DIGITAL MEGATRENDS

A perspective on the coming decade of digital disruption

June 2019 update

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ABOUT THIS REPORT
This is the June 2019 update of research into digital megatrends by Data61 Insights. The previous version was published just over one year ago in May 2018. Some of the content is identical. But significant parts of the report and narrative have changed due to rapid advances in digital technologies and their application and impact. We hope to keep this material up-to-date and will aim to release updates when things have changed.

ACKNOWLEDGEMENTS
The authors express gratitude to the hundreds of people who have attended our conference presentations, seminars and other public speeches. Your questions and suggestions have enriched our thinking and told us about what matters.

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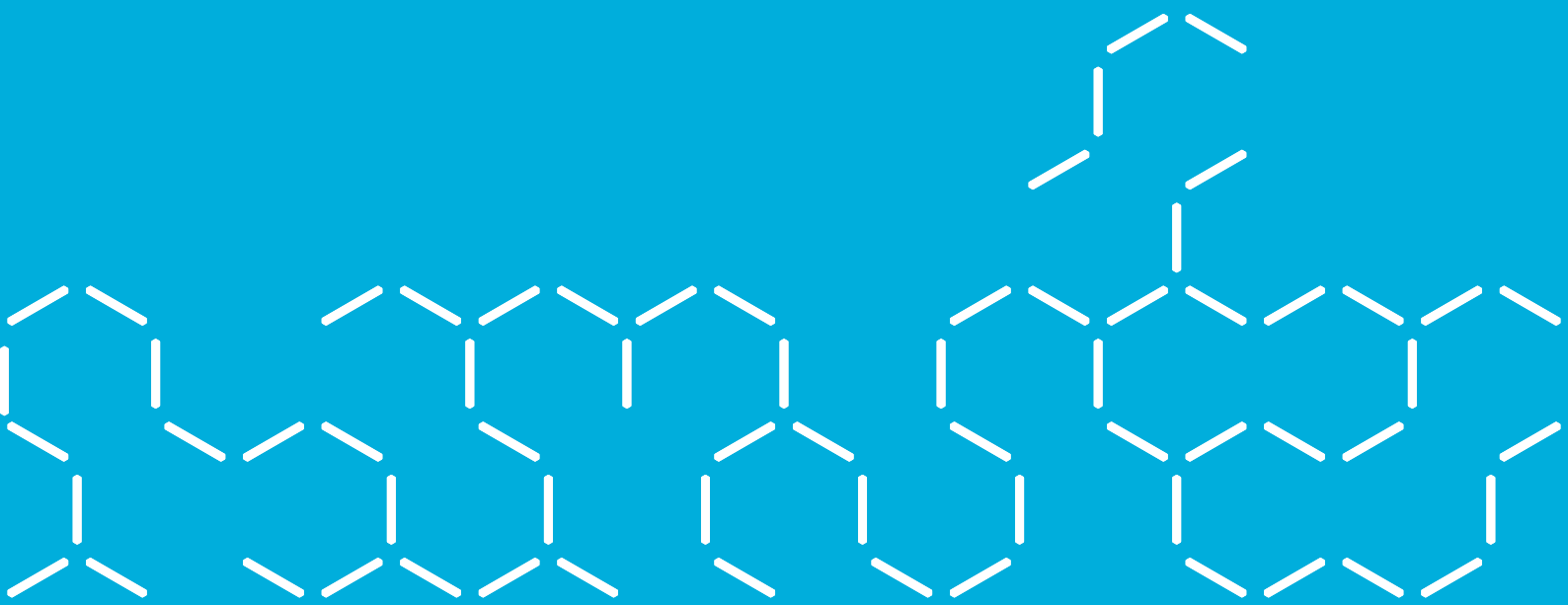

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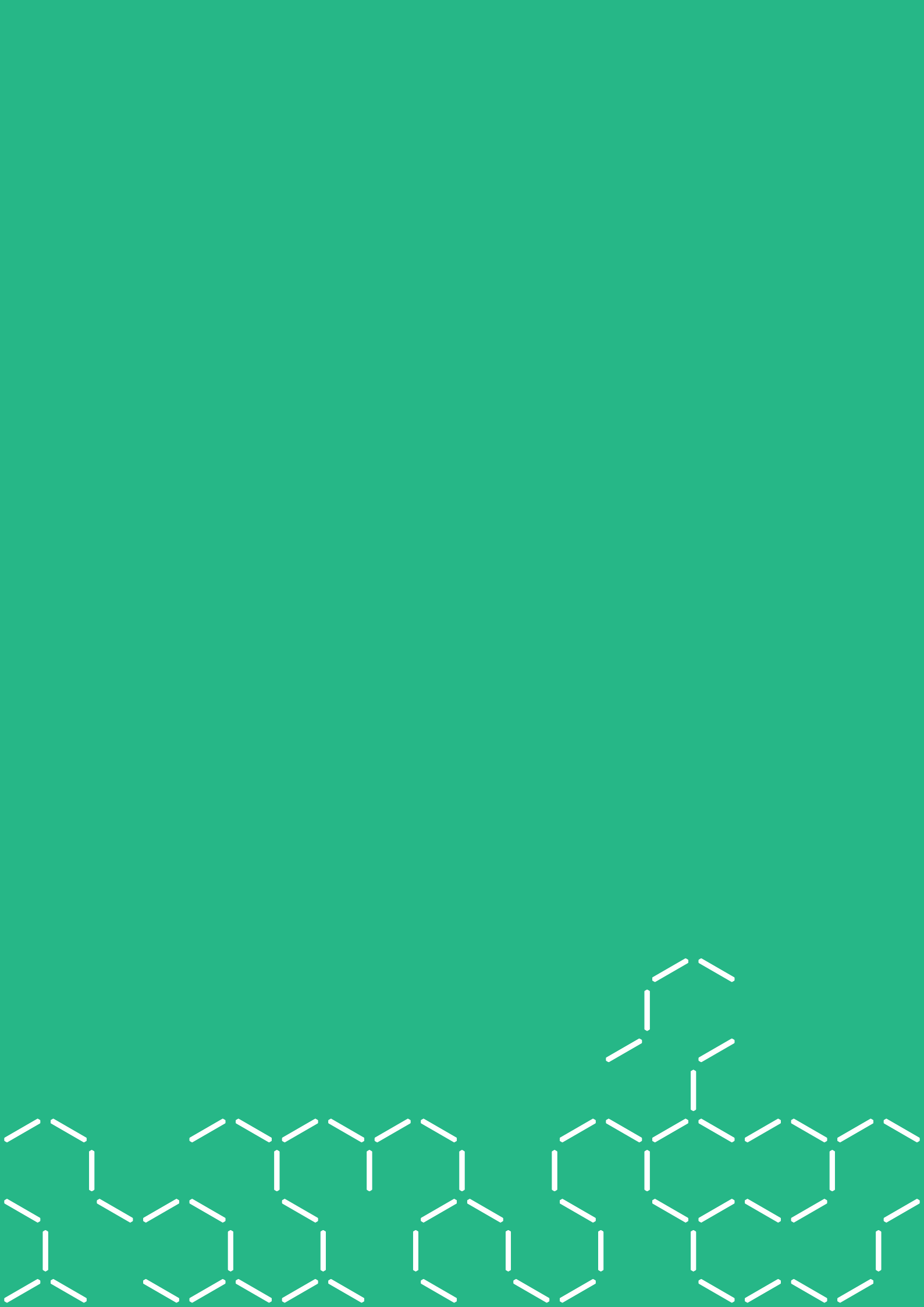


