skills

Although the Fourth Industrial Revolution has created unprecedented opportunities, it also entails a number of challenges, the greatest of which is the future of skills and work. Each industrial revolution has always cost people their jobs, as skills that were relevant once suddenly become obsolete. More than 200 years ago, innovations enabled by water- and steam-powered equipment characterizing the First Industrial Revolution left many workers out of work, such as handloom weavers and stocking frame knitters. The ongoing technological revolution will not be different. On the contrary, early signs indicate that its impact on skills and work will be even greater, as it has changed the nature of skill demand shifts we used to witness in previous technological paradigm shifts.

Unlike earlier revolutions, Industry 4.0 has increased the relative demand for skills in a non-monotonic manner across the distribution of wages. Digital technologies strongly complement the abstract tasks of high-wage jobs and, at the other extreme, have little impact on the non-routine manual tasks of many low-wage service jobs such as waiters and cleaners. However, they put at risk workers who perform routine tasks characteristic of many traditional middle-wage jobs, such as those in transportation, logistics and administrative occupations. The consequence of this new "U-shaped" pattern of demand shifts is twofold. First, it means a polarization of labour demand in favour of more-skilled workers resulting in rapidly growing inequality.[50] Second, it implies that some jobs will disappear while others will be created. A key challenge for policymakers is therefore to find a way to address the growing mismatch between the demand and supply of skills that, if not smoothed out, will likely hold back economic growth and threaten social stability.

Recent research shows that current college students do not feel like they will be prepared for the workplace after their education.[51] In addition, employers stress the need for the education system to generate prospective employees that are productive from their first day on the job onwards – an expectation which is rarely fulfilled. Education institutions and systems must therefore change. They must learn to anticipate what skills are necessary to succeed in the future and incorporate them in their programmes. For some, science, technology, engineering and mathematics (STEM) skills as well as coding will be essential, as they will enable people to develop a competitive edge and work with technology, boosting their innovative capacity. These technical skills will not be sufficient however. A recent survey conducted by PwC among CEOs shows that today's business leaders recognize they will need workers with soft skills to run their technical processes. Studies have also shown that the source of many unintended social consequences of technological developments in the last century can be traced back to a failure to incorporate "non-technical" dimensions to the problem.[52]

It will therefore not be possible for future workers to manage their daily tasks by exploiting solely the expertise they have in the field and their technical knowledge. Future workers will need to be proficient in communication, teamwork, collaboration and networking, as well as cultural understanding given that the future of work will increasingly be transdisciplinary and take place in a globalized world.[53,54] In addition, against the backdrop of uncertainty and unprecedented change, cognitive skills such as originality, creativity and active learning will also become increasingly important.[55,56]

This new demand for more emotional and cognitive skills will require a coordinated change in educational programmes. New models of education will need to emerge characterized by a long-term perspective, a strong emphasis on life-long learning, the establishment of a stronger connectivity with the industry and labour market, and new teaching methods built on new technologies.[57,58]

By identifying the fundamental skills for the future, and by monitoring the readiness of countries to integrate such skills in curriculum planning, the quality of education will be improved, and life-long learning opportunities will be promoted. As a result, the number of youth and adults possessing the relevant skills for employment will increase and the spillover effect of the skills gap on the share of youth not in employment, education or training will be reduced. Hence, further achievements towards SDGs 4 (quality education) and 8 (decent work and economic growth) will be noticed.

1.4. Knowledge dimensions

Now that we have acknowledged the importance of both technologies and skills for the future, we also need to understand how they can be developed. If properly nurtured, we think that they can 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 society.

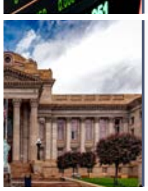
For us, harnessing this opportunity will require investment in five key dimensions known to be preconditions for knowledge-based development as exemplified by the Global Knowledge Index 2017.[59] This will require proactive collaboration between a wide range of players, including policy-makers, scientists, academic experts, education leaders, school teachers, civil society, technology champions and investors. The five knowledge dimensions we will look at include:

Education
at its pre-university, technical and vocational education and training and higher education levels, which includes the quality of education institutions and training programmes targeting new technologies and programmes ability to face the current skills mismatch;

Research, Development and Innovation (RDI) and Science
which entails both the research infrastructure and competencies of researchers and companies needed to create new knowledge inputs in the field of new technologies and Future Skills;

Technology
which refers to the technological infrastructure and ICT necessary for knowledge exchange and the creation of new technologies and new teaching methods;

Economy
which is comprised of the financial resources needed to deploy new technologies and support the development of new educational programmes more aligned with the future of work;



Enabling environment
which covers the governance frameworks, policy protocols and regulations that help create an environment conducive to innovation and entrepreneurship.

GLOBAL KNOWLEDGE INDEX

The Global Knowledge Index (GKI) aims at measuring knowledge as a broad concept that is intricately related to all aspects of modern human life, in a systematic approach that builds on solid conceptual and methodological principles.

The GKI is composed of six sectoral indices: (1) Pre-University Education, (2) Technical and Vocational Education and Training (TVET), (3) Higher Education, (4) Research, Development and Innovation (RDI), (5) Information and Communications Technology (ICT), (6) and Economy. The seventh pillar "General Enabling Environment" was added to support these six indices, as the sectors they represent do not operate in isolation from their surroundings, but rather in a space governed by a range of contextual factors - political, socio-economic, health related and environmental.

The Global Knowledge Index aspires to evolve - in the near future - into a systematic tool that helps countries find realistic, objective and accurate answers to four fundamental questions concerning their knowledge status:

Where are they now? (diagnosis of the status quo);

Where do they want to be? (the desired situation);

What path should they follow? (development strategy);

What progress are they making? (monitoring, tracking and evaluation).

Therefore, this knowledge initiative represents a direct contribution to global sustainable development efforts; it contributes to the creation of a tool to measure the availability of objective data regarding the various discrepancies between countries in terms of their ability to generate and use knowledge in a way that fosters development.

The structure of the GKI reflects the fact that knowledge has many dimensions that can be seen in all areas of human life, reflected in key components that relate to vital sectors closely linked to sustainable development. Hence, it is assumed that the more these sectors interact with each other and are integrated in a given country, the more the level of knowledge in that country increases, rendering it more capable of achieving sustainable human development.[60]

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2 METHODOLOGY

2 METHODOLOGY

2.1 A methodological approach based on alternative metrics

The present methodology is based on recent developments in the community of impact evaluation practitioners, scientists and policymakers regarding the use of alternative metrics for impact assessment. With the advent of digital transformation of society, there has been increasing utility in alternative metrics to support impact assessments and to set the direction of decision-making in the best interest of society. The availability of webometrics[1] has enabled the increasing use of publicly available information for assessing the societal impact of an object of evaluation.

From the scientific community to policy-making institutions, the interest in alternative metrics for evaluation has complemented traditional evaluation metrics, democratized the evaluation process (from expert-centric models to wider peer review models), and integrated the actual societal views within the evaluation process. As an example, the European Commission has recently set an Expert Group on Altmetrics with the purpose of discussing and providing evidence on alternative metrics for impact assessment (applied to the impact of science and innovation) and of formulating recommendations for their future utilization. The group's final report "Next-generation metrics – Responsible metrics and evaluation for open science" (2017),[2] lays the groundwork for the use of alternative metrics as complementary to traditional metrics in impact evaluation.

Within this context, our team has had the opportunity to implement the logic behind the use of alternative metrics for evaluation under the prominent European project "Digital Entrepreneurship Monitor," where PwC developed and applied a methodology for assessing technology uptake using "real-time big data" extracted from publicly available sources.[3]

Our methodological approach for the assessment of the future of knowledge societies is based on the latest state-of-the-art scientific developments in impact evaluation, and represents a pertinent complementary approach to the assessment of the future of knowledge.

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

As explained in more detail in the sections below, we selected three types of metrics commonly used in social monitoring and listening for measuring future knowledge development:

- 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);
- Sentiment concerning a specific topic (i.e. overall mood associated with the context in which a specific set of keywords appears, which can be either positive, neutral or negative).

Our rationale for selecting these metrics finds its roots in the process of knowledge creation. Knowledge is in itself an important source for further knowledge creation.[4] Following Nonaka's SECI model for knowledge creation, new knowledge is created through the conversion of existing knowledge, both tacit and explicit.

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 and which depends highly on the existence of communication and diffusion processes of knowledge.

The amount of socialisation and the intensity of communication and rate of dissemination of (explicit) knowledge occurring within a community can therefore be used as a proxy of that community's capacity for future knowledge creation.

In an innovative attempt to quantify these key processes for knowledge creation, this pilot study uses the number of mentions, the level of engagement and metrics from a sentiment analysis as representative measures of the current, real-time knowledge socialization, communication and dissemination within a country. By analysing the web data collected for these metrics around critical future fields for each country, it will then be possible to extrapolate each country's potential for further knowledge development in those particular areas and in the future in general.

2.2.2. Data collection using a social listening tool

In order to collect web data, a social listening tool was required. The tool had to be able to crawl all public web pages and public social media sites, across the globe in a wide variety of languages.

The selected tool, the Digital Intelligence Platform, collects data from 150 million public sources and covers sources in over 180 languages. The tool uses keywords and Boolean operators, along with advanced analytics with artificial intelligence capabilities, to allow for the extraction of the most relevant data. In addition, it computes numerous key metrics, such as audience engagement (total number of audience interactions with a page/post, i.e. likes, shares, retweets, comments) and sentiment analysis (positive, negative or neutral), determined via a machine learning algorithm.

2.2.2.1 Defining research scope

20 countries were selected for the pilot study based on their rankings on the Global Knowledge Index 2017. Only data from these countries were retrieved, extracted and analysed:

Countries

Americas	Europe	Arab States	Africa	Asia
United States, Brazil, Chile	Switzerland, Finland, Sweden, Netherlands, United Kingdom, Germany	United Arab Emirates, Egypt, Saudi Arabia, Jordan, Morocco	Rwanda, Tanzania	Singapore, India, Japan, Turkey

Sources

The platform enables collection and analysis of over 150 million public sources. Of all the data collected for this analysis, the total proportion of results found for each media type by country is shown in Table1. Most results come from Twitter, followed by online news.

While typically covered by the platform, for the current analysis, Instagram results were excluded. Instagram produced higher levels of irrelevant results compared to the other sources. Additionally, its content (mainly visual in nature, i.e. images, drawings) was found to differ highly from the other web sources (news sites, blogs, Twitter), which were mainly text. Therefore, Instagram results were removed.

Table 1: Proportion of Media by Country

	Online news	Newspapers	Magazines	Blogs	Forums	Twitter	Other
Brazil	21.96%	3.62%	0.69%	27.04%	1.08%	44.96%	0.65%
Chile	6.96%	2.44%	0.62%	13.59%	1.11%	74.98%	0.30%
Egypt	18.15%	0.00%	0.04%	17.79%	6.54%	57.35%	0.12%
Finland	10.87%	3.22%	1.18%	9.13%	1.42%	73.22%	0.96%
Germany	27.36%	5.31%	2.01%	16.21%	11.45%	33.11%	4.56%
India	13.49%	3.47%	0.10%	11.73%	0.15%	70.65%	0.41%
Japan	17.08%	0.19%	0.05%	17.55%	0.67%	64.41%	0.05%
Jordan	13.83%	1.09%	0.00%	1.52%	0.08%	83.46%	0.02%
Morocco	41.35%	2.50%	0.68%	13.14%	0.33%	42.00%	0.00%
Netherlands	17.00%	0.44%	0.59%	25.79%	0.90%	54.86%	0.43%
Rwanda	6.64%	0.00%	0.00%	4.42%	0.00%	88.94%	0.00%
Saudi Arabia	6.47%	0.85%	0.08%	6.38%	1.81%	84.36%	0.04%
Singapore	22.40%	0.55%	0.32%	4.93%	0.23%	71.25%	0.32%
Sweden	16.08%	5.54%	1.27%	16.39%	0.57%	59.59%	0.57%
Switzerland	13.82%	2.58%	0.75%	4.19%	8.19%	69.82%	0.66%
Tanzania	7.04%	1.28%	0.00%	6.71%	0.00%	84.96%	0.00%
Turkey	22.31%	1.90%	0.55%	7.34%	0.57%	66.83%	0.52%
UAE	14.76%	1.12%	0.36%	6.70%	0.03%	72.47%	4.56%
UK	9.13%	5.80%	1.11%	6.05%	0.64%	76.15%	1.12%
US	11.67%	0.34%	0.70%	11.70%	5.21%	68.94%	1.43%

Time Period

One year's worth of data was extracted from the platform for each country. All data was published online between September 4, 2017 00:00:00 GMT+1 and September 2, 2018 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

Using the Digital Intelligent Platform to retrieve data requires the development of queries, which are requests for information from a database written in a specialized language (which in this case involves using Boolean operators). We built efficient queries by carefully defining keywords, designing and translating the queries.

Keyword Definition

An iterative review and validation process was used in order to define the keywords which were used to retrieve the data from the Digital Intelligence Platform.

- First, a set of English keywords were defined 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, based on a review of literature, articles and social media posts, as well as input from expert experience using the platform.

- This first set of keywords was then discussed and edited at a workshop with technology, education and development experts to refine and elaborate upon the keywords where agreed.

- Finally, this edited list was reviewed and tested by a linguistic expert on the platform in order to increase the relevance of the results and reduce the amount of 'noise' as much as possible.

- In the process of this final review, problematic keywords were removed from the list and a set of exclusion keywords was created. The following example is illustrative of the important results of this step. The keywords first selected for the Education dimension included: course, e-learning, seminar, webinar, curriculum, hackathon, coding camp, programming camp, training. However, upon inspection of the results, training had to be removed as a keyword (due to a high amount of irrelevant results related to training and machine learning, i.e. training a model, training data). On the other hand, a few irrelevant results were discovered due to the various definitions of course in English. In this case, course remained in the query but these "false positives" were added to the exclusions list in order to avoid retrieving results with the incorrect course (e.g. 'of course', 'golf course', 'course of treatment', etc.).

Query Design

Once all of the keywords were validated, queries were constructed using special Boolean operators, which 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.

Using these operators, the future field keywords were connected to the knowledge dimension keywords to a distance of 10 or less words. These Boolean operators allow a higher probably for relatedness between two sets of keywords, and thus higher likelihood for the result to be relevant to the dimension.

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Using these operators, the future field keywords were connected to the knowledge dimension keywords to a distance of 10 or less words. These Boolean operators allows a higher probably for relatedness between two sets of keywords, and thus higher likelihood for the result to be relevant to the dimension.
The final portion of the query was the geo-localization operator. This operator restricts the results to only those originating from the defined countries or regions.

The location is determined by the platform based on the metadata available for the result, according to the following order: 1) the geo-location of the article/post, if enabled by user; 2) location found within the contact/profile section (i.e. a company address or a Twitter profile's selected location); 3) if news or website, the IP address or if social media, the posting language (designated to the country with the most speakers of that language, e.g. if English or unknown, it will be tagged as the United States).

Based on the scoping of the current project, the English language query had all 20 country filters applied to it, i.e. any matching results in English from any of the 20 countries were retrieved.

For all queries in languages other than English, the geo-localization was applied only for the countries which have that language an official language. For example, the German language query was appended only with the country filters for Germany and Switzerland.

Query Translation

After the English queries were validated, they were translated into 15 additional languages corresponding to the 20 selected countries. The translations were performed by a professional translation agency.

After translation, a random sampling of queries and results were reviewed by a native speaker to confirm the quality of the results.

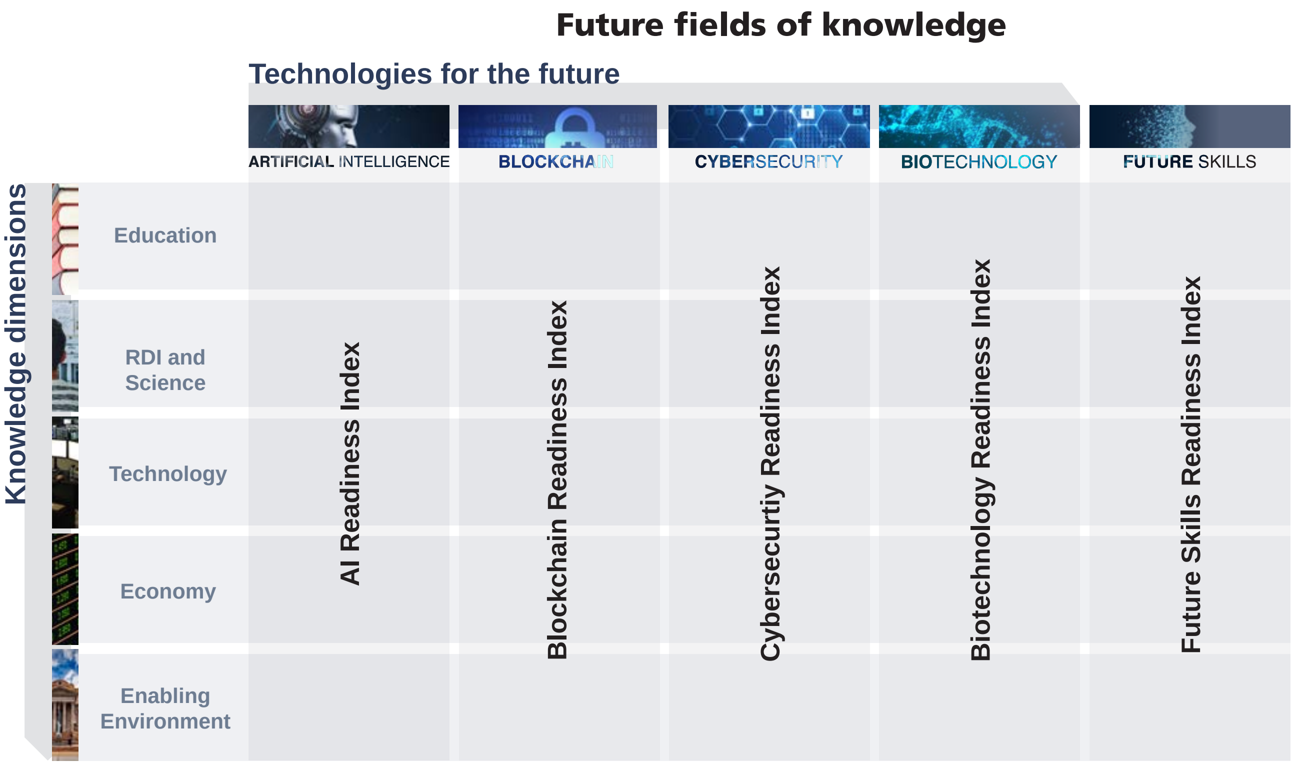
The 15 languages are as listed below:

French	Arabic	Spanish	German	Dutch
Finnish	Swedish	Mandarin	Japanese	Malay
Turkish	Kinyarwanda	Hindi	Portuguese	Swahili

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

In order to be aligned with our conceptualization of the future of knowledge (see Chapter 1), we aggregated the raw data across two axes, as shown in the illustration below, and created a series of indices.

Figure 6: Structure of the Future of Knowledge Model



We first created five **Future Field Readiness Indices** corresponding to the five future fields of Knowledge:

- Four Technology Readiness Indices, corresponding to the four key technologies for the future i.e. AI, Cybersecurity, Blockchain and Biotechnology; and
- The Future Skills Readiness Index.

To create these indices, we aggregated the raw data vertically (across knowledge dimensions), as shown in the illustration above. We calculated these indices separately for each of the 20 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, in order to portray the overall performance of each country across the four technology readiness dimensions, we constructed the **Global Technology Readiness Index (GTRI).**

For the calculation of each index, we first aggregated the raw data (mentions and engagement) in the level of aggregation defined by the index, and then built the index as described below.

2.3.1 The structure of the model

Future Field Readiness Indices

To construct each of the five Future Field Readiness Indices ***i***, the score for country ***j*** is based on the aggregation of the raw data across the five substitutable knowledge dimensions of equal importance (***k***= {Education, RDI and Science, Technology, Economy and Enabling Environment}) and determines the performance of the country within each of the five indices.

$$\text{Future Field Readiness Index}_{j,i} = \sum_k \text{Knowledge dimension}_{k,j,i}$$

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 2.3.2 discusses in detail how we moved from raw data to the aggregation stage for the construction of the composite Indices.

Global Technology Readiness Index

The Global Technology Readiness Index is a composite index that refers to the four Technology Readiness Indices that are conceptually different to the Future Skills Readiness Index. We derived the ranking of each country ***j*** by aggregating the raw data and computing a score for all four technologies (***i***= {AI, Blockchain, Biotechnology and Cybersecurity}). This form of ranking shows that we treat the components of the GTRI as substitutable and of equal importance. This means that, for instance, a deficit in AI can be compensated by a surplus in Blockchain.

$$\text{GTRI}_j = \sum_i \text{Technology}_{j,i}$$

2.3.2 Calculation of composite indices

The **Future of Knowledge Model** is structured with a hierarchy of four levels: the Global Technology Readiness Index, the Future Field Readiness Indices, the knowledge dimension indicators, and variables.

We selected two key social metrics: (a) the number of mentions, and (b) 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 52 weeks of the study period and for 20 countries, resulted in 52,000 measures. Another 78,000 measures come from the sentiment analysis. The latter were not incorporated in the calculation of the indices,[5] but are shown as stand-alone results in Chapter 3, section 3.2.

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**.

$$\text{Mention Density} = \frac{\text{Mentions}}{\text{Internet users}} * 1{,}000{,}000$$

In a similar vein, to be able to compare different levels of engagement, we standardized engagement by dividing total engagement with the number of mentions for each country to compute the **engagement density.**

$$\text{Engagement Density} = \frac{\text{Engagement}}{\text{Mentions}}$$

Based on the above, we calculated each composite index as follows.

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

where *V1* is the normalised value of mention density and *V2* is the normalised value of engagement density, respectively.

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:

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

The nature of calculating any 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 above standardization and normalization procedures. However, there are reasons these 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 difference scales. It therefore removes the scale effect, thereby enabling the linear combination of the two variables composing 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, respectively. Conversely, a score of 100 means that both the mention density and the engagement density are the highest for the knowledge dimension, future field or country of interest.

Table 2: Internet users

	Year	Share of Internet users (% of total population) *	Total population#
Brazil	2016	69.87	207,652,865
Chile	2017	82.33	18,054,726
Egypt	2017	44.59	97,533,151
Finland	2017	87.47	5,523,231
Germany	2017	84.40	81,114,224
India	2016	29.55	1,324,171,354
Japan	2017	90.87	127,484,450
Jordan	2016	62.30	9,455,802
Morocco	2017	61.76	35,739,580
Netherlands	2017	93.20	17,035,938
Rwanda	2016	20.00	11,917,508
Saudi Arabia	2017	80.08	32,938,213
Singapore	2017	84.45	5,708,844
Sweden	2017	96.41	9,910,701
Switzerland	2017	93.71	8,476,005
Tanzania	2016	13.00	55,572,201
Turkey	2017	64.68	80,745,020
UAE	2017	94.82	9,400,145
UK	2016	94.78	66,181,585
US	2016	76.18	324,459,463

*Source: International Telecommunication Union (ITU), ITU World Telecommunication/ICT Indicators Database
#Source: United Nations Department of Economic and Social Affairs (UN DESA), World Population Prospects 2017

2

ENDNOTES

1. 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" (Björneborn L. and Ingwersen P., 2001).
2. European Commission, 2017.
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5. As most research suggests that sentiment influences processes of knowledge co-creation, we originally planned to incorporate the sentiment metric in our Index. We decided ultimately to remove it, as we did not have the opportunity to verify the accuracy of the sentiment value (positive, neutral, negative) assigned to each post by the platform's AI algorithm in the scope of this assignment.

3 KEY FINDINGS

3 KEY FINDINGS

The Fourth Industrial Revolution is ushering in a wave of creative destruction, as new technologies give birth to new markets and overhaul traditional modes of production. AI, Cybersecurity, Biotechnology and Blockchain open new ways for companies to address the needs and preferences of their customers, for sovereigns to supply public goods to residents, and for consumers to optimize between hours worked and leisure. On a global scale, the key challenge is to ensure that economic agents fully capture such opportunities, leveraging digitalization to create a better future. The aim of the Future of Knowledge Model is to assess the extent to which the labour markets of a select number of countries are well-positioned to adjust to the changes that technological transformation brings.

The evidence that we gather will present a preliminary and up-to-date snapshot of the relative levels of readiness across a group of 20 countries, and will encourage decision makers at the national and supranational level to create policies that raise awareness about the future and accommodate technological uptake and skills development. This evidence will also better position companies and labour market participants to understand why future technologies are important and how they can help in value creation.

To ensure a reliable representation of the variation in readiness for the future across countries, it is essential to use tools that enable the gathering of data as close to real time as possible. This helps us identify and discuss the latest technological advances, the future impact of technological change on the economy and society, and the level of technological awareness that characterizes labour markets. It also allows us to detect national approaches to Future Skills development, skills challenges and concrete actions to improve the country's skills system.

This analysis employs information collected from sources openly available on the web. These sources include articles from online press and dedicated blogs, comments from industry web pages, social media websites, forums, broadcast television and other forms of online media.

The data that we collect refers to works of text and images covering billions of web conversations from 150 million sources in 180 languages. We access this data through a Digital Intelligence Platform that provides an interface between the database and the user. By introducing particular keywords, hashtags and filters, using text mining and sentiment analysis techniques, we are able to extract relevant data and quantify an online discussion on a topic in question.

The above approach generated 4.8 million results (mentions) that informed a multi-level analysis on future readiness. In this global comparison of 20 countries, we find that the United States, the United Kingdom, Singapore, Finland and Switzerland are the countries best placed to profit from technological change. We also observe that all countries in our sample have acknowledged the importance of technological change and are taking steps towards upskilling and/or investing in expanding Internet coverage, which is essential to the successful dissemination of information and the fostering of knowledge synergies. We observe that people also take an interest in the development of soft skills, as they correctly recognize the importance of possessing a wide assortment of social dexterities in order to successfully integrate into the labour market of tomorrow. Discussions surrounding this thematic consistently feature in smaller volume in comparison to future technologies, while the main locus of interest seems to be the quality of the education system.

Our analysis points out to a number of lessons learned, with the cases of the Netherlands and Sweden offering two examples of best practices. The Netherlands capitalize on a highly granular approach towards building technological readiness. Instead of a small number of major events that enjoy international coverage, the country promotes the organization of a plethora of events, such as hackathons and forums, in multiple cities. This practice is successfully raising the prominence of future technologies, Blockchain technology in particular, which encourages labour market participants to invest in upskilling. Sweden, on the other hand, invests in gathering and analyzing information on current and future skills gap in the country, to better adapt the industrial and labour strategy of the country to rapid technological change. It achieves this through the 'Skills Anticipations Program,' a multi-level intervention that assesses Future Skills and estimates the gap in future skills through forecasting and employer surveys.

In terms of Future Skills, we find that teacher shortage is a common problem among the countries in our sample. If not resolved, this shortage will adversely impact the ability to equip the new generation with the skills necessary to make the most out of technological change. Here, we underscore that while engineering and sciences are fields central to the jobs of the future, soft skills are also of great significance. We observe that most countries in our sample face challenges in primary and secondary education. Low-quality teaching in the early years of human development may strongly affect the development of relevant soft skills.

In Section 3.1, we first discuss the overall level of readiness in the sampled countries for the five future fields. Then we separate the five future fields in two groups - technologies and skills - and we investigate the level of readiness for each country.

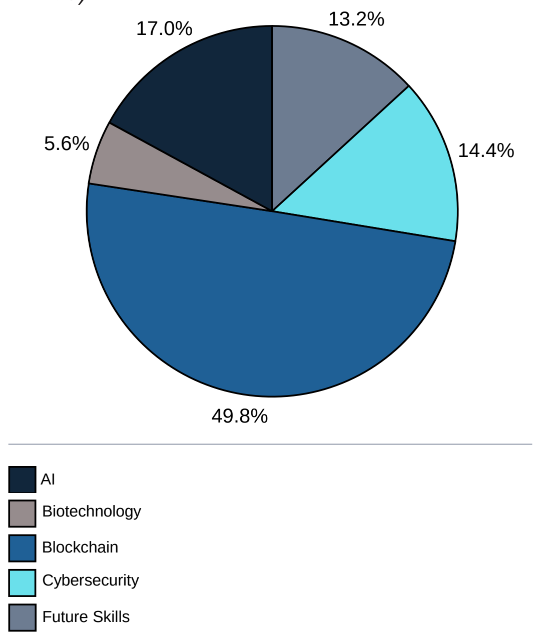
Section 3.2 and 3.3 flesh out our two-level approach to readiness. Section 3.2 looks at the comparative performance across countries, which reveals how well a country is performing in terms of technological and Future Skills readiness in relation to the rest. Section 3.3 looks at readiness in terms of a balanced awareness. The perspective adopted by this section does not accommodate cross-country comparisons in terms of scores. Instead, it offers insight on the relative degree of balance in readiness of each country between the five future fields.

3.1 General observations

3.1.1 Most popular fields

A high-level analysis of the mentions aggregated by future field for all 20 countries between 4 September 2017 and 2 September 2018 is presented in Figure 7. Among the five future fields that this report investigates, Blockchain accounted for 49.8 percent of relevant online discussions, while AI, Cybersecurity, Future Skills and Biotechnology accounted for 17 percent, 14.4 percent, 13.2 percent and 5.6 percent, respectively. These results are in line with recent trends in technological salience and the emerging technologies' hype cycle. The salience of Blockchain matches the recent rise in prominence of cryptocurrencies and the proximity of the technology to the *peak of inflated expectations*, as defined by Gartner.[1] Indeed, Biotechnology is a well-established field with numerous applications that have passed the emerging phase. Nonetheless, as new applications, such as the use of cultured/artificial tissue or the intersection of biomaterials with nanorobotics, climb the hype cycle, we expect to observe a rise in the importance of Biotechnology within the online community.

Figure 7: Online popularity of future fields (20 countries)



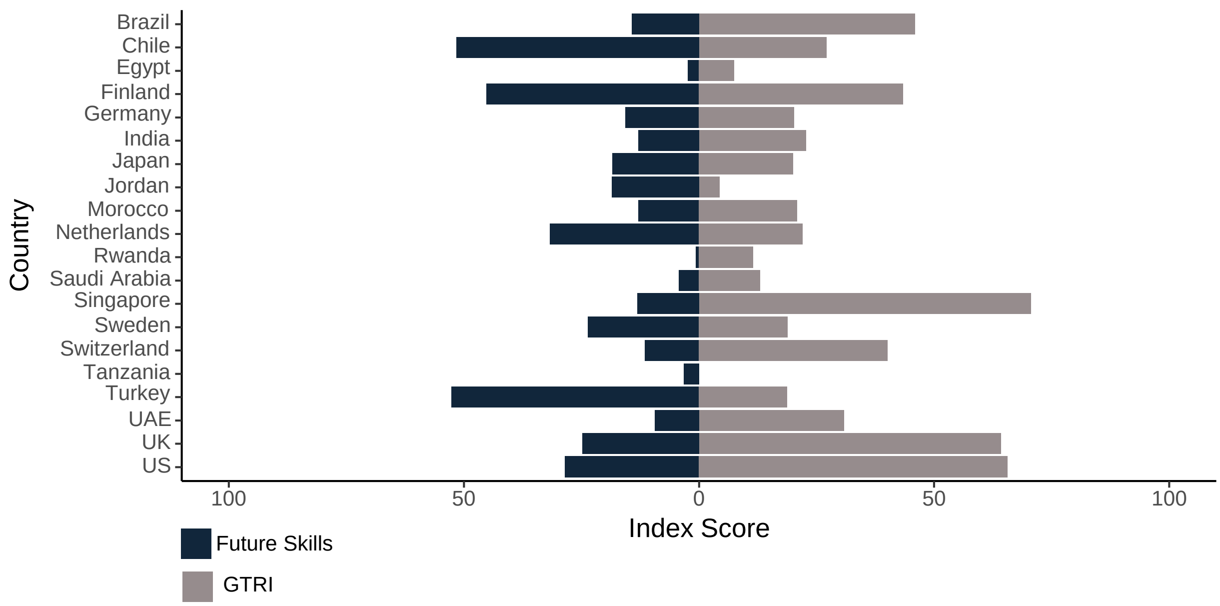
3.1.2 Comparison between countries

The Global Technology Readiness Index (GTRI) and the Future Skills Readiness Index are both appropriate indicators for the comparison of future readiness across countries. Figure 8 illustrates the scores on both indices.

The analysis of GTRI scores, aggregated over the period of observation for each of the 20 countries of interest, shows clear differences in the prominence of emerging technologies in the public debate. The scores are mainly concentrated in Singapore, the United States and the United Kingdom. Arab countries are the ones with the most distance to cover in terms of raising awareness and having experts/practitioners engage in discussion with the rest of the Internet using population. Tanzania is the least well-performing country in our sample.

The analysis of the Future Skills Readiness Index scores across countries shows a significant concentration of scores in three countries: Turkey, Chile and Finland. A more in-depth analysis of online activity reveals that a public debate on the teacher deficit drives the observed mentions upwards for Turkey, and to a lesser extent for Finland.

Figure 8: Future readiness across countries (20 countries)



3.1.3 Limitations of our approach

This report deploys a pilot approach to the observation of technological readiness, thus it comes with a number of caveats, that we, nevertheless, do not deem insurmountable in future versions of the index nor do we see as detrimental to the validity of the current results. We recognize five distinct instances that may threaten the validity of our approach.

The occurrence of a major event that does not relate to technology uptake will drive online activity (for a country) upwards. During the sampling period, we identify two such events that may drive results. First, the implementation of the General Data Protection Regulation (GDPR) on 25 May 2018. This change in legal framework is one of the most significant changes in data privacy regulation of the past 20 years and had a great effect on online discussions taking place within the European Union and overseas. Second, the recent spike in the price of Bitcoin (together with other cryptocurrencies) has attracted attention in Cryptocurrencies. Cryptocurrencies use Blockchain technology, which results in a higher frequency of Blockchain-related vocabulary use in online discussions. This heightened level of activity however, does not relate directly to technology adoption. Instead, it reflects a speculative environment of early-stage developments along the hype cycle of the technology. In terms of validity of results, we observe that Blockchain has a largely global impact in driving results, while the GDPR topic features more prominently in Europe, Brazil and in countries where international press has a strong presence.

The sampling period introduces a bias that inflates results for certain countries above their true value. We recognise two factors that may drive the score of a country upwards: elections and teacher shortages. Elections, local or national, tend to drive online activity upwards for a country. As only some of the countries we include in our sample experienced a pre-election period between September 2017 and September 2018, results for these countries will be inflated. It does not seem reasonable to assume that online activity will not drop post-elections.[2] In a similar vein, not all the countries in our sample experience a teacher shortage. Our methodology for the formation of the Future Skills ranking rewards countries that have identified a shortage in teachers and debate in public on solutions to the issue at hand. However, in the event of zero debate on teacher shortages, our methodology ranks equally countries unaware of an existing teacher shortage and countries where no teacher shortage exists. Given that we cannot safely assume that all sampled countries exhibit a shortage in teachers during the sampled period, our methodology for Future Skills penalizes countries with no teacher shortage.

Limited access to the Internet impacts the validity of our results. In the instance where only a small subgroup of the population has access to the Internet, our sample ceases to be representative. As is the case of Rwanda, where only 20 percent of the total population has access to Internet, access to Internet functions as proxy of upper socio-economic status. Since our ranking methodology uses activity frequencies discounted by the size of the local online population, overrepresentation of individuals of upper socio-economic status is likely to bias results upwards. In a similar vein, a high degree of activity concentration among a small number of users will bias results upwards. Our methodology does not take into consideration the “monopoly power” of users. For instance, in the case of the United Arab Emirates, we identify that the Productivist peer to peer network accounts for 28 posts that generate 55,700 instances of engagement (50 percent of total likes/comments/retweets /shares). Moreover, Productivist is a French company based in Nice, which provides manufacturing solutions powered by Blockchain, AI and Internet of Things. Since the company is not currently active in the region, related activity may be tied more to market expansion than to a higher degree of technological awareness. We only find one more similar incident, in Morocco, for Biotechnology. Here, a U.S.-based website (statnews.com) focusing on the pharma, health and biotech sector drives the country score upwards, where 35 mentions generate 5,079 instances of engagement, which accounts for 40 percent of total engagement (second to a regional website, hespress.com). Unless statnews.com enjoys great popularity in Morocco – for which we find little proof – these results stem from the activity of Internet users based in the United States that identify themselves as Moroccans. The algorithm that our methodology uses likely assigned the location “Morocco” to their online activity based on information available through contact/profile sections.

Noisy data due to linguistic idiosyncrasies may inflate results upwards. We find little evidence of linguistic idiosyncrasies in our sample that present a challenge in terms of performing text mining. The main linguistic challenge that we face is with regard to Future Skills. High use frequency of relevant keywords in everyday discussions inflates our results for this field across all countries. However, as our key metric is an index score that we interpret in comparative terms (ranking), we expect this drawback to have little impact on the validity of our findings.

Press freedom has a dual effect on country results. The direction of the total bias for a country where the government suppresses the freedom of speech is not clear. Suppression of freedom of speech leads to a lower number of observed mentions and engagement. This suggests that individuals may not discuss technology/future skills adoption online. In that case, our methodology will underestimate the true value of readiness. However, diffusion of ideas and information is a central part of effective technological adoption. As a low level of freedom of speech necessarily impairs on the quality of the information/ideas transmission mechanism, we expect that it will also adversely affect technology/future skills adoption, thereby exercising a downward effect over the level of readiness for the country.

3.2 Future fields

ARTIFICIAL INTELLIGENCE

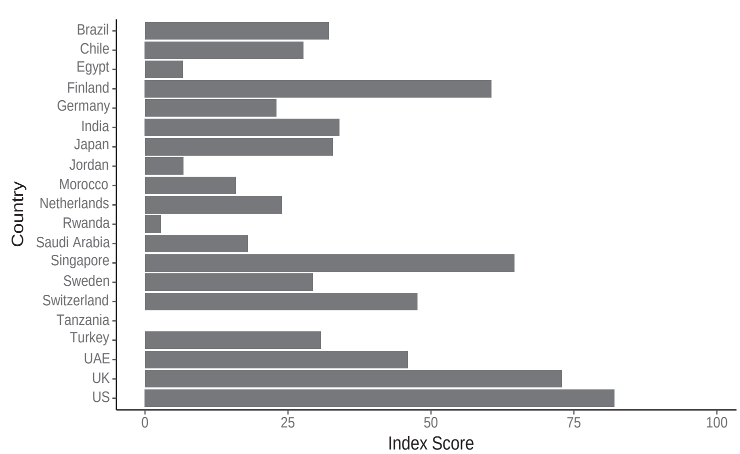
The analysis of the AI Readiness Index scores depicted in Figure 9 shows the United States as the country in which AI is most discussed among Internet users. News relating both to isolated events, such as the AI Summit in San Francisco and New York, and to private sector pioneers, such as Google, Facebook, YouTube, Apple, IBM and Tesla, capture the attention of the online community. Unlike other countries, the United States presents a plethora of mentions on AI applications across sectors of activity and company size, while demographic analysis of online activity underscores that users with a wide breadth of interests and professions are keen to engage into discussion.

The high ranking of the United States in terms of readiness reflects more than technology adoption. It underscores the importance of having in place an effective network for the exchange of information. In addition to using the current lingua franca as the principal language of publication, which increases the probability of international engagement for a mention, the United States is the global leader in terms of information dissemination. Major news outlets target consumers from around the world, thereby increasing the salience of international stories in the daily news agenda. In addition, the Silicon Valley has been the incubator for most of the current social media giants. All these factors increase the availability of information, aiding the sustainment of a higher level of readiness in the online community.

The United Kingdom, Singapore, Finland and Switzerland closely trail the performance of the United States. We treat these findings with caution, as debate on AI may not solely relate to technological uptake. Instead, discussions around the social cost of the technology and the desire to regulate it may be among the key drivers of the volumes we observe. Nevertheless, the above ranking is largely in line with recent events, such as the launch of “AI Singapore” (Singapore’s national programme in AI) in late August 2017 and the inauguration and execution of its associated initiatives between August 2017 and August 2018. These results are also in line with the recent analysis by Asgard that places Switzerland as the leading AI nation with the most AI companies per capita, followed by Finland, the United Kingdom.[3] Our methodology suggests that major events, such as the annual AI Summit in London, can contribute to the ranking of countries by successfully engaging the online community into the discussion.

The adoption of a regional perspective underscores the performance of the United Arab Emirates as a local champion in the Arab region, ranking sixth best performer, behind Switzerland. This is in line with the coordinated effort of the government to improve public services through AI solutions. During the sample period, we observe two events that sparked online activity: the inauguration of the Panorama artificial intelligence and Big Data centre at the headquarters of the Abu Dhabi National Oil Company (ADNOC),[4] and the unveiling of the Salem Innovation Centre. The Salem Innovation Centre is the first fully autonomous medical fitness centre in the region.[5]

Figure 9: Artificial Intelligence Readiness Index across 20 countries



3.2.1.1 Mentions and level of engagement

The analysis of the total sum of online mentions for the period displays a largely stable trend in the volume of mentions about AI (Figure 10). The same trend is not present in the engagement metric, which appears to decrease over time (Figure 11). During this period, we did not identify a single event that drove engagement upwards. However, there were a number of noteworthy events captivating the attention of the international online community. These included the introduction of Sophia, the first humanoid that was granted Saudi citizen status, the development of Google Pixel Buds that translate up to 40 languages in real time, and a statement by Stephen Hawking on perils associated with the development of AI.

Figure 10: Mentions on AI (expressed in thousands of observations)

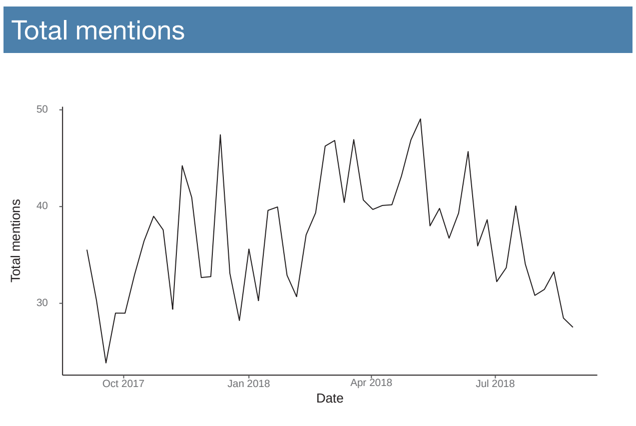
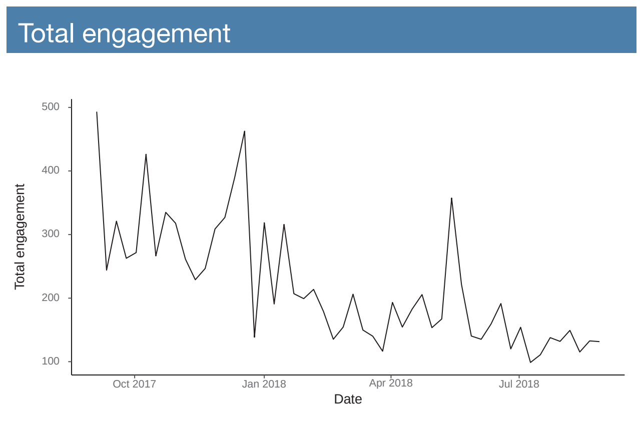


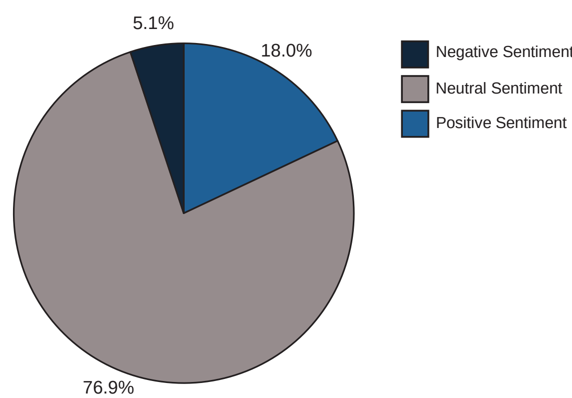
Figure 11: Level of engagement on AI (expressed in thousands of observations)



3.2.1.2 Sentiment analysis

The AI sentiment analysis offers insight into the nature of the online discussions about the technology in terms of positive versus negative views, and their combined share in relation to the total number of mentions. Figure 12 shows that neutral sentiment, linked to the share of factual information, dominates the online debate. Analysis of the net sentiment reveals that positive mentions largely outnumber negative mentions, while the latter have a particular focus on the "dark side of AI." Negative sentiment mostly relates to fears similar to the ones raised by Hawking, AI ethics and the replacement of human labour with machines.