DIGITAL MEGATRENDS
THE 2019 UPDATE

Since our inaugural digital megatrends report launched at the Vivid Sydney festival of light, music and ideas in June last year much has changed in the fast-paced world of digital technology. This report represents the first update. We've simplified the structure of the report and we've updated the megatrends making a few additions and edits.

There are several key updates in this report. We continue to get improved information on the size of the digital opportunity for the Australian economy. Last year we observed that, if we get things right, digital technology could boost Australia's economic growth rate by between 0.7% to 1.2% per annum [1]. A more recent study by Data61 and AlphaBeta finds that digital innovation can deliver AU$315 billion in gross economic value to Australia over the next decade [2]. In another study, consulting firm McKinsey [3] estimates digital technology could contribute AU$140 to AU$250 billion to Australia's GDP by 2025 and that automation technologies (a subset of digital technology) would comprise AU$30 to AU$60 billion for Australia over the same time period.

Artificial intelligence is a subfield of digital technology witnessing rapid growth and surge of activity since our report was launched last year. In recent times, 14 of the world's advanced economies have announced a total of AU$86 billion in artificial intelligence programs and activity. Additional non-publicised investment is likely. There is a widespread view among the world's largest national economies that artificial intelligence will boost industry and worker productivity and achieve competitive advantage in global markets. Consulting firm PwC [4] suggests artificial intelligence could be worth AU$22.17 trillion for the global economy by the year 2030. The developments in artificial intelligence and machine learning are captured in this updated report.

Since last year we've seen developments in how digital technology is impacting the labour market. The early work on job and task automation risk is receding into the distance. The focus is shifting towards the new jobs being created and the need to develop new skills and transition careers. Our research suggests Australian industry faces imminent and critical skills shortages in data science, machine learning, human language technologies, robotics and many other fields of digital technology. People with the right mix of skills in these fields are likely to have good career prospects and good salaries. In this update we investigate the new ways of working in the digitally enabled economy.

Another set of changes we've made to this report relates to governance, ethics and human centred design. The technology is only a small part of the broader socio-economic transformation towards "Industry 4.0" and digital enablement. Governments are actively exploring new ways to effectively regulate and manage the use of digital technologies which mitigate risks and capture opportunities. Societies are exploring and seeking to resolve unfamiliar ethical issues associated with artificial intelligence and data science. This report captures some of the emerging socio-economic and human issues associated with adapting to a digitally enabled world.

As per last year, this report explores plausible futures using methods of strategic foresight pioneered at CSIRO's Data61. We explore the coming decade of digital disruption through the lens of six interlinked megatrends using a Venn diagram to emphasise their interconnectedness (Figure 1). A megatrend is a significant shift in environmental, economic and social conditions that will play out over the coming decades. The concept was introduced by United States professor John Naisbitt in his best-selling book of the same title in the early 1980s. Today megatrends are widely used by large organisations, particularly in the technology sector, to describe trajectories of change taking us toward a new and different future.

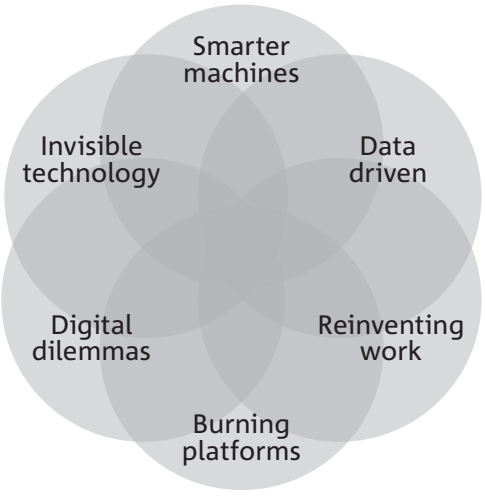


Figure 1. Digital megatrends: the 2019 update

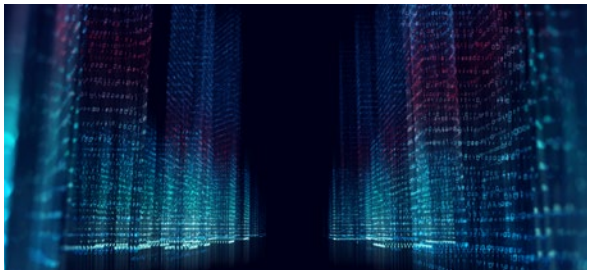
DIGITAL MEGATRENDS

1

Smarter machines

Artificial intelligence is a general purpose technology set to reshape practically every industry and every profession. There has been a surge of interest from governments and companies worldwide over the past year. Whether it's advanced machine learning technologies like deep learning or neural nets, or the natural language processing algorithms that convert speech to text and help smart home applications understand your voice, artificial intelligence technologies are set to transform almost every sector of the economy from healthcare through to agriculture, mining and transport. The ways in which we use and interact with machines are on the cusp of transformation.

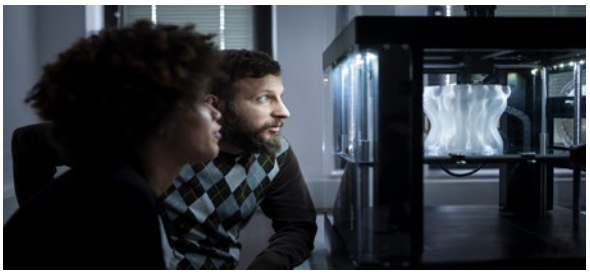
2



Data driven

The operations of practically every business in just about every industry are increasingly being driven by data. The bank, shop, hotel, hospital, insurer and library are all becoming data science operations. Every business is concerned with acquiring, screening, analysing, interpreting and using data to perform function better and make wiser choices. The field of data science and informatics is exploding with rapid growth in jobs and professional communities. The privacy and confidentiality aspects of data have heightened prominence. Organisations of the future will be much more heavily data driven.

3



Reinventing work

Earlier research identified that up to half of all professions were at high risk of being automated by computers and robots over the coming twenty years. More recent work has changed our perspective. Some jobs may disappear, but most jobs are impacted and reshaped by technology (but not extinguished). And lots of new jobs are created. Digital technology is reinventing the workplace. It's changing how we work, what we do and what we need to learn. Australia's employment environment over the next 10 years is likely to emphasise adaptability, flexibility, people skills, technical skills and the ability to learn.

4

Burning platforms

Online platforms provide a clearinghouse for buyers (providers) and sellers (consumers) of goods, services and information to make efficient exchanges. Companies such as Amazon, Freelancer, Uber and Facebook have been hugely successful and have disrupted existing marketplaces. The next decade is likely to see the continued expansion and diversification of online platforms into new areas. Blockchain and distributed ledger technology provide unprecedented potential for disintermediation as they allow two parties to exchange not only information but value (money, contracts, property rights...) without an intermediary. Many well established firms are standing on a burning platform for change.

5

Digital dilemmas

As our economy and society become more deeply immersed in digital technology the risks, challenges and emerging ethical dilemmas are becoming increasingly visible. Social media has been linked to higher levels of stress and anxiety. Governments are grappling with ways to prevent harmful and extremist material being circulated online. People are concerned about privacy and the cybersecurity threat continues to grow and morph as technology advances. This megatrend is about the rise of new digital dilemmas and the innovative efforts by governments, companies and communities to protect people from the risks whilst still capturing all benefits.

6

Invisible technology

For most of us there's no unplug option. However, as we become immersed in digital the marginal value of the physical world will rise. We will increasingly crave activities involving objects we can touch and feel along with nature-based experiences and real social interaction experiences. The necessity of visiting a shop, office or university campus will be diminished. But necessity will be replaced by choice. People will visit places they choose to visit. Architects and town planners will need to design buildings and urban environments which attract visitors due to their amenity and beauty. One of the major drawcards for people will be other people. Therefore, successful innovations will be human centred. The best technology of the future will be invisible. Human centred design will be at the forefront of successful digital technologies.

BACKGROUND

Digital technology can be defined to encompass all electrical devices which make use of information represented in digital form – such as binary code - to perform useful functions. Data connectivity is what makes a device (*e.g.* toaster) earn the status of "digital" (*e.g.* computer). Computers, robots, software, smartphones and sensory systems are all digital technologies. When connected they can be very powerful and give rise to new systems for human communication, governance models and business processes. We sometimes use the term "*digital*" as a noun to capture both the technologies and the new human systems they enable.

Often referred to as the fourth industrial revolution, or the information era, the current chapter of the human history is characterised by digital transformation. Digital technologies are changing the way we live, work and play. They are changing information flows and decision-making behaviours. Digital is associated with the birth and rapid ascendance of entirely new cultures, markets and societal norms. The exciting and daunting reality is that we are in the early phases of this transformation. If industrial revolutions happen over centuries we're still in the first quarter of the information era. The most significant change lies ahead.

Within this context organisations and individuals are faced with challenging strategic choices. Companies have seen what happened within the taxi industry and are actively asking: *Who's our Uber*? Another phrase commonly used within many organisations is: *What's our Kodak moment*? In other words, what's the nascent digital technology which could at some point redefine our core operations and purpose? Such questions may be considered existential risk and put in the "*too hard basket*". However, we have all witnessed events when an organisation's existential risk (or opportunity) associated with digital technology quickly became an operational day-to-day reality.

This means we need to look ahead. Whilst the future cannot ever be known the emerging research field of strategic foresight can help people understand what may potentially unfold. Strategic foresight can help us contemplate multiple plausible futures and make wiser choices. The expectation for this type of thinking is on the rise. For example, the concept of anticipatory governance is gaining traction in the world of public policy and corporate strategy. Citizens and shareholders have heightened expectations that decision makers will unveil the "black swans" (hard-to-foresee events) of digital technology and take proactive action.