Figure 12: AI sentiment



CYBERSECURITY

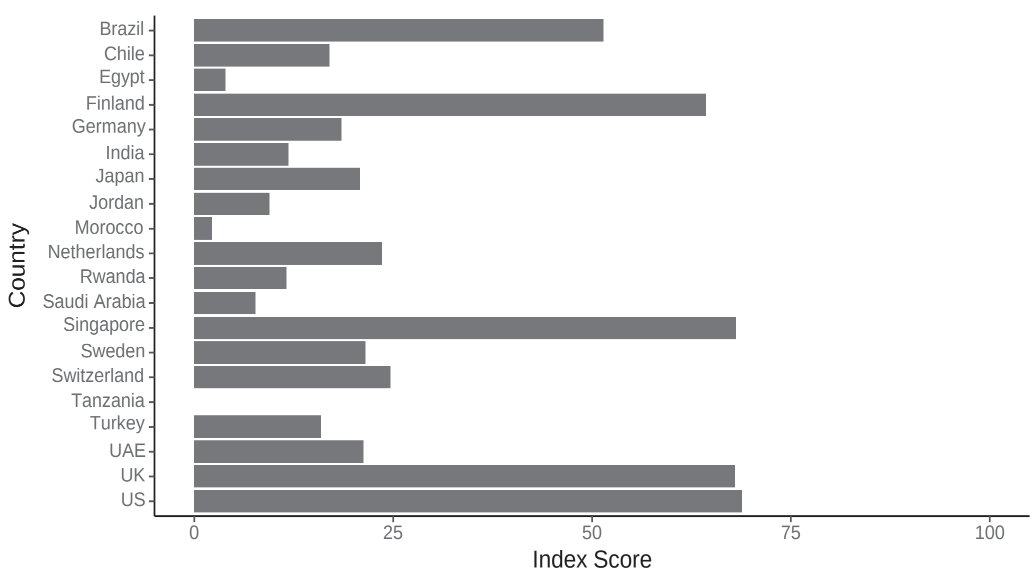
The analysis of the Cybersecurity Readiness Index scores presents a distribution of readiness among Internet users similar to the one for AI. The United States, Singapore, the United Kingdom and Finland comprise the four top performers. This is in line with the thematic overlap between AI and Cybersecurity; developers increasingly use AI technology as a tool to hone the capabilities of Cybersecurity applications, while adherence to tenets of ethical AI presuppose the placement of a secure environment catering to the exchange and storage of information.

Results are also in line with the International Telecommunication Union 2017 Global Cybersecurity Index (GCI) findings.[6] The GCI points to Singapore as the most committed country in terms of capacity building, cooperation and technical readiness within the theme of Cybersecurity. The dependency of the local economy on the smooth flow of financial capital, air traffic and freight groomed Singapore into a proponent for the establishment and sharing of regional best practices; during 2018, the country successfully hosted the 2018 ASEAN meeting and organised the 27th edition of the Cybersecurity week.[7]

In the United States, current affairs such as the Trump presidency and Cambridge Analytica scandals capture the attention of the online community, while regulatory issues account for the overwhelming share of total activity. The issue of regulation prominently appears in Finland and the United Kingdom, where discussions relate to the implementation of the GDPR and in particular the responsibility of social networks to uphold data privacy.

The addition of Brazil completes the set of top five performers in Cybersecurity. Here too, issues surrounding the enabling environment for Cybersecurity account for the vast majority of online activity. However, in addition to the GDPR, hacking frequently appears in online discussions, pointing to the transformation of Brazil into a magnet for hackers targeting the local banking system of the country. Brazil is home to infamous malware such as Bancos Trojans, ZeuS, SpyEye and CARBERP, while losses due to credit card fraud alone amounted to US$22.5 billion in 2017.[8]

Figure 13: Cybersecurity Readiness Index across 20 countries



3.2.2.1 Mentions and level of engagement

The analysis of the sum of online mentions for the period displays a stable trend in the volume of mentions about Cybersecurity (Figure 14), with the exception of the period between April and June. This spike reflects the rise in interest due (primarily but not exclusively) to the GDPR legislation among European countries. A similar trend is present for the engagement metric, highlighting that mentions trail engagement during this period (Figure 15). Regulation is the key driver of engagement throughout the period.

Figure 14: Mentions about Cybersecurity (expressed in thousands of observations)

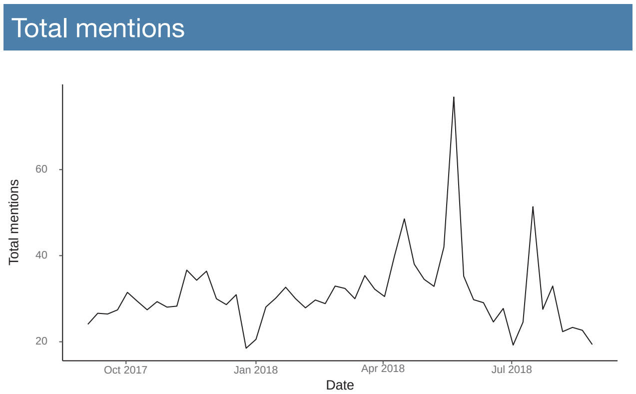
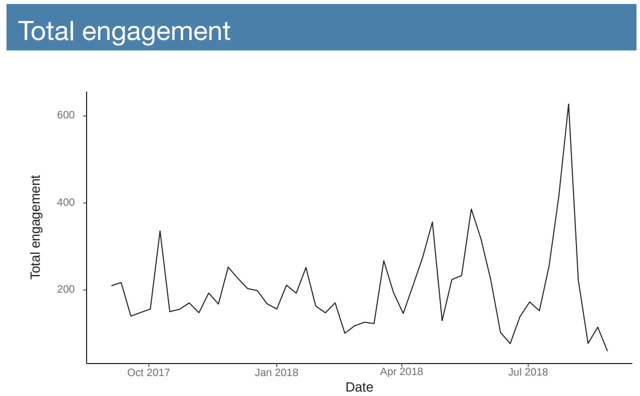


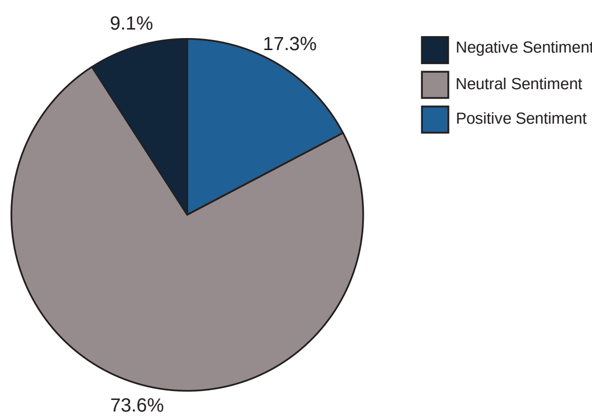
Figure 15: Level of engagement on Cybersecurity (expressed in thousands of observations)



3.2.2.2 Sentiment analysis

The Cybersecurity sentiment analysis offers insights into the nature of online discussions on Cybersecurity. Figure 16 shows that non-negative sentiment accounts for the overwhelming majority of mentions.

Figure 16: Cybersecurity sentiment



BIOTECHNOLOGY

The Biotechnology Readiness Index produces a ranking with some similarities. The United Kingdom, the United States and Singapore feature again among the best performing countries, together with Switzerland and Morocco.

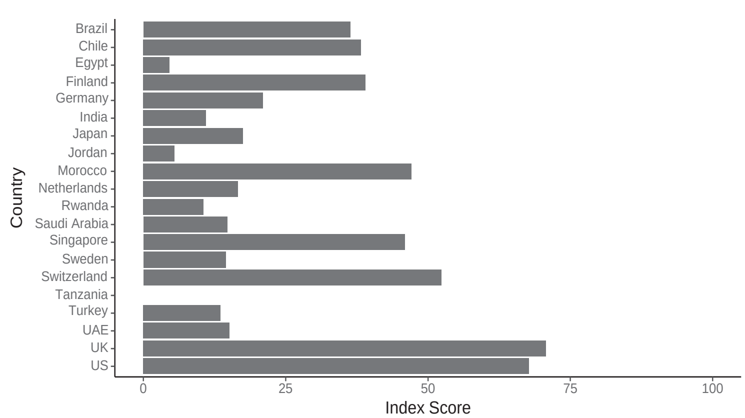
The United Kingdom leads the ranking, with RDI and Science, and Economy accounting for 80 percent of total activity in the field. Readiness within these dimensions relates more to investment in Biotechnology, awards/funding through competition and entrepreneurship. The United Kingdom online community links Biotechnology more with the healthcare and cosmetic industries and less with the food industry. Applications such as genomics and bioinformatics feature prominently, while small events capture only a moderate share of attention.

The United States follows in the ranking with a plethora of interests accounting for online activity in the field. Major events in the field such as the biotech showcase 2018, the Digimed show and the JPMorgan Healthcare conference account for short-lived spikes observed during the sampled period. The majority of the volume of discussions that the online community produces focuses on the healthcare/pharma side of Biotechnology and revolves around four key points of interest. First, the potential of novel Biotechnology applications, such as CRISPR (DNA sequencing), genomics and cryogen;[9] second, the search for finance for companies active in biotech; third, the fight against diseases (primarily Alzheimer's and cancer); and fourth, the ethics of Biotechnology applications.

For Switzerland, as is the case for the majority of countries, we observe that Research, Development and Innovation (RDI) in Biotechnology drive more than 50 percent of online activity. The country's ranking is in line with its position in the Global Innovation Index 2018 where it is ranked as the most innovative economy in the world.[10] The Swiss industry benefits from a comprehensive education system oriented towards the formation of a workforce with diverse skills and levels of qualification, while the high standard of living is key in attracting international talent. The Biotechnology sector is the largest export industry in the country, together with chemistry and pharmaceuticals, accounting for 44.8 percent of total exports in 2016.[11]

Analysis of the posts in Morocco reveals that the online community of the country displays a high degree of readiness in topics relating to agricultural activities. Here, Biotechnology occupies a prime spot as a discussion theme. This is in line with the country's current investment activities in agricultural Biotechnology for the support of the local livestock and poultry production.[12]

Figure 17: Biotechnology Readiness Index across 20 countries



3.2.3.1 Mentions and level of engagement

Analysis of the total sum of online mentions for the period displays stability in the volume of mentions about Biotechnology (Figure 18), with the exception of June that presents a sharp spike in the number of mentions. The engagement metric points to five distinct spikes – before and after January 2018, two spikes close to the month of April and the last one in August. Nevertheless, none of the deviations from the trend appear to relate to a specific event. Most prominent stories in terms of engagement during this period link to marijuana consumption, a forecasted chocolate shortage and politicized topics such as birth control and the donations for the Vote Leave campaign in the United Kingdom.

Figure 18: Mentions about Biotechnology (expressed in thousands of observations)

Total mentions

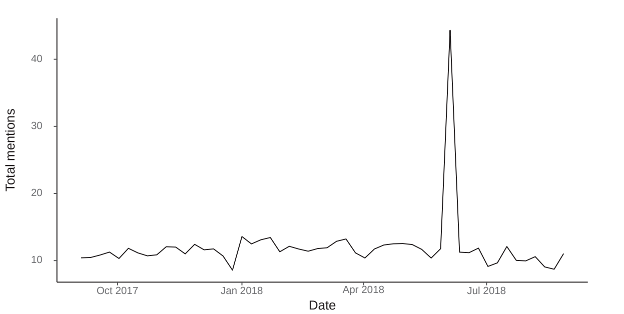
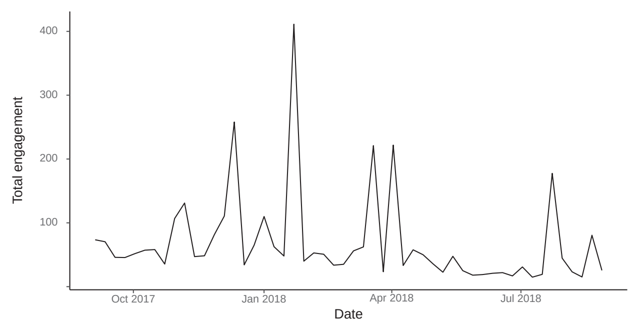


Figure 19: Level of engagement on Biotechnology (expressed in thousands of observations)

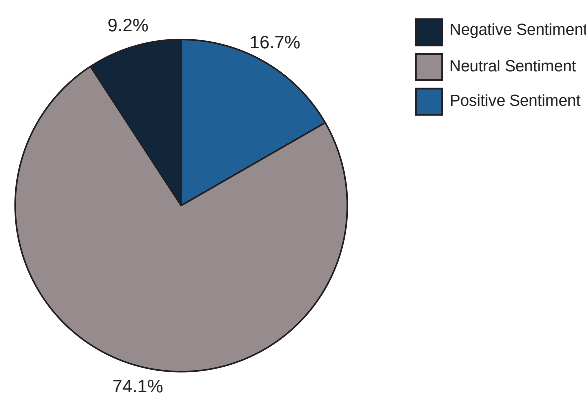
Total engagement



3.2.3.2 Sentiment analysis

The sentiment analysis offers insights into the nature of online discussions on Biotechnology. Figure 20 shows that non-negative sentiment accounts for the majority of mentions. Themes that account for the overall level of negative sentiment include CRISPR, stem cell technology, genetically modified organisms and ethics in Biotechnology.

Figure 20: Biotechnology sentiment

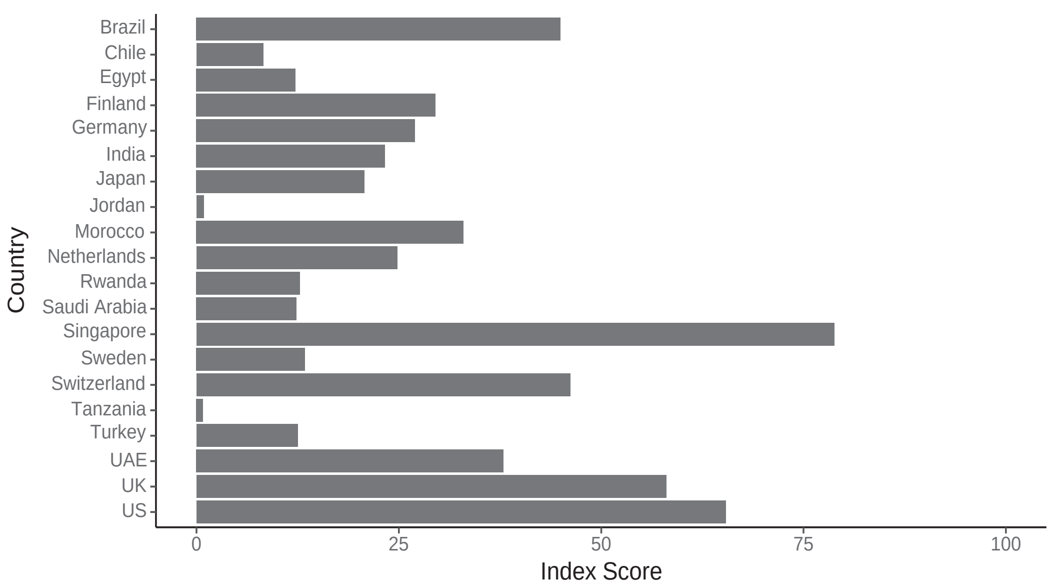


BLOCKCHAIN

The analysis of the online debate surrounding Blockchain technology stands out among the other four future fields due to the media coverage enjoyed following the spike in the value of Bitcoin. Thus, an overwhelming part of the discussions our algorithm captures relates to cryptocurrencies and not to the entire spectrum of applications that the distributed ledger technology incorporates.

Analysis of the Blockchain Readiness Index scores, presented in Figure 21, points to Singapore as the top performer. The United States, the United Kingdom, Brazil and Switzerland complete the group of five top performing countries. In all five, two distinct themes drive the online discussion on Blockchain: major gatherings (e.g. World Blockchain Conference,[13] World Blockchain Summit[14]) and Cryptocurrencies.

Figure 21: Blockchain Readiness Index across 20 countries



3.2.4.1 Mentions and level of engagement

Analysis of the total sum of online mentions for the period between 4 September 2017 and 2 September 2018 displays a rising trend that reaches a peak in late April, before stabilizing around the pre-peak level of close to 120 thousand mentions per week for the ensuing period. During this period, no single event appears to drive the interest of the online community. Within the Blockchain theme, cryptocurrencies account for most of the mentions, followed by international conferences such as the 2018 Asia Blockchain Summit[15] and the Blockchain Leadership Summit.[16]

The engagement metric presents a somewhat different trend, where the steep hike in engagement (October to early February) precedes the spike in mentions. This could point to a dynamic relationship where mentions are reactive to past engagements. The hike in engagement perfectly coincides with the rise in value of Bitcoin (currently the most highly valued cryptocurrency).[17]

Figure 22: Mentions about Blockchain (expressed in thousands of observations)

Total mentions

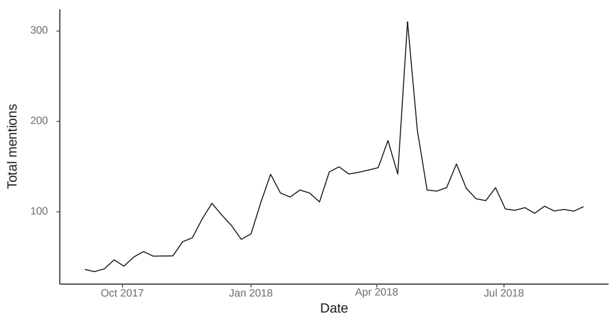
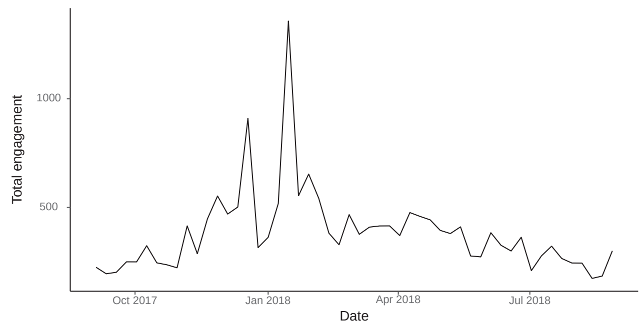


Figure 23: Level of engagement on Blockchain (expressed in thousands of observations)

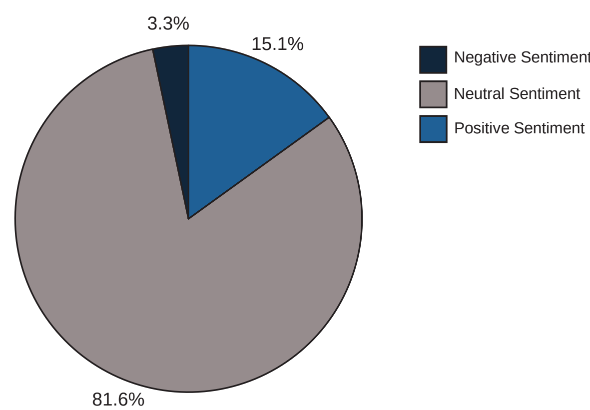
Total engagement



3.2.4.2 Sentiment analysis

The Blockchain sentiment analysis visualized in Figure 24 underscores that the nature of discussions surrounding the technology is non-negative. The main driver of negative sentiment appears to be the uncertainty relating to the fundamentals behind the current trading price of cryptocurrencies.

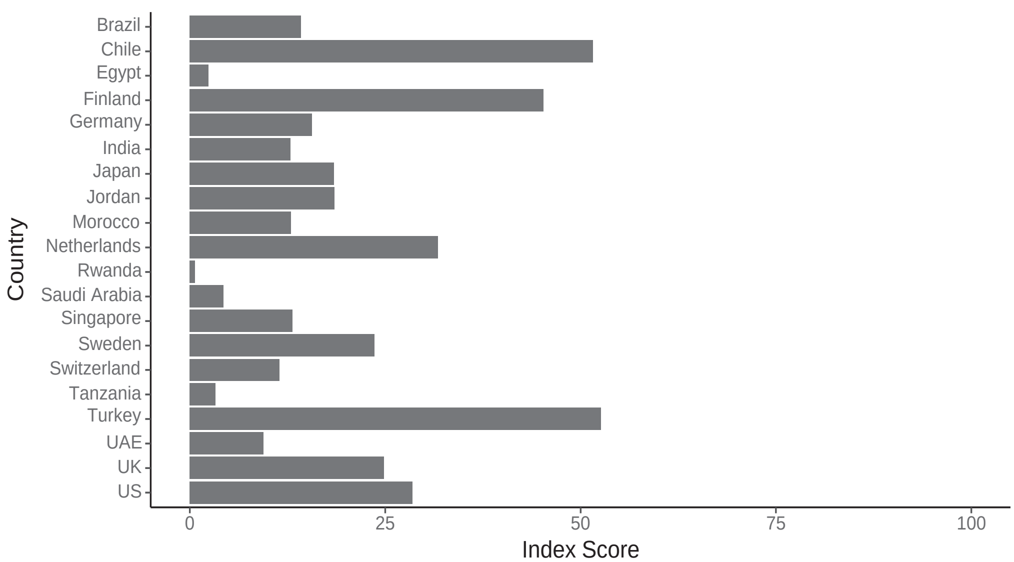
Figure 24: Blockchain sentiment



FUTURE SKILLS

Online activity within the Future Skills field presents the highest density in Turkey and Chile; Finland, the Netherlands and the United States complete the group of five countries displaying the highest density in online activity. We note that the key driver of overall activity in Future Skills is the dimension of Education, accounting for 58.8 percent of total activity. Within Education, one of the principal points of attention is a current deficit in teachers. This is most evident in primary and secondary education, critical years for the development of the fundamental cognitive and soft skills that we identify as necessary for the employment market of the future. Countries where this issue is most present in online discussions are the United States, the United Kingdom, Sweden, Tanzania, Turkey and the Netherlands.

Figure 25: Future Skills Readiness Index across 20 countries



By contrasting our results to the findings of the Worldwide Educating for the Future Index ranking,[18] we observe that, with the exception of Turkey, the Index places the five countries displaying the highest online debate density in the "best environment" or the "good environment" category.

Table 3: Worldwide Educating for the Future Index

Best environment	Good environment	Moderate environment	Needs improvement
3. Finland	10. Germany	22. Brazil	29. India
4. Switzerland	12. United States	24. Turkey	30. Saudia Arabia
5. Singapore	15. Chile		33. Egypt
6. United Kingdom			
7. Japan			
9. Netherlands			

Source: The Economist Intelligence Unit 2017, Worldwide Educating for the Future Index

3.2.5.1 Mentions and level of engagement

The series of the total sum of online mentions for the period appears very noisy, but oscillations take place around a stable weekly trend magnitude of 25,000 and 30,000 observations. This suggests that no single event drives global Future Skills readiness. Meanwhile, Turkey and Japan seem to account for a large share of the results (jointly accounting for 57 percent of total mentions). Levels of engagement present a similarly noisy trend, where we recommend treating the spike near October as an outlier: no single event seems to account for sharp rise in activity.

Figure 26: Mentions about Future Skills (expressed in thousands of observations)

Total mentions

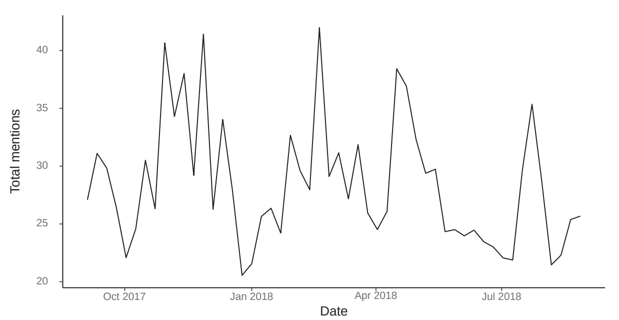
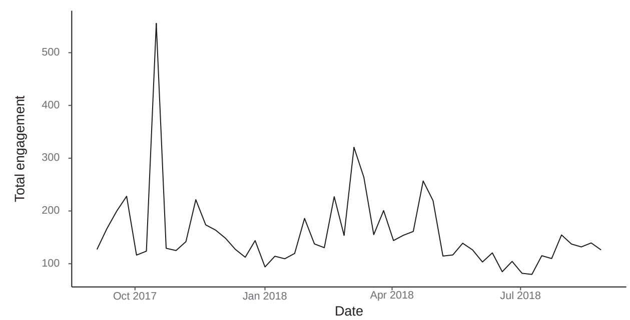


Figure 27: Level of engagement on Future Skills (expressed in thousands of observations)

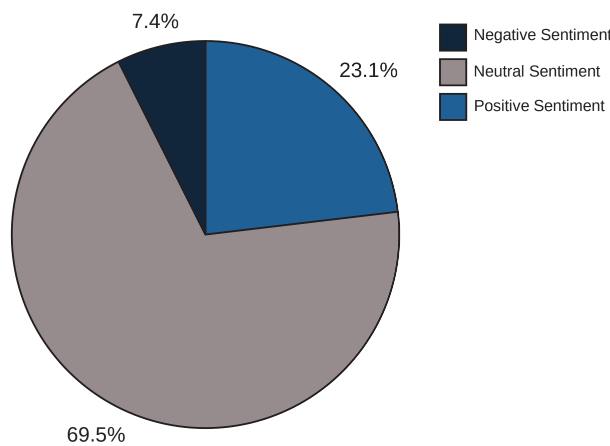
Total engagement



3.2.5.2 Sentiment analysis

The Future Skills sentiment analysis presents a strongly non-negative view of the overall state of affairs. Negative sentiment almost exclusively relates to teacher shortages.

Figure 28: Future Skills sentiment in 2018



3.3 COUNTRY PROFILES

[redacted]

BRAZIL

GDP per capita
$ 9,821 2017

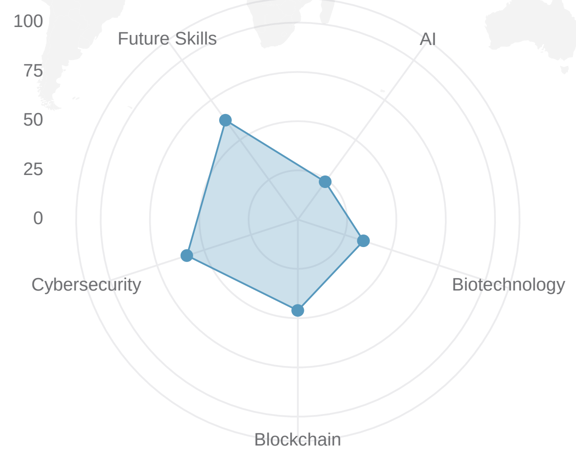
HDI
0.759 2017

GKI (rank)
58 2017

627 unique authors per million Internet users

The Future Field Readiness Indices for Brazil show that in terms of readiness the country is strongest in Future Skills and Cybersecurity. Overall, Brazil does not present a strongly balanced picture in terms of readiness for the five fields. Blockchain trails the performance of the top fields, while Biotechnology and AI are comparatively weakest fields in terms of online activity.

Figure 29: Future Fields Readiness Indices scores in Brazil

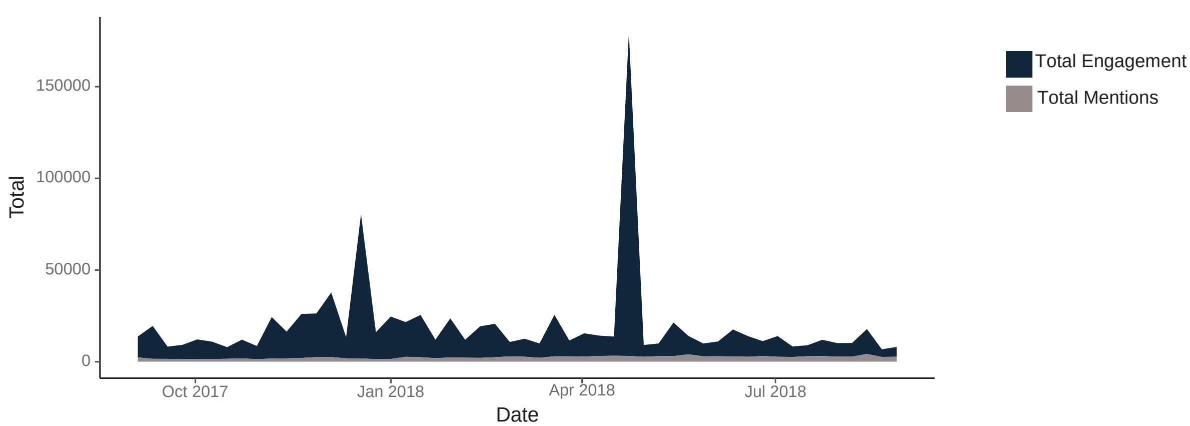


Brazil's level of interest in key technologies for the future

The volume of online activity in Brazil within the theme of the four technologies displays an average value of 2,237 mentions and 16,152 instances of engagement per week, with respective median values of 2,332 and 9,668. The two series also show a zero degree of co-movement, indicating that influential articles are mainly driving online activity. The online community of Brazil also shows a high degree of responsiveness to publications, as engagement is six times more volatile than mentions.[19]

During the sampled period, two important peaks of economic activity stand out, on 18 December 2017 and 30 April 2018. The first engagement peak is mainly related to the rise of the bitcoin value in December 2017.[20] The second peak most likely is linked to the Cybersecurity attack that hit "O Boticário" – the second biggest Brazilian cosmetic company – on 26 April 2018.[21]

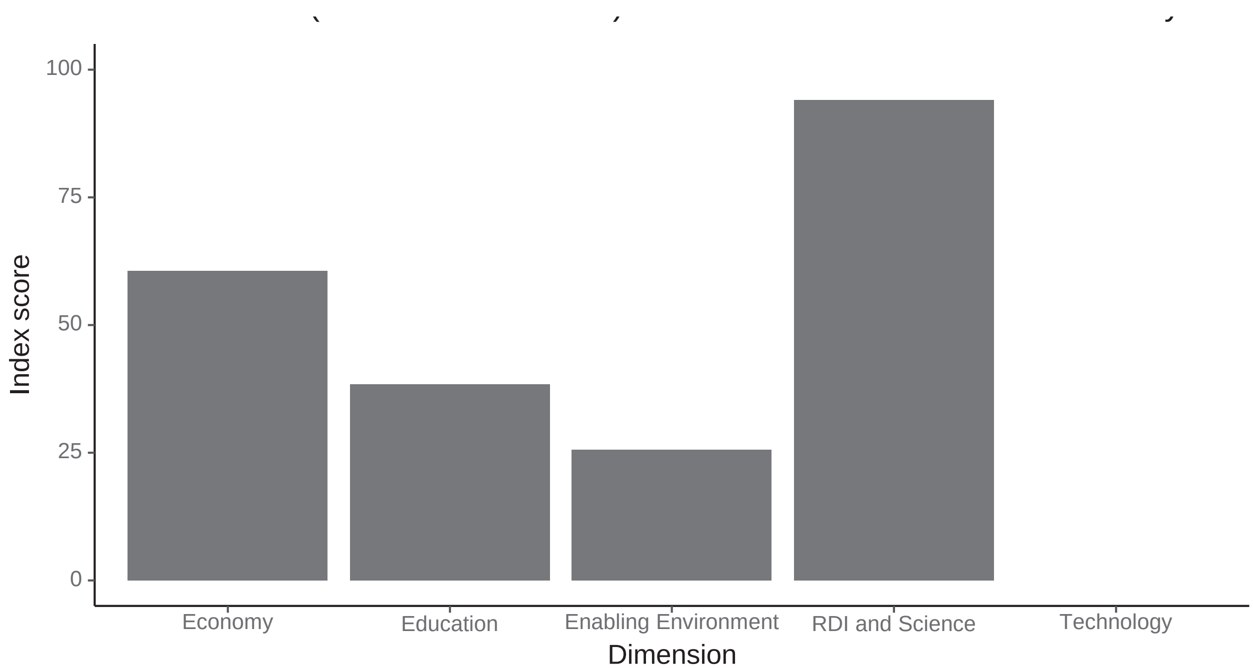
Figure 30: Volume of discussions and engagement level associated with the four key technologies for the future in Brazil (Sept 2017 - Sept 2018)



When breaking down the Global Technology Readiness Index (GTRI) into the five knowledge dimensions, RDI and Science comes out as the strongest dimension for Brazil. This suggests that Brazil has been creating, publishing, discussing, or sharing content about innovation hubs, technology labs, research infrastructures, awards and patents. This content has been generating buzz online, more so than content about the other four knowledge dimensions.

The Technology dimension shows particularly weak for Brazil in this analysis. It appears that, for this period, Brazil has not been devoting much attention to discussions of supporting technologies and technological requirements, such as open data sources, cloud computing and quantum computing.

Figure 31: Brazil's Global Technology Readiness Index by knowledge dimension (Sept 2017 - Sept 2018)

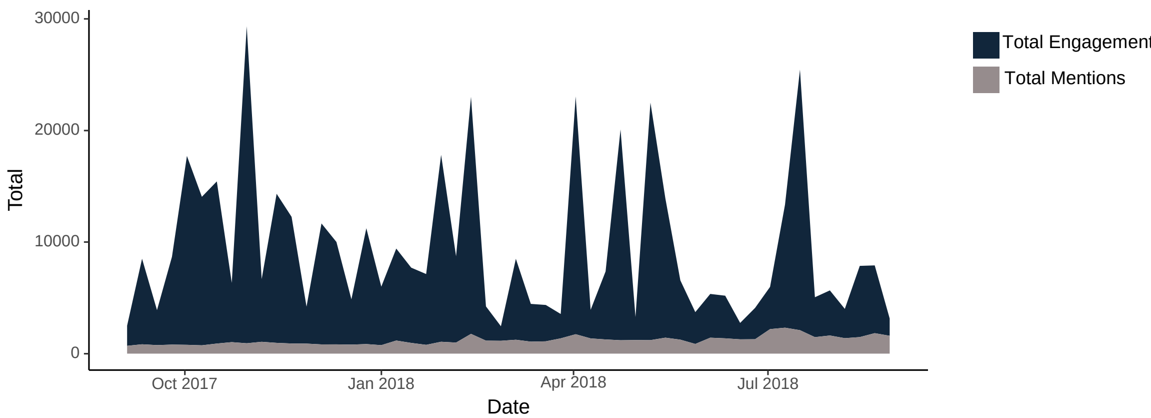


Brazil's level of interest in Future Skills

The volume of online activity in Brazil within Future Skills is significantly lower in comparison to online activity relating to the four technologies. In Brazil, online activity in Future Skills presents an average value of 1,179 mentions and 8,067 instances of engagement per week, with respective median values of 1,138 and 6,078. The two series show a low degree of co-movement (0.1 coefficient of correlation), suggesting that a small number of influential publications, rather than major events, are the main driver of online activity. The low degree of volatility displayed by both engagement and mentions suggest a weak level of responsiveness of the online community to publications.

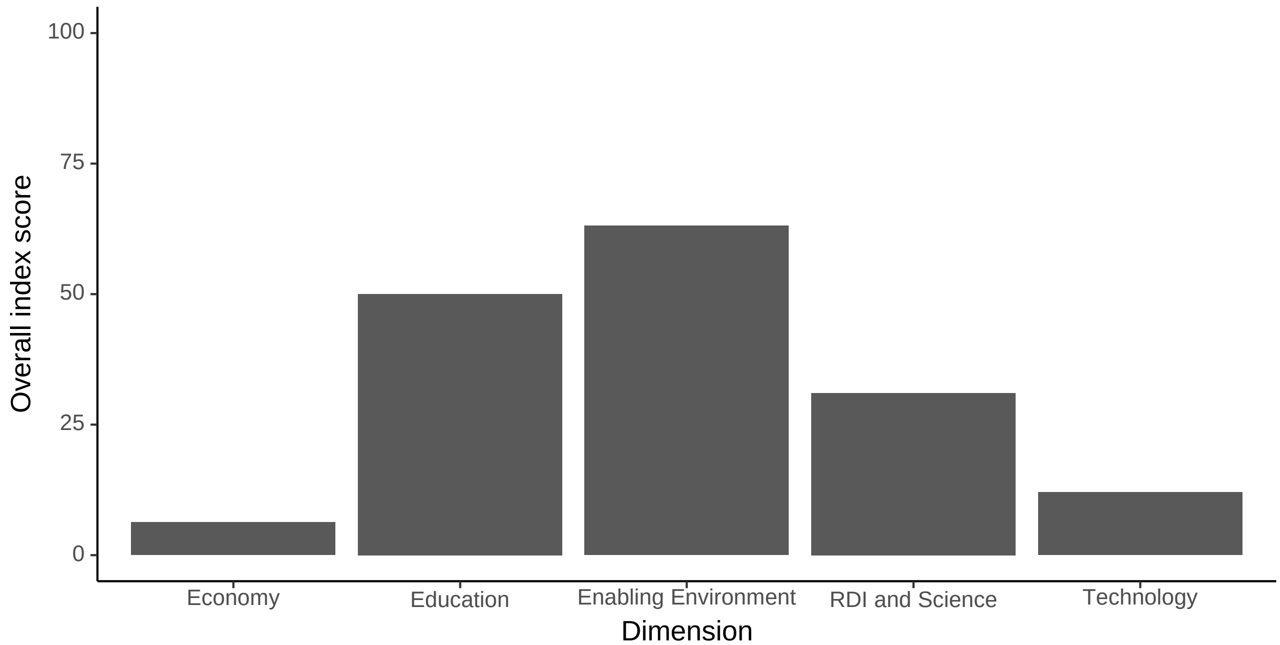
A deeper analysis of the trends reveals that most of the mentions (63 percent of all of Future Skills mentions of Brazil) are related to the Education dimension. In addition, most of the engagement peaks come from Education and Enabling Environment.

Figure 32: Volume of discussions and engagement level associated with Future Skills in Brazil (Sept 2017 - Sept 2018)



Brazil's Future Skills Readiness Index separated by knowledge dimension confirms the above results by revealing that Enabling Environment and Education are the strongest categories. Brazilian Internet users appear to be primarily concerned about the teaching/learning of new skills and how the government is/is not supporting the development of Future Skills. However, upon deeper analysis of the results, the enabling environment dimension appears to have been connected to Brazil's elections in October 2018 by political articles.

Figure 33: Brazil's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Brazil's strengths and areas for improvement

Brazil is an overall good performer in terms of technological readiness. The country scores within the top five in two fields, Cybersecurity and AI (see section 3.2). However, this is not necessarily a positive sign. One of the key determinants of this performance is the transformation of the country to a hotspot for cybercrime. The high density of online activity within these two fields relates to the efforts of the private and public sector to develop defenses against cybercriminals. The use of ethical hackers (white hats) and Blockchain technology feature prominently in terms of overall readiness.

2 CHILE

GDP per capita
$15,346
2017

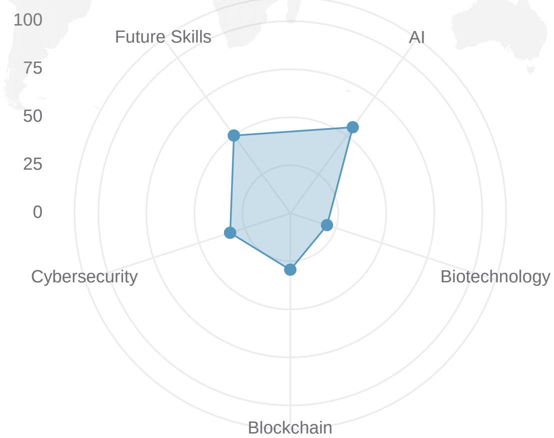
HDI
0.843
2017

GKI (rank)
47
2017

740
unique authors
per million
Internet users

The analysis of Chile's scores for the Future Field Readiness Indices suggests that there is currently a focus on AI and Future Skills in Chile. The other three fields (Cybersecurity, Blockchain and Biotechnology) all come in at similar index scores, performing around two times lower than AI, the strongest field.

Figure 34: Future Fields Readiness Indices scores in Chile

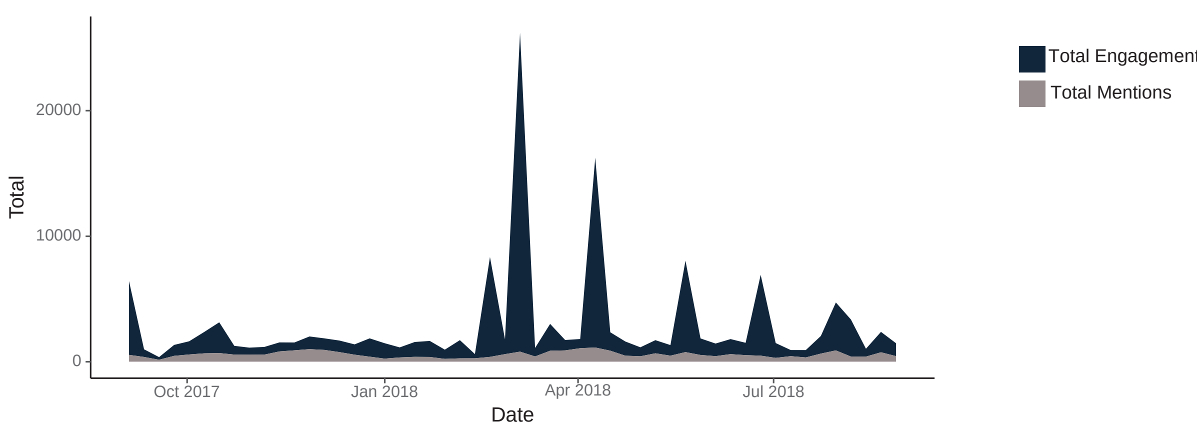


Chile's level of interest in key technologies for the future

The volume of online activity in Chile within the theme of the four technologies displays an average value of 536 mentions and 2,178 instances of engagement per week, with respective median values of 501 and 990. The two series also show a low degree of co-movement (0.27 coefficient of correlation), suggesting that the online community takes little notice of major events in the four technologies. Instead, influential publications drive a greater share of online activity. Moreover, engagement displays a significantly high degree of volatility in comparison to mentions, which may point to a strong responsiveness of the online community to influential publications.

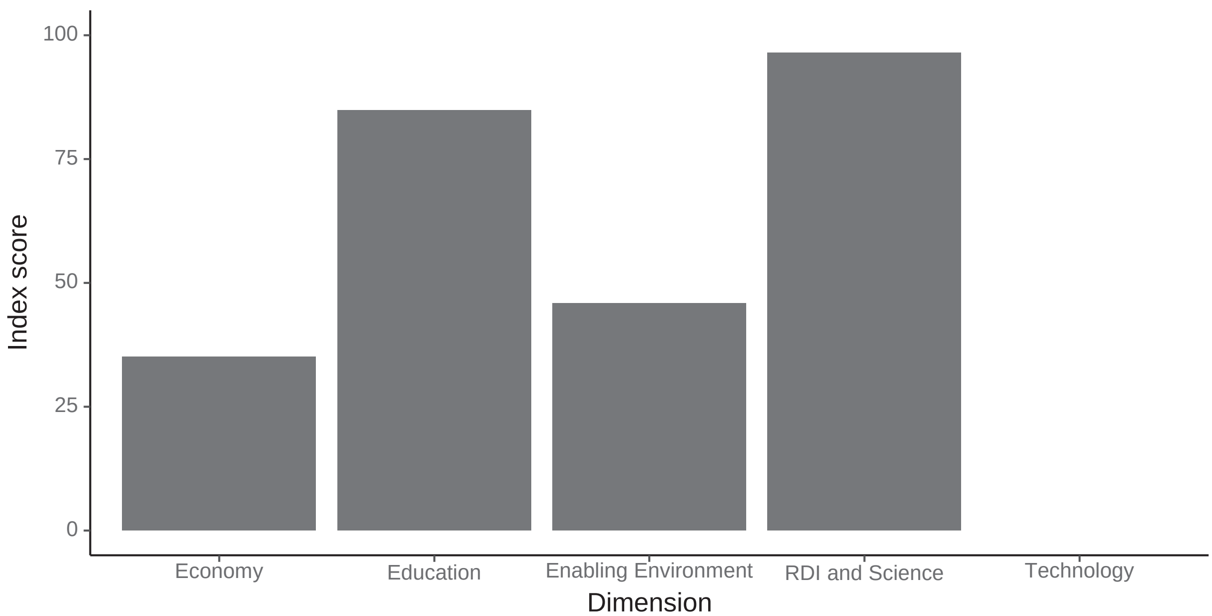
The most significant peak in engagement occurred in the field-dimension of AI-Education on 5 March 2018. The spike was due to newspaper articles about a young Chilean girl having participated in the INDEX conference in San Francisco.[22] The young girl was taking online Artificial Intelligence courses with the support of IBM and presented her chatbot at the conference, which she created in IBM laboratories in Chile.

Figure 35: Volume of discussions and engagement level associated with the four key technologies for the future in Chile (Sept 2017 - Sept 2018)



Viewing the technologies across the five knowledge dimensions reveals that, in Chile, discussions are mainly concentrated around two dimensions, i.e. RDI and Science and Education. Economy and Enabling Environment closely to follow. These results reflect the salience of topics relating to research infrastructure, innovation capacity and new education programmes.