Strategic foresight is a field of research concerned with the structured analysis of future events and "the four P's of the future"; namely the probable, plausible, possible and preferable (Figure 2). In this report we apply the strategic foresight concept of *megatrends* to analyse and explore driving forces of change related to digital technologies. A megatrend is a pattern of change reshaping the future operational and strategic context of government, industry and community organisations.

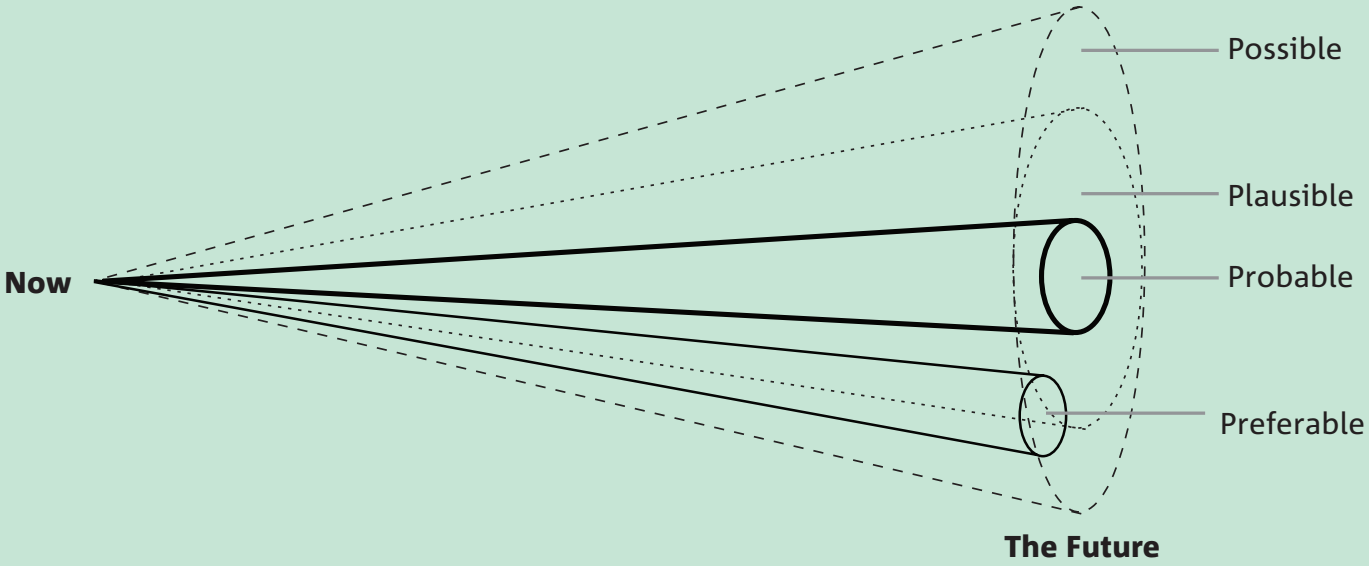


Figure 2. The futures cones showing four Ps of the future. The diameter of the circle is proportional to the amount of uncertainty.

Megatrends typically play out over decadal time frames and occur at the intersection of numerous geopolitical, economic, environmental, social, technological and legal trends. Trends have tighter spatial, temporal and typological definition than megatrends. Megatrends build gradually but eventually express with explosive force. The extent to which the risk is averted, or the opportunity harnessed, comes down to how well the megatrend was read and the accuracy of early and proactive strategic actions.

The term megatrends was coined by the US academic John Naisbitt who wrote a New York Times bestselling book with the same title published in the year 1984. Some researchers refer to megatrends as “drivers of change” or “metatrends” which are closely related concepts. Today technology and consulting firms such as Hewlett Packard, Siemens, Price Waterhouse Coopers (PWC), The World Economic Forum, the European Commission, KPMG, University of Sydney Business School, Ernst and Young and countless other firms and institutions use the concept of megatrends to explore and describe forthcoming change.

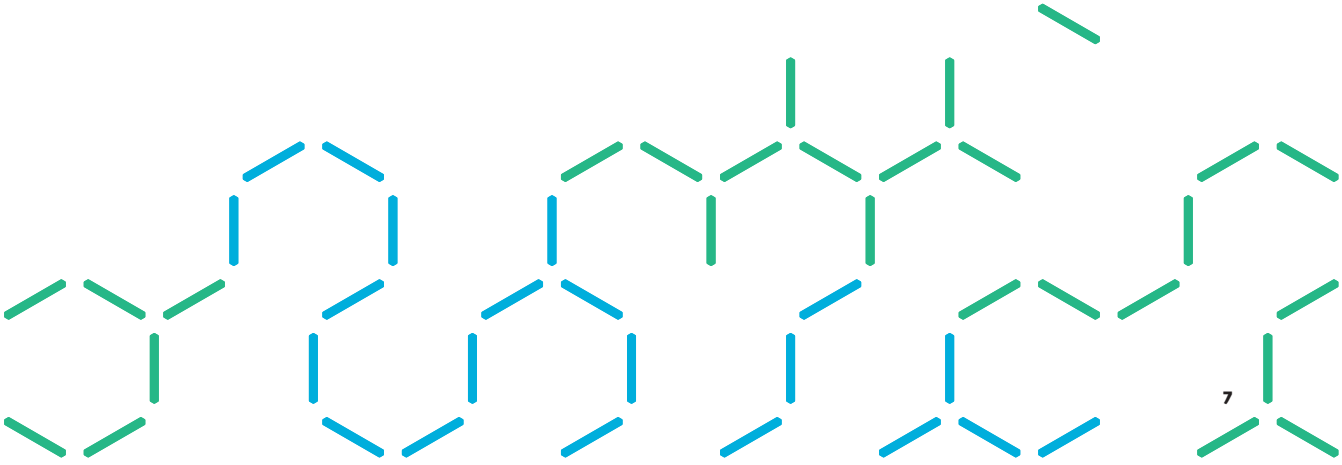
This report considers the next ten years of digital transformation within the context of the longer term, and larger, information era. We aim to give governments, businesses and communities insight into near term trends and drivers. The report opens with an overview of the digital megatrends. Each megatrend is then briefly described with reference to a set of interconnected underlying trends and drivers. We conclude the report with a description of our strategic foresight methods.

SMARTER MACHINES

Artificial intelligence is a general purpose technology set to reshape practically every industry and every profession. There has been a surge of interest from governments and companies worldwide over the past year. Whether it's advanced machine learning technologies like deep learning or neural nets, or the natural language processing algorithms that convert speech to text and help smart home applications understand your voice, artificial intelligence technologies are set to transform almost every sector of the economy from healthcare through to agriculture, mining and transport. The ways in which we use and interact with machines are on the cusp of transformation.

That little droid and I have been through a lot together.

– LUKE SKYWALKER CONCERNING THE FICTIONAL ROBOT R2D2 IN THE FILM STAR WARS



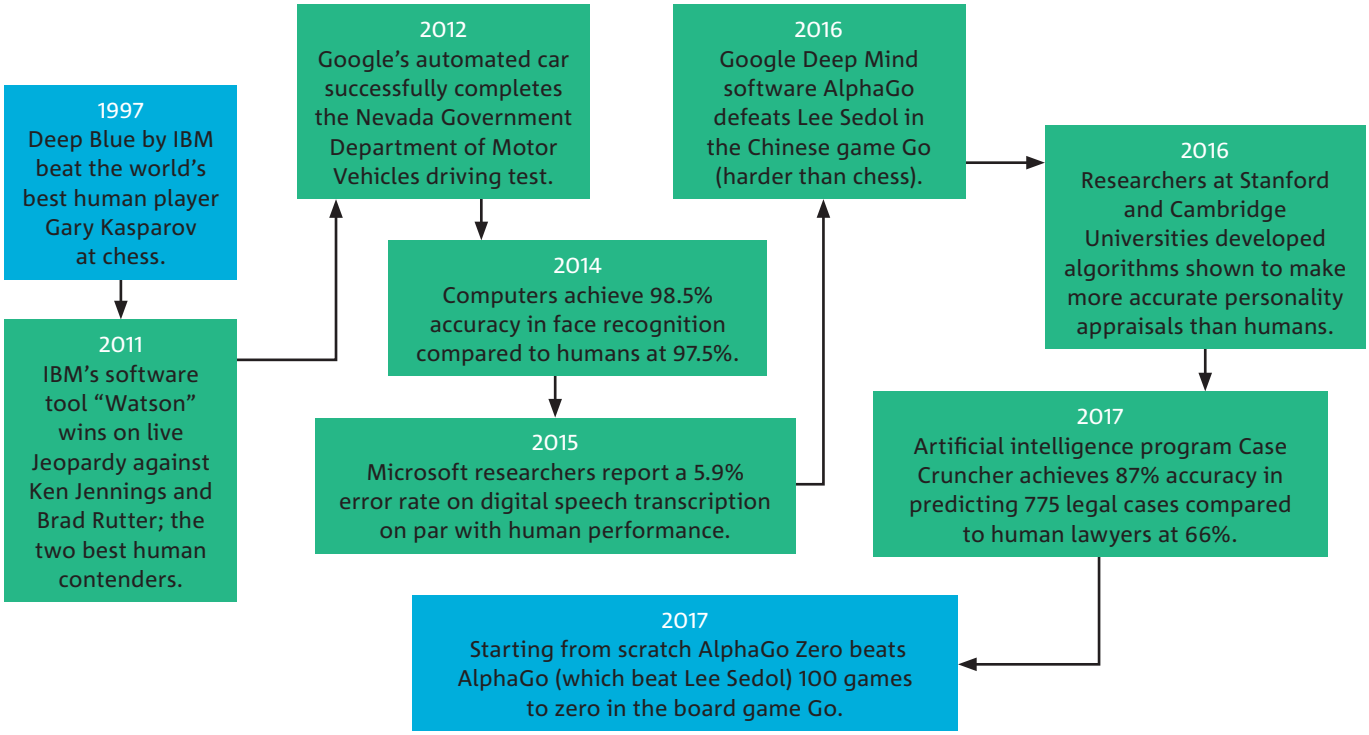


Figure 3. Artificial intelligence breakthroughs. What will we achieve in the next ten years?

Technological innovation isn't a straight line. It's not like a skyscraper with one floor of scientific achievement built vertically on top of another. Innovation is better represented as an inverted pyramid where one idea leads to several more which support yet more ideas. In his new book "*How Google Works*" Google Chairman Eric Schimdt argues humanity is entering an era of "combinatorial innovation" where the pace of change is accelerating.

Combinatorial innovation means breakthroughs in sensory systems, predictive analytics, image analysis, speech recognition, machine learning, neural networks and other scientific fields are combining to create a new and much higher platform for future technological advancement. Today's building blocks for tomorrow's artificial intelligence are more powerful, and more diverse, than ever before in history (Figure 3). This creates a future world with vast potential for transformative artificial intelligence technologies.

This megatrend is about the increased capability and application of machine learning and other artificial intelligence technologies. It captures both the scientific achievements and the increased application by governments and companies.