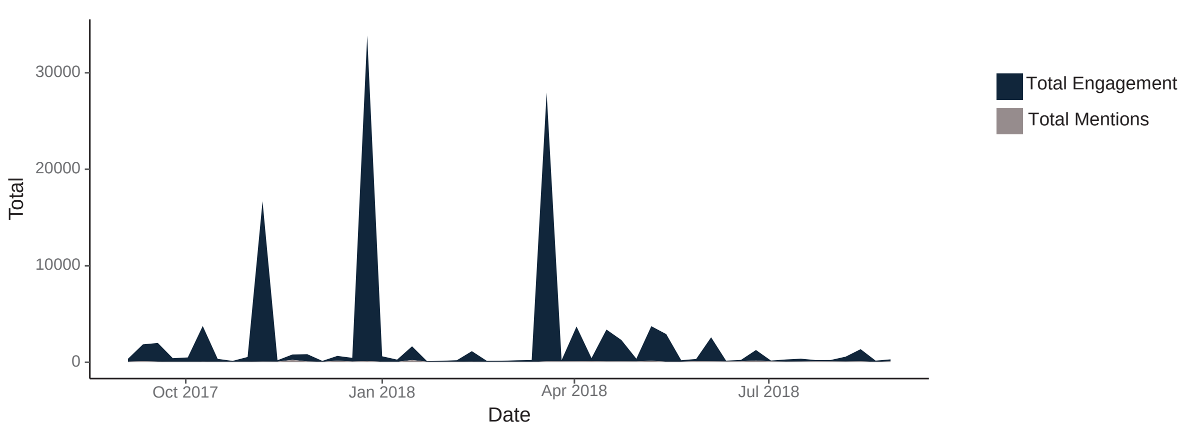
Figure 36: Chile's Global Technology Readiness Index by knowledge dimension (Sept 2017 - Sept 2018)



Chile's level of interest in Future Skills

The volume of online activity in Chile within Future Skills is significantly lower in comparison to online activity relating to the four technologies. In Chile, online activity in Future Skills presents an average value of 81 mentions and 2,254 instances of engagement per week, with respective median values of 73 and 297. The two series show a low degree of co-movement (0.12 coefficient of correlation), presenting a similar picture to the one for the four technologies. The online community reacts more to influential publications than major events. Again, similar to the results for the four technologies, engagement is more than five times more volatile than mentions. This corroborates the finding of an online community that strongly responds to a small number of online publications.

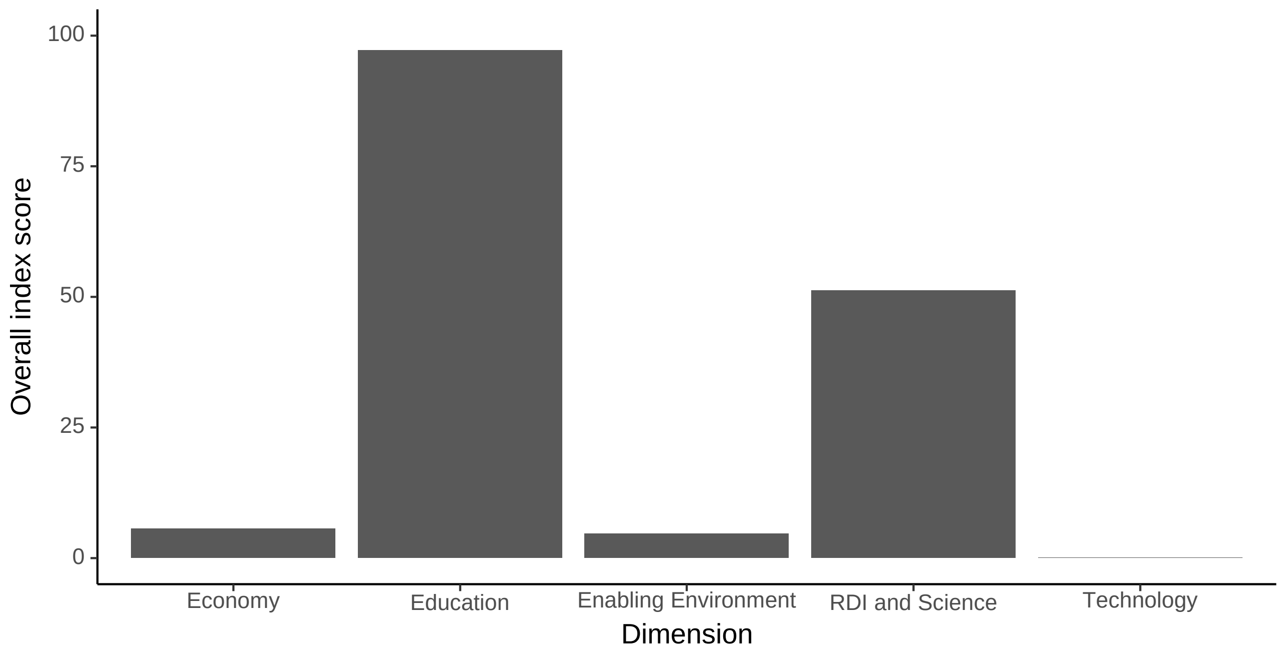
Figure 37: Volume of discussions and engagement level associated with Future Skills in Chile (Sept 2017 - Sept 2018)



Education is the knowledge dimension that shows the highest score when analysing online discussions concerning Future Skills. The score obtained for Education is almost two times the score obtained for RDI and Science, the second highest score. The remaining dimensions follow at a great distance. This pre-eminence of Education reflects the good level of readiness in the country related to the existing deficit in teachers, where online activity focuses both on raising awareness and on finding an effective solution to the problem.

RDI and Science, Economy, Technology and Enabling Environment follow at a great distance – RDI and Science performs more than seven times lower than Education. This pre-eminence of Education is largely the result of noise coming from elections in the country.

Figure 38: Chile's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Chile's strengths and areas for improvement

Chile is an overall good performer in terms of technological readiness. The country performs well in the overall comparison, better in terms of Future Skills than in terms of the four technologies. Chile performs best in the technology field of Biotechnology, holding a middle ranking for AI and Cybersecurity. The weakest field for the country is Blockchain.

Despite a good level of overall Internet coverage and an average share of unique authors in total Internet using population, Chile displays a low level of activity and a weak link between events and online activity. Elections and a small number of influential articles seem to account for the majority of spikes in terms of both mentions and engagement.

Associated literature points to the education system as a key area for improvement in the country. Lack of debate on the quality of the current system or potential teacher shortages suggests a low level of awareness surrounding current events and caveats relating to the adoption of new technologies in the country.

GDP per capita
$ 2,413 2017

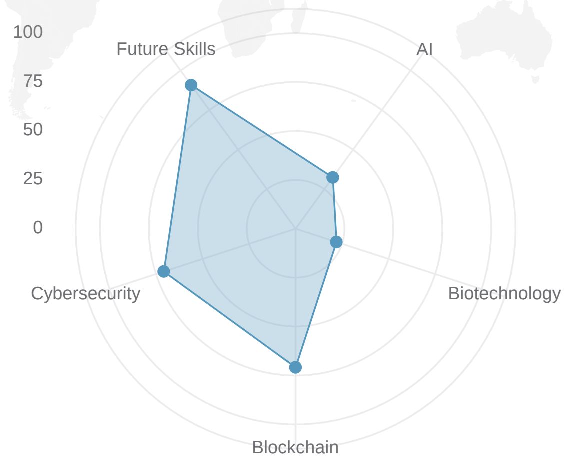
HDI
0.696 2017

GKI (rank)
95 2017

379 unique authors per million Internet users

Future Field Readiness Indices in Egypt are not equally distributed among the five different fields. The top three fields, Future Skills, Blockchain and Cybersecurity, perform four times higher than the lowest scoring fields, AI and Biotechnology. This asymmetry in attention and engagement is clearly visualised in Figure 39.

Figure 39: Future Fields Readiness Indices scores in Egypt



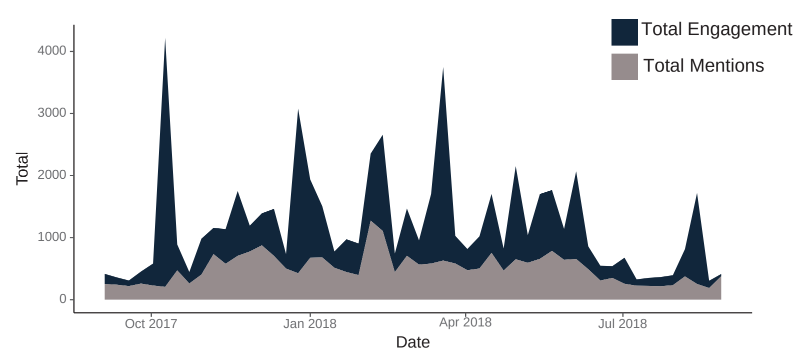
Egypt's level of interest in key technologies for the future

The volume of online activity in Egypt within the themes of the four technologies displays an average value of 456 mentions and 654 instances of engagement per week, with respective median values of 442 and 403. The two series also show a low degree of co-movement (0.22 coefficient of correlation), indicating the importance of a small number of influential publications as the key drivers of online activity. Moreover, the similarity in the magnitude of volatility for mentions and engagement suggests a weak responsiveness of the online community to online content related to the four technologies.

There is one main peak in mentions in the beginning of February. This peak appears to be driven by AI-Economy, with tweets around the World Government Summit 2018 in Dubai. The mentions in this peak consist mainly of tweets about Mohammed Al Gergawi's opening statement on the importance of investing in AI now, and in bigger proportions than for what was invested in the oil sector.[23] However, this peak in mentions does not coincide with a particularly high rate of engagement.

The mention that received the most engagement (October) relates to an article by Bloomberg Business Week Middle East discussing how Vanuatu accommodates the provision of citizenship to foreigners through investment in Bitcoin.[24] At the time of analysis, it had earned almost 4,000 shares on LinkedIn. The hype about Bitcoin is also reflected in an article in Egypt Today, an Egyptian English-language monthly magazine, that received 13 Twitter shares, almost 2,000 Facebook shares, and 192 LinkedIn shares.

Figure 40: Volume of discussions and engagement level associated with the four key technologies for the future in Egypt (Sept 2017 - Sept 2018)

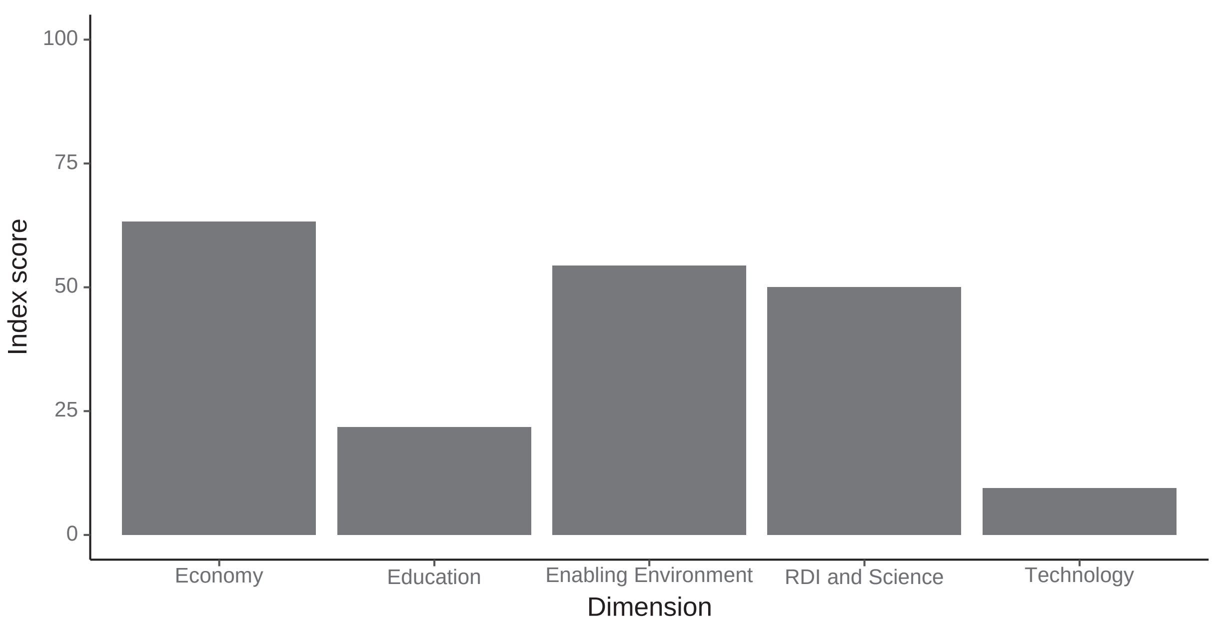


Egypt performs high in three of the knowledge dimensions for the GTRI: Economy, Enabling Environment, and RDI and Science. Education and Technology appear to be areas with significantly fewer mentions and engagement. Interpreting this, it appears that for the period analysed there is a focus on the research, investment and regulation of the future technologies in Egypt, while less attention is paid to the educational and technological aspects in this area.

We find that the Economy dimension consists of largely Blockchain-related content. Blockchain thus is the main contributor to the high mentions and engagement for this knowledge dimension in Egypt.

Looking at just the volume of mentions for Blockchain-Economy overtime, we can see the uptake of this topic by Egyptian online authors and the continued attention given to it. There was a low volume of mentions for Blockchain-Economy prior to November 2017, and then around 6 November, the volume began to rise. This volume peaked in December 2017, but remained considerably high (for Egypt), with other significant peaks, throughout the remainder of the period.

Figure 41: Egypt's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Egypt's level of interest in Future Skills

The volume of online activity in Egypt within Future Skills is lower in comparison to online activity relating to the four technologies. In Egypt, online activity in Future Skills presents an average value of 135 mentions and 347 instances of engagement per week, with respective median values of 148 and 257. The two series also show an average degree of co-movement (0.56 coefficient of correlation), while engagement is almost twice as volatile as mentions. These results point to the importance of events in driving online activity in the country.

For engagement, there is one spike driven by a publication by the American University in Cairo, falling under the Education dimension.[25] The publication detailed faculty contributions by the Department of Journalism and Mass Communication, which included the attendance of various faculty members at conferences/workshops dedicated to the future of journalism and teaching Future Skills.

Figure 42: Volume of discussions and engagement level associated with Future Skills in Egypt (Sept 2017 - Sept 2018)

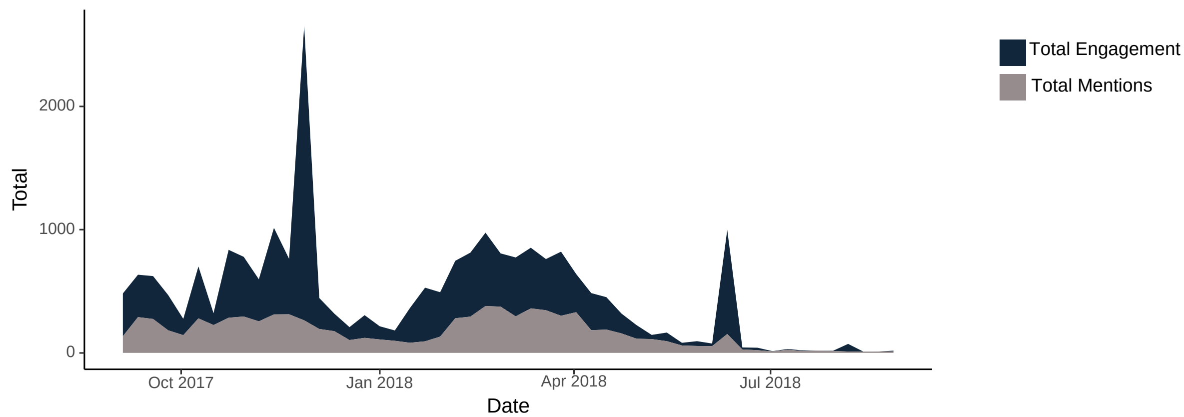
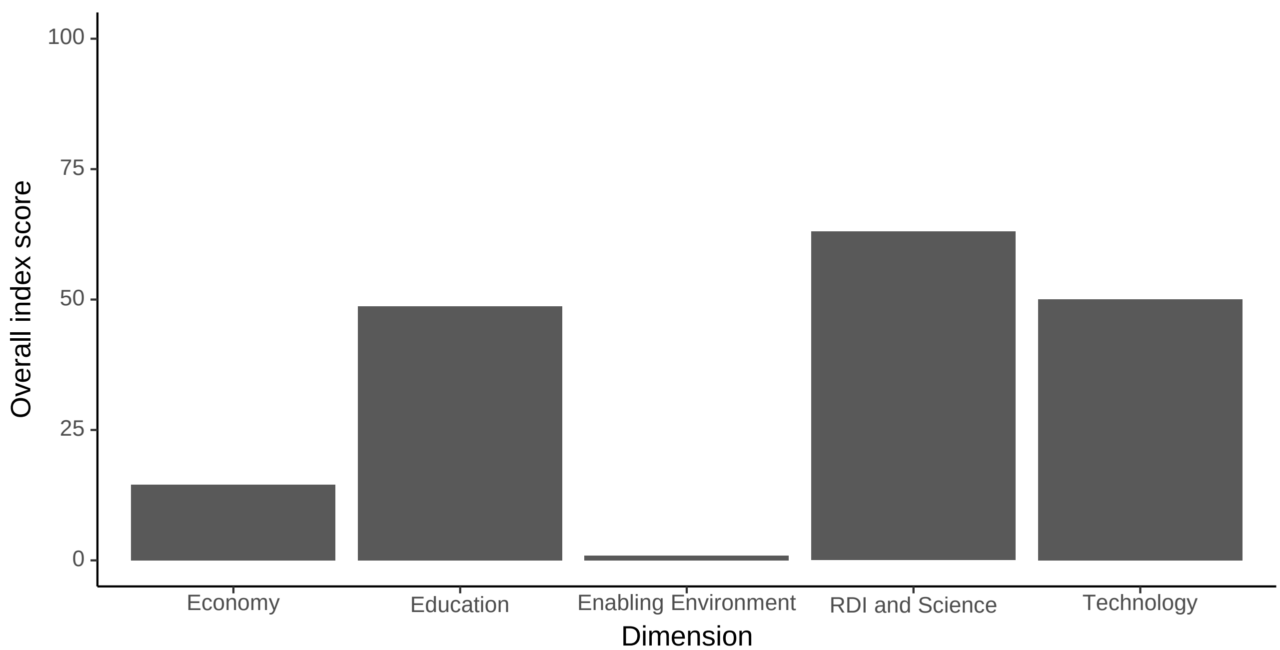


Figure 43 shows that for Future Skills, Egypt is currently higher performing in RDI and Science, Education and Technology than for Economy and Enabling Environment. Therefore, in Egypt, more attention may be devoted to discussing and publishing about upskilling/educational research, future skills courses or trainings, and supporting technologies (open data source, virtual reality, etc.).

Figure 43: Egypt's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Egypt's strengths and areas for improvement

Egypt is an overall weak performer in terms of cross-country comparison. The country occupies the lowest positions in the GTRI for all four technologies, and occupies below average positions in the respective technology rankings.

Within the Arab States, Egypt is the weakest performer in terms of share of unique authors in the total Internet-using population. This highlights that the network of information dissemination in the country is still at an infant stage. Moreover, total volume of activity is not due to a constant interest in one of the fields. Instead, we observe a fleeting level of readiness. This dynamic becomes particularly notable in terms of Future Skills.

We observe a similar degree of infancy in terms of technological readiness, as even though Egypt performs well in Blockchain the great majority of discussions revolve around cryptocurrencies – an insular application in the field of Blockchain.

Overall, the country has a significant distance to cover in preparing its labour market for the fourth and upcoming industrial revolutions. Fostering the emergence of public discussion on future fields would be a first step in the right direction.

4 FINLAND

GDP per capita **$45,703** 2017

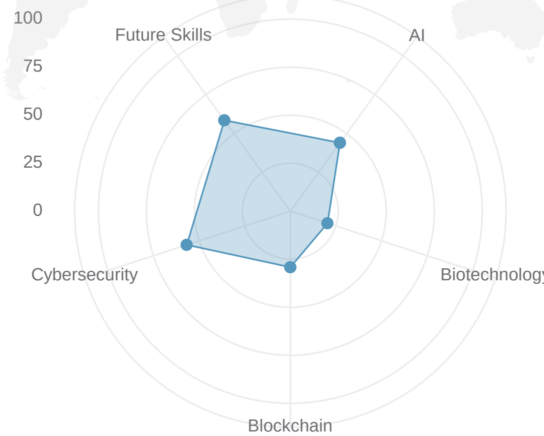
HDI **0.92** 2017

GKI (rank) **3** 2017

3436 unique authors per million Internet users

The five Future Field Readiness Indices for Finland reveal that the country scores highest in Future Skills, Cybersecurity and AI. Overall, Finland presents a balanced picture in terms of readiness for three out of five fields. Blockchain and Biotechnology are comparatively weaker for Finland in terms of online activity. Nevertheless, the two lowest scoring fields are less than three times lower than the highest scoring ones. This suggests that the Finnish online community is not focusing on one or two fields to the detriment of the rest.

Figure 44: Future Fields Readiness Indices scores in Finland



Finland’s level of interest in key technologies for the future

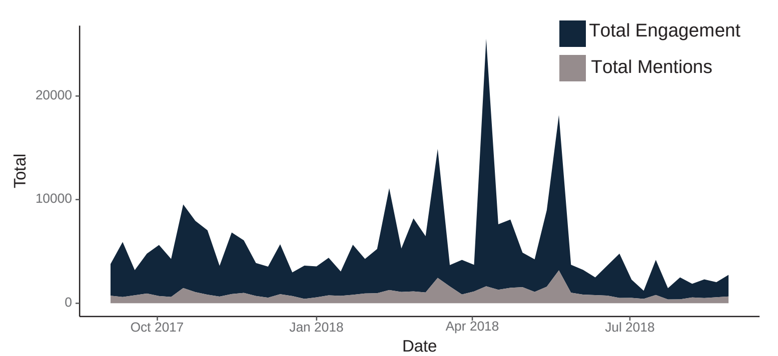
The volume of online activity in Finland within the thematic of the four technologies displays an average value of 874 mentions and 3,984 instances of engagement per week, with respective median values of 753 and 2,991. The two series also show a significant degree of co-movement (0.74 coefficient of correlation), suggesting a strong impact of major events on online activity.

The graph of online activity over time for Finland shows two major peaks in total engagement for the four technologies, one in early April and one at the end of May. Both peaks relate to Cybersecurity.

The first peak (April) reflects discussions surrounding a new plan of the government to address the rising costs of social and healthcare services.[26] According to that, all eligible citizens will be assigned a score based on their projected use of social and healthcare services. The score is to be based on data from various national registers to gauge the medical history and lifestyle-related risks for each individual.[27] Despite the benefits of this policy, the population of a single database with such a detailed account of health data is a cause for concern. The leak of sensitive information could have detrimental effects on access to healthcare for individuals.

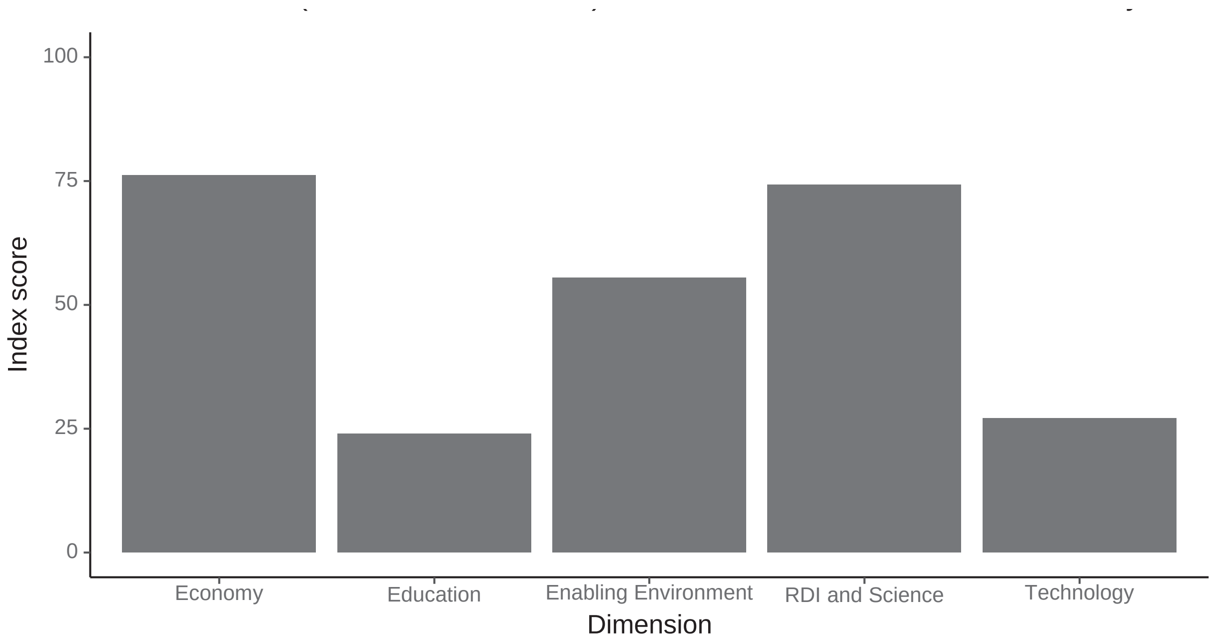
The second major peak (end of May) relates to a proposal by the ex-Defence Minister, Elisabeth Rehn, to overhaul the civilian and military service system.[28] The plan of Minister Rehn foresees the expansion of the listing to all citizens, with the option to enlist in the army or undergo critical skills training. Such skills include protection protocols, anti-terrorism methods or Cybersecurity capabilities, thereby encouraging the uptake of some of the skills necessary for the labour market of the future.

Figure 45: Volume of discussions and engagement level associated with the four key technologies for the future in Finland (Sept 2017 - Sept 2018)



The analysis of the GTRI by knowledge dimension for Finland shows that Economy, RDI and Science and Enabling Environment score the highest, while Education and Technology score the lowest, three times below the Economy score. This result suggests a strong focus by the country on the economic aspect of the future technologies, such as funding sources, investment and initial public offerings, as well as the research and innovation side of AI, such as awards, patents, the work of AI labs and research hubs and AI conferences.

Figure 46: Finland's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

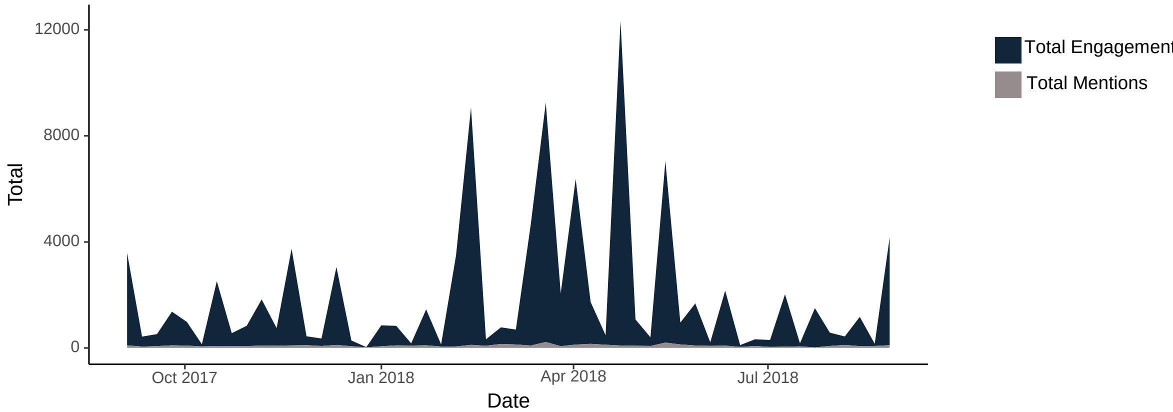


Finland's level of interest in Future Skills

The volume of online activity in Finland within Future Skills is significantly lower in comparison to the online activity related to the four technologies. In Finland, online activity in Future Skills presents an average value of 83 mentions and 1,827 instances of engagement per week, with respective median values of 80 and 751. The two series show an average degree of co-movement (0.48 coefficient of correlation), suggesting that major events are an important driver of online activity also for Future Skills. Moreover, engagement is three times as volatile as mentions, pointing to a strong responsiveness of the online community to publications.

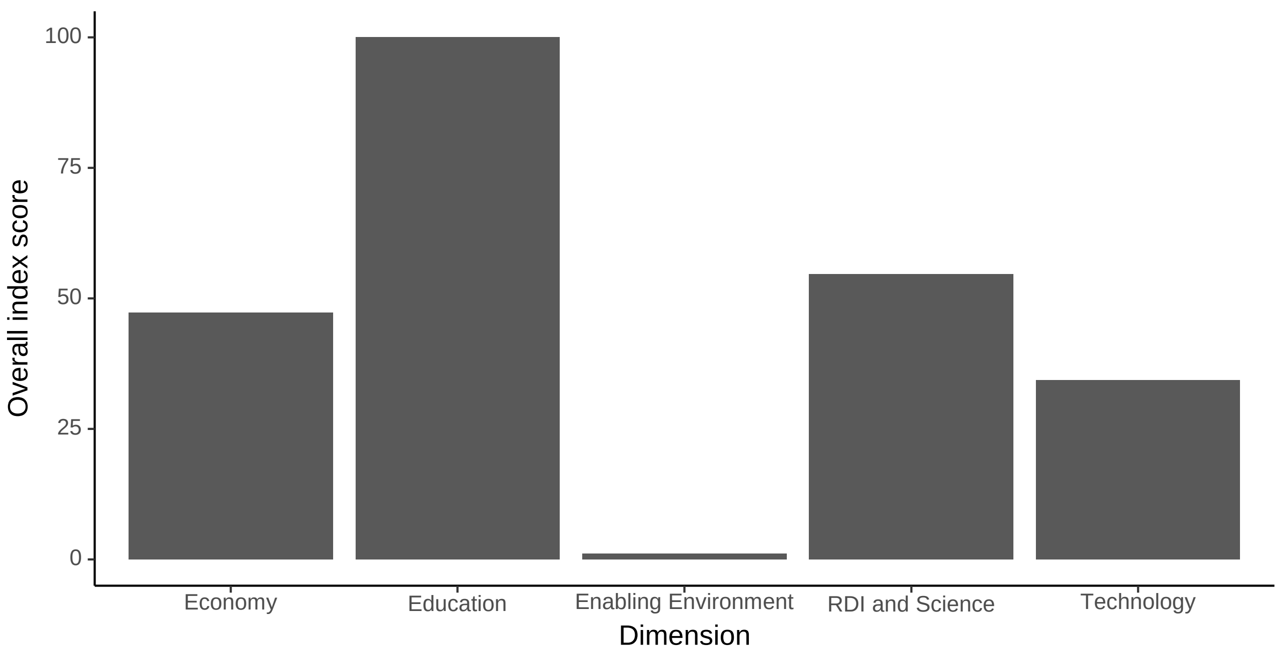
For engagement, the main spike on the 29 April 2018 is due to one article which received over 10,000 engagements. The article was an opinion piece on the role of primary school teachers in society. Similarly, the next spike in engagement (the third week of May) is also driven by education-related Future Skills mentions.

Figure 47: Volume of discussions and engagement level associated with Future Skills in Finland (Sept 2017 - Sept 2018)



In line with the engagement results, Future Skills in Finland score the strongest along the Education dimension. Mentions in the category flesh out topics relating to future skills education and the future of education as a sector, in line with the position of Finland in the literature as a pioneer in the field of education.[29]

Figure 48: Finland's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Finland's strengths and areas for improvement

Overall, Finland is a strong performer in terms of technological readiness. The country scores among the top five performers in the GTRI, as well as in the cross-country comparisons for AI, Cybersecurity and Future Skills. Finland also ranks in the top ten in the Blockchain and Biotechnology cross-country comparison. This is a powerful indication that the country is well positioned to benefit from the ongoing technological revolution.

The online community in Finland presents strong responsiveness to major events, suggesting a good level of knowledge in relation to recent developments and caveats towards the successful adoption of new technologies. The education system of the country presents the main focus area for improvement. Despite having a high-quality education system, Finland faces a teacher shortage like many other countries in the sample that in the coming years may adversely affect the readiness of its labour force.

5 GERMANY

GDP per capita
$44,470 2017

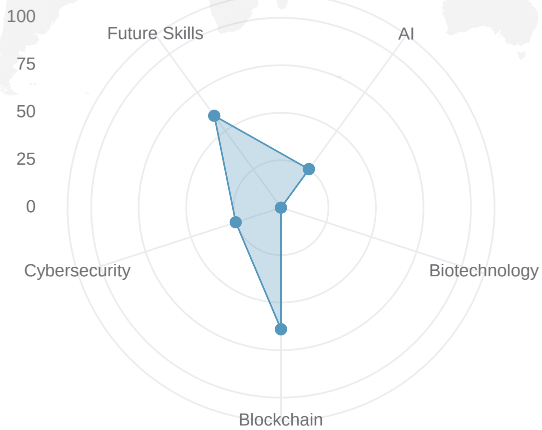
HDI
0.936 2017

GKI (rank)
15 2017

1739 unique authors per million Internet users

The five Future Field Readiness Indices for Germany reveal that the country scores highest in Blockchain and Future Skills. Overall, Germany does not present a balanced picture in terms of readiness for the five fields. Cybersecurity and AI trail the performance of the top fields, with a score around 2.5 times less than for Blockchain. Biotechnology is the weakest field for Germany in terms of online activity.

Figure 49: Future Fields Readiness Indices scores in Germany

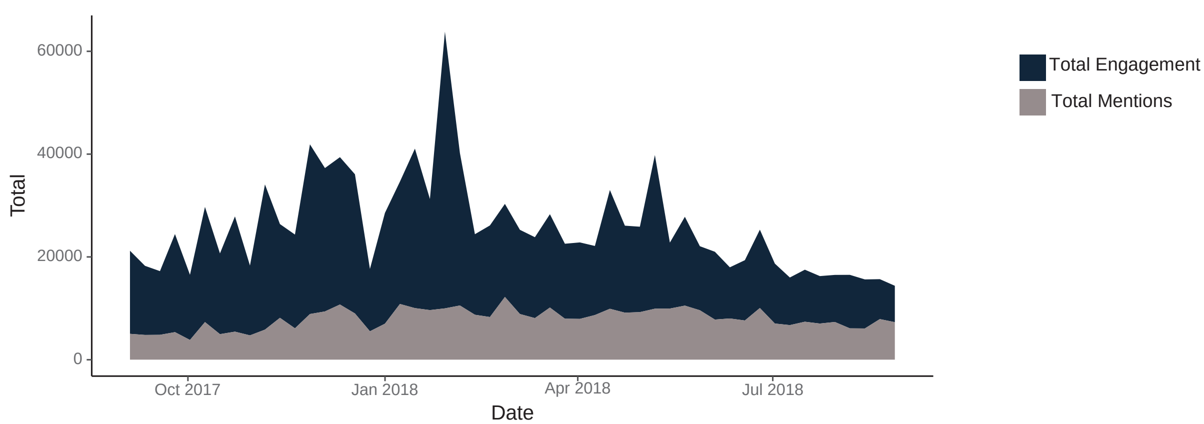


Germany's level of interest in key technologies for the future

The volume of online activity in Germany within the themes of the four technologies displays an average value of 7,202 mentions and 15,812 instances of engagement per week, with respective median values of 7,153 and 14,128. The two series also show an average degree of co-movement (0.44 coefficient of correlation). This suggests a strong importance of major events for online activity.[30]

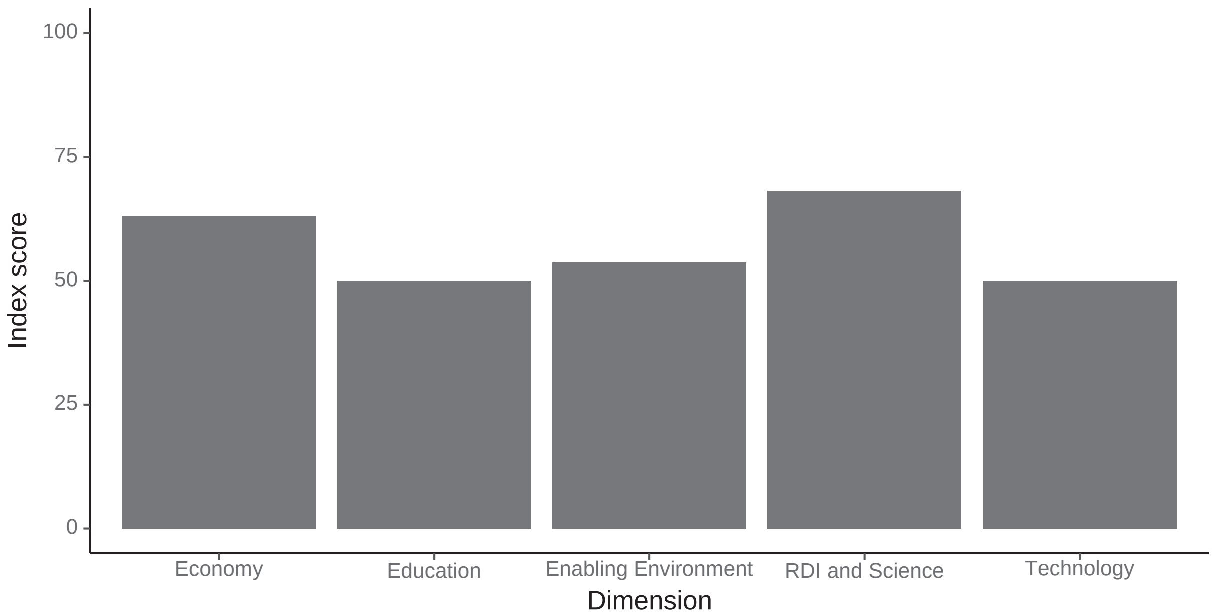
During the period of analysis, one significant peak in engagement stands out (the last week of January/early February). The spike was due to one article of Business Insider Germany, a US financial and business news website with international editions for more than 15 countries. The publication discusses one incident of successful investment in cryptocurrencies.[31] The article received over 25,000 shares on LinkedIn.

Figure 50: Volume of discussions and engagement level associated with the four key technologies for the future in Germany (Sept 2017 - Sept 2018)



The analysis of the GTRI for Germany by knowledge dimension presents a strongly balanced degree of online activity across all five dimensions. The lowest dimensions (Education and Technology) are less than 30 percent below the highest dimension (RDI and Science).

Figure 51: Germany's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

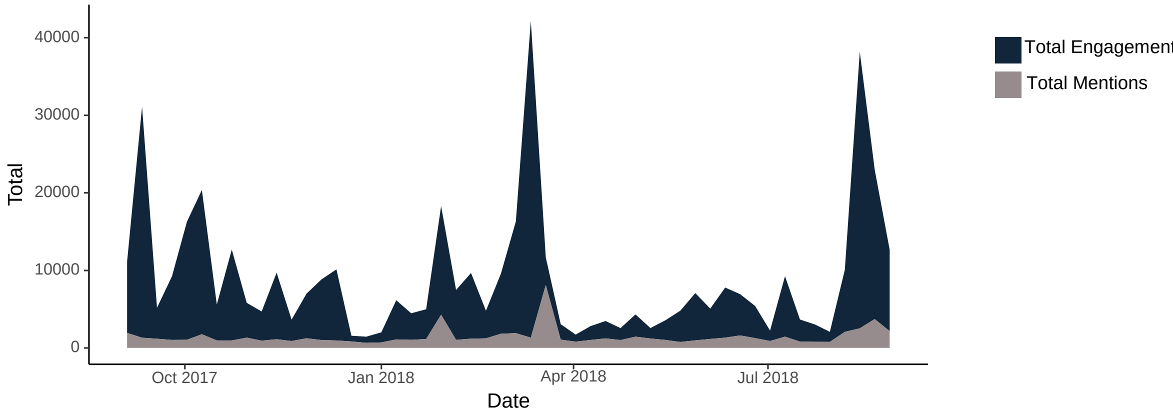


Germany's level of interest in Future skills

The volume of online activity in Germany within Future Skills is significantly lower in comparison to online activity relating to the four technologies. In Germany, online activity in Future Skills presents an average value of 1,425 mentions and 7,484 instances of engagement per week, with respective median values of 1,126 and 4,558. The two series show a low degree of co-movement (0.23 coefficient of correlation), while engagement is 1.5 times more volatile than mentions. Together, these results suggest a significant responsiveness of the online community to influential articles, and to a lesser extent to events in the field.

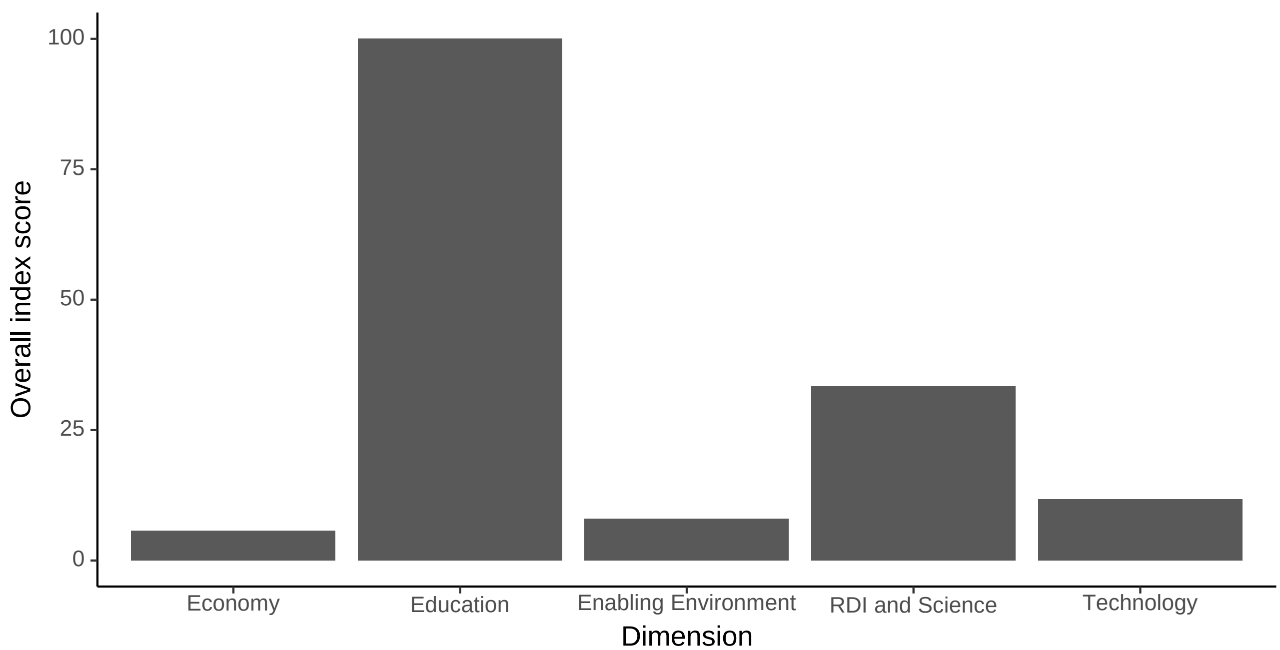
Two of the spikes in online activity relate to teacher shortages in Germany. According to a study by the Bertelsmann Foundation, the primary school teacher shortage may worsen unless a significant number of new teachers are hired.[32] Currently there are an estimated 2,000 unfilled teacher positions in German primary schools; however, the study predicts that, if left unaddressed, there will be a shortage of 35,000 teachers by 2025.

Figure 52: Volume of discussions and engagement level associated with Future Skills in Germany (Sept 2017 - Sept 2018)



Consistent with the results of the engagement and mention analysis, when the Future Skills Readiness Index is segmented into the five dimensions, Education comes out on top with a large margin. The score for the second highest dimension, RDI and Science, is around three times lower than that of Education. This depicts the high amount of attention the education sector is currently receiving (comparatively to the other dimensions in Germany), due mostly to the teacher shortage and the uncertainty of the quality of education in the future as a result.

Figure 53: Germany's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Germany's strengths and areas for improvement

Germany displays an overall good level of readiness, with the country consistently scoring between 9th and 14th in the rankings. This balance in the performance is also present in the within-country analysis, where Germany retains a balanced level of readiness across all knowledge dimensions for the four technologies. Moreover, online activity in the country displays a strong link with major events in the future fields, highlighting that the online community is up to date with current developments and existing bottlenecks that the labour market faces in terms of adapting to technological change.

The same distribution of readiness across the five dimensions of knowledge is not present in Future Skills. The Education dimension receives a considerably high score, however it is driven up by the mentions and engagement around the primary school teacher shortage in Germany which is one of the key areas for improvement for the country. The development of an Education system that displays geographic homogeneity and provides students with the right tools for the development of future skills will be key to achieving a smooth transition into Industry 4.0 mode of production for the workforce of the country.

6 INDIA

GDP per capita
$ 1,940 2017

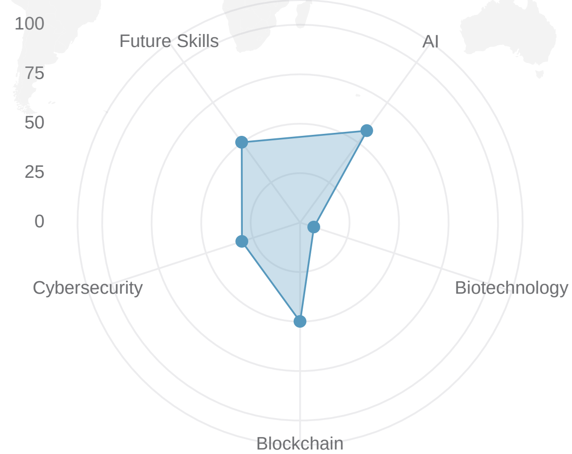
HDI
0.64 2017

GKI (rank)
82 2017

272 unique authors per million Internet users

The five Future Field Readiness Indices for India show that the country scores highest in AI, Future Skills and Blockchain. Overall, India presents a balanced picture in terms of readiness for four out of five dimensions. Biotechnology readiness is comparatively weaker for India. This shows that online discussions appear in similar volumes for four out of five fields, while Biotechnology accounts for a significantly smaller portion of online activity.