A surge of interest. In only the last few years there has been a surge of interest, and investment, in artificial intelligence which is unprecedented in the sphere of technology development. In recent times, 14 of the world's advanced economies have announced a total of AU$86 billion in artificial intelligence programs and activity [5,6]. Additional non-publicised investment is likely. There is a widespread view among the world's largest national economies that artificial intelligence will boost industry and worker productivity and achieve competitive advantage in global markets. Consulting firm PwC [4] suggests artificial intelligence could be worth AU$22.17 trillion for the global economy by the year 2030.

Artificial intelligence developments in Australia. The last year has seen some major initiatives by Australian institutions to develop artificial intelligence capability. On 12 March 2019 CSIRO's Data61 announced the opening of a new Robotics Innovation Centre in Queensland. This purpose-built research facility for robotics and autonomous systems will help build an industry forecast to be worth AU$23 billion by 2025. On 19 November 2018 CSIRO announced an AU$19 million initiative on artificial intelligence and machine learning "to target artificial intelligence-driven solutions for areas including food security and quality, health and wellbeing, sustainable energy and resources, resilient and valuable environments, and Australian and regional security"[7]. In this year alone, the Australian Research Council has approved 45 research projects commencing into areas of artificial intelligence and image processing, with investment amounts (per project) ranging from roughly AU$262,000 to AU$782,000 [8]. States and territories are also investing. South Australia invested AU$7.1million into a Machine Learning Institute at University of Adelaide [9] and the Queensland government has announced AU$3 million for an Artificial Intelligence Hub at its innovation centre "The Precinct" in Brisbane [10].

Machines that learn. Perhaps what has made humanity so interested in artificial intelligence are breakthroughs in the underlying field of machine learning. Giving machines the ability to learn and problem solve without explicit guidance from a human is why we're all so excited. For example, the Chinese boardgame "Go" is more complicated than chess and involves advanced strategy. Nobody taught Google Deepmind's software AlphaGo Zero how to play the game. It completely taught itself *Tabula Rasa* (from scratch) using neural networks and self-play. AlphaGo defeated Grandmaster Lee Sedol in 2016 [11] and an upgraded version defeated world champion Li Kejie in 2017 [12]. Google pitted an improved artificial intelligence, AlphaGo Zero, against the original AlphaGo and AlphaGo Zero won 100 straight games. In 2018, Chinese media reported that a distinct new Chinese-made artificial intelligence, Golaxy, had also defeated Li [13]. These achievements are significant because of self learning; these artificial intelligence systems devised their own strategies without explicit human instruction. We are entering a world where machines can learn and solve complex problems without our help or guidance.

Artificial intelligence is making its own artificial intelligence. In 2017, researchers at Google developed AutoML; an artificial intelligence software tool that makes (codes) its own artificial intelligence. In the same year AutoML built NASNet; another piece of artificial intelligence used to recognise objects in images (*e.g.* people, cars and animals). Google researchers reported that NASNet, which was coded by AutoML (not a human), was 82.7% accurate in identifying objects. This represents a 1.2% improvement upon previously published systems coded by humans [14].

Robots perform well financially. A report commissioned by the European Commission found that between 2007 and 2014, the number of robotics-focused business incubators in the EU had grown by 360% [15]. It's no surprise why—robots often deliver powerful returns on investment. Economists studying the impacts of robotics between 1993 and 2007 found that in the countries studied, robotics had increased GDP by around 0.37 percentage points [16].

Better at recognising faces. In 2014 computers with 98.5% accuracy outperformed humans at facial recognition with 97.5% accuracy [17]. Today, facial recognition is routinely used as an alternative to household door locks and for smartphone activation.

Getting better at recognising emotions. One next step from face recognition is the ability to ascertain a person's emotional state from a photograph or image. A team of Microsoft researchers built an emotion recognition system which achieved 59.4% validation accuracy [18]. Automated emotion recognition has applications in education, healthcare, customer service and many other areas [19].

Better at speech recognition. In 2016 Microsoft researchers achieved a 5.9% error rate on speech recognition; on par with human performance. This has since been improved to 5.1% [20,21], making computers better transcriptionists than humans.

Getting better at personality judgements. In 2015, computerised algorithms developed by researchers at the University of Cambridge and Stanford University [22] made more accurate judgements about an individual's personality traits compared to human friends, family, spouses and work colleagues.

Getting better at predicting legal judgements. In 2017 an artificial intelligence program called "Case Cruncher Alpha" was pitted against 100 lawyers from London's best firms. The task was to predict the outcomes of 775 real cases relating to insurance mis-selling by the UK Financial Ombudsman. Case Cruncher achieved an accuracy rate of 86.6% compared to human lawyers with 66.3% [23].

Better at disease diagnosis. Artificial Intelligence has promise across a wide range of domains, with medicine being a key area. The ability of artificial intelligence to analyse patterns in large datasets is incredibly useful in creating new diagnostic tools to spot illnesses. In one case, researchers at the University of San Diego took data from 1.3 million patient admissions at a hospital in China and fed this data to artificial intelligence systems. When then given new cases that it had not seen before, the artificial intelligence was able to diagnose a number of conditions, such as the flu, chicken pox and glandular fever, with between 90% and 97% accuracy [24].

Worse at folding towels. Talented scientists and engineers at the UC Berkely robotics school designed the Berkeley Robot for the Elimination of Tedious Tasks (Brett). Brett's job was to pick-up and fold a towel. After years of effort Brett's best time was 20 minutes. More recent improvements involving deep learning algorithms have achieved best times of 1.5 minutes. However, Brett still gets stumped routinely when the laundry is messy [23,25]. Overall humans of all ages and skills outperform Brett at folding towels in a matter of seconds.

Moravec's Paradox. Brett's towel folding tribulations fall within the space of *Moravec's paradox*; an observation in the field of artificial intelligence that we can design computer algorithms which solve complex problems like winning at world-class chess or flying an aircraft but are unable to do simple tasks (for humans) like tying up shoelaces or folding a crumpled towel. Simple tasks that involve irregularity, complexity, creativity, ethical judgements and emotional intelligence are often beyond the reach of robotics. However, despite Moravec's paradox there is still much scope for artificial intelligence to automate previously human performed tasks over the coming decade. Furthermore, artificial intelligence has amazed us in recent history by solving complex problems that were hitherto considered impossible for a robot.

Companies are making big investments. A report by McKinsey [26] estimates that global technology corporations such as Google and Baidu spent AU$26 to AU$40 billion on artificial intelligence with 90% going into research and development and 10% into acquisitions. They also estimate global investment in artificial intelligence has increased three-fold over the past four years.

Adoption and business transformation is lagging. Despite an explosion in investment and technological capabilities, few businesses are adopting or adapting to an artificial intelligence enabled world economy. A study by McKinsey [27] of over 3,000 executives across 14 industry sectors and 10 countries found that only 20% were using some type of artificial intelligence technology as a core part of their business. However, there are expectations for adoption to accelerate in coming years.

Beyond Asimov. The three laws of robotics written in the 1940s by science fiction writer Isaac Asimov are receiving renewed attention. And it might be time for an update with a whole lot more detail. That's because advanced artificial intelligence with capabilities for autonomous decisions - especially in areas such as law enforcement, defence, healthcare, education, transportation, labour markets and security – will create increasingly complex social, cultural and ethical dilemmas. We are at the beginnings of understanding plausible and preferable artificial intelligence futures. There is much uncertainty about how things may play-out and society's preferred outcomes. At a recent technology conference in Paris Microsoft Chief Executive Officer Satya Nadella said that artificial intelligence is the "*defining technology of our times*" and "*the future we will invent is a choice we make*" [28]. This is perhaps the most powerful and daunting aspect of the artificial intelligence transformation. We are in the driver's seat. We can choose and build the future we want.

The ethics of artificial intelligence are of growing importance. In 2019, Australia released a discussion paper on an Ethical Framework for artificial intelligence, which was one of several documents guiding Australia's use of Artificial Intelligence technologies. The document highlighted numerous of cases from around the world where the use of artificial intelligence prompted ethical dilemmas and set forth a number of tools that can be used to shape more ethical development of artificial intelligence. Around the world, governments and multilateral organisations are preparing plans to govern the ethics of artificial intelligence.

DATA DRIVEN

The operations of practically every business in just about every industry are increasingly being driven by data. The bank, shop, hotel, hospital, insurer and library are all becoming data science operations. Every business is concerned with acquiring, screening, analysing, interpreting and using data to perform function better and make wiser choices. The field of data science and informatics is exploding with rapid growth in jobs and professional communities. The privacy and confidentiality aspects of data have heightened prominence. Organisations of the future will be much more heavily data driven.

Data is the new oil. It's valuable, but if unrefined, it cannot really be used.

– CLIVE HUMBY, BRITISH MATHEMATICIAN

Recent years have seen the emergence of the "data driven organisation". This is an organisation that has become adept in all aspects of data handling. A data driven organisation can efficiently capture information relevant to its current and future operations. It stores and protects the data it holds and ensures access is granted only to persons with security clearance and a legitimate need to view/modify records. Privacy, confidentiality and ethical integrity are maintained by a data driven organisation in all aspects of data handling. A data driven organisation makes effective use of data in decision making; including day-to-day operational decisions and long term strategy. Increasingly data driven organisations use automated systems based on artificial intelligence and machine learning to handle large, complex inflows of diverse data.

Arguably all organisations are on a pathway to becoming data driven organisations. Data is reinventing traditional businesses. Banks, hospitals, insurance companies, travel agents and law firms are all becoming data science operations. The manager of a hospital is equally concerned about a data breach as they are a legionnaires outbreak. The day-to-day operations of practically all organisations depend upon acquiring, storing, analysing and transmitting digital data. How well they do these things is what gives them a competitive edge over other organisations in their sector.

This megatrend is about the shift towards data driven organisations and a data driven economy. It has implications for organisational structures, staff skills, risk management and research. This megatrend has implications for large and small organisations in the public and private sector in every industry and sector.

Rising rates of data consumption. In 2017, Australia's fibre connections doubled, reaching nearly 3 million subscribers [29]. Between 2015 and 2017 Australia doubled its entire data consumption from 1.7 million terabytes in the last three months of 2015 [30] to 3.5 million terabytes in the same period in 2017 [29]. The increase in data consumption from streaming services like Netflix [31] parallels this growth and is likely a key contributor, and this illustrates how one technological advancement can dramatically drive up Australia's data needs.

Data is a growing source of value. Data and digital technology firms tend to rely largely on knowledge based capital, including data and software. Google and Facebook, for example, only have 15% of their value in the form of physical assets (as of 31 December 2013) [32]. The remaining 85% of value is derived from digital data assets (including software) and brand value. Some analysts predict exponential growth in data value over the coming years [33].

The explosion of the data scientist profession in Australia. The importance of data to firms and industries is reflected in employment statistics. Australia had an estimated 301,000 data scientists in 2017 and that figure is expected to grow by 2.4% each year until 2022. This contrasts with average job growth of 1.5%. Data Science workers with postgraduate IT qualifications are expected to see average annual salaries rise from approximately AU$111,634 to AU$130,176 in this period [34].

And worldwide. IBM predicts that by 2020, the number of job openings for data scientists in the US will reach 2,720,000, from 364,000 in 2016 [35,36]. Along with data specialists, data generalists will be required, with managers needing to be able to grasp and utilise analytics in decision-making, not to mention the probability that basic data entry jobs will face significant change or automation in the years ahead as demand for data increases and new technologies offer solutions.