Figure 54: Future Fields Readiness Indices scores in India

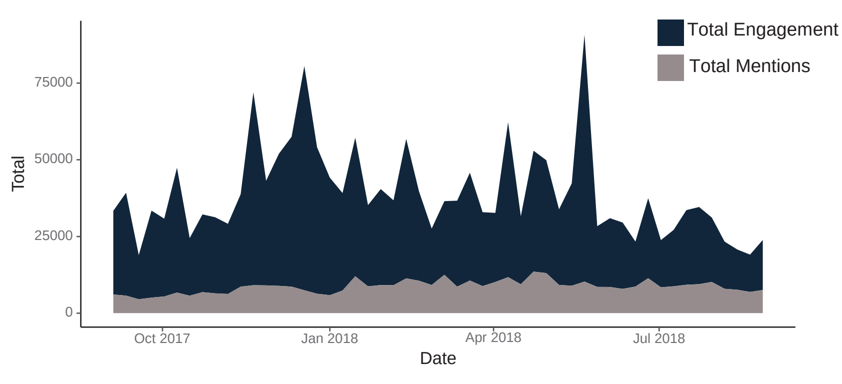


India's level of interest in key technologies for the future

The volume of online activity in India within the themes of the four technologies displays an average value of 7,881 mentions and 26,377 instances of engagement per week, with respective median values of 7,941 and 22,701. The two series also show a low degree of co-movement (0.26 coefficient of correlation), while engagement is twice as volatile as mentions. These results suggest a good degree of responsiveness in the country, pointing that influential articles have a strong effect on online activity.

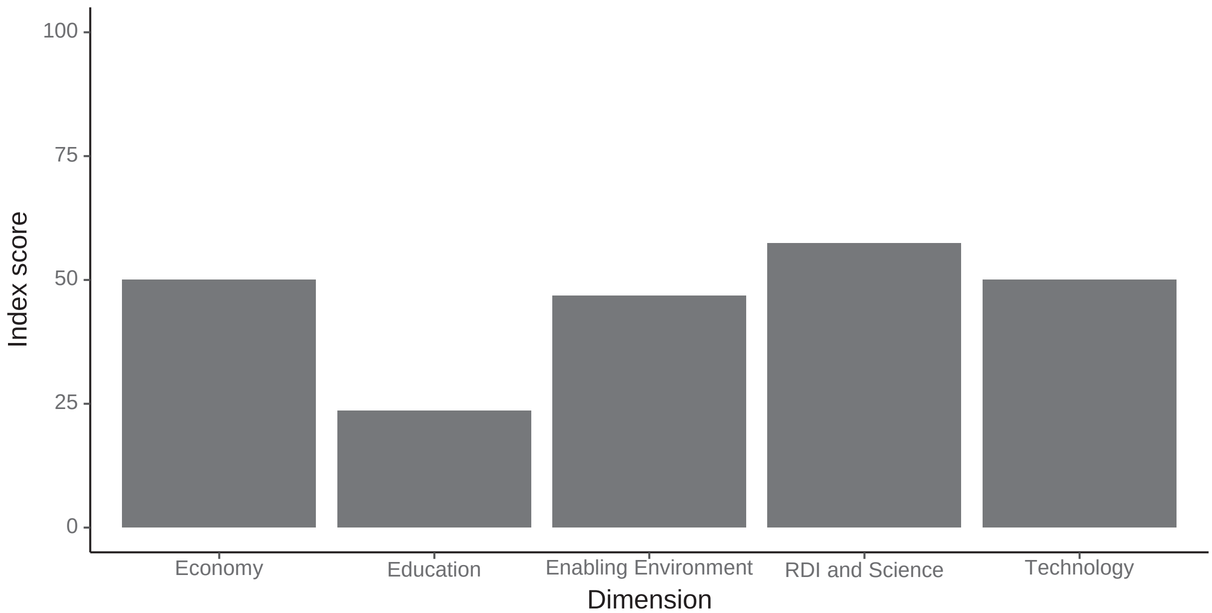
The analysis of the volume of online activity reveals that publications relating to AI drive three out of four spikes in online activity, while Blockchain accounts for the fourth spike. The article with the most engagement in the end-of-November spike is an AI-Education-related article published in India Today, a fortnightly Indian news magazine (and television channel) that publishes in English. The article covers the announcement of a scholarship programme from Google to train 130,000 Indian developers and students.[33] This article received over 50 Twitter shares, over 16,000 Facebook shares, and around 20 comments. Also relating to education, the engagement spike at the end of May appears to be mainly due to one article on The Asian Age's online news site, which explains artificial intelligence and a few important terms such as machine learning, deep learning, training data, etc.[34]

Figure 55: Volume of discussions and engagement level associated with the four key technologies for the future in India (Sept 2017 - Sept 2018)



India's GTRI decomposed into the five knowledge dimensions shows a fairly equal distribution of attention across four out of five knowledge dimensions; RDI and Science, Economy, Technology, and Enabling Environment score within 10 points of each other. The Education dimension, however, performs 2.5 times below RDI and Science, the highest scoring dimension.

Figure 56: India's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



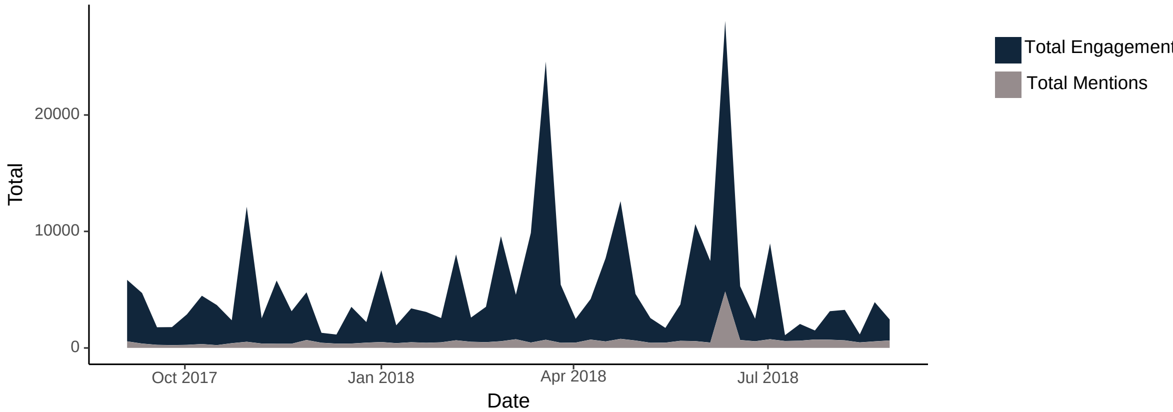
India's level of interest in Future Skills

The volume of online activity in India within Future Skills is significantly lower in comparison to online activity for the four technologies. In India, online activity in Future Skills presents an average value of 580 mentions and 4,515 instances of engagement per week, with respective median values of 482 and 2,934. The two series show a significant degree of co-movement (0.6 coefficient of correlation), pointing to the importance of major events in driving the interest of the online community.

The graph of Future Skills mentions over time in India reveals one major spike in mentions around 11 June 2018. This increase relates to tweets and articles about the success of 26 children in Bihar who passed the competitive Indian Institute of Technology (IIT) entrance exam, thanks to the help and training of the innovative educational programme 'Super 30 Academy' that targets talents from economically vulnerable sections of society.[35]

Mentions on the Super 30 Academy also account for the spike in engagement, with the main tweet receiving over 15,000 likes and 5,000 retweets. The other significant spike in engagement around 21 March 2018 concerns topics related to India's National Council of Educational Research and Training (NCERT). The engaging article details the reactions of students to the Class 12 Maths exam.[36]

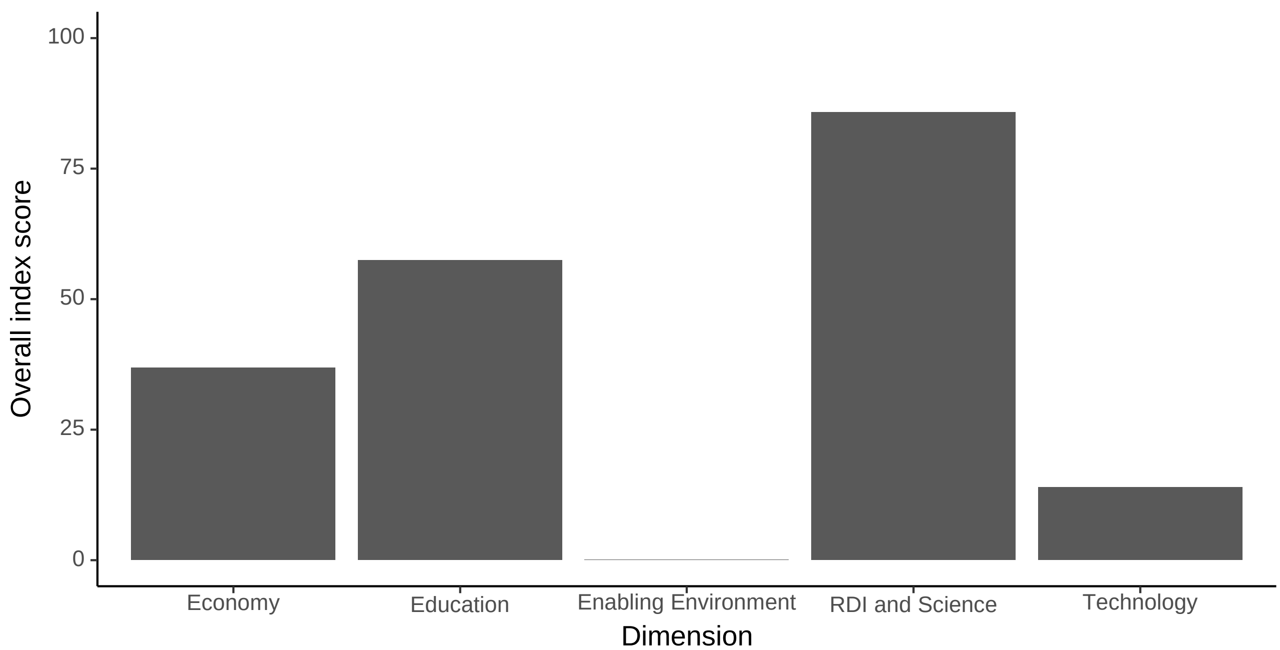
Figure 57: Volume of discussions and engagement level associated with Future Skills in India (Sept 2017 - Sept 2018)



The analysis of the Future Skills Readiness Index by knowledge dimension reveals a significant level of variation in terms of online activity. RDI and Science rank first, Education second and Economy third. Technology and Enabling Environment perform significantly less strongly, ranking fourth and fifth.

These results suggest a current emphasis on the research and innovation of the education sector, learning methodologies and upskilling techniques. Indian Internet users appear to spend less time discussing online the potential impact of government measures and/or legislation in support of Future Skills growth, such as upskilling strategies.

Figure 58: India's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



India's strengths and areas for improvement

India is a solid performer in terms of overall readiness. The country occupies positions in the middle of the rankings for the five future fields online activity. Looking at each of the Future Field Readiness indices separately, we observe that the performance of India in AI is considerably stronger than its performance in the other fields. That is to say, while there is an internal balance in terms of online activity distribution across four out of five future fields, the country performs significantly better in terms of AI readiness.

Internet coverage and inclusion of the Internet-using population in the discussion on future fields is the principal caveat that India will need to address on the way to achieving a smooth labour market transition to the new environment of work that the Fourth Industrial Revolution ushers in. India has the smallest share of unique authors in the total Internet-using population after Tanzania and Morocco, underscoring that the information dissemination network is still at an infant stage.

7 JAPAN

GDP per capita
$38,428 2017

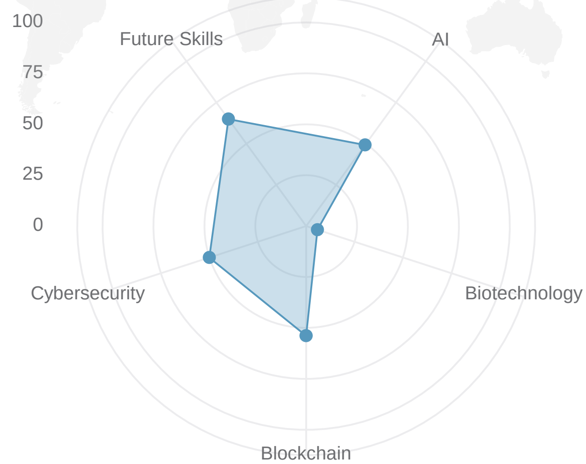
HDI
0.909 2017

GKI (rank)
14 2017

1516
unique authors per million Internet users

The five Future Field Readiness Indices for Japan show that the country scores highest in Blockchain and Cybersecurity. Overall, Japan presents a balanced picture in terms of readiness for four out of five fields. Biotechnology readiness appears to be comparatively weaker for Japan. This shows that online discussions appear in similar volumes for four out of five fields, while Biotechnology accounts for a significantly smaller portion of online activity.

Figure 59: Future Fields Readiness Indices scores in Japan

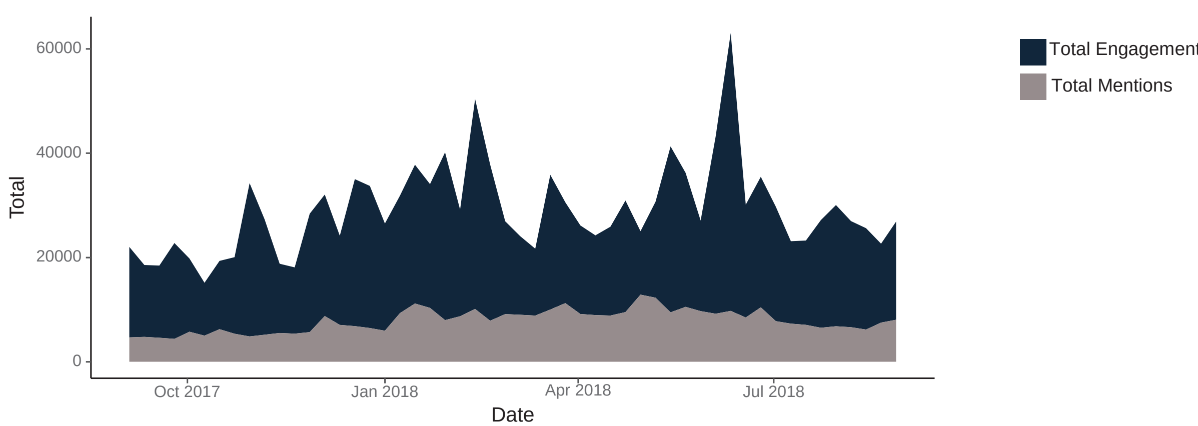


Japan's level of interest in key technologies for the future

The volume of online activity in Japan within the themes of the four technologies displays an average value of 8,266 mentions and 21,894 instances of engagement per week, with respective median values of 8,204 and 20,722. The two series also show a low degree of co-movement (0.37 coefficient of correlation). This suggests that events are not necessarily the principal driver of online activity; influential publications also play an important role.

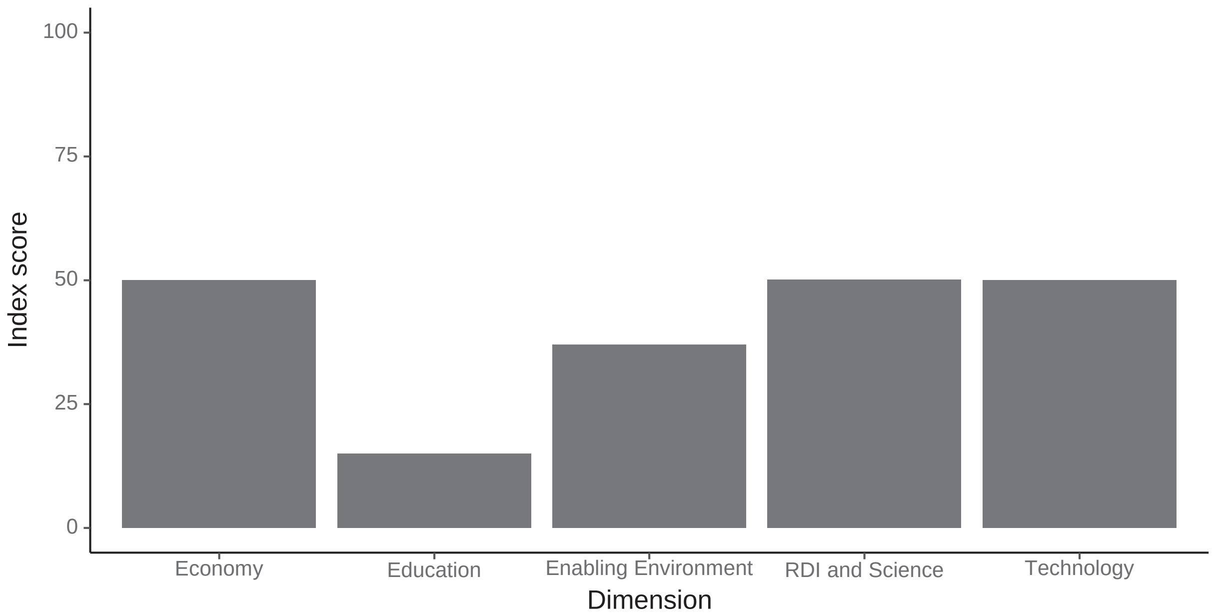
Analysing engagement, the highest spike is triggered due to the engagement around one tweet, which falls under Blockchain-Economy/Enabling Environment.[37] The tweet is a satirical piece that shows how complex the duo innovation-regulation can be. At the time of analysis, the tweet had earned over 22,000 likes and over 14,000 retweets.

Figure 60: Volume of discussions and engagement level associated with the four key technologies for the future in Japan (Sept 2017 - Sept 2018)



Analysing Japan's GTRI score by knowledge dimension reveals that for Japan, online activity spreads equally across four out of five dimensions. Japan is publishing engaging mentions in the fields of Economy, RDI and Science, and Technology. Topics such as AI courses, Cybersecurity trainings and Blockchain degrees appear to be less engaging.

Figure 61: Japan's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



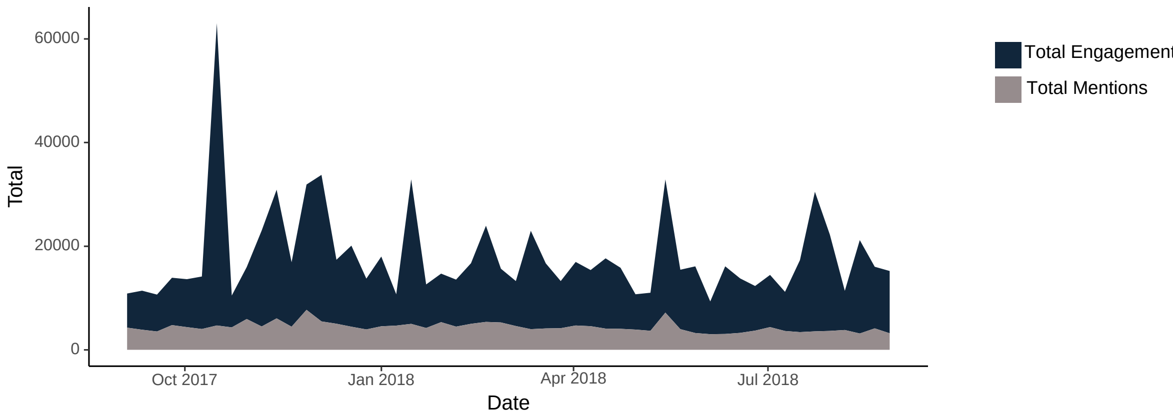
Japan's level of interest in Future Skills

The volume of online activity in Japan within Future Skills is lower in comparison to online activity related to the four technologies. In Japan, online activity in Future Skills presents an average value of 4,737 mentions and 14,345 instances of engagement per week, with respective median values of 4,511 and 12,118. The two series show an average degree of co-movement (0.42 coefficient of correlation), pointing to the importance of events in driving online activity. Engagement is twice as volatile as mentions highlighting a high degree of responsiveness to publications.

Japan's Future Skills mentions over time show two main spikes for the weeks of 27 November 2017 and 14 May 2018. Teacher shortage has a strong presence in online discussion, and both spikes relate to this. The spike in November was driven by tweets on elementary school teacher shortages.[38] In May, we observe a rise in mentions due to a statement by the Hiroshima board of education, which said that teacher recruitment cannot keep up with teacher retirement.[39]

Overall, the most engaging article relates to Education, but focuses on the quality of teaching staff. The article discusses an incident where a young Japanese boy in Fukui died by suicide after being repeatedly harshly scolded by his teachers. The article also takes issue with the school environment in Japan, as other teachers, administrators and even fellow students had heard the teacher loudly, relentlessly reprimand the boy, but failed to take any steps to address the issue.[40]

Figure 62: Volume of discussions and engagement level associated with Future Skills in Japan (Sept 2017 - Sept 2018)



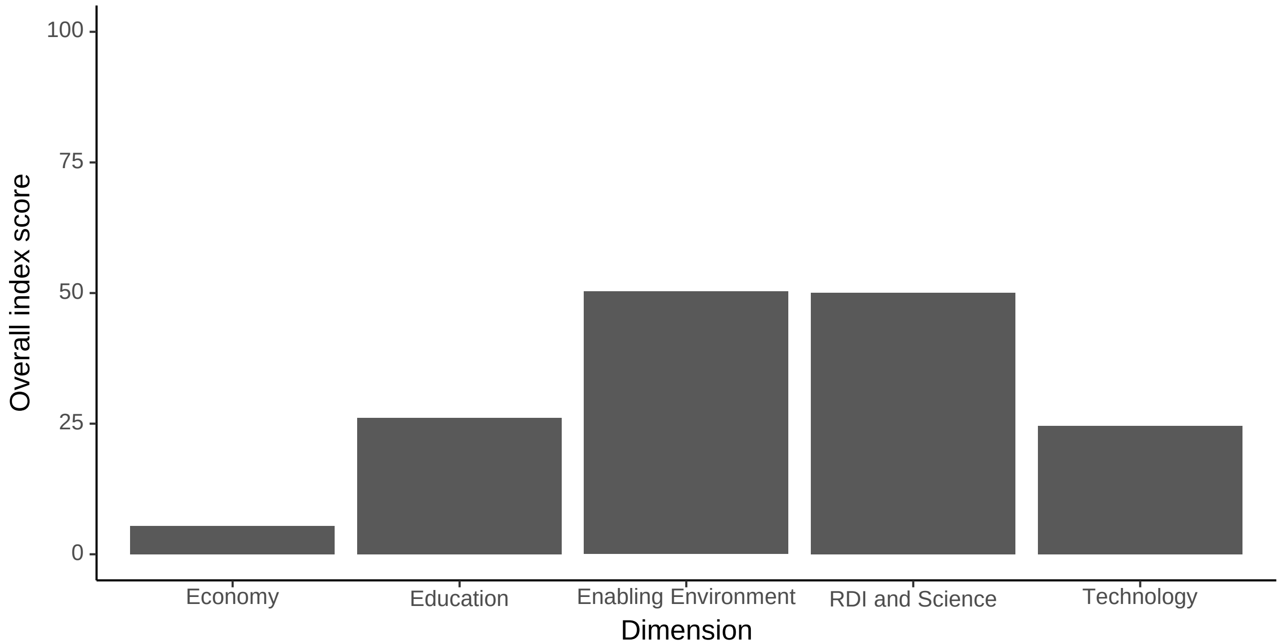
The analysis of the Future Skills Readiness Index by knowledge dimensions for Japan shows that RDI and Science and Enabling Environment are the highest scoring dimensions for Japan. While Education had large spikes in volume and articles with the most engagements, Figure 63 reveals that these were just temporary upsurges. RDI and Science and Enabling Environment have a more lasting volume of online activity across time.

Looking into the data, these two dimensions are high scoring for different reasons in Japan. Enabling Environment produces the least amount of mentions among all the Future Skills dimensions. However, it is strongest in terms of engagement. Enabling Environment posts in Japan, while lower in volume, have an engagement rate of over eight engagements per post. On the other hand, RDI and Science is high scoring due to its volume of mentions. In Japan, for the period analysed, just under 200,000 results fall under the Future Skills RDI and Science dimension. In comparison, the other four dimensions when combined only have around 51,200 results in total.

It appears thus that Japan is currently creating a lot of content around Future Skills - RDI and Science and, while the posts about Enabling Environment are not as high in number, the articles are strongly impactful.

Economy is the weakest dimension for Japan, scoring nine times less than the strongest dimensions. This comparatively low volume/impact of mentions may point to a low readiness surrounding Future Skills funding and investments in Japan.

Figure 63: Japan's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Japan's strengths and areas for improvement

Japan is an overall strong performer, scoring consistently well across all the fields of the GTRI as well as in terms of Future Skills. One of the key strengths of the country is its international standing as a host of major events in the area of future fields. Such events stand out as good practice in raising awareness among the public.

The within-country analysis reveals that Japan displays a balanced degree of readiness across all five future fields, suggesting a holistic approach in raising readiness. This is beneficial as it better accommodates technology uptake through cross-field synergies. Compared to the other four future fields, the online community in the country does not appear as interested in Biotechnology, indicating a weaker readiness level. However, the lower salience of Biotechnology is in line with both the overall results outlined in section 1.2 and the Gartner hype cycle where major Biotechnology applications are positioned far away from the peak of the cycle, which the literature associates with a greater degree of public interest.

For Future Skills, Japan has high scores for both the RDI and Science and Enabling Environment dimensions. Japan appears to be producing mainly RDI and Science content in particular- with RDI and Science accounting for more than 75 percent of all Future Skills mentions in Japan.

The Education dimension for Future Skills is behind the significant spikes in mentions and volume, however the volume increases are short-lived and thus in the long-term Education scores on the lower end. It appears that, in Japan, readiness and attention around the education system are much more sporadic, seemingly triggered by traditional media coverage and amplified via Twitter. The sporadic character of the online activity surrounding education is alarming. The articles behind the spikes suggest that there is room for improvement in the education system of the country, but the lack of consistency in online activity suggests that there is little pressure for change.

8 JORDAN

GDP per capita
$ 4,130
2017

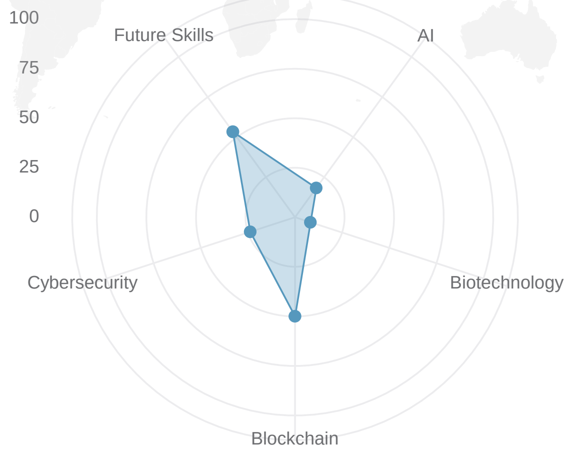
HDI
0.735
2017

GKI (rank)
62
2017

560
unique authors per million Internet users

The Future Field Readiness Indices show similar scores for Future Skills and Blockchain in Jordan. The country performs weaker in terms of Cybersecurity, AI and Biotechnology. These results reflect that online discussions appear in varying volumes across the five fields, with a stronger interest by the online community in Blockchain and Future Skills.

Figure 64: Future Fields Readiness Indices scores in Jordan



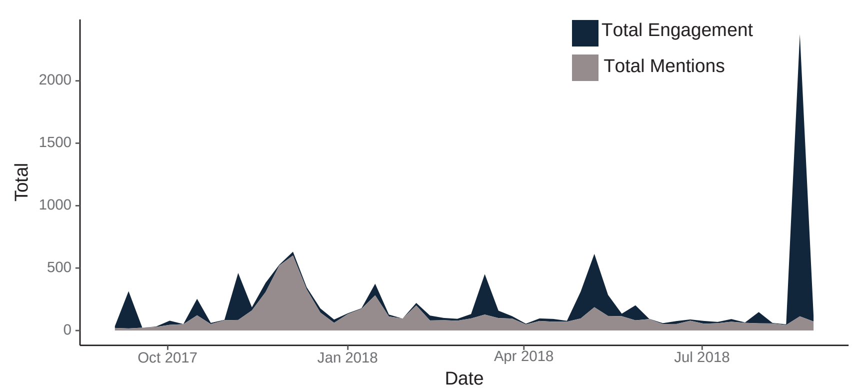
Jordan's level of interest in key technologies for the future

The volume of online activity in Jordan within the themes of the four technologies displays an average value of 101 mentions and 75 instances of engagement per week, with respective median values of 72 and 20. Jordan is the only country in our sample, where the average value of mentions exceeds that of engagement. This result may suggest a low level of general public interest in the field or a general unease with engaging in public discussion on the topic. Suggestive evidence shows that there is a strong interest in Jordan around future fields, but Internet users rarely engage with technical publications through commenting or sharing. Instead, interest of the online community is mainly limited to a private level – raising awareness through reading local or international publications. The two series also show a zero degree of co-movement. This suggests that events have little impact on online activity. Instead, the occasional appearance of influential publications better account for jumps in the level of engagement.

Online activity reaches its peak level between end of November and mid-December 2017, with Blockchain – cryptocurrency price – being the main locus of interest.

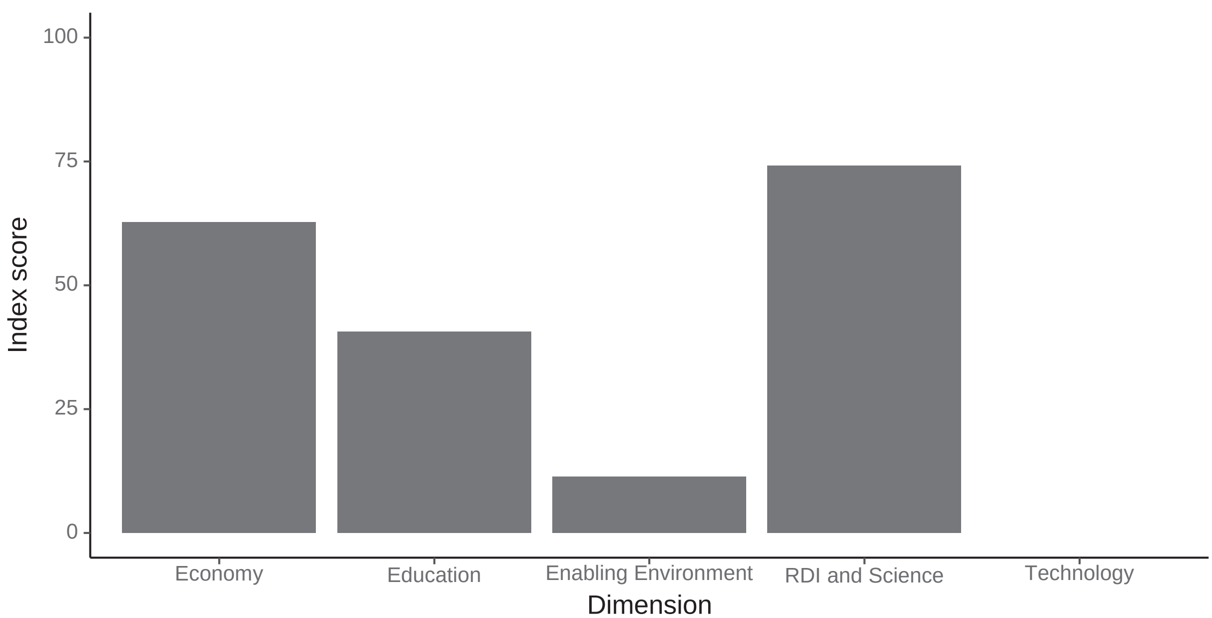
Interestingly, while mentions spike at this time, engagement does not rise, as can be seen in Figure 65. The one major peak in engagement occurs at the end of August in response to articles announcing that the Jordanian army is seeking to recruit graduates in Cybersecurity and IT.[41]

Figure 65: Volume of discussions and engagement level associated with the four key technologies for the future in Jordan (Sept 2017 - Sept 2018)



As seen in Figure 66, Jordan's GTRI broken down by knowledge dimension reveals disparities amongst the five knowledge dimensions. Jordan produces the highest score for RDI and Science. The RDI and Science dimension has both a rather high amount of results (for Jordan) and the highest engagement rate of all the dimensions for the GTRI. On the other hand, the supporting Technology dimension, with a score of zero, suggests that there is low readiness around technological resources such as data centres, cyber physical systems, cloud computing, etc.

Figure 66: Jordan's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



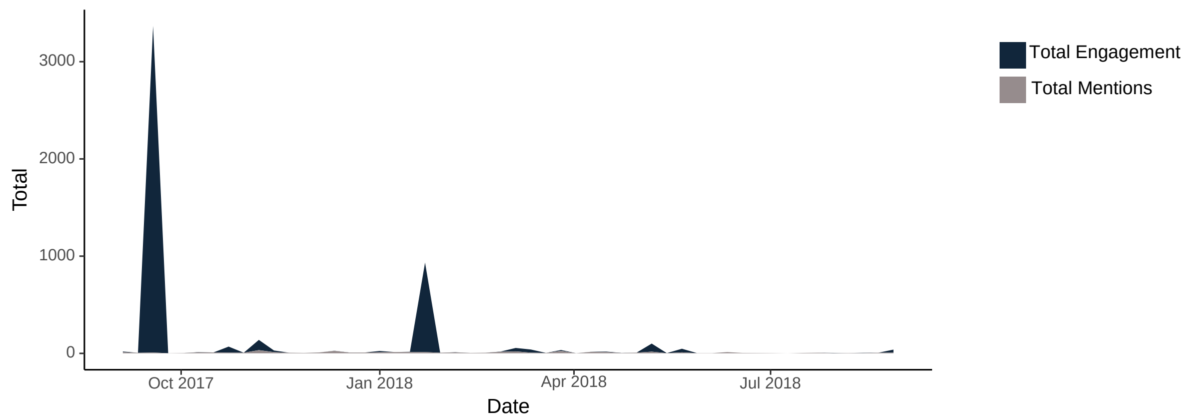
Jordan's level of interest in Future Skills

The volume of online activity in Jordan within Future Skills is lower in comparison to online activity relating to the four technologies. In Jordan, online activity in Future Skills presents an average value of eight mentions and 91 instances of engagement per week, with respective median values of seven and zero. This result supports the hypothesis of limited interest in Future Skills. The two series show a zero degree of co-movement, while engagement is six times as volatile as mentions. These results portray an online community that engages with published content on a sporadic basis. A small number of influential articles seems to drive online activity.

The first and largest spike was in reaction to one article posted by the Jordan Times that discussed the possibility for Syrian children without documents to join schools and highlighted the opening of 200 schools providing catch-up programmes to young refugees who would have missed more than three years of schooling.[42] The article received over 3,000 engagements (shares, likes, retweets and comments).

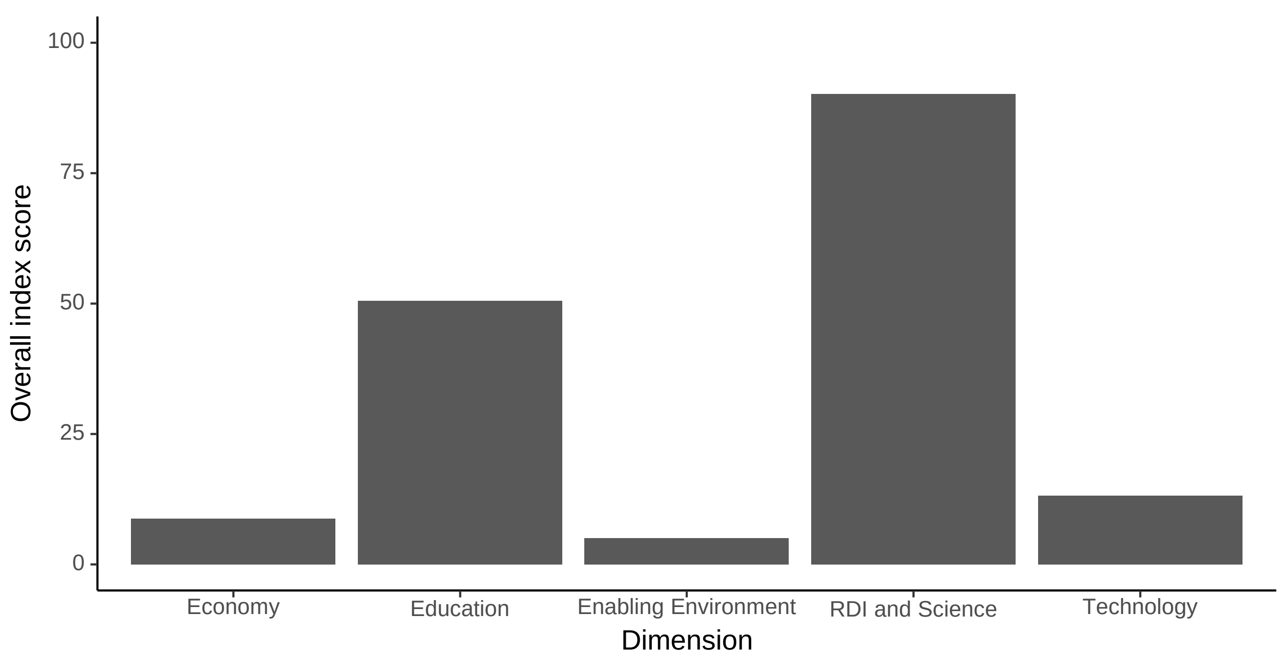
The second smaller peak in engagement is related to three articles regarding the MIT-led incubator, the Refugee Learning Accelerator (RLA) in Amman. The programme aimed at bringing together Arab engineers and developers to develop e-learning solutions for refugees.[43]

Figure 67: Volume of discussions and engagement level associated with Future Skills in Jordan (Sept 2017 - Sept 2018)



For Jordan's Future Skills Readiness Index, RDI and Science is the knowledge dimension with the highest score. RDI and Science is almost 1.8 times higher than the second-place dimension, Education. However, all remaining dimensions are especially weak when compared with the second strongest dimension (Education): performing respectively 3.8 times lower for Technology, 5.8 times lower for Economy and 10 times lower for Enabling Environment. It appears thus that in Jordan, while overall there are low results on Future Skills, the articles and posts that are published online are chiefly about RDI and Science and Education. These dimensions, however, may also be inflated due to the high amount of engagement on 1-2 articles within each dimension, i.e. the articles on the RLA (RDI and Science) and about the Ministry of Education's decision to allow Syrian children to join schools (Education). Excluding these articles, the engagement for these dimensions are rather similar to the other weaker dimensions.

Figure 68: Jordan's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Jordan's strengths and areas for improvement

Jordan performs second to last in the GTRI, while it is an average performer in the Future Skills country comparison. Online activity is not linked to major events in the field, while engagement is strongly sporadic. On the one hand, we convey a note of caution in terms of the country readiness score, as suggestive evidence shows that despite a fair volume of mentions among the society in future fields, and in particular in future technologies, Internet users do not engage with information through liking/sharing/commenting. On the other hand, we note that engagement may have a positive effect on technological uptake by raising awareness through salience and informal networking.

The cities of Russeifa, Amman and Irbid host frequently international conferences and summits on relevant topics, such as Data Analytics, Biotechnology, High Computing and AI.[44] Nevertheless, we observe very little online discussion surrounding the events. This suggests that unlike in countries like Japan where events have strong externalities for the general public and enjoy good press coverage, the technology community in Jordan appears to be relatively insular.

Future Skills is the strongest field for Jordan, both internally and in the country comparison where Jordan is ranked 8th overall. However, a major amount of interest relates to a topic that has little to do with technological uptake, i.e. the school enrolment of Syrian migrant children.

9 MOROCCO

GDP per capita
$ 3,007
2017

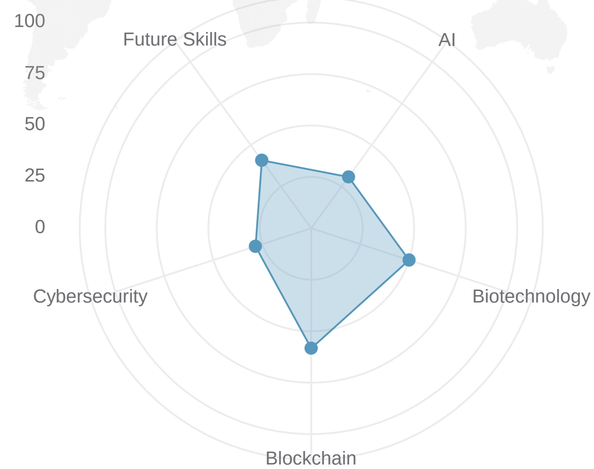
HDI
0.667
2017

GKI (rank)
77
2017

245
unique authors per million Internet users

The five Future Field Readiness Indices for Morocco show that the country scores highest in Blockchain and Biotechnology. Overall, Morocco presents a balanced picture in terms of readiness; Cybersecurity and AI are the two lowest scoring fields for Morocco, yet the respective readiness scores are only twice as small as the score for the leading field, Blockchain. This shows that online discussions appear in relatively similar volumes across the five fields.

Figure 69: Future Fields Readiness Indices scores in Morocco



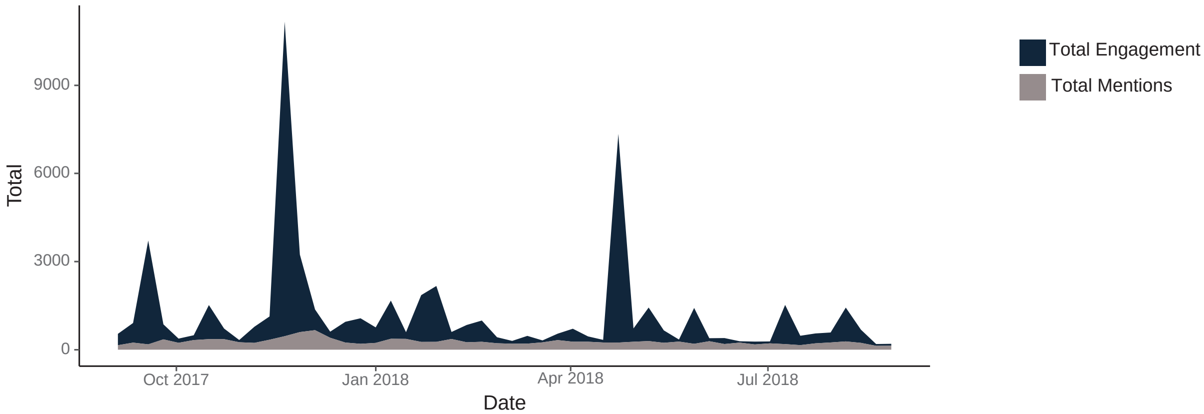
Morocco's level of interest in key technologies for the future

The volume of online activity in Morocco within the themes of the four technologies displays an average value of 253 mentions and 801 instances of engagement per week, with respective median values of 233 and 360. The two series also show a low degree of co-movement (0.37 coefficient of correlation), while engagement is four times as volatile as mentions. These results suggest that major events only drive a small share of online activity, with the appearance of influential articles better accounting for variation in online activity.

We observe one major spike in online activity during the sampled period. In late November, Telquel, a privately-owned French-language Moroccan weekly magazine published an article on the decision of the Moroccan Exchange Office to prohibit Moroccans from using digital currencies.[45]

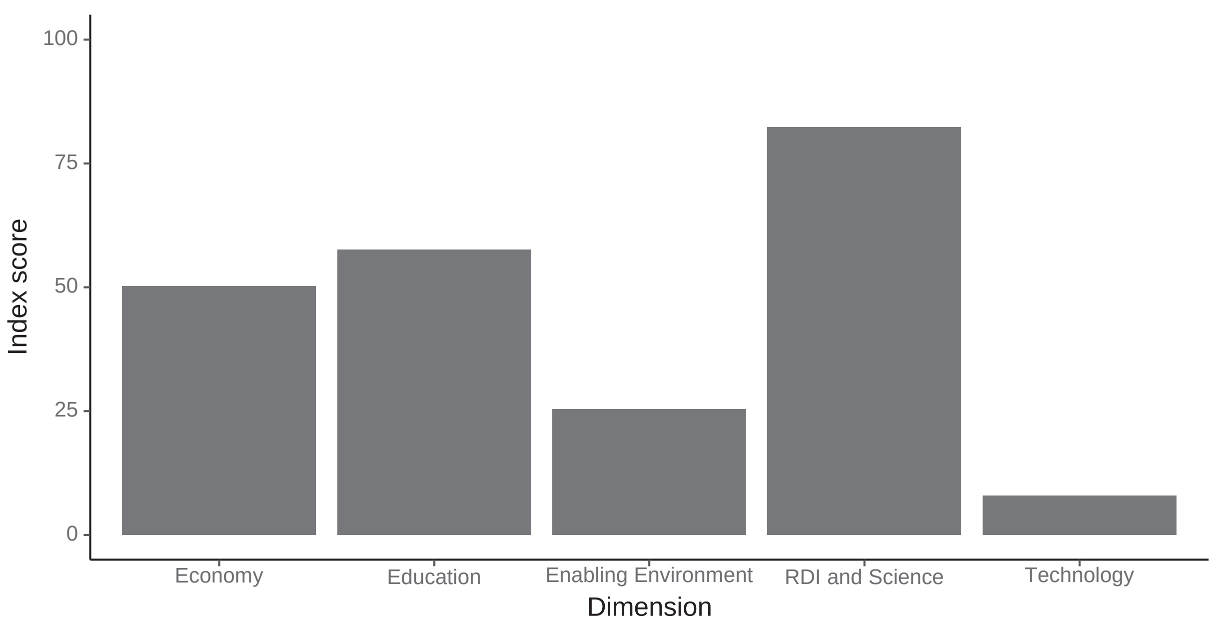
The above article, which received over 3,500 engagements, highlights a significant interest of the online community in a hot topic within the Blockchain–Enabling Environment thematic, the regulation of cryptocurrencies. According to Telquel, the decision of the government to communicate the ban of cryptocurrencies followed a statement by the Morocco Trade and Development Service (MTDS), a provider of network security, data centre and hosting services, which expressed the intention of MTDS to accept bitcoin payments. In its communication, the government highlights that the use of cryptocurrencies, which as a mode of payment is not backed by financial institutions registered with the Bank Al-Maghrib (the central bank of Morocco), is highly risky. The little control that the national monetary authority has over the supply of the currency, together with its frequent association with illegal activities, appear to be the two main reasons behind the ban. Morocco is not the only country that has put a ban in place on the use of cryptocurrencies. Algeria, Brazil, India, Mexico, the United Kingdom and the United States also have some bans on cryptocurrencies.[46]

Figure 70: Volume of discussions and engagement level associated with the four key technologies for the future in Morocco (Sept 2017 - Sept 2018)



The analysis of the Global Technology Readiness Index by knowledge dimension displays a varying degree of readiness for Morocco. RDI and Science is the highest performing dimension. Education and Economy follow closely, while the low scores in terms of Enabling Environment and Technology point to a comparatively low volume of online activity surrounding the two dimensions.

Figure 71: Morocco's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

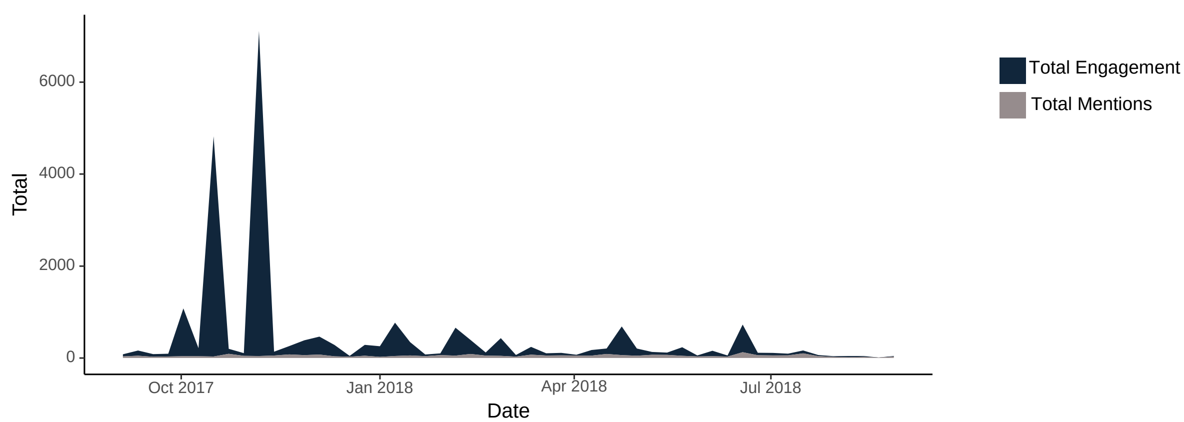


Morocco's level of interest in Future Skills

The volume of online activity in Morocco within Future Skills is lower in comparison to online activity relating to the four technologies. In Morocco, online activity in Future Skills presents an average value of 50 mentions and 391 instances of engagement per week, with respective median values of 48 and 75. The two series show a zero degree of co-movement, pointing to the importance of influential articles in driving activity, rather than major events.

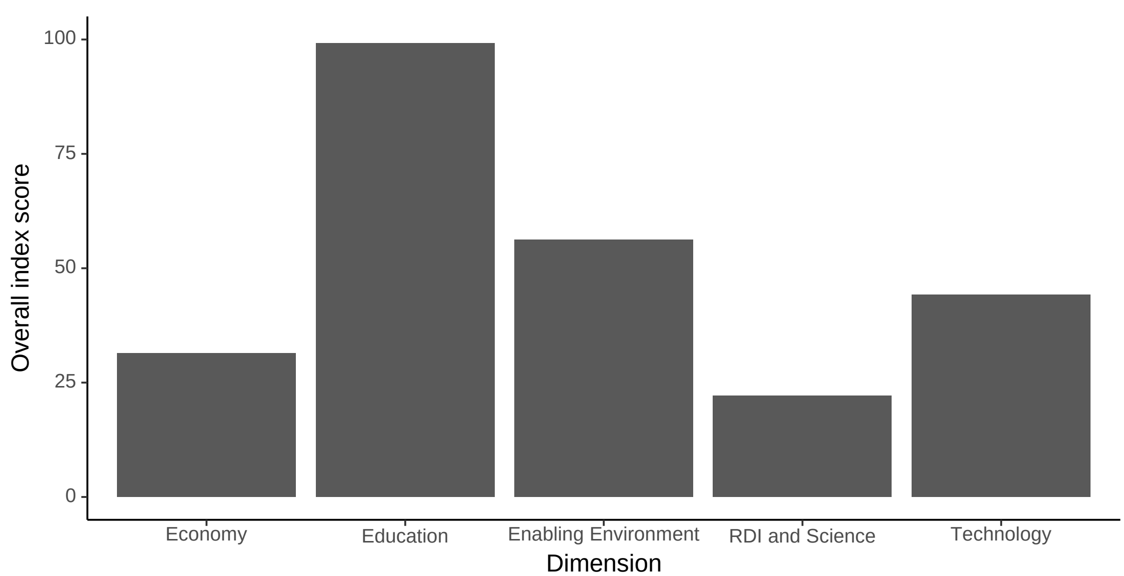
Spikes in engagement activity primarily reflect a rise in shares/likes/comments surrounding the Education dimension. For instance, near the end of October 2017 we observe a jump in online activity due to a Moroccan World News article on the decision of the Moroccan Ministry of Education to ban the niqab in schools.[47] This decision followed the January 2017 decision to ban the manufacturing and selling of burqa for security reasons. The niqab ban in schools reflects a heightened preoccupation of the government on the pedagogic effects of clothing, and in particular on the effect of clothing on socialization among pupils. The article received over 4,000 engagements from online audiences. Morocco is not the only country in the Arab States to have taken such steps; Algeria introduced a similar law in September 2017.[48]

Figure 72: Volume of discussions and engagement level associated with Future Skills in Morocco (Sept 2017 - Sept 2018)



Across the knowledge dimensions for the Future Skills Readiness Index, Education scores the highest. It is the dimension which has the most Future Skills mentions and the highest rate of engagement for Morocco. The remaining four dimensions display readiness scores that are over 40 percent lower compared to Education.

Figure 73: Morocco's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Morocco's strengths and areas for improvement

Morocco is a good performer in terms of overall future technology readiness according to the GTRI, with the country scoring second among Arab States evaluated in this model, behind the United Arab Emirates. Blockchain and Biotechnology are the two fields where the country performs the strongest, ranking in the top ten. In the international comparison for the rest of the fields, the country performs less strongly, with its ranking falling close to that of the bottom five performers.

We observe that major events in the field account for only a small variation in online activity. Engagement spikes for Morocco during the period of analysis occur due to a small number of influential publications over a broad range of topics. The few that stand out reflect either Bitcoin or the education debate and the place of the niqab within the Moroccan society. These two topics are a good signal in terms of engagement for the online community, however their impact in terms of GRTI score is fairly limited. Cryptocurrencies comprise a very small application within the entire spectrum of Blockchain technology. In a similar vein, the niqab ban is a controversial decision, and its effect in terms of socialization and educational achievement remains unclear.

The existence of a critical mass of online discussion across all five future fields is an important strength of the country as the population displays a willingness to learn about the new technologies. Over the coming years, Morocco will need to work towards developing an upskilling momentum. Events and targeted guidance from the government may contribute towards better engaging the online community.

10 NETHERLANDS

GDP per capita
$48,223
2017

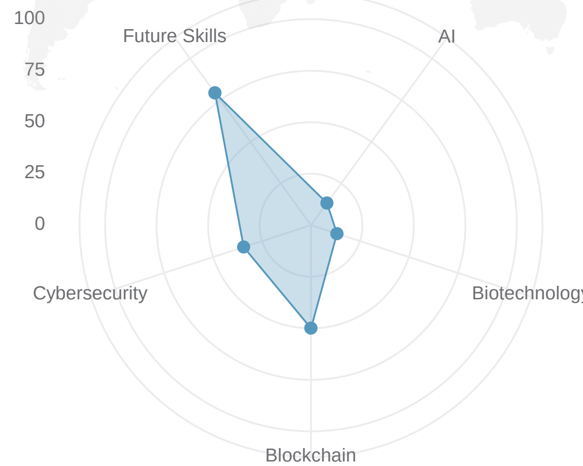
HDI
0.931
2017

GKI (rank)
5
2017

3149
unique authors per million Internet users

The Future Field Readiness Indices for the Netherlands show that in terms of readiness the country is strongest in Future Skills. The Future Skills score is considerably higher than the other fields. This score is driven by the high volume of and high engagement with articles and posts about teacher shortages. Among the key Technologies, Blockchain has the highest score. AI and Biotechnology have comparatively the weakest readiness in the Netherlands, with readiness scores six times lower than for the strongest future field (Future Skills).

Figure 74: Future Fields Readiness Indices scores in the Netherlands



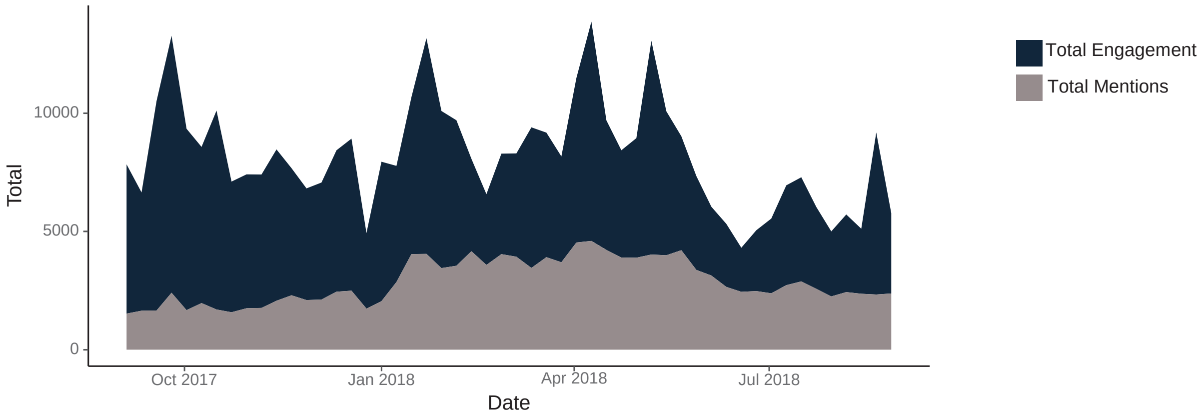
Netherlands' level of interest in key technologies for the future

Looking at the volume of key Technology mentions in the Netherlands, we can see an overall increase over time. In 2018, mention volume increases over 50 percent This increase continues until June when mentions fall slightly. However, the mentions from June – September 2018 are still 40 percent higher than the volume of mentions observed from September – December 2017.

The volume of online activity in the Netherlands within the themes of the four technologies displays an average value of 2,603 mentions and 4,688 instances of engagement per week, with respective median values of 2,267 and 4,607. The two series also show zero co-movement, while both engagement and mentions display a low degree of volatility, underscoring the significance of a largely stable mass of online activity. Results suggest that major events drive a very small portion of online activity, as influential articles seem to be more effective in triggering the interest of the Internet-using community.

For a majority of the engagement spikes in the Netherlands, the high volume is due to many articles with high engagement, as opposed to one article with the majority of total engagement. For example, the week of 25 September 2017 has a total engagement level of over 9,000 engagements. These 9,000 engagements came primarily from four articles with over 400 engagements each, five with over 200 engagements each, and 11 with engagement levels over 100. This result fleshes out the existence of a high spread of activity across online users. The adoption of a more granular approach to raising awareness regarding Future Technologies, and in particular Blockchain – events are organised in multiple cities across the country and have a more local character – has enabled the Netherlands to become an emerging leader in the field of Blockchain. Notably, recent activity includes a series of government-supported Blockchain pilot projects and partnerships with the World Bank, the United Nations and the EU forum.[49]

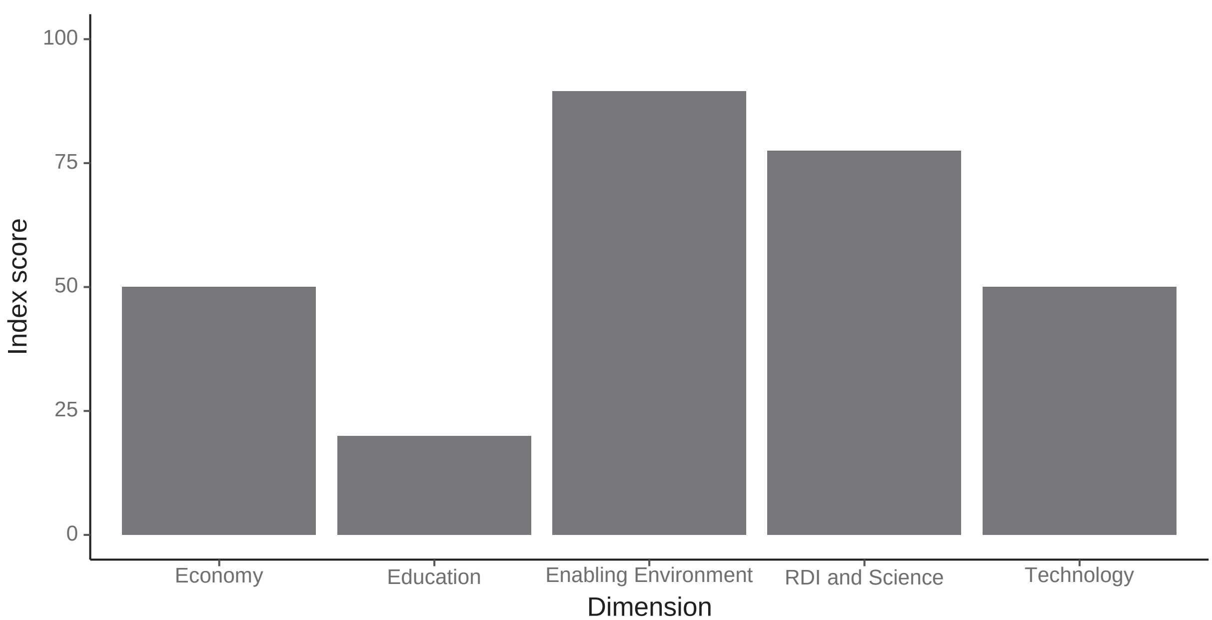
Figure 75: Volume of discussions and engagement level associated with the four key technologies for the future in the Netherlands (Sept 2017 - Sept 2018)



Breaking down the GTRI for Netherlands by knowledge dimension shows increased readiness around Enabling Environment and RDI and Science. In contrast, Education appears to have the most limited readiness in the Netherlands, 4.5 times below Enabling Environment. Economy and Technology fall in the middle with similar scores.

This suggest that in the Netherlands there is a higher level of readiness around the research and regulation of new technologies. Enabling Environment scores particularly high for Cybersecurity and Blockchain. Cybersecurity mentions focus on information sharing and GDPR; Blockchain mentions focus on cryptocurrencies and smart contracts.

Figure 76: Netherlands' Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

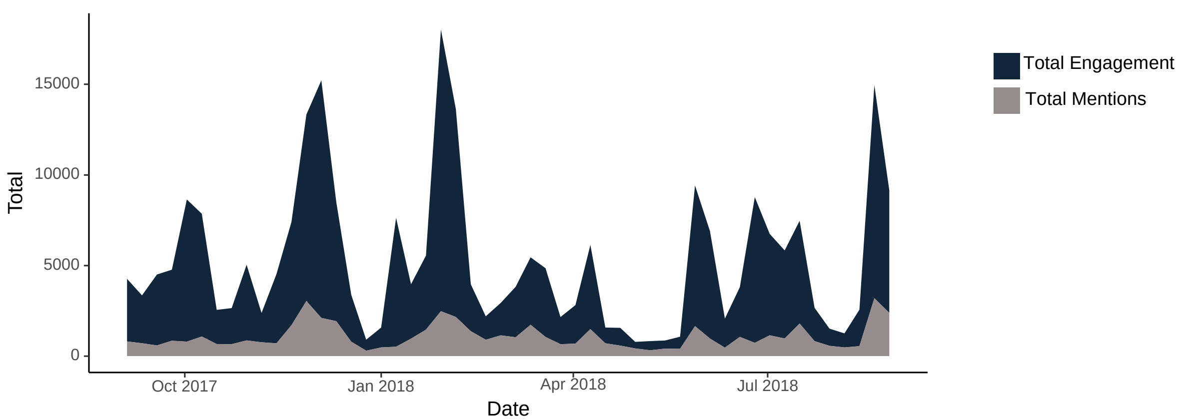


Netherlands' level of interest in Future Skills

The volume of online activity in the Netherlands within Future Skills is lower in comparison to online activity relating to the four technologies. In the Netherlands, online activity in Future Skills presents an average value of 1,074 mentions and 4,136 instances of engagement per week, with respective median values of 833 and 3,228. The two series show a significant degree of co-movement (0.78 coefficient of correlation), pointing to a high importance of events in driving online activity. Mentions present a similar degree of volatility to that of engagement, suggesting here that spikes in online activity for engagement closely follow the ones for mentions.

Around 41,200 mentions of the 55,900 total Future Skills mentions are linked to the teacher shortage in the Netherlands. These mentions are responsible for most of the spikes in mentions and engagement. The mention spike in November 2017 appears to be triggered by an article on NRC which highlighted the fact that in the past ten years the teacher shortage still has not been solved, despite efforts put in place by the *'LeerKracht!'*[50] There was another increase in mentions and engagement in late January/early February brought on by a flu wave, which was reducing the already low number of teachers and which put the teacher shortage again in the spotlight.[51]

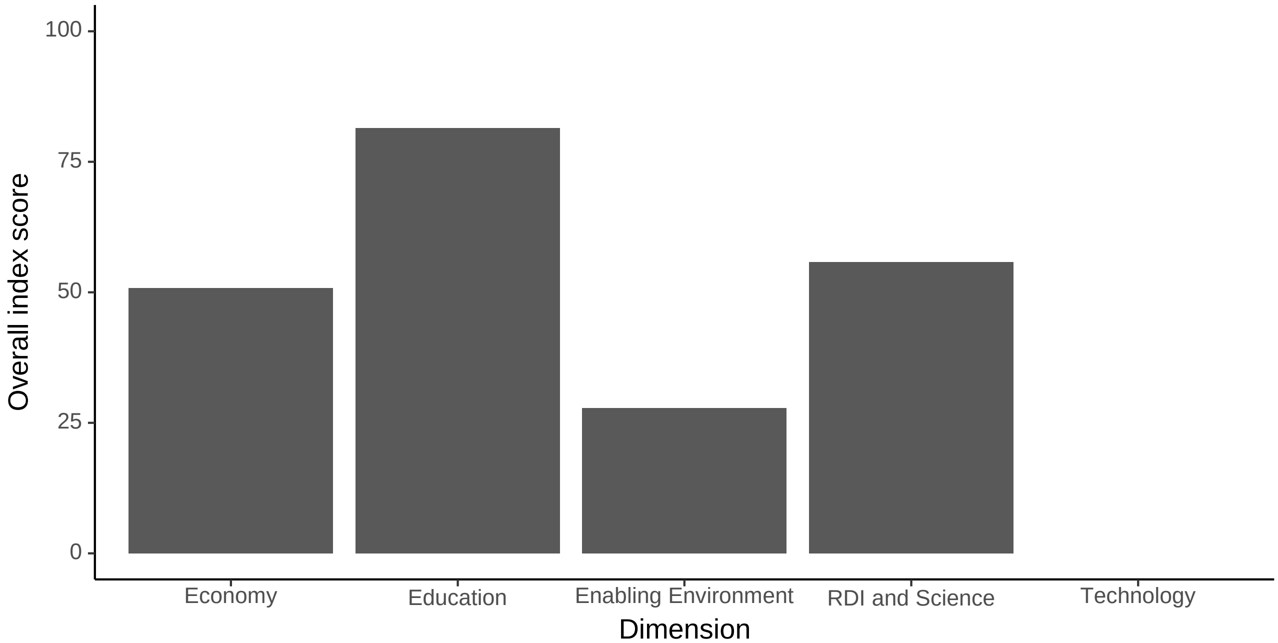
Figure 77: Volume of discussions and engagement level associated with Future Skills in the Netherlands (Sept 2017 - Sept 2018)



The analysis of the Future Skills Readiness Index by knowledge dimension reveals that the Economy and the RDI and Science dimensions also generate a significant volume of online activity – 7,000 results. However, we are unable to identify a single story to account for the majority of the remaining results.

Technology and Enabling Environment are the weakest dimensions in terms of readiness for the country within the Future Skills field.

Figure 78: Netherlands' Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Netherlands' strengths and areas for improvement

The Netherlands ranks consistently around the average country performance across all the technology fields of the GTRI. Its strongest performance is in terms of Future Skills. However, the reported readiness level relates to a teacher shortage in the country; the Netherlands present a weak pupil to teacher ratio. Awareness around a teacher shortage is essential and, for the Netherlands, it appears to be a well-discussed topic (with over 40,000 results over the year analysed). Nevertheless, the teacher deficit still poses a potential obstacle to Netherlands' future knowledge growth. Additionally, in contrast to the readiness around Future Skills Education, the Education dimension for the GTRI appears to have the weakest readiness in the Netherlands. Therefore, Education appears to be an important dimension of improvement for the Netherlands.

Interesting to note is the granular approach the country uses to raise awareness regarding Future Technologies, and Blockchain in particular. With events being organized across the whole territory, the Netherlands has managed to take on board quite a large share of his Internet users in Blockchain discussions.

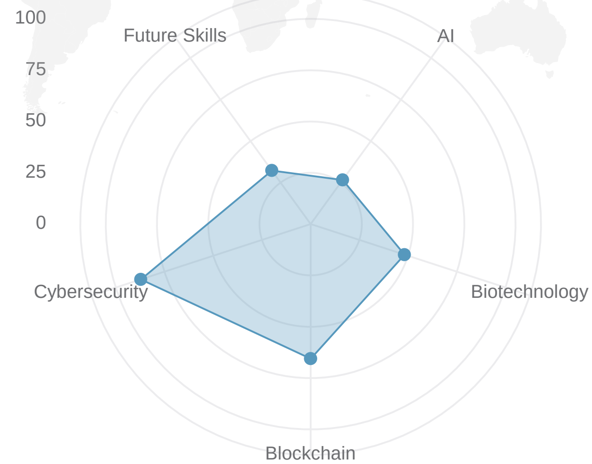
Lack of another distinct topic emerging from the online activity of the country hinders us in proceeding with further inferences on strengths and weaknesses. Associated literature highlights that the Netherlands performs well in terms of business sophistication, knowledge absorption, innovation linkages and research collaboration between universities and the industry.

11 RWANDA

GDP per capita $ 748 2017 | HDI 0.524 2017 | GKI (rank) 93 2017 | 352 unique authors per million Internet users

The Future Field Readiness spider graph for Rwanda presents a relatively balanced degree of readiness across the five fields. Rwanda's readiness appears to be highest for Cybersecurity. Readiness around Blockchain and Biotechnology follows shortly behind. The lowest readiness appears to be around AI and Future Skills, with minimal mentions and engagement for both fields, around three times lower than Cybersecurity, the strongest field.

Figure 79: Future Fields Readiness Indices scores in Rwanda



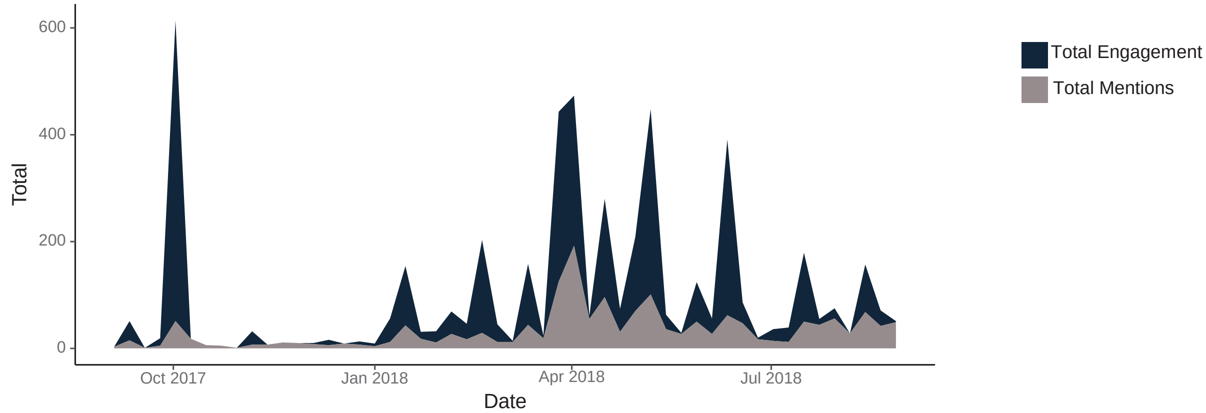
Rwanda's level of interest in key technologies for the future

The volume of online activity in Rwanda within the thematic of the four technologies displays an average value of 28 mentions and 46 instances of engagement per week, with respective median values of 16 and 18. The two series also show a significant degree of co-movement (0.78 coefficient of correlation). This suggests that major events account for the majority of spikes in online activity. This high degree of correlation is in line with our hypothesis of a homogeneous community of Internet users in terms of socio-economic characteristics in Rwanda. As we stress in the limitations outlined in section 3.1, access to the Internet is limited in Rwanda to a small portion of the population that is likely to be wealthier. Individuals in this group also often occupy a post in a multinational firm or work for the government, as our analysis of mentions and engagement suggests. We expect that this similarity in terms of socio-economic background also suggests a high degree of similarity in terms of interests. Thus, high correlation between mentions and engagement will be the result of not only events driving the attention of the online community, but also a consequence of the online community sharing similar interests and engaging with similar publications irrespective of the content, event or influential article.

The first spike in engagement in the beginning of October relates to an article on The New Times about the first private Cybersecurity firm to enter the Rwandan market, Cyber-Tech.[52] Total engagement breaks down to 28 Twitter shares, 60 LinkedIn shares and 160 Facebook shares.

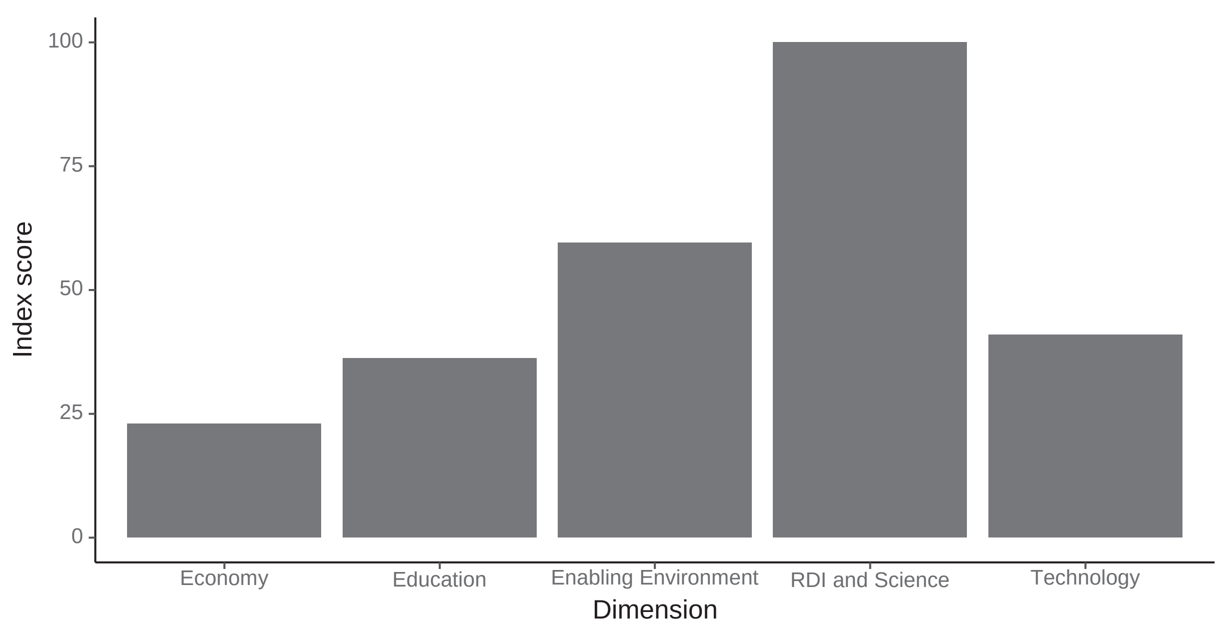
Another large spike in engagement in the beginning of May is due in part to tweets around the Transform Africa Summit 2018 in Kigali and more particularly about the Blockchain hub within the summit. Additionally, engagement was also high this week due to a tweet by the University of Rwanda about collaborating with L.E.A.F Pharmaceuticals to make Rwanda a hub for Biotechnology Research and Development.[53] At the time of writing, the tweet had earned 71 likes and 24 retweets.

Figure 80: Volume of discussions and engagement level associated with the four key technologies for the future in Rwanda (Sept 2017 - Sept 2018)



Based on the analysis of the mentions and engagement for the GTRI in Rwanda, it is not surprising that RDI and Science comes out on top among the knowledge dimensions. RDI and Science has the highest number of mentions and highest engagement rate in Rwanda for the key Technologies (AI, Biotechnology, Blockchain and Cybersecurity). Meanwhile the other dimensions appear to be much more limited in readiness in Rwanda, especially the Economy dimension which is 4.4 times lower than RDI and Science. These results suggest that Rwanda is currently more focused on (and more interested in) sharing information on research, development and innovation taking place within centres, hubs, start-ups, etc.

Figure 81: Rwanda's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



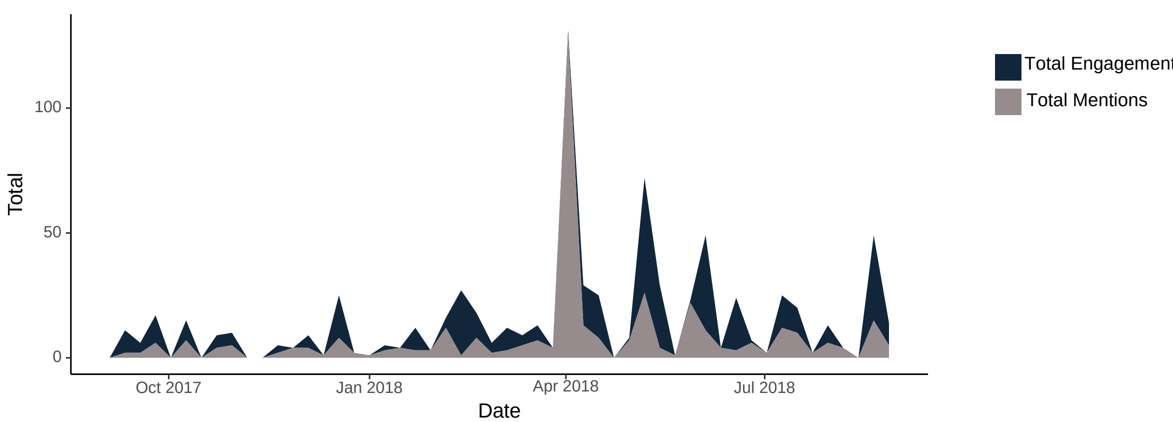
Rwanda's level of interest in Future Skills

The volume of online activity in Rwanda within Future Skills is significantly lower in comparison to online activity related to the four technologies. In Rwanda, online activity in Future Skills presents an average value of five mentions and six instances of engagement per week, with respective median values of four and three.

Rwanda's Future Skills mentions over time remain rather low and stable throughout the beginning half of the period analysed (September 2017 – March 2018). However, in April, we see one comparatively large spike in mentions (46 mentions in one week). Important to note however, is that engagement does not rise with it. After this point, mentions and engagement increase slightly and become a bit more erratic. The large spike observed in the beginning of April is due to promotion of the Transform Africa Summit, which was held 7–10 May in Kigali and which featured talks and sessions on Future Skills-related topics such as digital skills and entrepreneurship.

The one spike in engagement in the beginning of May is linked to a tweet from the New Times (Rwanda) account on the Spring Meeting of the Broadband Commission that focused on 5G, Digital Skills and how to boost broadband in Africa.[54]

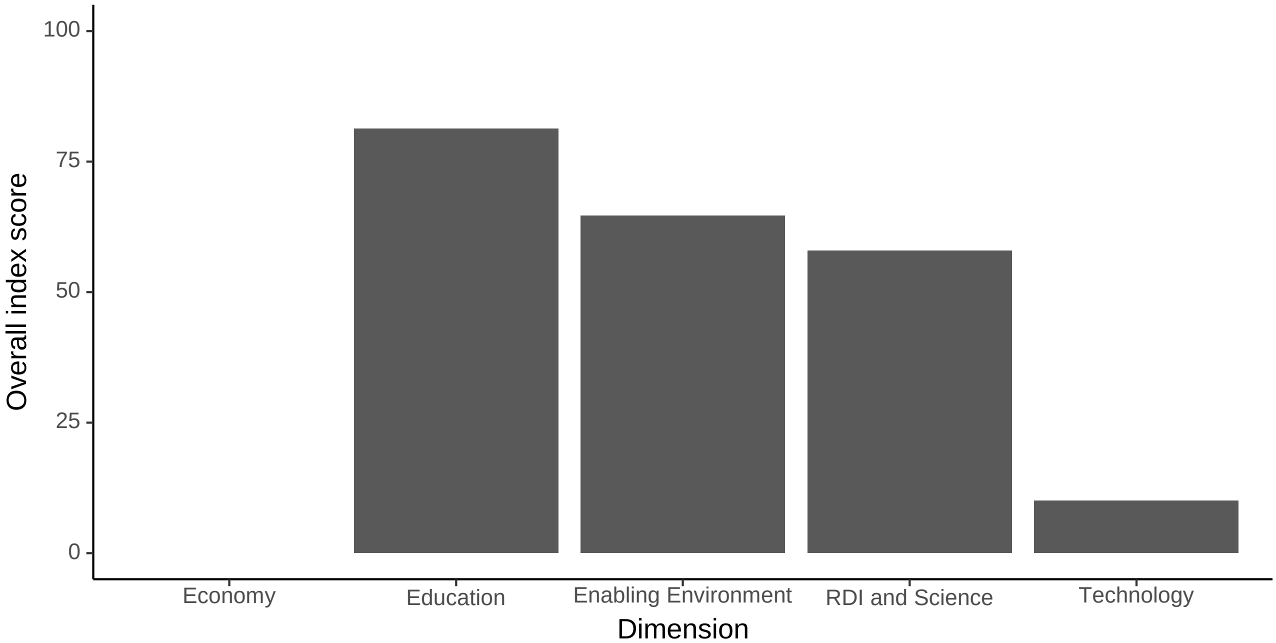
Figure 82: Volume of discussions and engagement level associated with Future Skills in Rwanda (Sept 2017 - Sept 2018)



Looking at Rwanda's Future Skills Readiness by knowledge dimension, Education received the highest score. Following Education, Enabling Environment performs below, similarly to RDI and Science. Technology is the second weakest score, eight times below Education, and Economy was last with a score of zero.

These results suggest that of all the dimensions for Future Skills, Rwanda appears to have the most readiness around the Education dimension, both in terms of the education system quality (student achievement, teacher satisfaction, etc.) and course offerings (trainings, e-learnings, etc.). However, Enabling Environment and RDI and Science are not far off and may potentially have a similar level of readiness in Rwanda. On the other hand, the Technology and Economy dimensions appear to attract much less interest in Rwanda.

Figure 83: Rwanda's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Rwanda's strengths and areas for improvement

Rwanda is not a strong performer in terms of future readiness, ranking between 14th and 20th in the future fields. Technological adoption is at an infant stage. In addition, despite recent improvements in access and affordability, Internet use remains limited to a small fraction of the population.[55] Average online activity is low for both future technologies and future skills. Even though peaks in engagement correlate with peaks in mentions, it is difficult to say that major events drive online activity. Instead, the key takeaway from the analysis of online activity in Rwanda is that the general public does not seem to participate in online discussions surrounding the future fields. Continuing to work towards more inclusive Internet access needs to be one of the targets of the government.

The Global Knowledge Index (GKI) highlights a number of areas for improvement. Within the education system of the country, we observe weaknesses in the pre-university education system as well as in the system of tertiary education. In particular, the gross enrolment ratio for upper secondary education remains low, as does the gross enrolment ratio for early childhood education and the teacher-pupil ratio.[56] Despite the high score of Rwanda in terms of Education, our results show a very weak level of interest for these particular topics. This is alarming given the importance of raising the quality of the education system to a level that it can successfully equip students for the challenges that the future labour market presents.

The strengths of Rwanda in terms of readiness mainly focus on RDI and Science, with the most influential publications discussing knowledge sharing through major events – summits, conferences, meetings and strategic partnerships.

12 SAUDI ARABIA

GDP per capita
$20,761
2017

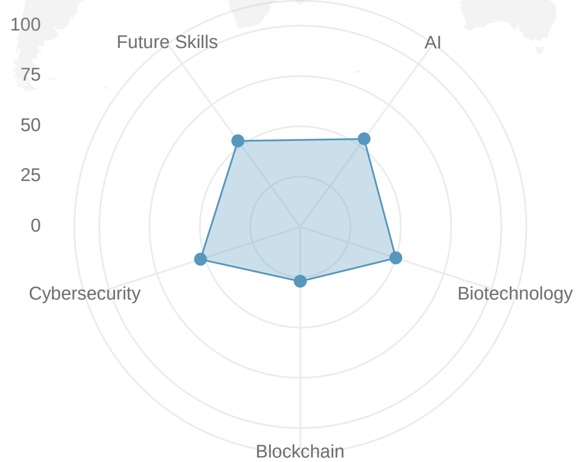
HDI
0.853
2017

GKI (rank)
68
2017

849
unique authors per million Internet users

The future readiness of Saudi Arabia is fairly equally spread across the five future fields. During the period of study, the online community discusses/reads most on Cybersecurity, Future Skills, AI and Biotechnology. Blockchain is the technology that the online community of the country discusses/reads comparatively less. This performance may relate to the "Vision 2030," an ambitious programme that employs a holistic approach in modernizing the Saudi economy.[57]

Figure 84: Future Fields Readiness Indices scores in Saudi Arabia

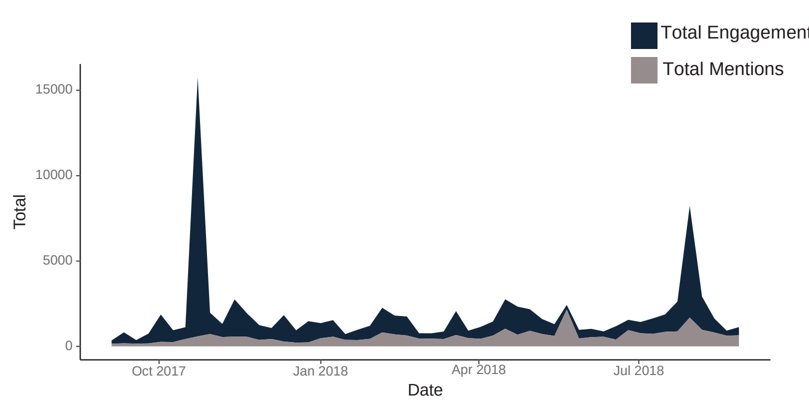


Saudi Arabia's level of interest in key technologies for the future

The volume of online activity in Saudi Arabia within the themes of the four technologies displays an average value of 561 mentions and 1,125 instances of engagement per week, with respective median values of 523 and 677. The two series also show a low degree of co-movement (0.14 coefficient of correlation), suggesting that major events do not have a strong influence over online activity. Instead, a small number of influential publications may be more effective in driving online engagement. Moreover, engagement is almost four times more volatile than mentions, which could also support the above hypothesis.

During the period of study, we identify just two events that significantly influence online activity. First, in October 2017, when Saudi Arabia became the first country to grant citizenship to a robot.[58] Interestingly, this event had a limited impact on mentions but a significant impact on engagement, generating a total of 9,200 engagements.[59] Second, on 30 July 2018, the first Haji Hackathon was held in the country. The Saudi Federation for Cybersecurity, Programming and Drones[60] organized the event, in which four women[61] took first place. The event was hailed as a step towards the modernization and improved facilitation of the pilgrimage experience. The event was also seen as a significant feat of logistics,[62] and broke the world record[63] for attendance.[64]

Figure 85: Volume of discussions and engagement level associated with the four key technologies for the future in Saudi Arabia (Sept 2017 - Sept 2018)

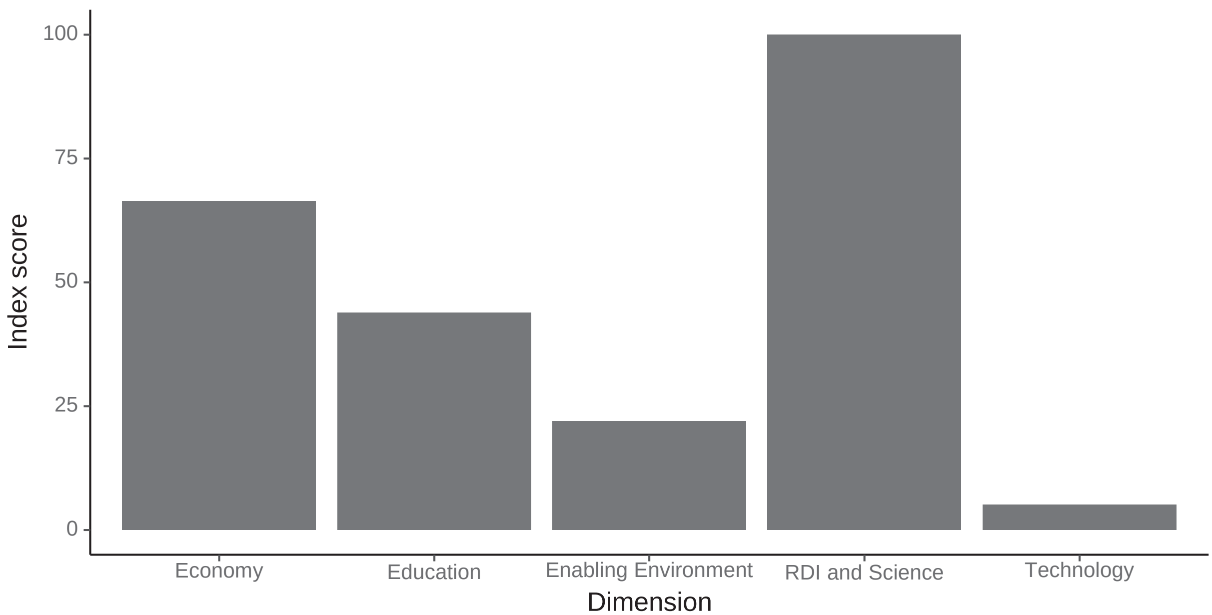


Analysis of GTRI by knowledge dimension points to RDI and Science as the strongest dimension of the index for Saudi Arabia. The Economy features 1.5 times less strongly, followed closely by Education and Enabling Environment.

News relating to the first humanoid Saudi citizen account for a big proportion of the engagement activity during the period in terms of RDI and Science, together with the Healthcare Summit in Dammam.[65] The one-day summit focused on how Blockchain can influence and revolutionize healthcare.

The Economy dimension is driven primarily by publications and engagement around Blockchain and, to an extent, AI. For instance, in line with the *"Vision 2030,"* the country aims to become a global leader of the digitized economy by capitalizing on Blockchain technology.[66] In line with this, Saudi Arabia hosts major events in the field of future technologies, such as the Crypto Investment and Blockchain Tech 4.0 that aimed to present the disruptive potency of Blockchain technology.[67]

Figure 86: Saudi Arabia's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

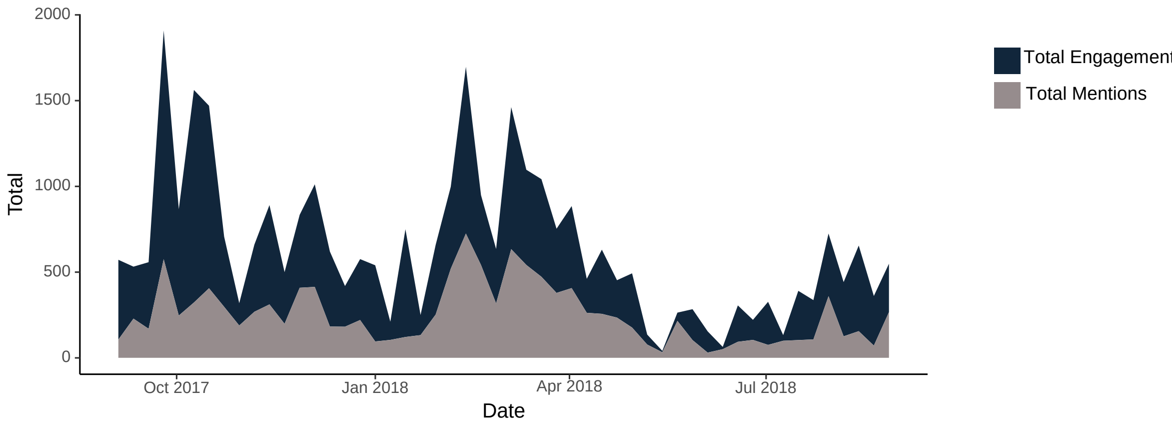


Saudi Arabia's level of interest in Future Skills

The volume of online activity in Saudi Arabia within Future Skills is significantly lower in comparison to online activity relating to the four technologies. In Saudi Arabia, online activity in Future Skills presents an average value of 248 mentions and 383 instances of engagement per week, with respective median values of 216 and 316. The two series show a significant degree of co-movement (0.68 coefficient of correlation) pointing to the importance of events in driving online activity. Engagement and mentions display similarly low volatility, highlighting a low volume of responsiveness to events that capture the attention of the online community.

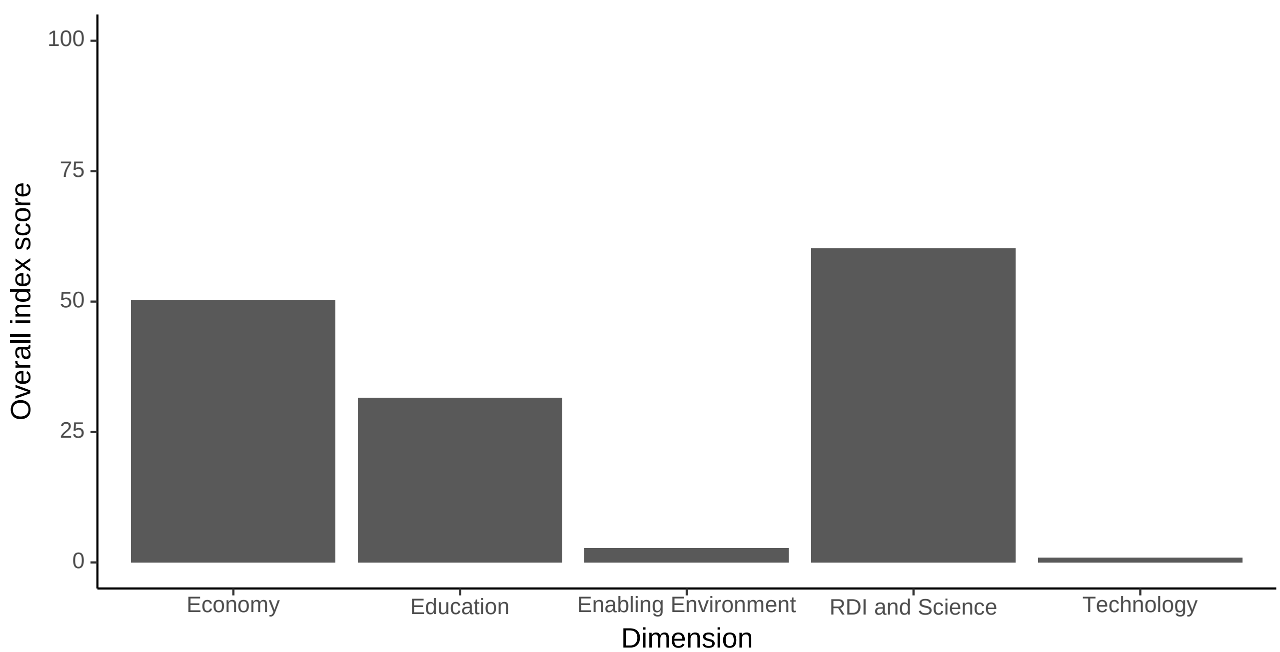
RDI and Science is the main driver of online activity; however, we find little evidence that a specific theme drives the interest of the community.

Figure 87: Volume of discussions and engagement level associated with Future Skills in Saudi Arabia (Sept 2017 - Sept 2018)



The analysis of Future Skills by knowledge dimension indicates stark difference in terms of readiness among the different dimensions. RDI and Science features the most in online activity, followed by Economy and Education. Publications surrounding different forms of active learning methods accounts for the largest share of activity in RDI and Science. The locus of online activity in the economic theme appears to peak around two mentions. The first is from the Misk Foundation[68] on effective investment in human capital. The second is from Arab News, commenting on a programme tackling youth unemployment and refugee integration in Jordan.[69] The unprecedented spike in engagement for Saudi Arabia may highlight the importance of the issue for the local population.[70]

Figure 88: Saudi Arabia's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Saudi Arabia's strengths and areas for improvement

Saudi Arabia is not a strong performer in terms of technology readiness, scoring low in the GTRI. However, this is not necessarily an accurate reflection of the level of readiness in the country. Through Vision 2030, Saudi Arabia is currently undertaking an ambitious economic and industrial transformation programme that employs digitization and AI technology as key enablers in the transformation of the country. Successful implementation of Vision 2030 will build sustainable cities and communities, improve the health and well-being of citizens and the quality of education, and boost innovation.

Despite the significant impact of Vision 2030 on the economy, the ambitious programme creates a small volume of online activity. Several factors may contribute to the weak dissemination of information across the online community network that may not necessarily reflect a low interest associated with Vision 2030. Nevertheless, they still impede the overall level of technological readiness in the country by discouraging technological knowledge synergies.

The Global Knowledge Index finds that Saudi Arabia performs well in terms of ICT access and use, especially in terms of scientific and technical articles.[71]

13 SINGAPORE

GDP per capita **$57,714** 2017

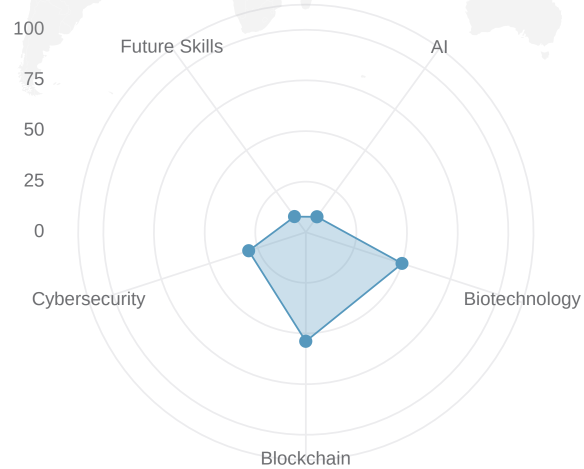
HDI **0.932** 2017

GKI (rank) **2** 2017

10330 unique authors per million Internet users

A first high-level view on the Future Field Readiness Indices scores for Singapore suggests a partially unbalanced degree of readiness across the five fields of interest. Singapore scores high for Biotechnology and Blockchain, but significantly lower for Cybersecurity, Future Skills and AI.

Figure 89: Future Fields Readiness Indices scores in Singapore

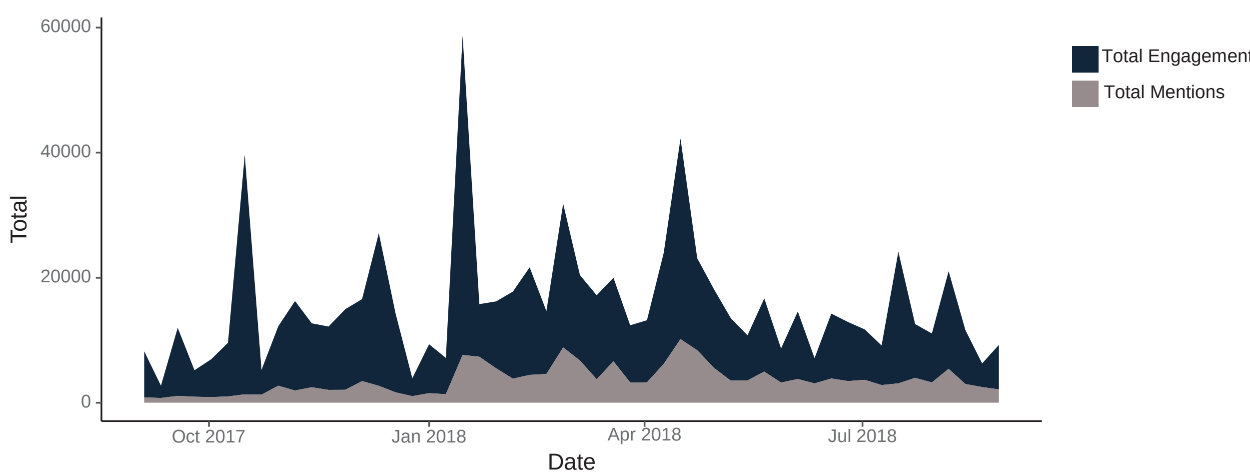


Singapore's level of interest in key technologies for the future

The volume of online activity in Singapore within the themes of the four technologies displays an average value of 3,409 mentions and 10,707 instances of engagement per week, with respective median values of 2,994 and 8,564. The two series also show an average degree of co-movement (0.56 coefficient of correlation), which suggests that major events gather significant attention. Engagement and mentions presents a similar degree of volatility, pointing to a proportional responsiveness of the two metrics to major events.

The online community of Singapore shows a strong interest in Blockchain, particularly within the frame of research with "ælf," a decentralized cloud computing Blockchain network, accounting for the biggest share of activity.[72]

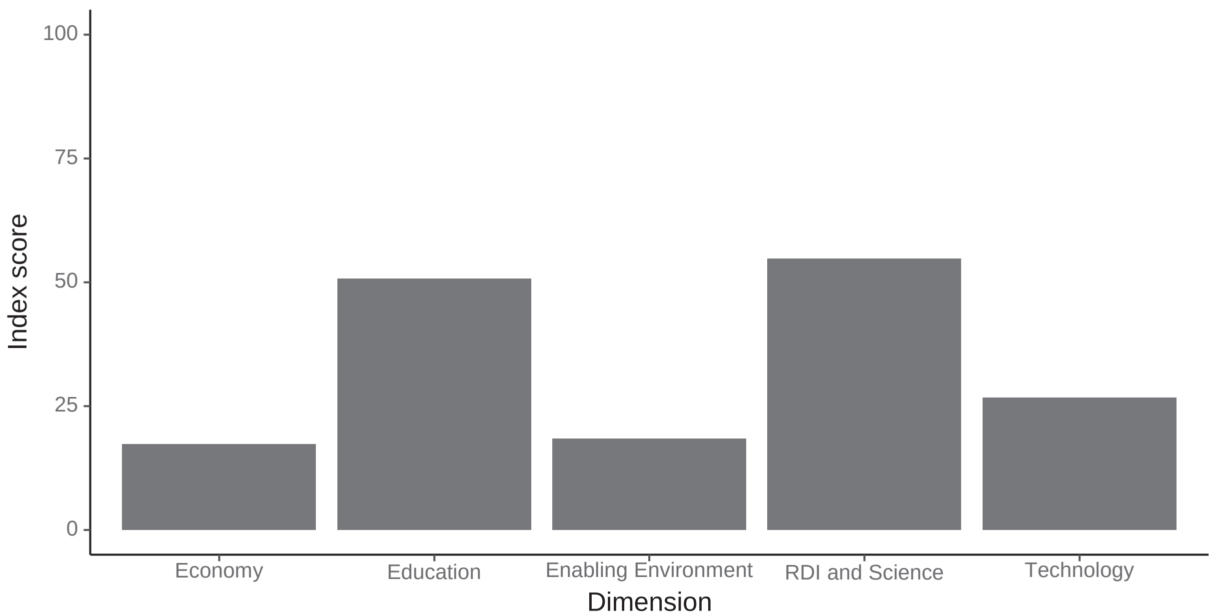
Figure 90: Volume of discussions and engagement level associated with the four key technologies for the future in Singapore (Sept 2017 - Sept 2018)



RDI and Science is the highest scoring dimension within the GTRI, followed closely by Education. Topics and events in Cybersecurity, AI, Machine Learning, Neural Networks, Big Data and Blockchain feature most commonly within the two dimensions.

Technology, Economy and Enabling Environment feature approximately half as often in online discussions on the four technologies. However, this is not to say that the raw volume of activity is low along these dimensions. Instead, we observe the high interest in firm-attendance to events, together with hackathons and courses driving the shape of the comparison.

Figure 91: Singapore's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

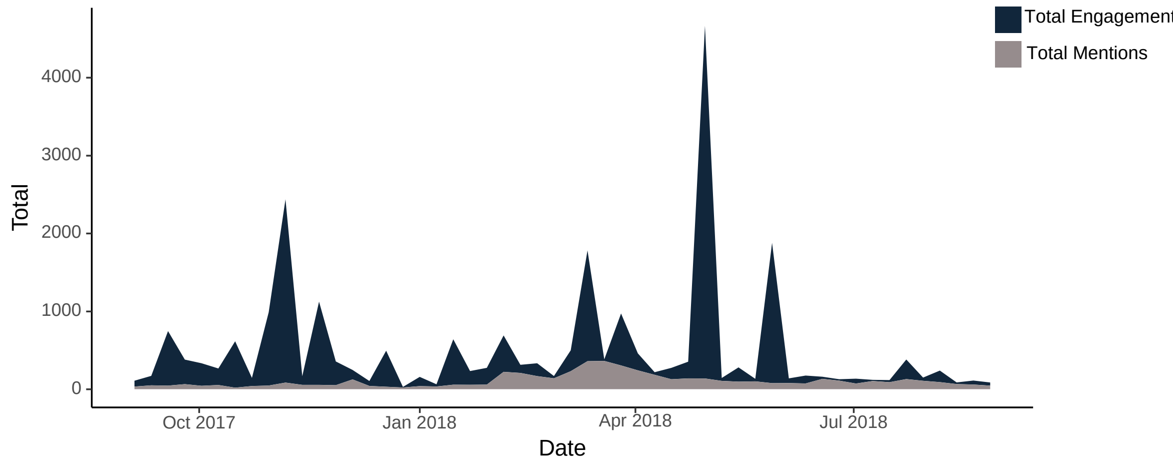


Singapore's level of interest in Future Skills

The volume of online activity in Singapore within Future Skills is significantly lower in comparison to online activity related to the four technologies. In Singapore, online activity in Future Skills presents an average value of 52 mentions and 204 instances of engagement per week, with respective median values of 40 and 59. The two series show a low degree of co-movement (0.19 coefficient of correlation), which suggests that a small number of influential publications play a major role in driving online activity.

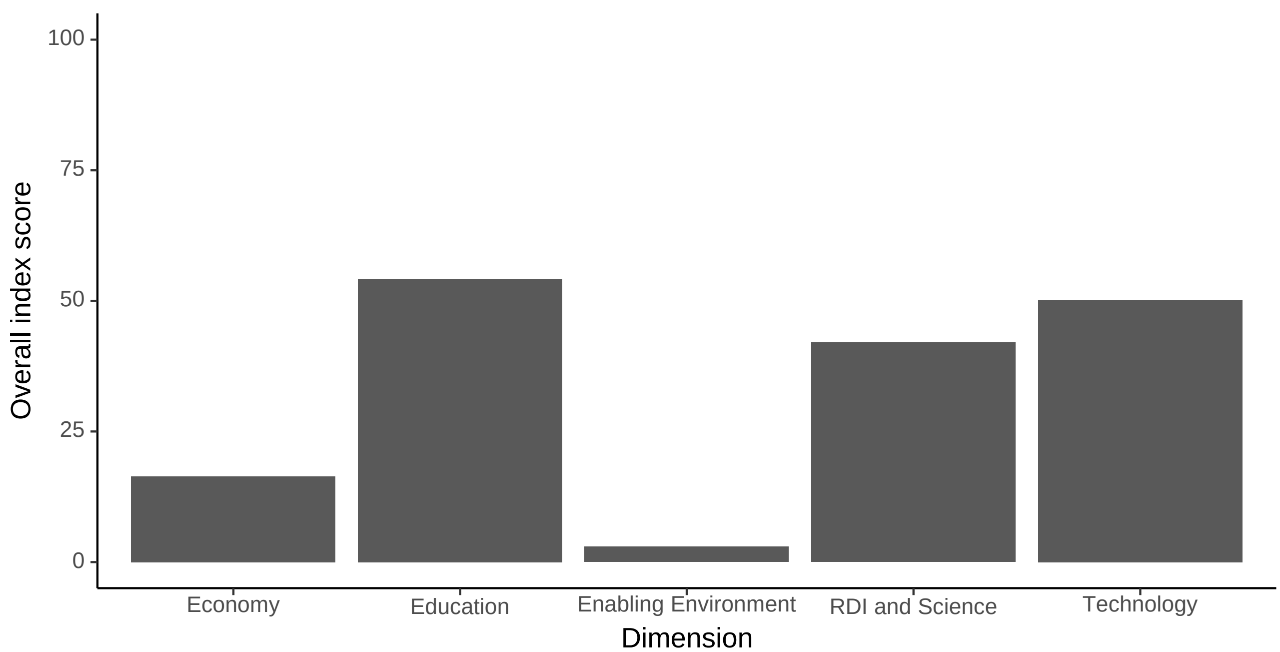
However, two instances stand out in terms of the interest they capture. First, the statement by the Minister for National Development and concurrently the Minister for Finance, Laurence Wong.[73] The minister argued for the need for labour market participants to focus on skills rather than qualifications listed in CVs, identifying Future Skills and overall societal capacity as key areas of focus towards adapting to technological change. Second, a statement by the Minister of Education on the benefits of reducing class size issues for students.[74]

Figure 92: Volume of discussions and engagement level associated with Future Skills in Singapore (Sept 2017 - Sept 2018)



The analysis of the Future Skills Readiness Index by knowledge dimension for the period exhibits a fairly balanced distribution of interest between Education, RDI and Science, and Technology. Taking a step deeper into the analysis of online activity within these fields by focusing on online communication using hashtags, we observe that common topics feature new modes of learning such as e-learning and the use of virtual reality in learning.

Figure 93: Singapore's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Singapore's strengths and areas for improvement

Singapore is a very strong performer in terms of the four technologies, ranking best in the GTRI. Singapore also ranks within the top five performing countries for each of the four technology-specific indices. Online activity in the four technologies displays a strong link with major events in the field, while the strong responsiveness of both content generation and engagement highlights a robust interest across the online community. The functioning of the country as host to major events, the public engagement of government officials with topics surrounding Future Skills and educational quality as well as the strong interest of the private sector in investment in new technologies[75] contribute to the salience of future fields in online discussions.

The Global Knowledge Index ranks Singapore first in terms of pre-university education, third in terms of higher education and 8th in terms of General Enabling Environment, highlighting the top performance of the country in terms of regulatory quality and government effectiveness.[76] The Enabling Environment of the country is a major strength of the country, which explains why online discussions in the theme feature very little. The high level of technological readiness that our methodology attributes to Singapore reflects a high level of awareness stemming from successful knowledge diffusion, high quality of tertiary education and research and development, business sophistication, and knowledge-intensive employment.

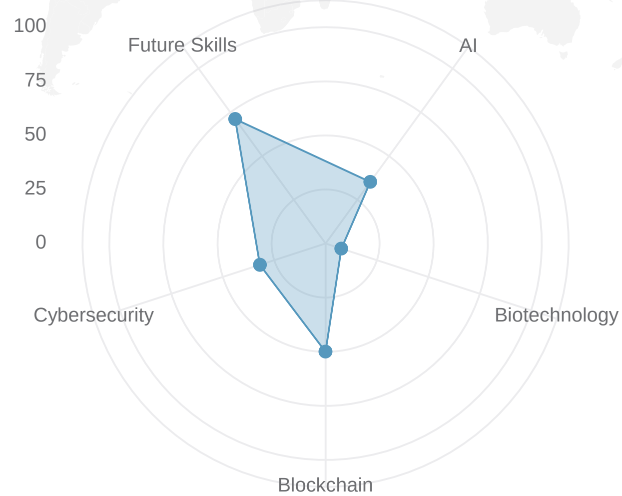
However, we do not observe the same good performance within the Future Skills field, where Singapore ranks among the bottom five performers. It seems that besides the recognition of the teacher to student ratio as a major caveat to the quality of the education system in the country, the online debate remains limited.

14 SWEDEN

GDP per capita **$53,442** 2017 | HDI **0.933** 2017 | GKI (rank) **4** 2017 | **2575** unique authors per million Internet users

The analysis of the five Future Field Readiness Indices for Sweden shows that the online population presents a very high degree of readiness in respect to Future Skills, Blockchain, AI and Cybersecurity. Biotechnology is the weakest field, featuring nine times weaker in comparison to Future Skills. The *"Skills Anticipations Program"*[77] is a key driver of the level of Future Skills readiness among the population. The programme is comprised by a multitude of activities that aim to: i) assess future skills (how can drivers impact future skills demand) and ii) forecast the future skills gap through the use of projections and employer surveys.

Figure 94: Future Fields Readiness Indices scores in Sweden

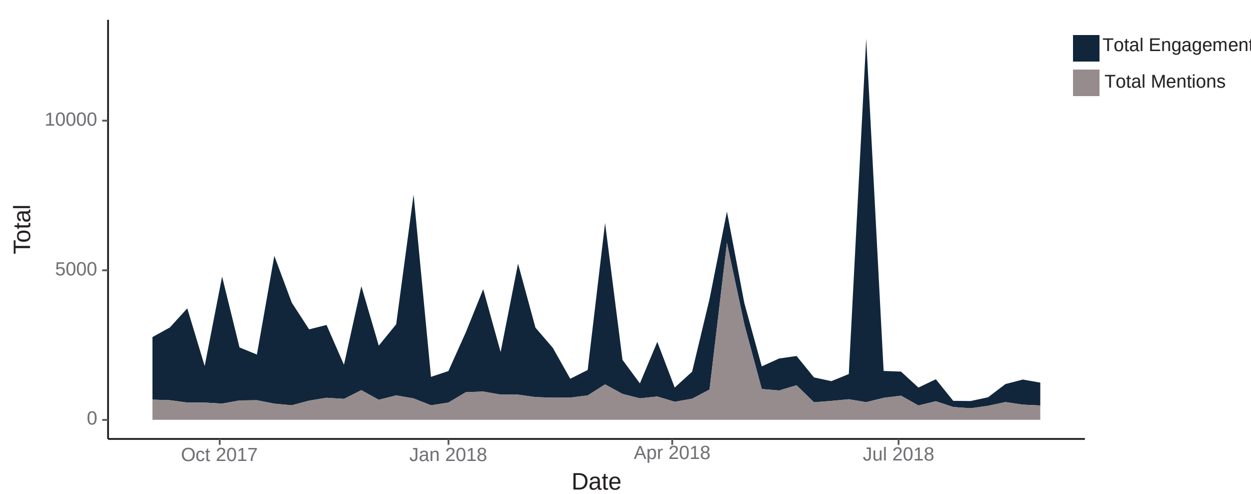


Sweden's overall readiness for the future

The volume of online activity in Sweden within the themes of the four technologies displays an average value of 800 mentions and 1,881 instances of engagement per week, with respective median values of 644 and 1,055. The two series show a zero degree of co-movement, which underscores the importance of a small number of influential publications in driving online activity.

By taking into consideration the high volume of activity that the field of Blockchain generates, we identify the topic of Cryptocurrency as a key culprit, accounting for the generation of a number of influential articles across the duration of the sample period.[78] In a similar vein, we note that the only event that stands out as a source of online activity is the New York Blockchain Week - 11th of May.

Figure 95: Volume of discussions and engagement level associated with the four key technologies for the future in Sweden (Sept 2017 - Sept 2018)



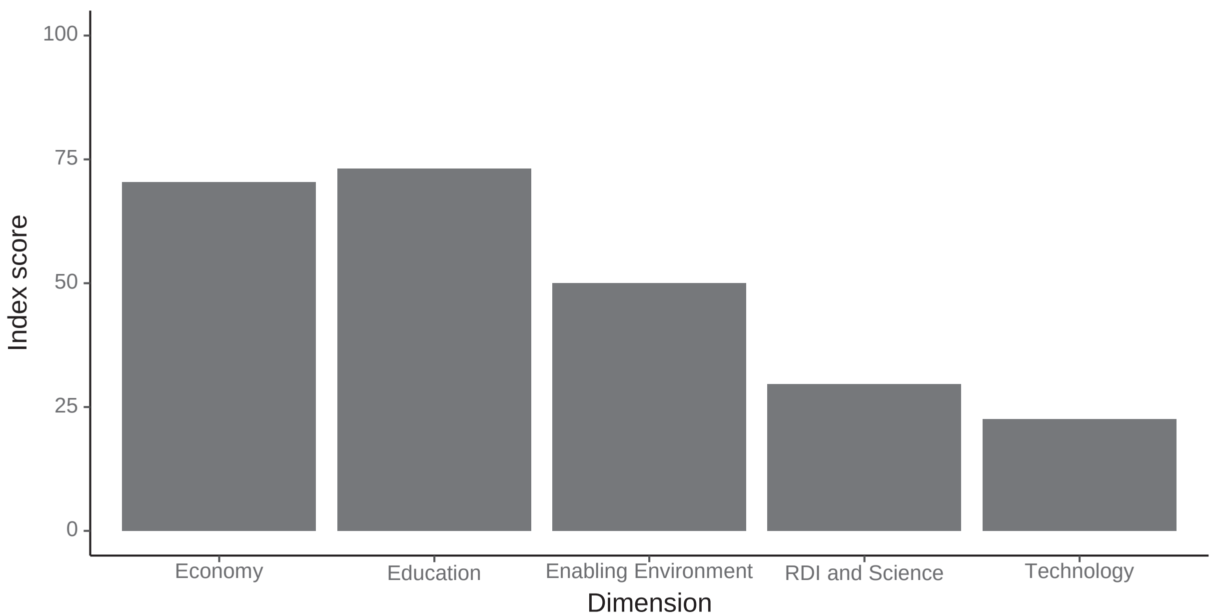
The analysis of the Global Technology Readiness Index by knowledge dimension indicates that most of the online publications and audience interactions relate to teaching, learning and funding provision – Education and Economy are the two dimensions that feature most prominently.

Education mentions and engagement reflect the interest of the Swedish online community in courses and seminars on Blockchain, and to a lesser extent, on AI. In particular, the topics that generated most interest among Internet users include tutorials on Syscoin, a new Blockchain development platform,[79] seminars on techniques of blockchain development[80] and the Almedalen AI summer seminar week.[81]

Economy mentions and engagement also point to high interest in Blockchain and AI technologies, and in particular investment in these two technologies.[82]

Our results further underscore that the remaining knowledge dimensions also perform well, as the country presents a relatively balanced level of readiness across the five dimensions.

Figure 96: Sweden's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

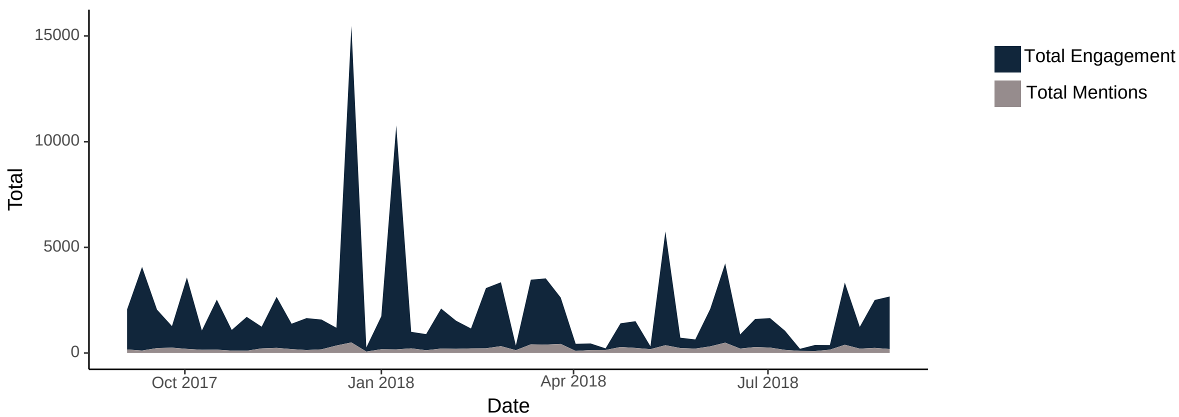


Sweden's level of interest in Future Skills

The volume of online activity in Sweden within Future Skills is lower in terms of mentions but higher in terms of engagement in comparison to online activity relating to the four technologies. In Sweden, online activity in Future Skills presents an average value of 217 mentions and 1,951 instances of engagement per week, with respective median values of 203 and 1,328. In addition, the two series show a significant degree of co-movement (0.48 coefficient of correlation). Moreover, engagement presents a volatility twice the size of mentions, highlighting a higher response of online activity to events in terms of engagement than in terms of mentions.

Both mentions and engagement that relate to future skills exhibit higher activity within the Education dimension. However, discussions do not have a positive undertone. The main topic of interest is the teacher shortage that the country currently faces, which may account for the pre-eminence of future skills over future technologies.[83] The issue of teacher shortage appears to affect the performance of the Swedish labour market through different channels. One of the publications that triggered a significant amount of activity is a statement by the Swedish finance minister, who drew a link between the teacher shortage and the weak integration of the foreign population into the Swedish society.[84]

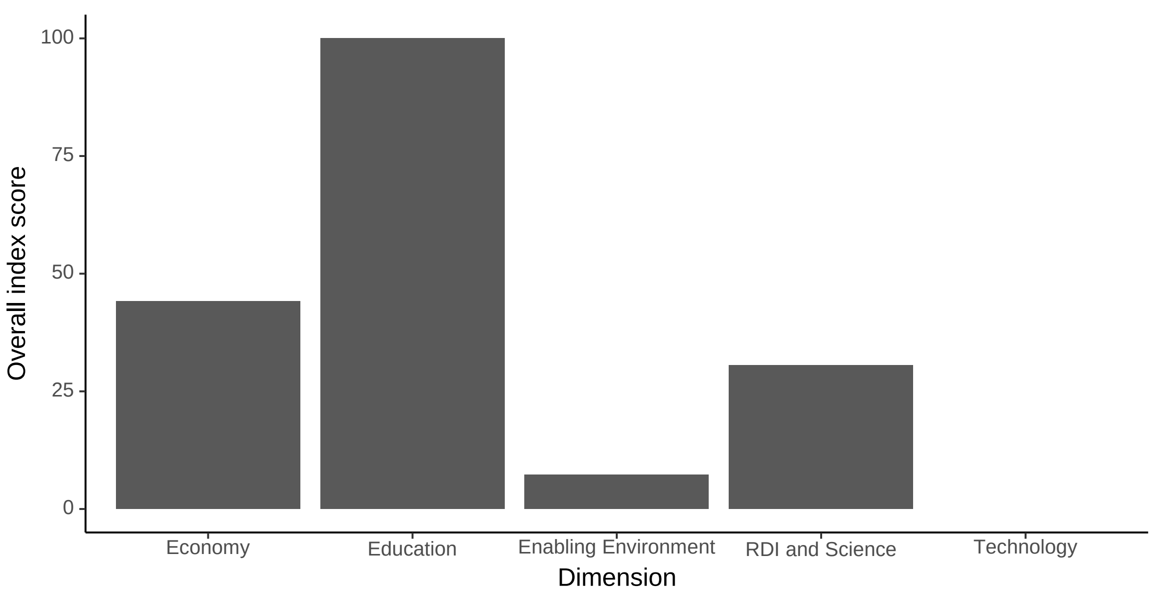
Figure 97: Volume of discussions and engagement level associated with Future Skills in Sweden (Sept 2017 - Sept 2018)



Education, Economy and RDI and Science are the only three dimensions that score highly in the analysis of the Future Skills Readiness Index by knowledge dimension.

A closer look into the Economy dimension reveals that Sweden is taking steps towards addressing the teacher shortage. We observe a rising volume of activity created by discussion surrounding the importance of investing in education,[85] and the necessity of training people with the required future skills.[86]

Figure 98: Sweden's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Sweden's strengths and areas for improvement

Sweden is a good performer in terms of cross-country comparison, scoring close to the median in the GRTI. The country performs very well in terms of formal upskilling, with the private sector investing in formal training of the workforce and the online community displaying a strong interest in upskilling through online courses. The Skills Anticipation Program is a best practice in the field. Close surveillance of developments in the labour market will contribute to effectively adapting policy to the needs of the future labour market.

However, gathering data on the supply and demand of skills requires an effective information dissemination policy to raise awareness and drive upskilling within the labour force of the country. Reflecting on the results of the country comparison and the country profile, we observe that despite large investments in education, world-class researchers in the field, good innovation linkages between industry and academia, and a high density of knowledge workers within the labour force, caveats still remain on the way to bridging the Future Skills gap in Sweden. The most prominent issue that the country needs to address is a shortage of teachers. Nevertheless, the good level of readiness that the online community displays on the issue together with the active debate on addressing the issue signal a good overall performance in terms of Future Skills readiness.

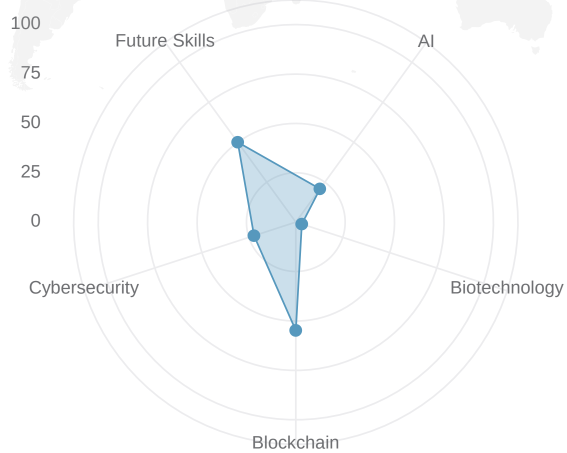
Despite an overall high volume of online content creation, engagement - in particular related to future technologies - remains low and dissociated with major events in the field. Findings of this report suggest that hosting major events in the field that are open to the public can be a successful way to better and more broadly engage the online community with the technologies of the future.

15 SWITZERLAND

GDP per capita	HDI	GKI (rank)	5829
$80,190 2017	0.944 2017	1 2017	unique authors per million Internet users

A first high-level view on the future field Readiness indices scores for Switzerland suggests an unbalanced degree of readiness across the five fields of interest. In terms of volume of online activity within the country, Switzerland displays a higher degree of readiness in Blockchain, closely followed by Future Skills. AI and Cybersecurity feature less than half as frequently as Blockchain.

Figure 99: Future Fields Readiness Indices scores in Swtizerland

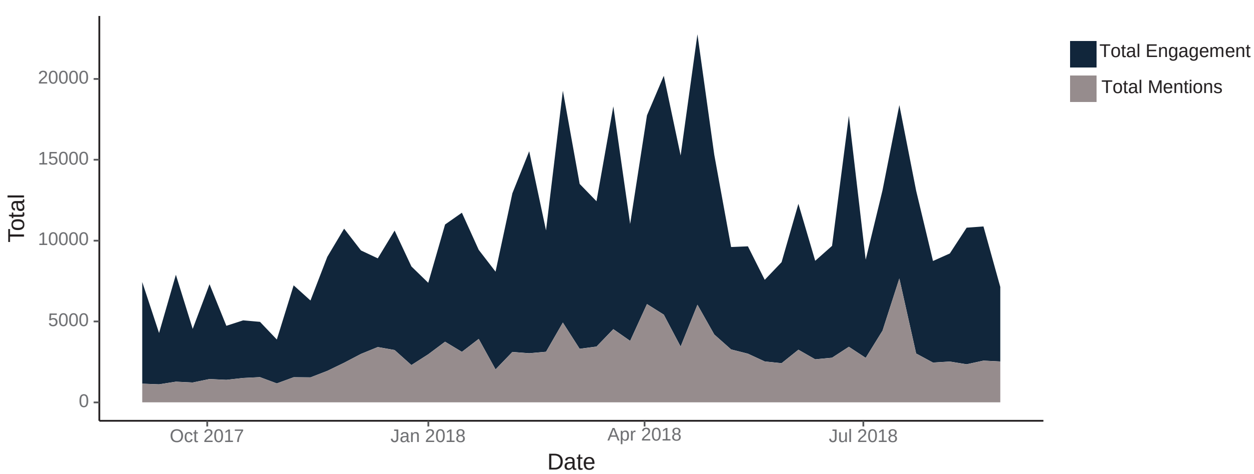


Switzerland's level of interest in key technologies for the future

Switzerland has an online community that is highly reactive to publications on the four future technologies. The volume of online activity in Switzerland within the themes of the four technologies displays an average value of 2,818 mentions and 6,827 instances of engagement per week, with respective median values of 2,801 and 5,931. The two series also show a significant degree of co-movement (0.65 coefficient of correlation), which suggests that the online community displays a strong interest in major events. Engagement and mentions present a similar degree of volatility, pointing to a proportional responsiveness of the two metrics to major events.

Events such as the Blockchain Summit, held in the Crypto Valley in Zug (Switzerland), on 25-26 April 2018, together with general interest in cryptocurrencies and initial currency offerings in particular, contribute to the salience of the Blockchain future field.

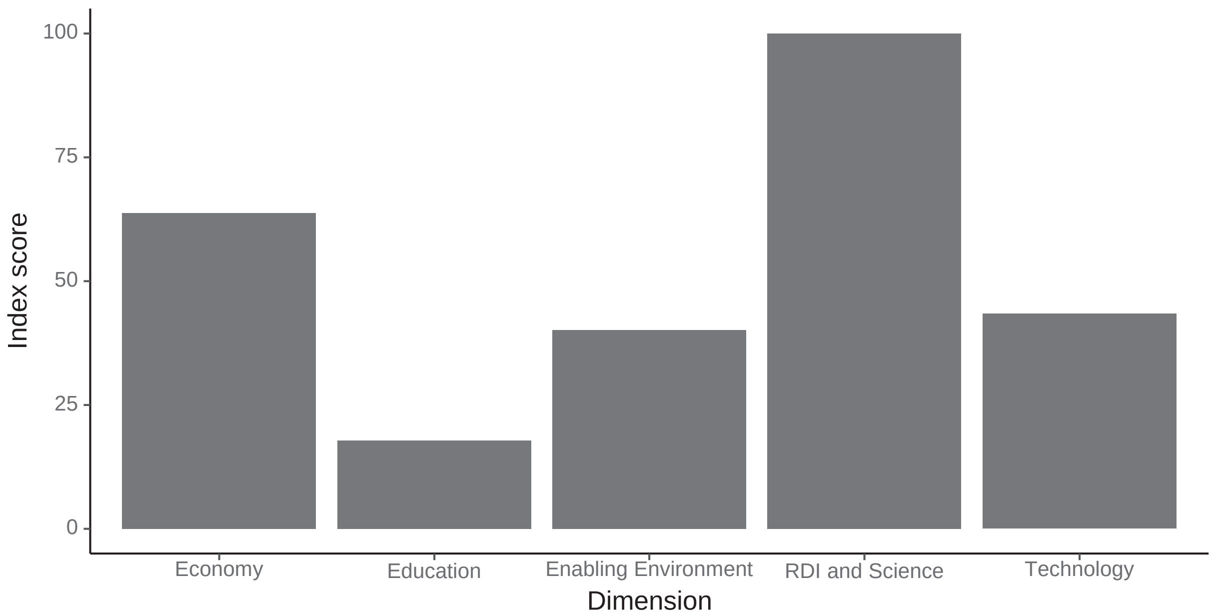
Figure 100: Volume of discussions and engagement level associated with the four key technologies for the future in Switzerland (Sept 2017 - Sept 2018)



The analysis of the GTRI by knowledge dimension reveals that the Swiss online community is most interested in topics surrounding RDI and Science and the Economy. This result reflects a high degree of readiness in cryptocurrencies, initial coin offerings, machine learning and the use of AI in Healthcare.[87]

We observe a subdued level of activity within themes that relate to government policy, education and technology across the four technologies. This result suggest that advances made in these knowledge dimensions are seen as "business as usual" by the Internet users, as they do not generate much excitement online.

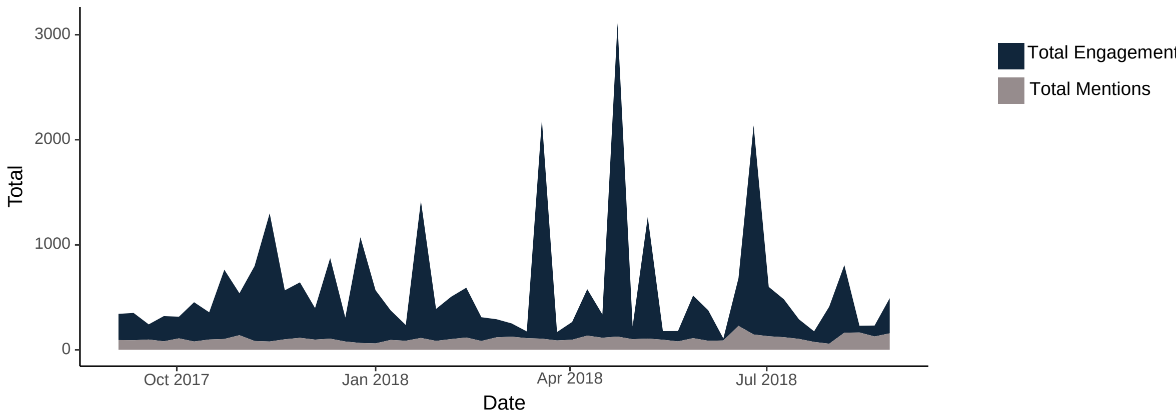
Figure 101: Switzerland's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Switzerland's level of interest in Future Skills

The volume of online activity in Switzerland within Future Skills is significantly lower in comparison to online activity relating to the four technologies. In Switzerland, online activity in Future Skills presents an average value of 103 mentions and 475 instances of engagement per week, with respective median values of 99 and 300. The two series show a low degree of co-movement (0.12 coefficient of correlation), which suggests that major events are not the key driver of online activity; influential articles also affect the intensity of online activity. The engagement metric is significantly more volatile than mentions, which is in line with the primacy of influential articles hypothesis.

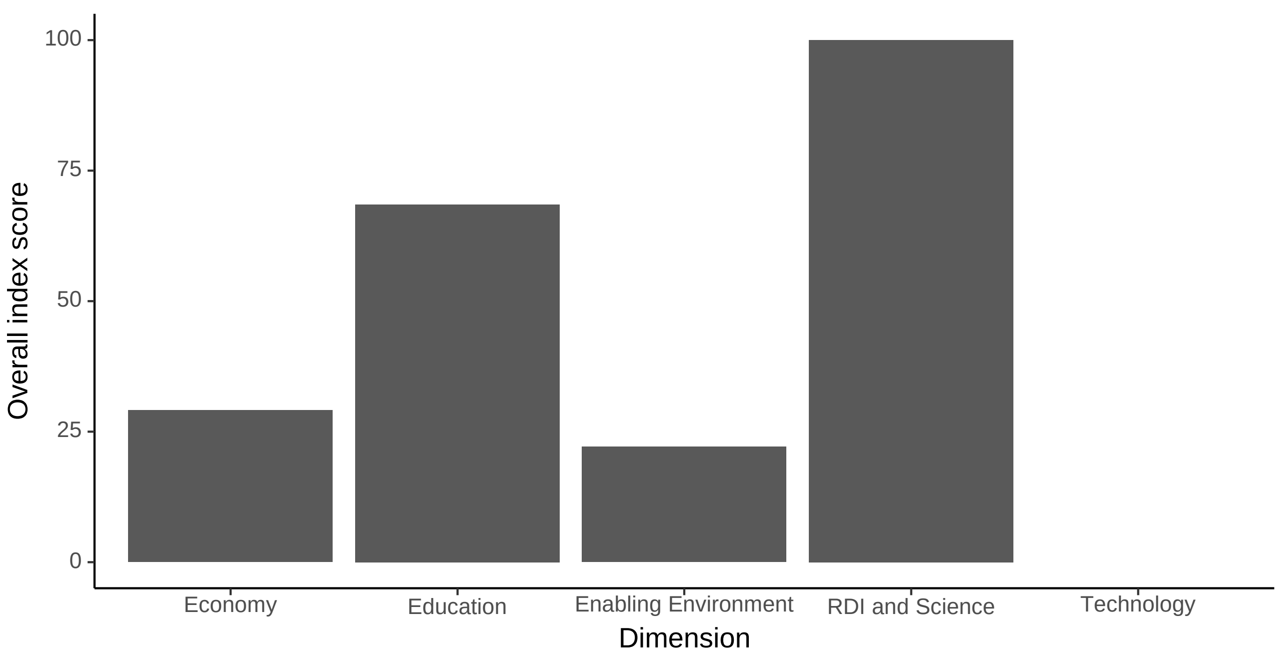
Figure 102: Volume of discussions and engagement level associated with Future Skills in Switzerland (Sept 2017 - Sept 2018)



RDI and Science and Education account for the biggest shares of online activity in Future Skills, highlighting the importance that the online community attributes to recent research in the field and the overall high level of readiness in terms of the quality of the education system. In relation to these two leading dimensions, we observe that the locus of interest rotates around teacher shortages, e-learning, coding classes and the use of AI and robotics in schools.

However, publications related to funding and governmental measures as well as technology developments favoring Future Skills development do not seem to capture significant audience attention.

Figure 103: Switzerland's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Switzerland's strengths and areas for improvement

The international comparison of section 3.2 names Switzerland as a top performer in three out of five fields of comparison: AI, Biotechnology and Blockchain. Home to world-class universities and host to international events in the field, the country is able to sustain a vibrant private sector that closely tracks the new labour market dynamics that Industry 4.0 unleashes.

Our analysis shows that Switzerland has an online community that is highly reactive to publication in the field of the four future technologies. We find that major local and international events in the field, such as conferences and summits, have a significant positive effect on online activity. Since the early 2000s, Switzerland has risen in prominence in the field of future technologies, with the business ecosystem of the country creating a number of new solutions on disruptive technologies such as AI, big data, augmented reality, medical technology and biotechnology.

The good performance of the country in terms of technological readiness also reflects the strong focus of the Swiss system of tertiary education on innovation. Switzerland is home to three world-class innovative Universities: Federal Institute of Technology in Lausanne, Swiss Federal Institute of Technology in Zurich, and University of Zurich.[88] Furthermore, research institutions in the country have a strong tradition of creating partnerships with private sector entities for the pursue of R&D, especially within the field of Biotechnology and MedTech.

Effective collaboration between private and public sector in the country directly relates to the existence of a well-functioning enabling environment that attracts investment.[89] In 2018, the World Intellectual Property Organization (WIPO) named Switzerland as the world's most innovative country for the seventh consecutive year.[90] This is in line with the findings of the Global Knowledge Index, which also underscores the outstanding performance of the country in terms of Research, Development and Innovation. Particular strengths include the quality of scientific institutions and production process sophistication.

Despite the overall good performance of Switzerland, some areas for improvement remain. First, it will be good to prioritize the resolution of the current teacher shortage, as the high quality of the education system is inextricably linked to the narrowing of the skills gap. Targeted investment in education will equip the new generation with the skills necessary to successfully meet the demand of the future labour market.

Second, despite a good level of researchers in the field of data storage, data analytics and quantum technologies, the country scores low in the Technology dimension of our Readiness Index, suggesting limited public discussion in the theme. Online content generation that is accessible to a wide public may generate stronger engagement of the online community and therefore encourage upskilling.

Third, literature in the field has pointed out that Switzerland has some distance to cover before the country becomes a top performer. We do not observe the issue of starting a business to feature prominently in discussions surrounding the enabling environment of the country. A higher degree of public engagement with the topic may translate to policy action that will better accommodate the needs of start-ups in the country. This will contribute to the strengthening of the innovative entrepreneurial community of the country, thereby targeting the future skills gap in the country by boosting employment and overall economic activity.

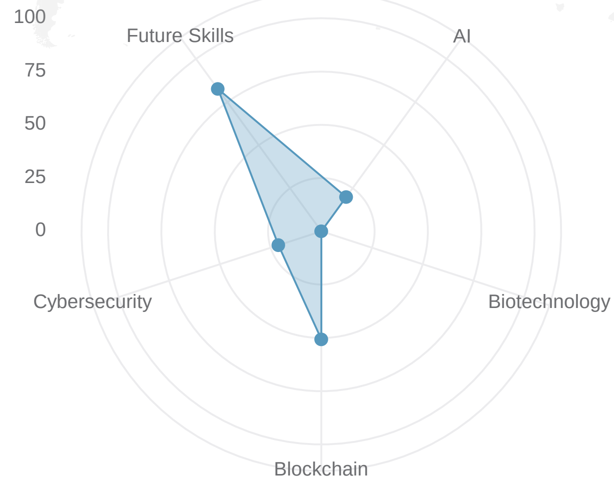
16 TANZANIA

GDP per capita $ 936 2017 | HDI 0.538 2017 | GKI (rank) 112 2017 | 152 unique authors per million Internet users

The analysis of the five Future Field Readiness Indices for Tanzania reveals that online activity in the country is most dense in the Future Skills and Blockchain fields. The two fields account for the majority of mentions and engagement in the country.

A possible explanation for the heighted interest in Future Skills during the period of study in Tanzania is the launch of a programme by the U.S. Agency for International Development aimed at increasing job opportunities for the future workforce of the country. In particular, the DAI *'Feed the Future Tanzania Advancing Youth'* programme[91] helps young people to develop skills vital to increasing their employability and works towards fostering public-private partnerships for the development of on-the-job training opportunities, internships and youth placements.

Figure 104: Future Fields Readiness Indices scores in Tanzania

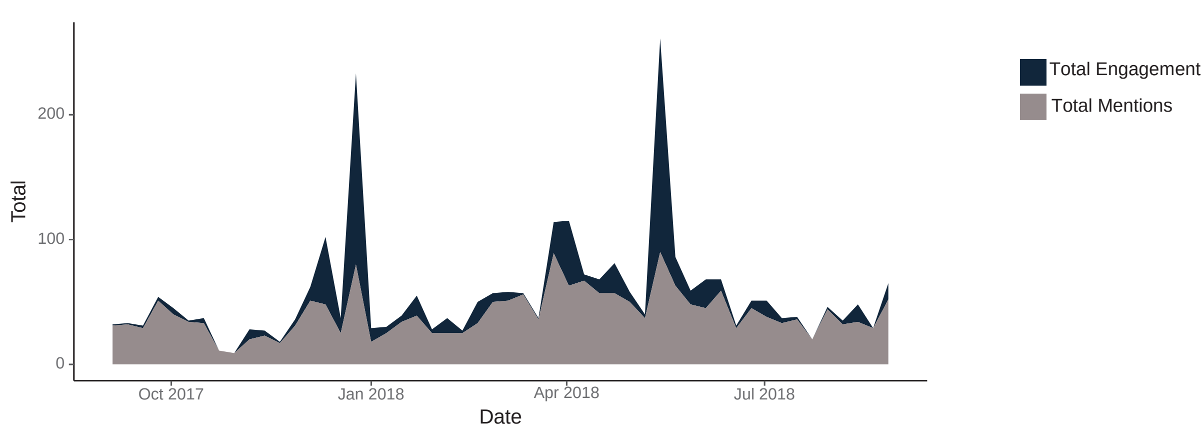


Tanzania's level of interest in key technologies for the future

The volume of online activity in Tanzania within the themes of the four technologies displays an average value of 37 mentions and 14 instances of engagement per week, with respective median values of 33 and 5. The two series also show a significant degree of co-movement (0.60 coefficient of correlation), which suggests that there is interest for major events in the four technology fields. However, the main takeaway is that the online community engages little with publications.

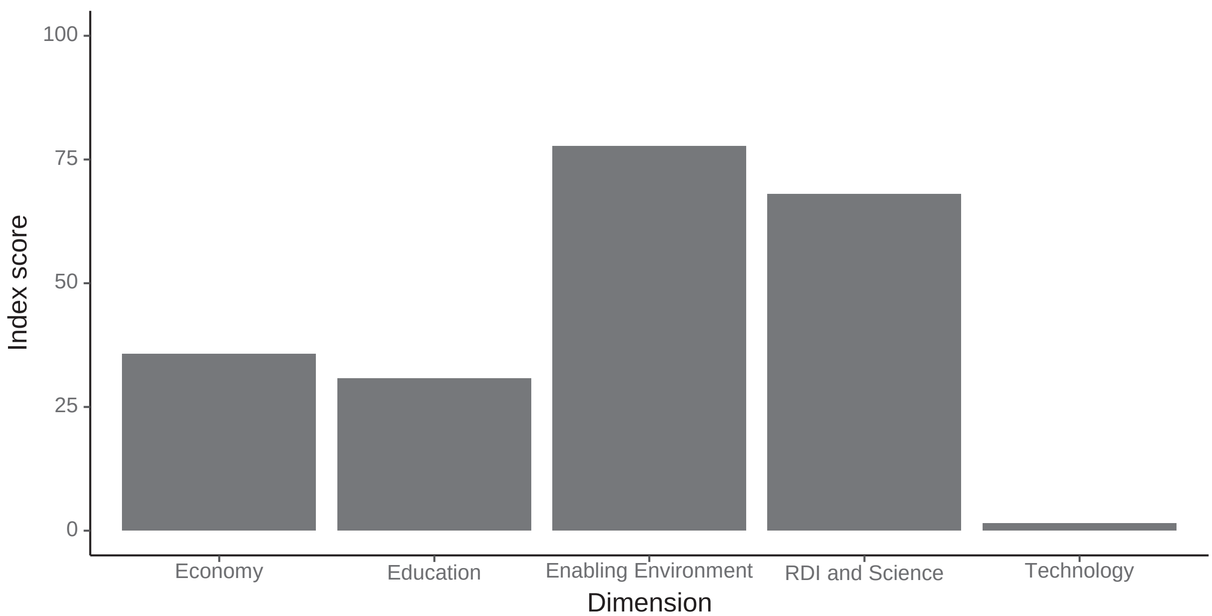
Online activity, while larger than in previous years, remains at an infant stage in comparison to the rest of the countries included in this report.[92] Public sector entities appear to be the principal source of online activity. The December peak relates to a Bank of Tanzania (BoT) statement that identified Bitcoin as a threat to the adoption of a common currency across the East African Community.[93] The May peak reflects a rise in online activity due to the introduction of the GDPR in Europe.

Figure 105: Volume of discussions and engagement level associated with the four key technologies for the future in Tanzania (Sept 2017 - Sept 2018)



The analysis of the GTRI by knowledge dimension reveals Enabling Environment and RDI and Science as the two leading dimensions of interest. The low volume of overall online activity is a result of having a few impactful events driving the analysis for Tanzania. This becomes most evident with the identification of the BoT statement and the introduction of the GDPR as the key drivers of Enabling Environment primacy. In a similar vein, the success of the Africa Blockchain Conference, held in May 2018 in Uganda, accounts for the observed activity in RDI and Science.

Figure 106: Tanzania's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



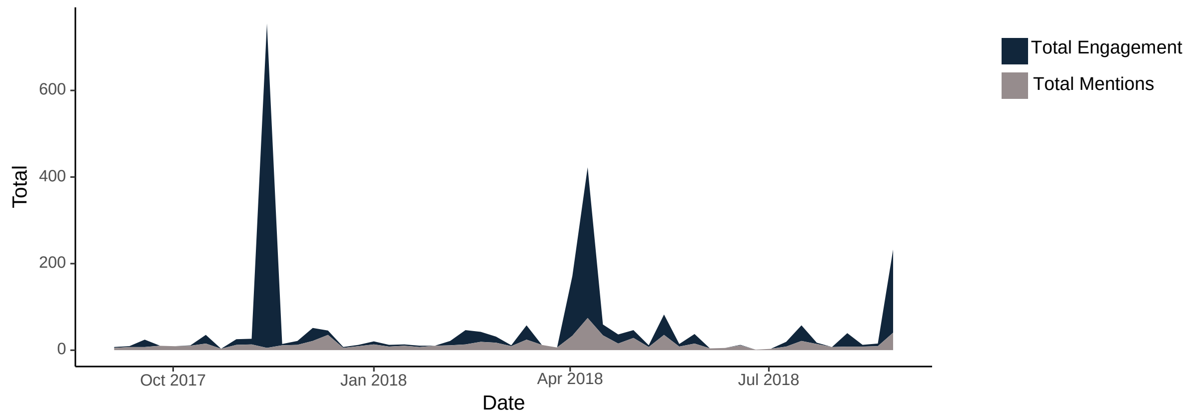
Tanzania's level of interest in Future Skills

The volume of online activity in Tanzania within Future Skills is lower in comparison to online activity relating to the four technologies. In Tanzania, online activity in Future Skills presents an average value of 13 mentions and 36 instances of engagement per week, with respective median values of 9 and 6. The two series show a low degree of co-movement (0.31 coefficient of correlation), however, the key takeaway here is that online activity in the field appears only in spurts, and the median is six times smaller than the mean value.

The analysis of the volume of discussions and level of interest relating to Future Skills in Tanzania reveals a low trend volume with respect to both total mentions and total engagement. The two peaks in the level of interest relate to the Education dimension, which is also the dimension featuring most often in public discussions of Future Skills. The great majority of activity in the dimension reflects the online debate on teacher shortages in Tanzania. For instance, one of the mentions that captured the attention of the online community referred to an initiative by politicians who took it up to themselves to address the science teacher shortage in a more direct way, by starting to teach.[94]

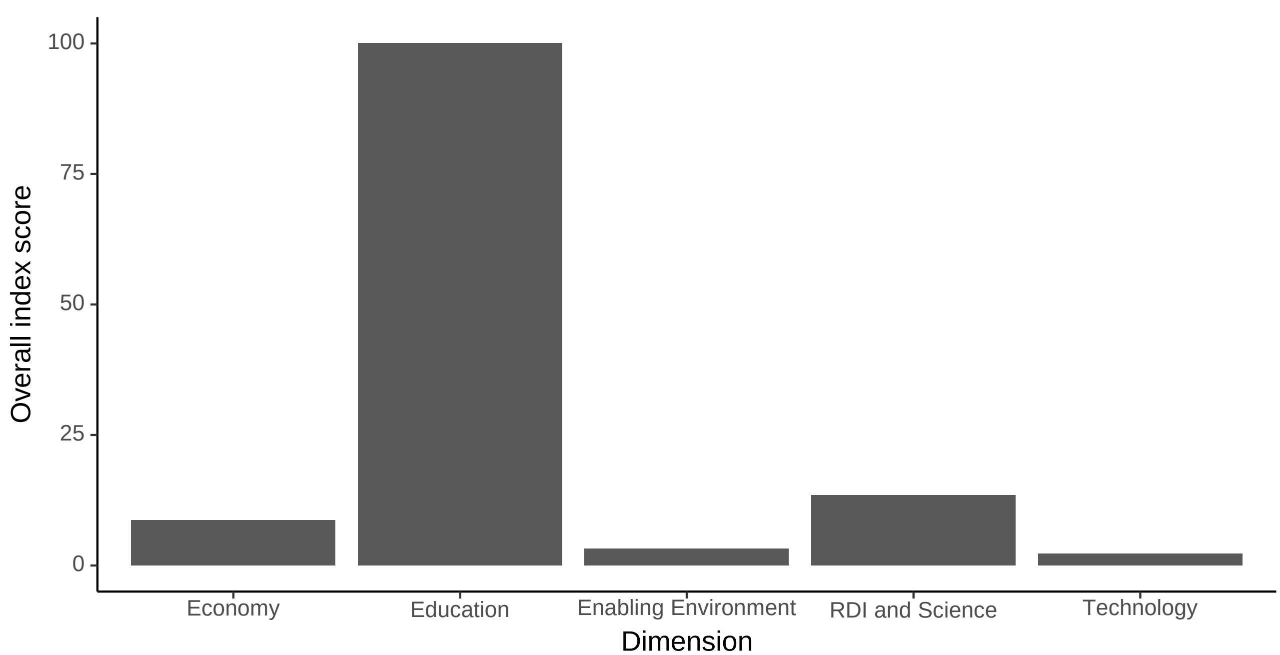
Another public initiative that stands out in terms of online activity, 161 Twitter likes and 30 retweets, is the inauguration of 'Launchpad Tanzania', a company that works towards the development of skills within the workforce aiming to foster a sustainable mode of economic growth.[95]

Figure 107: Volume of discussions and engagement level associated with Future Skills in Tanzania (Sept 2017 - Sept 2018)



The analysis of the Future Skills Index by knowledge dimension places Education as the highest scoring dimension within Tanzania. RDI and Science, Economy, Technology and Enabling Environment follow at a great distance – RDI and Science performs more than seven times lower compared to Education. This preeminence of Education reflects the good level of readiness in the country relating to the existing shortage of teachers, where online activity focuses both on raising awareness and on finding an effective solution to the problem.

Figure 108: Tanzania's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Tanzania's strengths and areas for improvement

Future Skills appears to be the strongest area among the five future fields analyzed in this model. This result is mainly due to the numerous articles and likes/comments/retweets/shares on the teacher shortage. This indicates that the country is aware of the issue and is ready to take on the next step to solve the problem.

The key takeaway from the analysis relates to the size of the online community in Tanzania. Tanzania performs poorly in all international comparisons, and only 13 percent of the total population has access to Internet. This reflects a lack of critical mass in terms of raising awareness and developing networks for the deployment of the technologies of the future.

However, the public sector of the country performs well in terms of sharing relevant information with the online community and guiding collective action. Increasing Internet coverage among the population will further boost the effect of the current communications in addition to supporting actions such as the "Feed the Future Tanzania Advancing Youth."

17 TURKEY

GDP per capita
$10,541 2017

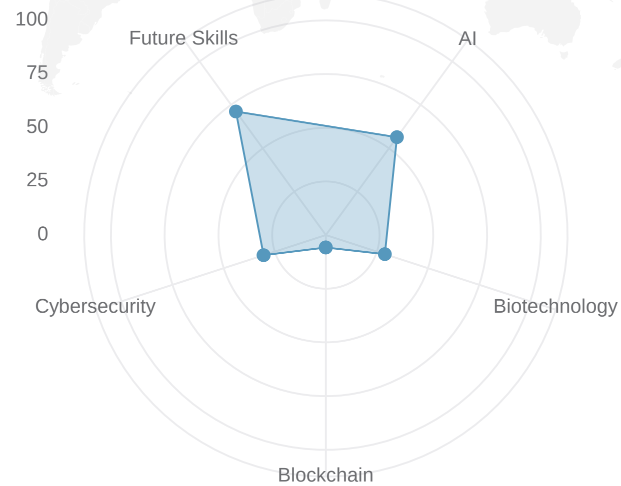
HDI
0.791 2017

GKI (rank)
69 2017

2215 unique authors per million Internet users

Awareness is not equally spread across the five future fields in Turkey. During the period of study, the online community discusses/reads most about Future Skills and least about Blockchain. AI is a close second in terms of overall activity, while Cybersecurity and Biotechnology feature less than half as often as Future skills.
These results reflect the transformation that the Turkish economy is currently undergoing. Through the implementation of *'Skills Vision 2020'*,[96] the government aims to reform the education system, invigorate the labour market and upgrade the current skillset of the workforce.

Figure 109: Future Fields Readiness Indices scores in Turkey



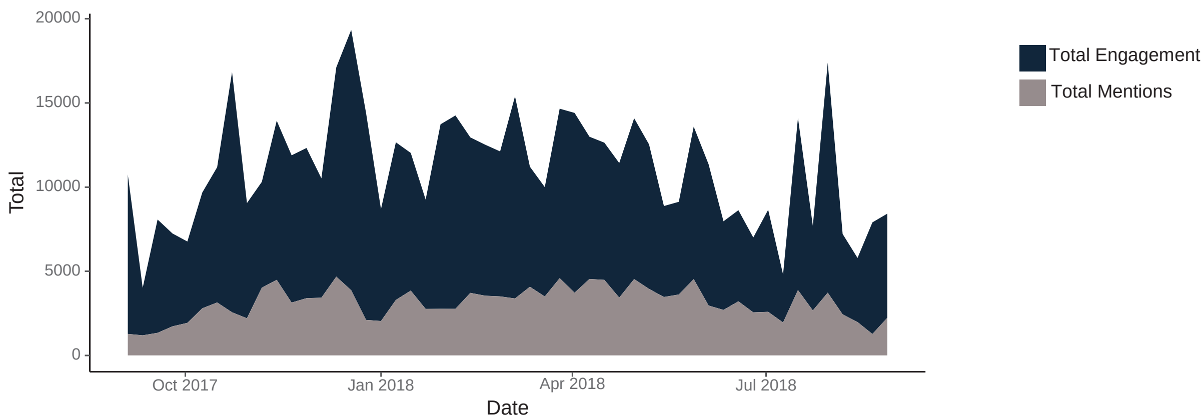
Turkey's level of interest in key technologies for the future

The volume of online activity in Turkey within the themes of the four technologies displays an average value of 2,850 mentions and 7,251 instances of engagement per week, with respective median values of 2,909 and 7,002. The two series show an average degree of co-movement (0.44 coefficient of correlation), which underscores that there is a significant interest in major events in the field. The two series are not strongly volatile, highlighting the existence of a robust core of online activity across the sample period.

The total volume of online activity associated with future technologies points to a substantial degree of awareness within Turkish society. However, analysis of the number of publications and the level of interest offers little to develop a coherent story on the readiness of the Turkish labour market. The lack of a key driver for engagement and mentions may point to the relatively limited importance that the Turkish online community attributes to events such as the Blockchain and Bitcoin Conference.[97] Alternatively, it could also suggest that the online community displays a high degree of decentralization; many unique authors make small contributions based on their interests that are not necessarily in line with any growing discussion trend or do not align their posts/engagement using a standardized manner of communication.

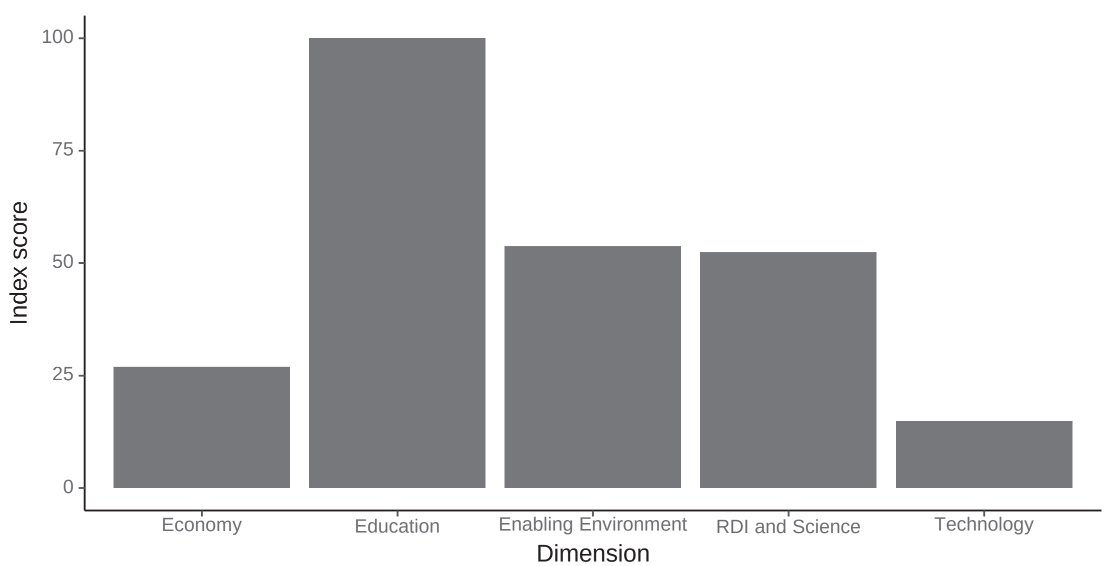
For Turkey, it appears that awareness and virality are not perfectly in line. While we observe that Future Skills and AI dominate the volume of online discussions, if we focus on modes of standardized communication using hashtags, we observe that Blockchain quickly jumps out as a core area of interest. In particular, we observe a significant amount of activity relating to Cryptocurrencies, with added focus on Bitcoin, Ethereum and Initial Coin Offerings. In relation to the latter, the Wemark project[98] appears to account for a significant volume of activity. Entrepreneurship and access to funding with attention to different modes of funding, including crowdfunding and penny stocks, also feature prominently, while discussion on machine learning and big data takes place primarily within the context of start-ups.

Figure 110: Volume of discussions and engagement level associated with the four key technologies for the future in Turkey (Sept 2017 - Sept 2018)



The analysis of GTRI by knowledge dimension for Turkey reveals an unbalanced degree of readiness across the five dimensions. Education scores the highest, almost twice as highly as Enabling Environment and RDI and Science. Articles and related audience interactions focus most on teaching and learning (of future technologies), and to a lesser extent on the results of academic research and government policy in the domain of the four technologies.

Figure 111: Turkey's Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

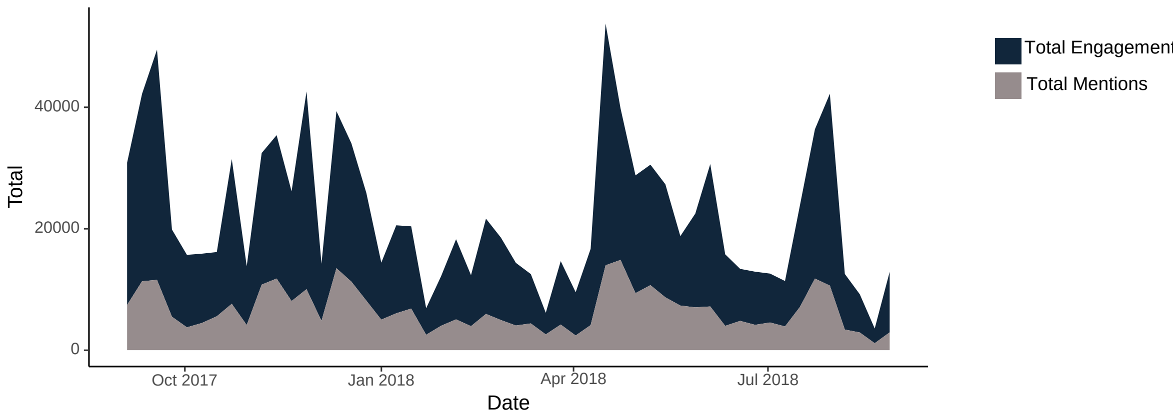


Turkey's level of interest in Future Skills

The volume of online activity in Turkey within Future Skills is lower in comparison to online activity relating to the four technologies. In Turkey, online activity in future skills presents an average value of 6,646 mentions and 15,566 instances of engagement per week, with respective median values of 5,528 and 12,863. The two series show a strong degree of co-movement (0.89 coefficient of correlation), suggesting an important role of major events in driving online activity in the country. Engagement and mentions display relatively low volatility,[99] pointing to the existence of a consistently high level of online activity across time surrounding the Future Skills field.

Here too, Education is the principal dimension of interest, followed closely by RDI and Science, Economy and Enabling Environment.

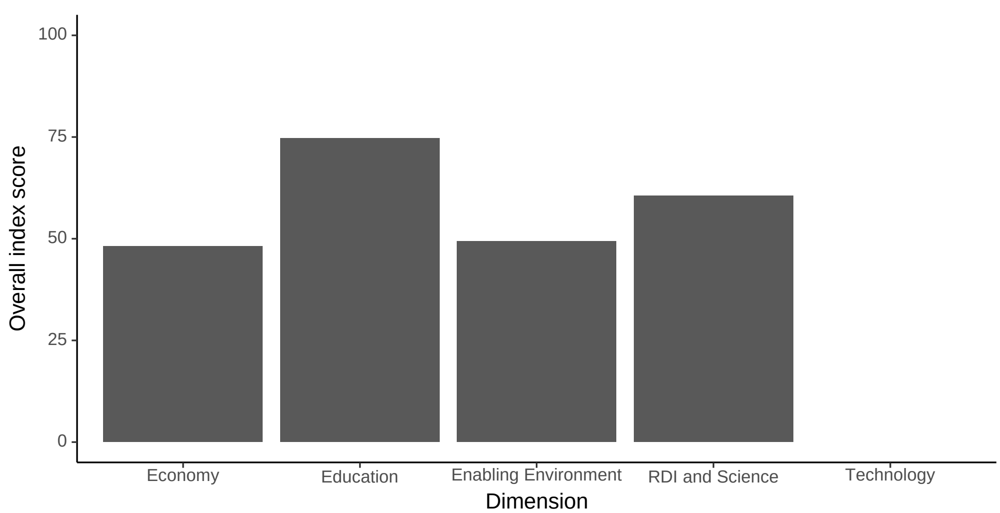
Figure 112: Volume of discussions and engagement level associated with Future Skills in Turkey (Sept 2017 - Sept 2018)



The primacy of Education within Future Skills relates to the education crisis that Turkey is currently facing due to an immense shortage of teachers. Online activity touches on three key facets of the current deficit, which suggests an overall good level of public awareness. Currently, excessive bureaucracy impedes the swift appointment of new teachers. The aftermath of the 2016 purge, following the attempted coup, exacerbates the current situation. The current system of appointment fails to address geographic asymmetries, as Ankara and the eastern province of Tunceli have an excess in teachers, while southeast provinces experience profound shortages.

Despite events in the field of Education in Turkey, the online community presents a fairly balanced level of awareness across the knowledge dimensions with the exception of Technology. This suggests that the development of Future Skills is still associated with traditional education systems that place less attention on the use of data lakes, robotics, augmented reality and novel learning methods (among others).

Figure 113: Turkey's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



Turkey's strengths and areas for improvement

Both levels of analysis (across and within countries) show that Future Skills is an important concern among Turkish Internet users. However, for the current level of awareness to translate into labour market readiness, it will be essential for the government to address successfully the concerns of the online community. Moreover, within the Future Skills field, despite the overall high level of readiness in the country, it is essential to effectively raise readiness in relation to the Technology dimension. Familiarity with data storage, sharing and analysis techniques will be essential in securing a smooth transition of the labour market to an Industry 4.0 mode of production.

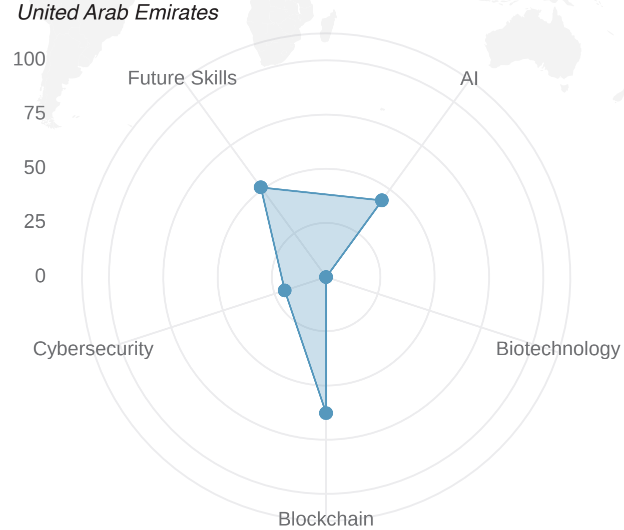
Finally, significant room for improvement remains in terms of raising the overall level of readiness in Turkey relating to the four technologies. As the experience of other countries suggests, hosting major international events, together with a coordinated strategy aimed at accommodating public sector upskilling/investment in new technologies, are steps in the right direction.

18 UNITED ARAB EMIRATES

GDP per capita **$40,699** 2017 | HDI **0.863** 2017 | GKI (rank) **25** 2017 | **2221** unique authors per million Internet users

The United Arab Emirates online community presents a rather skewed image in terms of Future Field Readiness Indices. Blockchain accounts for the greatest share of online activity, followed by Future Skills and AI. Cybersecurity and Biotechnology score the worst in terms of readiness. This is in line with the current strategy of the government that places a strong focus on Blockchain technology. UAE's Blockchain Strategy aims at transforming the current mode of government transactions, aiming by 2021 to perform 50 percent of transactions via Blockchain platforms.[100]

Figure 114: Future Fields Readiness Indices scores in the United Arab Emirates

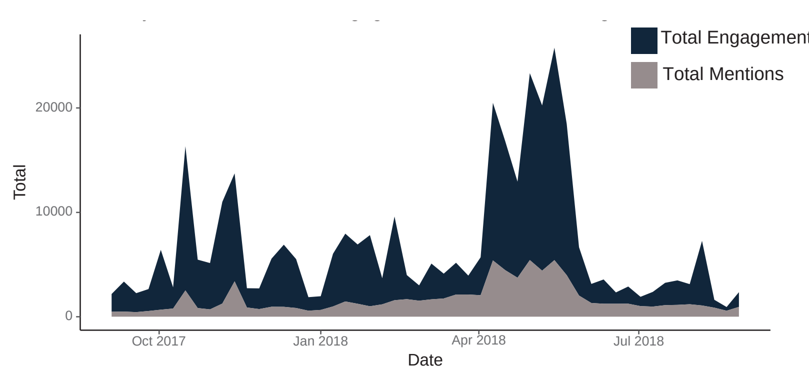


United Arab Emirates' level of interest in key technologies for the future

The volume of online activity in the United Arab Emirates within the theme of the four technologies displays an average value of 1,487 mentions and 4,500 instances of engagement per week, with respective median values of 1,069 and 2,576. The two series display a strong degree of co-movement (0.89 coefficient of correlation), which reflects high interest across the online community in major events in the field. Mentions and engagement are not strongly volatile, pointing to a sustainable level of online activity across the sampled year.

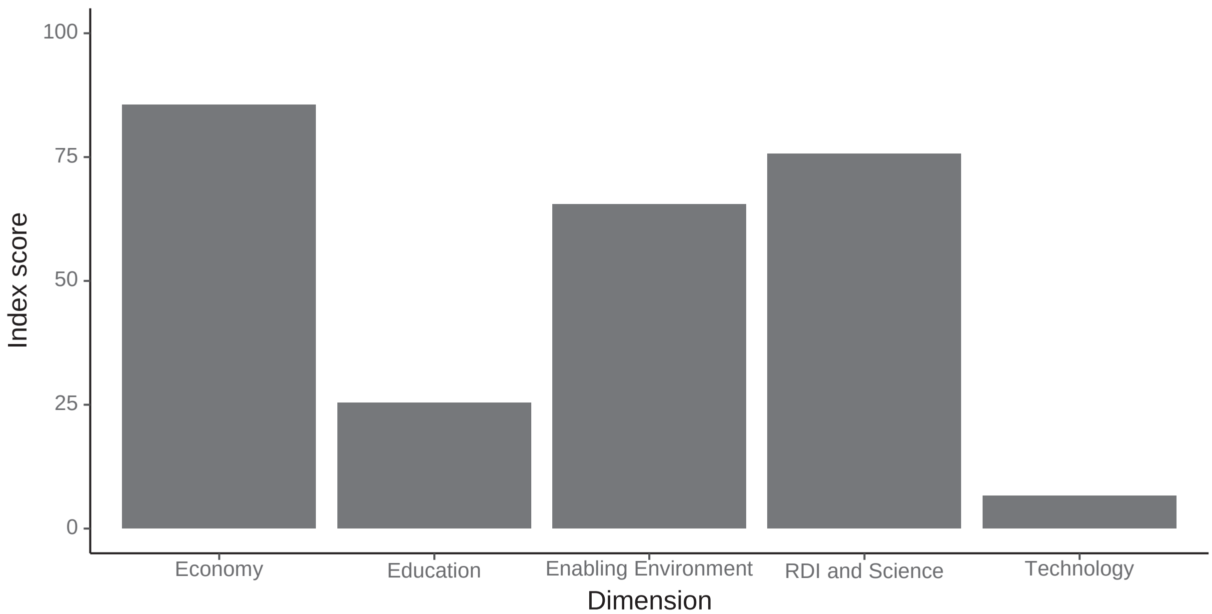
The analysis of the weekly total mentions and engagement for the four technologies reveals that the topic generates a significant volume of online activity. In the case of the United Arab Emirates, the concurrence of peaks in mentions and engagement highlights good awareness of Internet users with respect to current events and a high degree of concentration of online activity. Peaks in mentions and engagement on 13 October 2017 and 13 November 2017 refer to Artificial Intelligence, reflecting the inauguration of the Artificial Intelligence Centre in ADNOC and the appointment of Omar Al Olama as Minister of State for AI. Peaks in April and May showcase the centrality of Productivist[101] within the online population network. The smart manufacturing company accounts for 55 percent of total engagement during the months of April and May, followed by Global Reit[102] with 15 percent.

Figure 115: Volume of discussions and engagement level associated with the four key technologies for the future in the United Arab Emirates (Sept 2017 - Sept 2018)



The analysis of the GTRI for the United Arab Emirates by knowledge dimension reveals that the highest degree of readiness is attained for Economy. RDI and Science and Enabling Environment closely follow. These results reflect the salience of topics relating to cryptocurrency, the advent of new technologies and the centrality of government in new technology implementation.

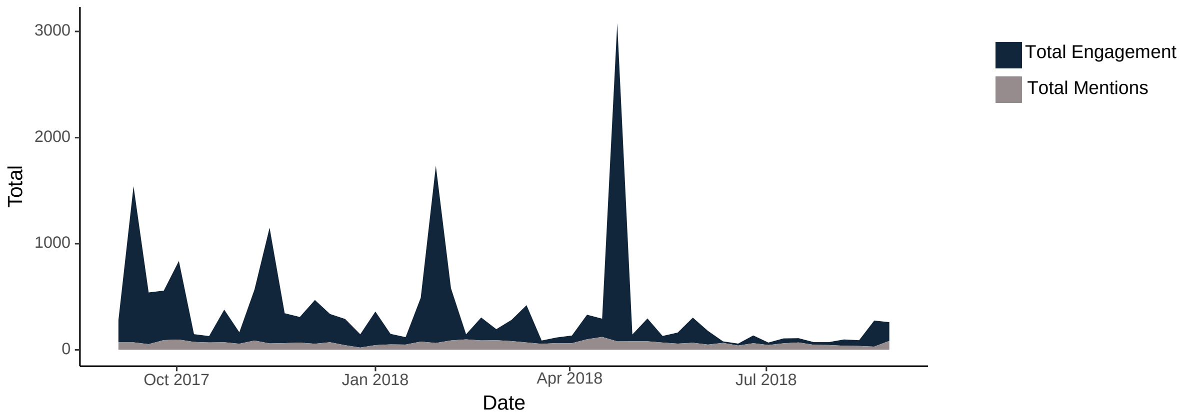
Figure 116: United Arab Emirates' Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



United Arab Emirates' level of interest in Future Skills

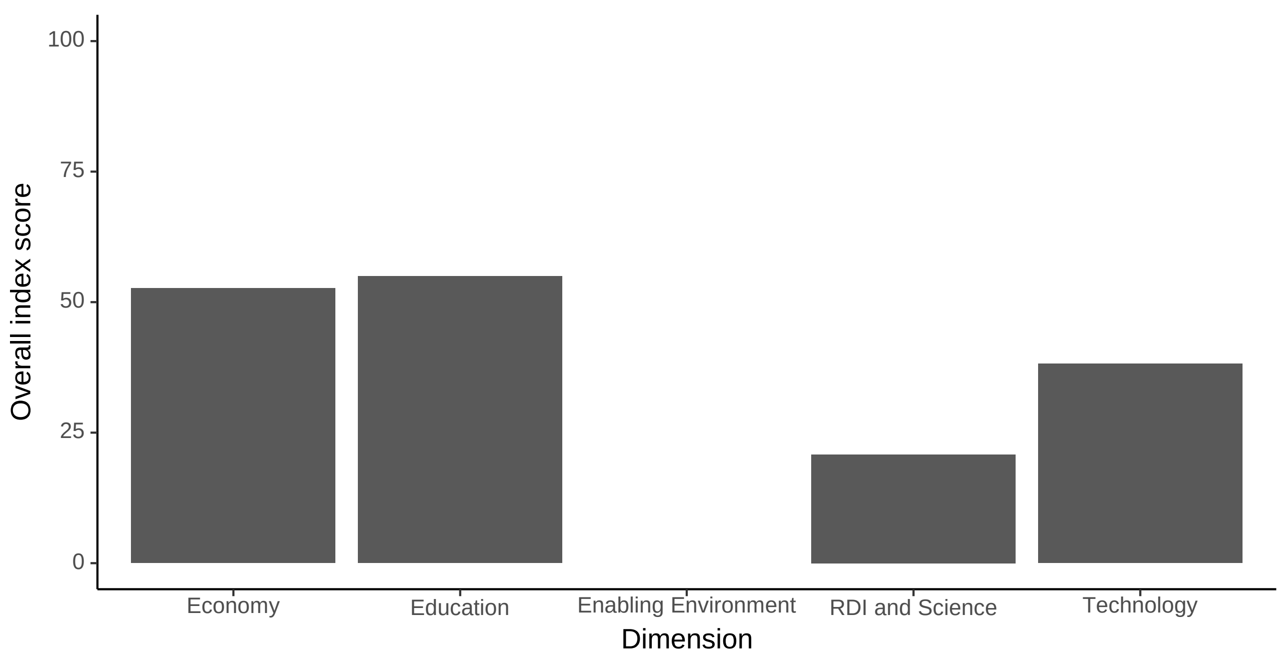
The volume of online activity in the United Arab Emirates within Future Skills is lower in comparison to online activity relating to the four technologies. In the United Arab Emirates, online activity in Future Skills presents an average value of 64 mentions and 310 instances of engagement per week, with respective median values of 64 and 172. Online content creation (publications) oscillates between 20 and 119 mentions per week pointing to a very low degree of online media responsiveness to major events in the field. 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. The two series also show a low degree of co-movement (0.17 coefficient of correlation), suggesting that major events do not drive a large volume of online activity in the country. Engagement is five times more volatile than mentions, which highlights a good level of engagement of the online community with the field, but also further supports the hypothesis that activity is driven by influential publications.

Figure 117: Volume of discussions and engagement level associated with Future Skills in the United Arab Emirates (Sept 2017 - Sept 2018)



The analysis of the United Arab Emirates Future Skills Readiness Index broken down by knowledge dimension reveals that the largest share of online activity surrounding future skills relates to access to funding and equipping the young generation with the necessary skillset for the labour market of the future. Technology and RDI and Science score significantly below the other two dimensions, while a relatively negligible amount of online activity surrounds the Enabling Environment dimension. This suggests a limited interest in the theme of technological development and research and innovation within the area of Future Skills.

Figure 118: United Arab Emirates' Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



United Arab Emirates' strengths and areas for improvement

AI and Blockchain are the two areas where the United Arab Emirates have put a coordinated action plan in place for the large-scale introduction of new technologies. This is most visible through the international comparison that section 3.1 offers, where the United Arab Emirates rank 6^{th} both in terms of AI and Blockchain readiness.

The performance of the country highlights one significant weakness. Results show that growth in readiness is significantly skewed between sectors. Most importantly, Biotechnology readiness and future fields readiness appears to remain at an infant stage as the country performs less strongly in the international comparison (section 3.1). This may result in even greater dependence on foreign countries for the supply of agricultural products and skilled labour to meet the challenges that the Fourth Industrial Revolution presents.

The analysis of the GTRI by knowledge dimension highlights the primacy of the economy within online discussions. However, readiness within the Economy dimension is almost solely located within the cryptocurrency theme – initial coin offerings and token sales. Online activity in the Economy dimension comes in stark contrast with activity in Education and Technology, where the latter are less salient but present a more complete portrait in terms of themes of discussion. Here, we observe a wide use of innovation, entrepreneurship, cybersecurity, robotics and big data hashtags.

With the goal of maintaining a narrow skills gap, the United Arab Emirates would benefit from consistent work on the weak points of the above fields/dimensions. In particular, it should invest in including its online community in the discussion surrounding public policy (Enabling Environment). The upskilling of the local workforce should ultimately contribute to a gradual reduction in skilled labour import dependency.

19 UNITED KINGDOM

GDP per capita **$39,720** 2017

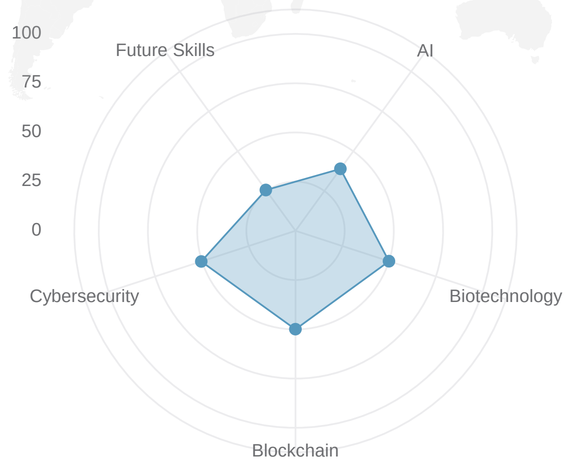
HDI **0.922** 2017

GKI (rank) **8** 2017

3367 unique authors per million Internet users

A first high-level analysis of the five Future Field Readiness Indices for the United Kingdom reveals that the country does not score equally in each of the five fields. Readiness of its online community is skewed towards Cybersecurity, Blockchain and Biotechnology.

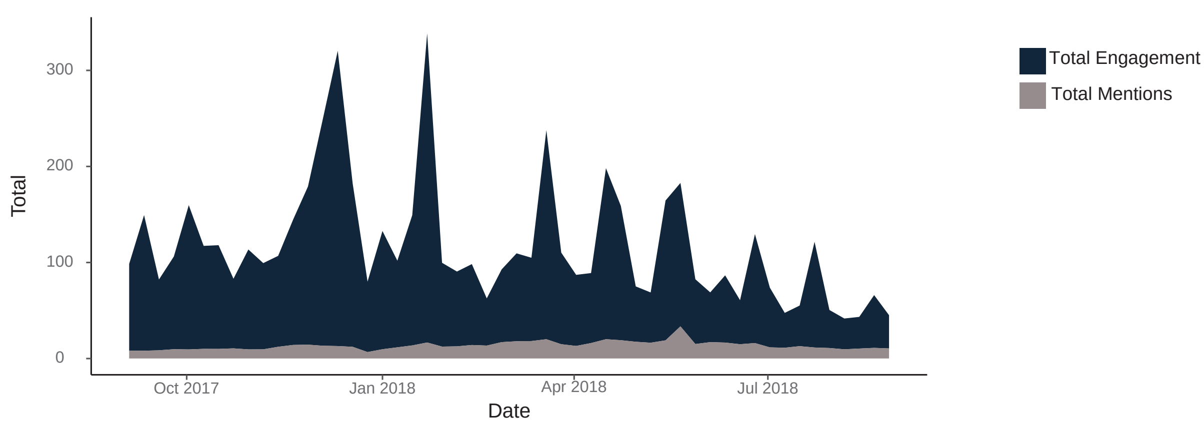
Figure 119: Future Fields Readiness Indices scores in the United Kingdom



United Kingdoms' level of interest in key technologies for the future

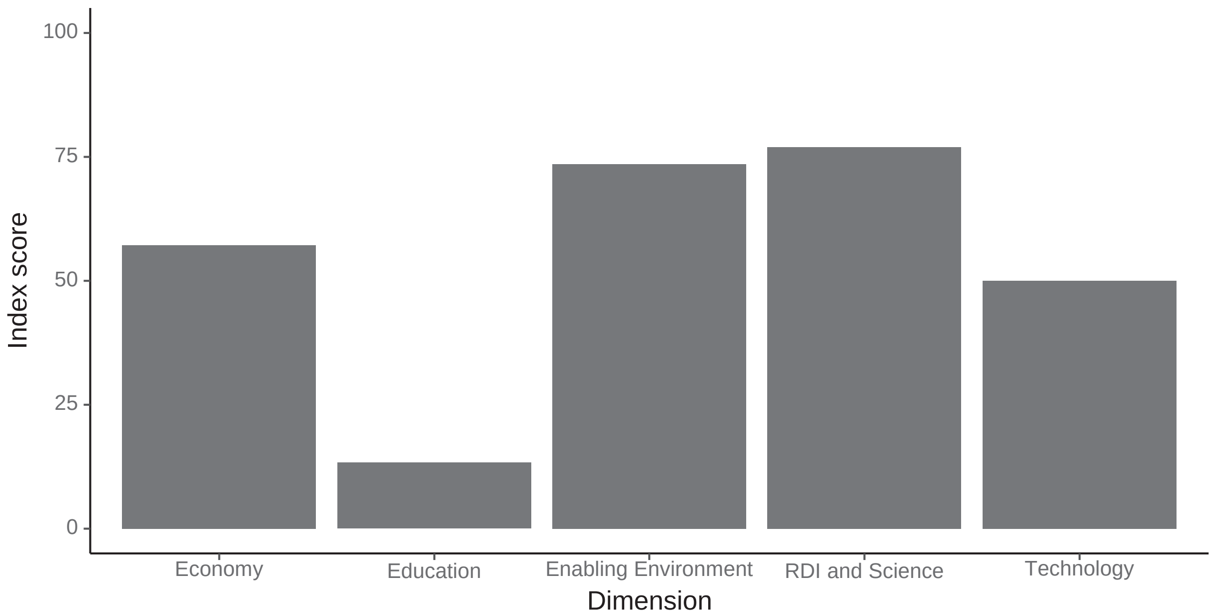
The volume of online activity in the United Kingdom within the themes of the four technologies displays an average value of 12,694 mentions and 92,688 instances of engagement per week, with respective median values of 12,058 and 79,166. The low degree of skewness, coupled with the high volume of online activity, underscores the centrality of the country within the global information dissemination network. Despite the low degree of co-movement (0.29 coefficient of correlation) that the two series show, qualitative analysis of the data indicates that events play an important role in driving variation in mentions. However, the centrality of the country within the global information network together with the use of English (lingua franca effect) as a language of publication, strongly encourage foreigners to engage with the content; local events may influence engagement from abroad, thereby driving down the correlation between mentions and engagement for the United Kingdom. In terms of volatility, we observe that the volume of both mentions and engagement oscillates closely to the respective mean, highlighting the existence of a robust core of online activity across the sample period.

Figure 120: Volume of discussions and engagement level associated with the four key technologies for the future in the United Kingdom (Sept 2017 - Sept 2018) (expressed in thousands of observations)



Dissecting the GTRI into the composite knowledge dimensions, we observe that issues relating to RDI and Science, together with government intervention and the existing legal framework, account for the majority of online activity around the four future technologies. Economy and Technology dimensions are also debated online, suggesting a keen interest in the access to funding, entrepreneurship and ICT applications. Education is the only dimension that scores significantly below the five - dimension average, six times below the highest score.

Figure 121: United Kingdom's Global Technology Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



United Kingdom's level of interest in Future Skills

The volume of online activity in the United Kingdom within Future Skills is significantly lower in comparison to online activity relating to the four technologies. In the United Kingdom, online activity in Future Skills presents an average value of 1,728 mentions and 14,899 instances of engagement per week, with respective median values of 1,480 and 11,197. Unlike the results for the four technologies, here the two series show an average degree of co-movement (0.42 coefficient of correlation). This may reflect a higher interest of local audience in the theme (compared to international audiences), which can be due to the high interest of the United Kingdom online community in the debate on teacher shortages. Engagement and mentions display relatively low volatility, which, together with the size of the mean values, points to the existence of a consistently high level of online activity across time surrounding the Future Skills field.

Future Skills - Education accounts for the greatest share of total engagement, which points to the importance that the online community attributes to the local education system for the development of the necessary Future Skills. Key areas of interest include the results of the National Student Satisfaction Survey, which invites students across the country to express their level of satisfaction with tertiary education as well as the debate between the incumbent government and the national teachers' union on: i) the recruitment and retention crisis ii) and, cuts in public spending on education.

Figure 122: Volume of discussions and engagement level associated with Future Skills in the United Kingdom (Sept 2017 - Sept 2018)

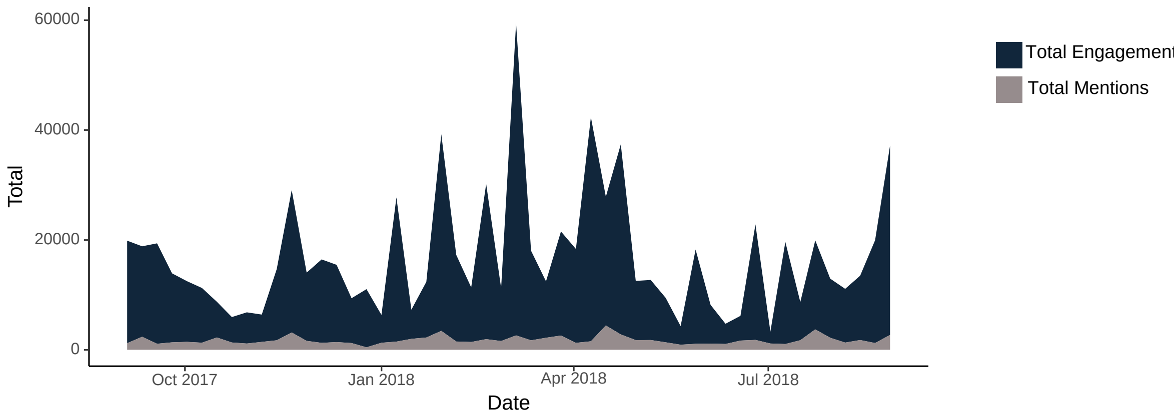
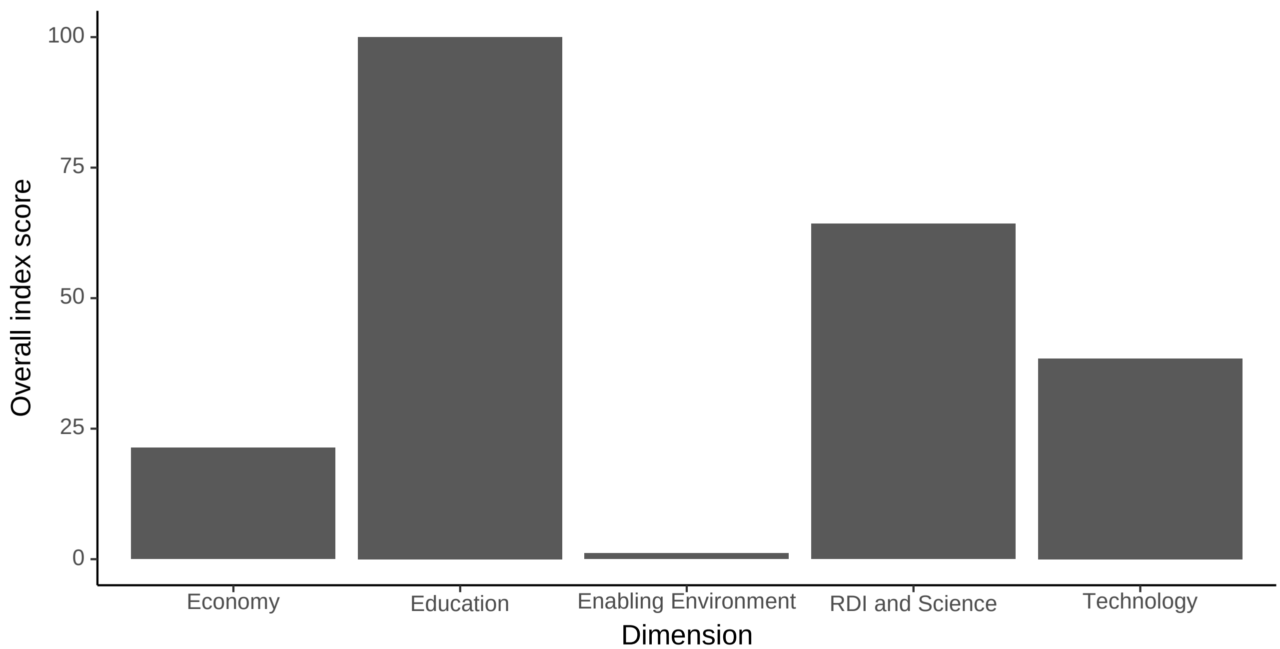


Figure 123: United Kingdom's Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



United Kingdom's strengths and areas for improvement

Biotechnology, Blockchain and Cybersecurity are the fields that generate the most online activity within the country. Drawing from the international comparison that section 3.2 provides, the United Kingdom is among the top five performers for each of the four Technologies. World-class universities and research centres, frequent international events and a vibrant private sector situated within a welcoming enabling environment contribute to the high performance of the country in terms of technological readiness.

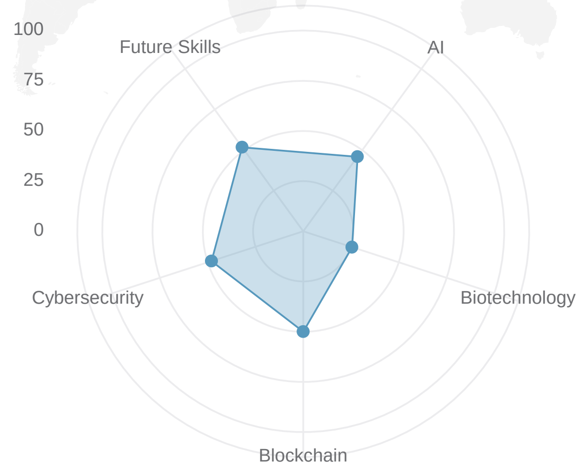
The path to maintaining a narrow skills gap is through education. The resolution of the education crisis is central to ensuring that coming generations in the United Kingdom are well equipped to embark on tertiary education and successfully integrate into the labour market of the future. The salience of the topic in online discussions is a positive sign, suggesting that the public is aware of the key area for improvement that this report identifies.

20 UNITED STATES

GDP per capita **$59,532** 2017 | HDI **0.924** 2017 | GKI (rank) **6** 2017 | **11,329** unique authors per million Internet users

The analysis of the five Future Field Readiness Indices for the United States suggests that the online community spreads its attention equally between AI, Cybersecurity, Blockchain and Future Skills. Biotechnology readiness is comparatively limited. However, this is not necessarily a cause for concern. The lower salience of Biotechnology is in line with both the overall results outlined in section 1.2 and the Gartner hype cycle where major Biotechnology applications are positioned far away from the peak of the cycle, which the literature associates with a greater degree of public interest.

Figure 124: Future Fields Readiness Indices scores in the United States

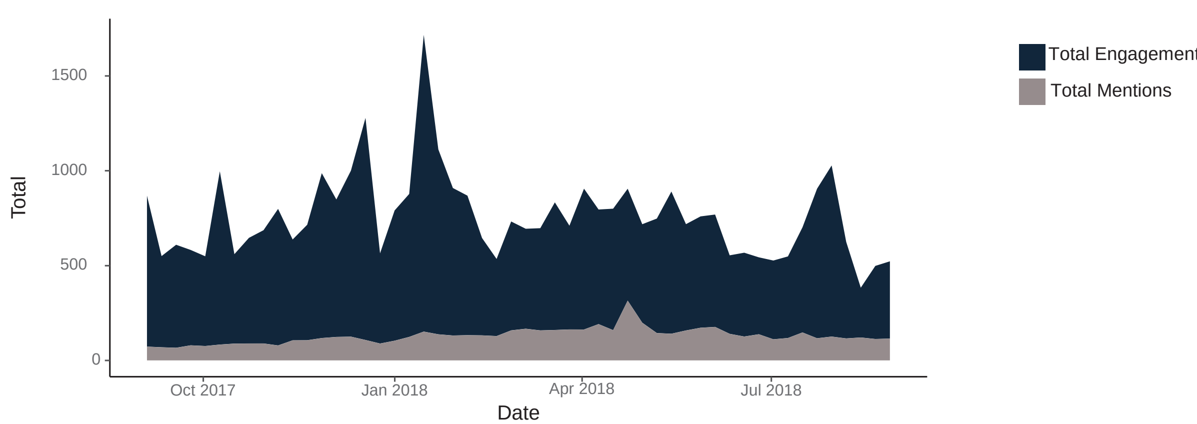


United States' level of interest in key technologies for the future

The volume of online activity in the United States within the themes of the four technologies displays an average value of 119,339 mentions and 546,554 instances of engagement per week, with respective median values of 115,456 and 507,730. The two series show a zero degree of co-movement. Both mentions and engagement display a high value of average activity and a small degree of volatility, which underscores the existence of a robust core of online activity across the sample period for the United States.

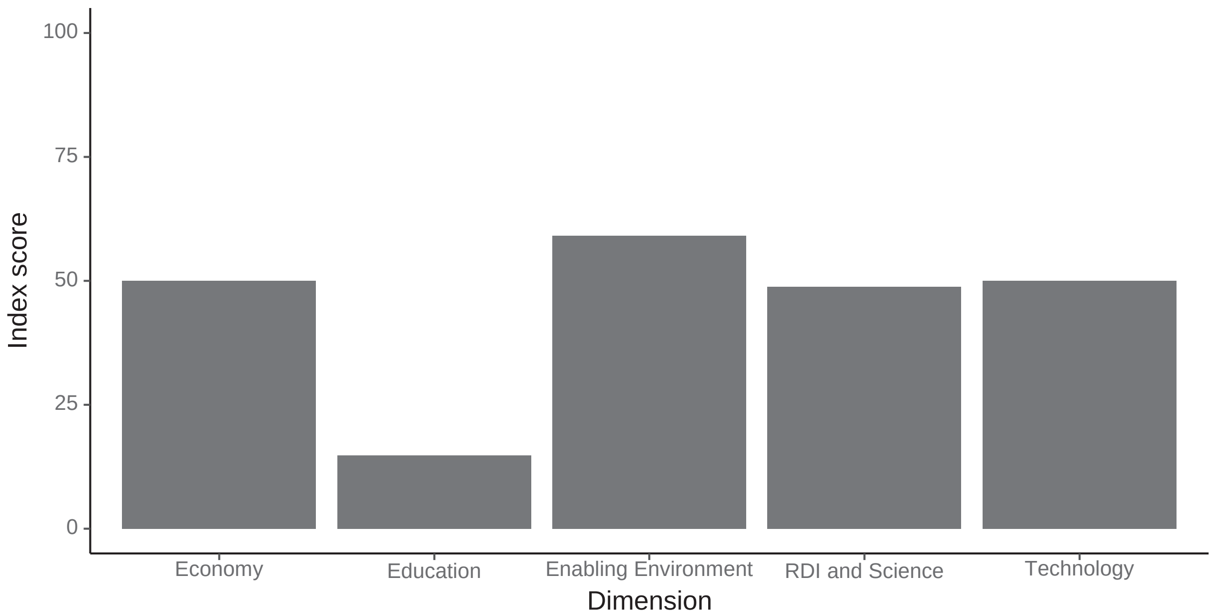
Blockchain discussions account for the spike in online activity after January 2018, where we identify as a key culprit an article on the new business opportunities that Blockchain technologies create for firms active in the field of Cybersecurity.[103]

Figure 125: Volume of discussions and engagement level associated with the four key technologies for the future in the United States (Sept 2017 - Sept 2018) (expressed in thousands of observations)



A shift in perspective of analysis from technologies to knowledge dimensions (Figure 120) reveals that the Enabling Environment, within which technologies are deployed, generates the highest volume of online activity in the United States; the Economy, RDI and Science and Technology follow closely. These results reflect a relatively lower level of technological readiness relating to the educational dimension.

Figure 126: The United States Global Technology Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)

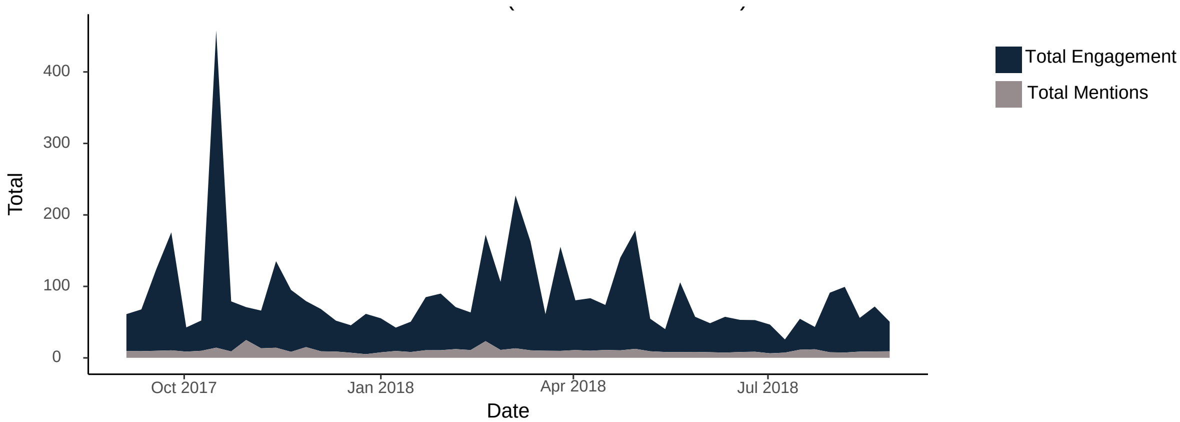


United States' level of interest in Future Skills

The volume of online activity in the United States within Future Skills is lower in comparison to online activity relating to the four technologies. In the country, online activity in Future Skills presents an average value of 9,970 mentions and 78,208 instances of engagement per week, with respective median values of 9,336 and 54,640. The two series show a low degree of co-movement (0.33 coefficient of correlation). Both mentions and engagement display a high value of average activity and a small degree of volatility, which underscores the existence of a robust core of online activity across the sample period for the United States.

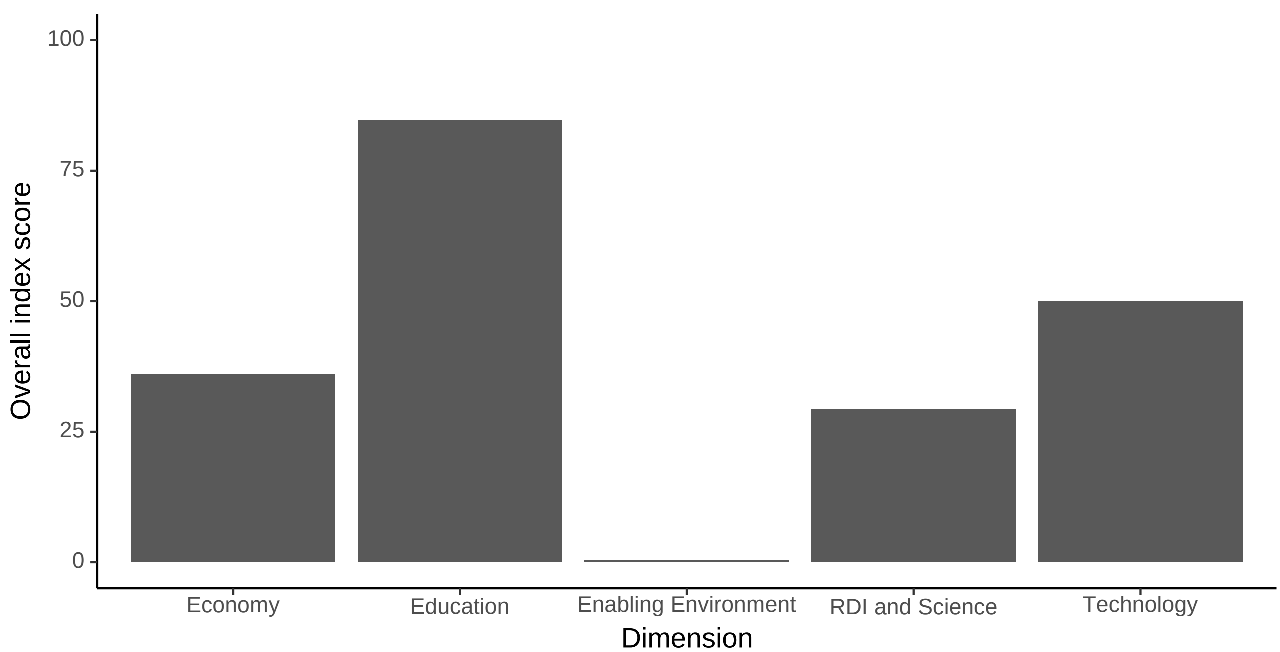
The field of Future Skills generates a very high volume of online activity. Education is the knowledge dimension that predominates within the Future Skills theme in respect to both mentions and generated engagement. During the period of analysis, we observe one notable spike in online activity. This links to a publication from the Bill and Melinda Gates foundation on the investment activities of the foundation and its impact on high school education.[104]

Figure 127: Volume of discussions and engagement level associated with Future Skills in the United States (Sept 2017 - Sept 2018) (expressed in thousands of observations)



Education scores the highest among the five knowledge dimensions in the United States, highlighting the perceived importance of the dimension for the development of skills necessary for the labour market of the future. Economy, RDI and Science and Technology score significantly lower, while the relatively infinitesimal volume of activity in Enabling Environment may point to the lower perceived importance of government strategy with respect to the development of Future Skills during the sampled period.

Figure 128: The United States Future Skills Readiness Index broken down by knowledge dimension (Sept 2017 - Sept 2018)



United States' strengths and areas for improvement

The United States is one of the top performing economies, displaying a high degree of readiness across all five future fields. The high level of readiness among the United States online community is in line with the position of the country as a pioneer in terms of RDI and Science. Places such as San Jose-San Francisco, San Diego, and Boston-Cambridge make up the top ten innovation hotspots of the world.[105]

In particular, the high volume of engagement activity in the country could suggest that i) the United States online community is in tune with major events and the latest development within the future technology theme, and ii) the United States online community functions as one of the epicentres for the dissemination of information in the field.

We identify Education as an area for improvement when looking at the key technologies for the future. Online discussions around technologies place particularly little attention on education. In addition, not much online activities happen at the intersection between Enabling Environment and Future Skills, suggesting that the Enabling Environment is another area for improvement for the country when it comes to future skills. Both weaknesses may adversely impact the speed of technological adoption and widen the skills gap in the country over the near future.

3

ENDNOTES

1. Gartner, 2018.
2. Controversial figures such as Jair Bolsonaro may allow for a higher degree of persistence of the "election effect" on results.
3. ASGARD, July 2017.
4. Bashir, 12 November 2017.
5. Alfaham and Bashir, 24 February 2018.
6. International Telecommunication Union, 2017.
7. Singapore International Cybersecurity Week, 2018.
8. Symantec Corporation, 2018.
9. Within the field of genomics, Project Shivom, a company that employs Blockchain technology for the safe and personalized storage of DNA information, is increasingly capturing the attention of the community.
10. Cornell University, INSEAD and WIPO, 2018.
11. Lucht, 2018.
12. USDA Foreign Agricultural Service, November 2017.
13. World Blockchain Conference, 2018.
14. World Blockchain Summit, 2018.
15. Asia Blockchain Summit, 2018.
16. Blockchain Leadership Summit, 2018.
17. Crypto Currency Chart, 2018.
18. The Economist Intelligence Unit, 2017.
19. For the calculation of volatility, we take into consideration the ratio of standard deviation over the mean.
20. Souza, 2017.
21. Globo, April 2018.
22. Flores, March 2018.
23. Al Gassabi, 2018.
24. Clemence, 2017.
25. American University in Cairo, November 2018.
26. Apu, April 2018.
27. Ilta-Sanomat, April 2018.
28. Finland currently still upholds military conscription for all male citizens aged 18-30. Men have the choice between a 6 to 12 months enlistment, a civil service position, or jail.
29. World Economic Forum, November 2016.
30. Volatility of mentions and engagement display similar values.
31. Bernard, January 2018.
32. Köppe, January 2018.
33. Ahmad, November 2017.
34. The Asian Age, 22 May 2018.

35. Gandhi, 2018.
36. Hindustan Times, March 2018.
37. Taneoka, June 2018.
38. The Mainichi, November 2017.
39. YahooNewsTopics, 2018.
40. The Mainichi, October 2017.
41. Hala Akhbar, August 2018.
42. Al Abed, September 2017.
43. Dupire, January 2018.
44. All Conference Alert, 2018.
45. Gharbaoui, November 2017.
46. Coinnounce, June 2018.
47. Morocco World News, October 2017.
48. 5Pillars, October 2017.
49. Vilner, October 2018.
50. Kan and Eekelen, November 2017.
51. RTL Nieuws, February 2018.
52. Bizimungu, October 2017.
53. University of Rwanda, May 2018.
54. The New Times, May 2018.
55. Freedom House, 2017.
56. United Nations Development Programme and Mohammed Bin Rashid Al Maktoum Knowledge Foundation, 2017b.
57. See: https://vision2030.gov.sa/en
58. Cuthbert, October 2017.
59. We observe 974 Twitter shares, 7,200 Facebook shares and 955 LinkedIn shares.
60. Abid and Hameed, August 2018.
61. Kopf, August 2018.
62. Ibid.
63. Abid and Hameed, August 2018.
64. Previously, the record was held by India.
65. Blockchain in Healthcare Summit 2018.
66. Crypto Investment & Blockchain Tech 4.0.
67. ICOholder, 2018.
68. Misk Global Forum, 2018.
69. Wilcox, October 2017.
70. Financial Times, April 2018.
71. Reporters Without Borders, October 2018.
72. See: https://aelf.io
73. Sen, May 2018.
74. Meng, November 2017.
75. World Bank Group, 2018.

76. United Nations Development Programme and Mohammed Bin Rashid Al Maktoum Knowledge Foundation, 2017b.
77. Skills Panorama, April 2017.
78. Rathod, April 2018 and Börsvärlden, 2018.
79. See: https://www.syscoin.org
80. Programming Blockchain interactive 2-day seminar.
81. Anttila, August 2018.
82. Boström, October 2017.
83. UKÄ/Swedish Higher Education Authority, March 2018.
84. Dagens Nyheter, December 2017.
85. Dagens Nyheter, July 2018.
86. Ericson, November 2017.
87. Fondation Botnar, 2018.
88. Ewalt, October 2018.
89. Wavestone, 2017.
90. Cornell University, INSEAD and WIPO, 2018.
91. DAI, 2017.
92. Ng'wanakilala, February 2018.
93. Odhiambo, January 2018.
94. Machira, May 2017.
95. See: http://thelaunchpad.or.tz/
96. European Training Foundation, November 2014.
97. Blockchain & Bitcoin Conference Turkey, Istanbul, March 2018.
98. See: https://www.ecosia.org/search?q=penny+stocks+turkey
99. For both mentions and engagement, standard deviation is half the size of the respective mean.
100. UAE Government, May 2018.
101. Productivist, 2018.
102. See: https://globalreit.io/
103. Kharif, January 2018.
104. Gates, October 2017.
105. World Intellectual Property Organization, December 2017.

4 CONCLUSION

4. CONCLUSION

We live in a time of transition, opportunity and uncertainty. The exponential growth and ubiquity of knowledge has led to change so rapid and so profound that it has radically altered the way we live, learn and work. Being the single most important and universal driver of innovation, competitiveness and growth, we require new methods, frameworks and tools to better understand the future of knowledge.

The results of Chapter 3 demonstrate how policymakers, business leaders, education institutions, international organizations and communities should be alert to new emerging topics that may become strategically significant for nations. It is reassuring that all the countries analysed in this report have initiated processes to explore emerging strategic topics. Nevertheless, turning change into opportunity still requires tremendous effort. Most of the countries surveyed have yet to develop a strategy to establish the foundations for creating new knowledge opportunities for future generations. This is the goal of this chapter, which presents a framework for building and implementing a future knowledge strategy. This framework, which we refer to as the 'knowledge future navigation framework', entails two components:

- The *future knowledge strategy*; and
- The *future knowledge development toolkit*.

4.1 The future knowledge strategy

4.1.1 Understanding the multidimensional nature of our knowledge future

Shaping our Knowledge future requires understanding what this future will entail. There is a need for a clear definition of our knowledge future, expressed in unambiguous and concrete terms, to allow for the design and operation of detailed action plans and related activities. Therefore, we suggest the following definition:

Our Knowledge future	=	issues and demands associated with our Knowledge future	+	future fields of knowledge	+	future knowledge dimensions	+	future knowledge creators

- **Issues and demands associated with our Knowledge future:** this refers to the problems that must be solved and solutions that must be developed to create the knowledge needed to tackle future societal challenges. The need for increased upskilling and stronger social capital are examples of such issues and demands.

- **Future fields of knowledge:** these comprise technologies and skills that can help build solutions to solve future societal challenges.

- **Future knowledge dimensions:** this refers to the framework conditions (financial, industrial, market, cultural, knowledge, regulatory and support)[1] necessary for the development of future knowledge fields.

- **Future knowledge creators:** the knowledge creators of the future will require an environment where learners successfully interact to help create and transform knowledge into new ideas and innovations for the benefit of society. Key to the successful implementation of this process is the redefinition of the principles that guide the education system in a way that caters for the new realities of perpetual learning.[2]

Based on this definition, countries can choose to vary their focus between different fields when building their future knowledge strategies, while retaining a holistic, anticipatory and inclusive approach. They may, for example, seek to develop answers to the following questions:

- What is the common foundation of the knowledge we want to build?
- What are the challenges related to our knowledge future?
- Who are our knowledge creators and knowledge providers?
- What are the key enablers of our knowledge future?
- What is missing and what must come next?

4.1.2 Transforming into leaders of the future

The leaders of the future will need to embrace the importance of knowledge-intensive business services. Technology will increase the dependency of modern employment structures on a workforce that is up to date with recent developments in what we define in this report *as key technologies for the future* – AI, Cybersecurity, Biotechnology, Blockchain, etc. – and possess a good command of relevant social, emotional and cognitive skills. The leaders of tomorrow will need to redefine the necessary industries and skills required to keep pace with technological developments and develop a concrete strategy for the future that ensures sustainable growth and institutions. The absence of such a strategy may lead to countries incurring significant opportunity costs that undermine their national welfare. Thus, raising awareness among leaders of the strategic importance of future technologies, industries and skills will represent a critical factor in achieving sustainable growth at the global level and successfully meeting ambitious targets such as the SDGs.

The leaders of the future will function as the navigators of our societies. They will need to understand their current *position*, define their *direction* of travel and provide the required impetus to attain the requisite *speed* of transformation.

- **Position:** leaders will need to encourage continuous independent assessments of the knowledge position of their countries. This will involve understanding the development trajectory that a nation has followed in accordance with key variables and desired end-goals. This will determine the position of each country on the knowledge continuum, thereby indicating its distance from the objective and illustrating areas for improvement.

- **Direction:** the leaders of the future will need to indicate the direction of development and identify the purpose of the country's timeline of technological uptake. The communication of the purpose is central to the process of successful upskilling, as it sets the scene for sustainable investment in education at a very granular level, through basic self-motivation.

- **Speed:** leaders will need to determine the optimum speed of technological uptake based on existing infrastructure and socioeconomic fundamentals.

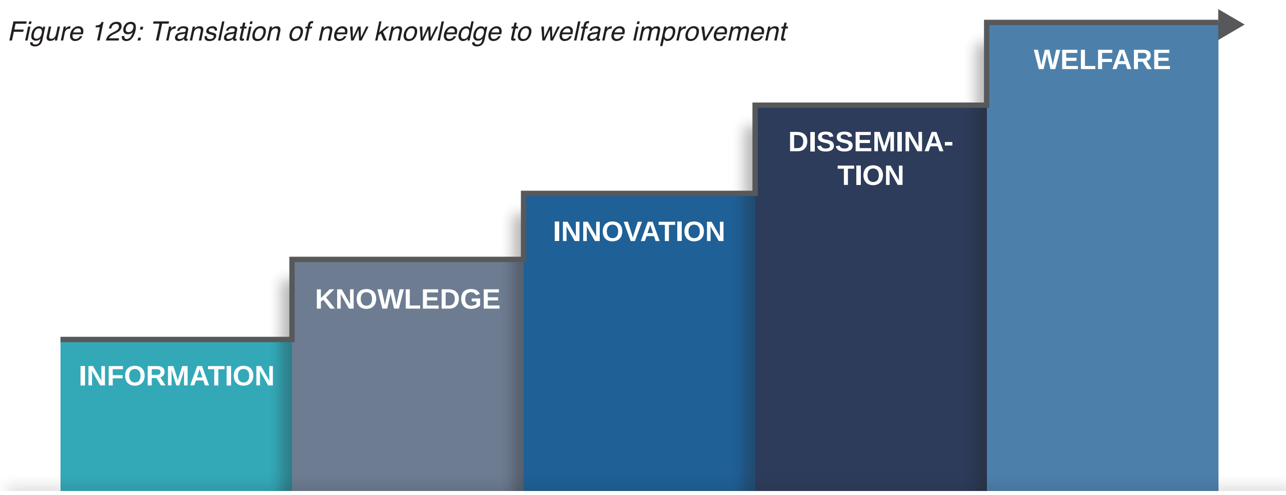
We identify research and development, education and vocational training as key focus areas in this process, and support the supposition that research-led policy will help to best optimise the use of physical, human and social capital. We also underscore the benefits of interdisciplinary analysis and the promotion of synergies across industries.

4.1.3 Establishing a vision for our knowledge future

Establishing a vision for a nation's Knowledge future is a forward-looking exercise that helps to define a common foundation for future development. A concrete vision will successfully foster collective action for the attainment of shared goals by successfully anticipating technological change, setting feasible objectives, drawing on best practices and including a broad section of the population in the transformation process.

The importance of adopting an inclusive approach to transformation stems from the multiplier effect of network dynamics in translating new knowledge into large-scale welfare improvements. The graphic below shows a simple blueprint of a technology adoption process that begins with random pieces of information and results in welfare improvement. In the real world, we observe a complex web of similar staircase crossing at different points as agents actively interact with one another.

Figure 129: Translation of new knowledge to welfare improvement



4.1.4 Choosing an integrated strategy

The next step concerns the means by which a country intends to realize its vision. It seems prudent to begin with an assessment of the current knowledge ecosystem[3] and an exploration of the possibilities for the Knowledge future. This assessment should necessarily include three levels of analysis corresponding to the three types of human needs identified by Maslow:[4] basic (i.e. physiological and safety); psychological (i.e. social and esteem); and self-fulfilment. Based on this assessment, a compelling vision of the knowledge ecosystem and value proposition is defined.

As with the smart specialization process,[5] this process is also location-specific, in that it builds on the assets and resources available to the country and on its particular challenges to identify unique opportunities for future knowledge development. It must also be a collaborative process, as the goal is to address emerging opportunities in a coherent manner while avoiding any duplication or fragmentation of efforts.

Thereafter, all stakeholders – policymakers, business leaders, education entities, international organizations and communities – may develop an integrated knowledge ecosystem concept and a strategic collaborative model that clearly lays out the roles and responsibilities of each actor. Effective ecosystem governance is also required to ensure prioritization of activities, enable fast decision-making and make the best use of investments.

4.2 The future knowledge development toolkit

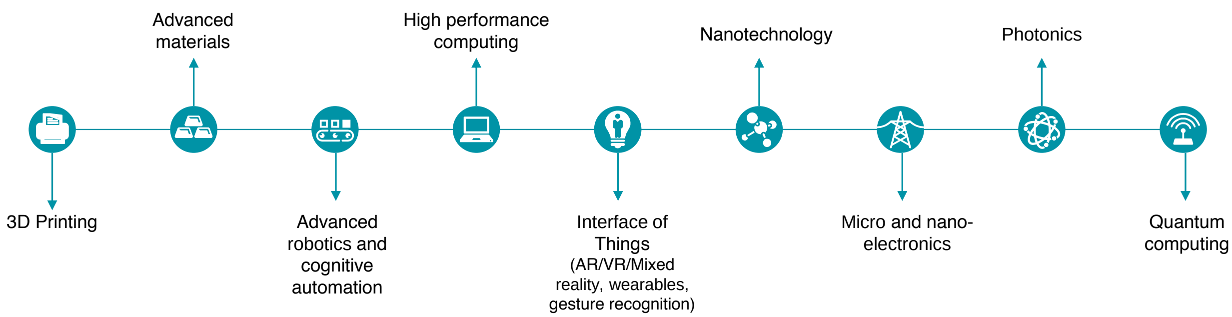
Developing and implementing a *future knowledge strategy* is a daunting task; therefore, we identify a series of models and tools to support practitioners in their endeavours.

4.2.1 Developing our foresight

One essential building block in the strategy is a deep insight into the starting position of the country to understand where it stands today. We understand this as a diagnosis of the status quo through the prism of the future; the picture we see before us should already include dimensions that will matter in that future. This is what we have sought to achieve with this report. Our future knowledge model can help countries to assess their readiness in terms of a range of fields of knowledge that we see as critical to the future based on our understanding of present trends.

The relation between present and future that we deem important when defining a country's current position has fundamental implications for the validity of the future knowledge model; e.g., although valid today, our model may not be valid tomorrow. Given the fast pace of change and the exponential growth of knowledge we are witnessing, there is a significant chance that other fields of knowledge will replace those identified in this report in less than five years (see Figure 130). Those attempting to evaluate their current position with a view to using it to navigate their knowledge future will therefore need to become masters of strategic foresight. This skill will enable national leaders to gain new perspectives on the present situation and 'learn their way into the future'. They will be able to identify what fields of knowledge will likely have the greatest impact on their (desired) future, and assure the validity of their knowledge future model by continuously aligning it with the most relevant fields of knowledge.

Figure 130: Emerging fields of knowledge



Because models of our Knowledge future must show flexibility and adaptability, the type and amount of data required, and the way we collect that data, must also change. Traditionally, we have measured our position based on a set of indicators developed at the global, regional and national levels. Data collected by statistical offices through surveys form the basis for the compilation of these indicators. We consider this approach to data collection to be ill-suited in a future context. As the last Sustainable Development Goals report illustrated,[6] the traditional approach to data collection used in monitoring is often associated with a lack of availability of data for key variables due to the poor statistical capacity of certain countries and low response rates. In addition, data collection and national reporting are time consuming and costly, which can prevent collection on a regular annual basis. These limitations call for the development of new tools and frameworks for data collection that can be adapted quickly and at low operational cost. The methodology we have used in this report goes in that direction. The data behind our future knowledge model originate from millions of data producers (i.e. Internet users) whom we accessed through one unique source (the Digital Intelligent Platform) when required.

Following an assessment carried out by the **United Nations Statistics Division in developing countries,**

only of the **40** applicable global SDG indicators **(20%)** are currently available

while another **47** global indicators **(23%)** are considered *easily feasible*

meaning that the **data source is, in principle, available**.[7]

4.2.2 Exploring and developing potential pathways to realization

Another building block of an effective strategy is an understanding of how the future may unfold. By combining insights on the present with elements of a future vision, a country may explore alternative options and ultimately decide which to pursue.

Such options are numerous, yet valuable options are few. Most will lead countries toward dead-end situations, while others will fail to follow the fastest route to their goals. Failure in selecting the right option is therefore unacceptable. Efforts are required to identify and build the dimensions of knowledge that are most critical for the future; this will allow the controlled development of key future fields of knowledge. This report has identified five key knowledge dimensions and their constituent components that require investment for the future: Education; RDI and Science; Technology; Economy; and Enabling Environment (see Table 4).

Table 4: Key knowledge dimensions

Education	RDI and Science	Technology	Economy	Enabling Environment
Courses, training, curricula	Infrastructure (e.g. think tanks, laboratories, innovation hubs	Digital infrastructure (e.g. data centers, open data, cloud computing, high performance computing)	Access to finance (e.g. bank loans, Business Angels funds crowdfunding)	Policies & strategies
	Competencies (e.g. awards, prizes, patents, mergers and acquisitions)		High-growth companies	Regulations
			Innovation partnerships	Transparent government

As for future fields of knowledge, we believe that such dimensions and their constituent components are dynamic. Macro-trends, together with the exponential growth of knowledge, are dictating the nature of the pillars of our future knowledge societies. We need to therefore find ways to better understand what awaits us and to learn to separate the true signals from the noise.

4.2.2.1 Identifying the power of weak signals

This report has identified weak signals and forerunners of change, such as the rise of the "gig economy", the explosion of "brain businesses", the growing number of social entrepreneurs and the development of pluralistic sectors. Overall, these weak signals may develop into the knowledge dimensions required to support the creation of the knowledge society we aspire to.

Those seeking to increase the readiness of their nations would do well to closely follow these weak signals and observe how they grow and evolve. They should also develop a mindset that is alert to new developments that may bring about a shift in how things are seen or done, as we believe that the weak signals we have identified are only the first in a long list. In particular, they should liberate themselves from the false precision of seeking what appear to be significant trends, as it is the weak signals that can often represent the small fringe of people who are ahead of their time and dare to think differently from the crowd.[8]

Figure 131: Weak signals and forerunners of change

Gig Economy	The gig economy – which rewards independent workers by paying them by the task or project – is by no means a new concept, but this past decade has seen it's significant expansion through the growth of new companies such as Uber and Airbnb. According to the EY Contingent Workforce Study, on average, by 2020 almost one in five US workers will be working in the gig economy – the equivalent of 31 million people.[9] Organizations and individuals will therefore need to adapt while policy-makers grapple with the policy implications of this shift.
Brain Businesses	Brain businesses are built on immaterial assets. These are manifested in the form of patents, registered trademarks or industrial designs. Research shows that investing in brain business hotspots increases chances of success. Regions with a higher ratio of brain business jobs tend to attract talent from abroad and to provide a more fertile ground for entrepreneurship and investments in new start-ups. Therefore, in order to stay ahead of the competition, governments and regions should develop brain business policies.[10]
Social Entrepreneurs	Social entrepreneurs are individuals with innovative solutions to society's most pressing social, cultural and environmental challenges.[11] Because they offer new ideas for system-level change, efforts should be taken to create an environment in which they can strive.
Pluralistic Sectors	A series of emerging industries have been identified in the 'spaces in-between' traditional sectors. These include, for example, the creative, eco, experience, maritime, mobile services, mobility, and personalised medicine industries.[12]

4.2.2.2 Benefiting from experiments and prototypes

Once countries have observed these weak signals and understood their potential value, they should seek to harness their power. A step towards converting weak signals into new ideas is to develop and apply experiments. For example, a group of people with different backgrounds from different functional areas are brought together in a start-up-friendly framework, insulated from the short-term pressures of the core businesses to experiment patiently, distil and scale up disruptive ideas.[13]

Another avenue is prototyping. Prototyping implies creating something that is the first of its kind and is prone to risk. This process is therefore often conducted in "safe" spaces, which range from research laboratories for testing scientific theories to policy labs for bringing innovation to policy-making or "living labs" for testing concepts in real life communities and settings. Those countries that can find a way to convert weak signals into opportunities before these become mainstream – and therefore become visible and known to all – will be the first ones to realise their goals.

Figure 132: Laboratories of the future

Gran Sasso National Laboratory, **Italy**	Nearly 1.5 kilometres beneath an Italian mountain range, in one of the least radioactive places on earth, physicists are seeking to isolate particles known as WIMPs that they believe hold the universe together.[14]
BLOXHUB, **Denmark**	BLOXHUB is a non-profit organization that strives to find solutions to the challenges associated with global urbanisation and climate change based on new means of collaboration.[15]
Wise Place, **Japan**	Wise Place is an ecosystem of continuing innovation that includes three locations for creating and accelerating innovation: the Future Center; the Innovation Center; and the Living Lab.[16]
EU Policy Lab, **Belgium**	The EU Policy Lab is a physical space designed to foster creativity and engagement in order to develop interactions, processes and tools that can help bring innovation to European policy-making.[17]

4.3 General conclusion

The revolutionary times we are living in constitute a great opportunity for visionary leaders – policy-makers, business leaders, training providers and individuals – to realize the benefits of the fields of knowledge that will shape the society, economy, science and the education of tomorrow.

However, the road ahead is not an easy one. As we have outlined in Chapter 4, visionary leaders will need to become experts in strategic foresight, conduct visionary exercises, engage in experimentation and prototyping and develop flexible monitoring tools for leading and coordinating the process of future knowledge development. Luckily, the many new technologies that are emerging at present can help us to develop solutions that support leaders in carrying out these new tasks. Our monitoring approach, based on big data collected through a single Digital Intelligent Platform, is one example of such a solution, but there are many other technological tools and products being developed by creative individuals, start-ups and companies that may be leveraged. All we need to do is put our future in focus, and be open and collaborative, to build collective new knowledge and develop our learning to acquire new skills.

4

ENDNOTES

1. European Cluster Observatory, December 2012.
2. Organisation for Economic Co-operation and Development, 2018.
3. We understand knowledge ecosystem as dynamic knowledge-intensive environments in which a wide range of actors – e.g. individuals, companies, organizations, education entities – interact with one another to create value by delivering the best knowledge outputs possible (knowledge products and services).
4. Kaur, 2013.
5. See: http://s3platform.jrc.ec.europa.eu/home
6. United Nations Department of Economic and Social Affairs, June 2018.
7. Ibid.
8. Watson, January 2018.
9. EY, 2016.
10. Fölster and Sanandaji, October 2017.
11. Ashoka, n.d.
12. European Cluster Observatory, July 2012.
13. Govindarajan, May 2016.
14. McKie, November 2012.
15. See: https://bloxhub.org/about
16. See: http://www.futurecenteralliance-japan.org/innovation/wiseplace
17. See:https://blogs.ec.europa.eu/eupolicylab/about-us

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