Physical data infrastructure is booming. A "hyperscale" data centre is a facility with thousands of servers, often defined by the fact it produces billions of dollars in annual revenue [36]. With global data traffic rising from an annual 220 zettabytes in 2016 to an estimated 850 ZB in 2021, more hyperscale data centres will need to be built to accommodate the sheer amount of data being produced [36]. There were only 336 hyperscale data centres around the world at the end of 2016, and this is expected to grow to a total of 628 in 2021, when they will handle just over half of the world's data traffic [36].

But still needs investment. Only the biggest data giants can afford to build their own hyperscale data centres and even though the amount of data shared on the "private cloud" is growing, public cloud data is growing faster. In 2016, 58% of the total cloud data was handled via public data centres, and that is projected to rise to 73% in 2021 [36].

Gee Whiz, 5G is almost here. The Australian Communications and Media Authority anticipates that 5G mobile technologies will begin rolling out from 2020 [37], though Telstra has also indicated it may be as soon as 2019 [38]. 5G will not just be an incremental upgrade to speeds, rather, the government defines it as "the underlying architecture that will enable the next wave of productivity and innovation across different sectors of the Australian economy" [39]. The NBN network has already faced significant challenges meeting the rapidly expanding demand [40], and 5G will play a role in meeting demand in future. However, 5G requires expensive infrastructure and, when compared to 4G, it's not so easy to guarantee coverage. This is because 5G requires a higher density of base stations [41]. New generations of smartphones and IoT devices will also need to be designed in order to take full advantage of new 5G technologies.

With high speed potential. Estimates of the potential speeds of 5G range between 25-50 Mbps in high traffic scenarios, through to minimums of 100Mbps in typical situations, all the way up to one Gbps per second for stationary users near cell towers [42]. If the potential of these estimates is realised it will be a game-changer for industry over the coming decade and transform the ways in which companies operate, but 5G-compatible smartphones will need to be developed [38]—this indicates the possibility of a near-future scenario in which 4G smartphones are quickly rendered relatively obsolete in comparison.

But keep the divide in mind: Australia's vast territory poses challenges to digital coverage for people in remote areas. A Digital Inclusion report commissioned by Telstra in 2017 found that the digital inclusion gap between capital cities and the rest of the country had narrowed overall in recent years, but the reverse had occurred in Victoria, New South Wales and Tasmania [43]. The report also found that indigenous Australians, the elderly and the disabled had lower rates of digital inclusion [43,44]. This will be crucial to keep in mind, because even if 5G lives up to its promise, it will be expensive to ensure wide coverage [45]. OECD research indicates that there is a strong connection between economic growth and broadband connectivity [46], so digital infrastructure development will be a key component of ensuring the economic future of regional and rural Australia.

Personal data is money. Data has taken on characteristics of both a resource and a currency—this can be seen in the willingness of companies to pay users to allow their data to be harvested and traded. There are apps that pay users to play and rate mobile games, while survey companies regularly pay interviewees small amounts to fill out online forms used for marketing purposes. These types of unskilled tasks are likely to remain low paid but could proliferate depending on how information is harvested in future.

But who owns the data? Multinational data giants like Google, Amazon and Facebook currently dominate the monetization of personal data, but blockchain-based apps are experimenting with systems that allow users to package and take charge of their own data so ordinary members of the public can sell their own data to whom they see fit [47].

Blockchain has influential backers. Whether or not blockchain will succeed in empowering consumers to control their data remains to be seen. Existing data giants will fight to retain a level of control over consumer data in order to survive. But blockchain has its own backers—internationally, senior government and industry figures have recognised the potential of blockchain for restructuring the entire digital economy and have signed on to measures to promote it [48].

Data in cities. Information technology hardware giants Cisco and Huawei are among a number of companies locked in competition to create entire learning ecosystems to drive cities. Huawei describes smart cities as the "digital transformation of a city to address challenges in the physical world", and indicates that a series of cameras, sensors and IOT objects would act as "nerves" gathering information, with an Intelligent Operations Centre acting as a "brain" [49]. Huawei is in the early stages of an agreement with a city in Germany to work develop certain smart city projects, but in Australia key Huawei projects have stalled on national security grounds [50]. Technological, social, political and privacy concerns will all need to be considered as smart technologies make their way into cities worldwide. The CSIRO is already working on a number of smart-city projects and data-driven infrastructure technologies [51].

Data in the home. In recent years, on-demand streaming services like Netflix have witnessed much faster growth than free to air competitors [52]. Streaming services require heavy data consumption [40], and Australia's recent rise in data consumption has occurred at the same time as the widespread uptake of streamed television [53]. As industry increasingly uses data in its operations, consumers will do so as well, with IoT devices increasingly being incorporated into smart-home operations.

And data in the mind. Human beings are subject to a wide array of cognitive biases which affect decision making [54]. Data can be free of bias, however the ways in which data is collected and presented is still often affected, to varying extents [55]. Machines and datasets, too, can reflect human cognitive biases if programmers use the wrong information, or as it's referred to in the industry—garbage in, garbage out. Improved data collection methods have the potential to reduce human error, saving lives and money, but the best results will require skills, discipline and open-mindedness to process and act on the right information.

Data quality and quantity both matter. The ability to collect data—while respecting privacy—will be crucial to the quality of the data. When one type of data is available while others are not, it can affect the results—illustrated by facial recognition systems which have higher error rates when the people scanned are not caucasian [56]. This kind of problem plays out in people's own judgements too—the availability heuristic is the tendency to believe and act on information that is familiar and available, rather than information that is good or hard to get [57]. A world awash with data, both good and bad, is a world where the availability heuristic runs the risk of burying good data and confirmation bias allows people to select sources that fit their ideology.

REINVENTING WORK

Earlier research identified that up to half of all professions were at high risk of being automated by computers and robots over the coming twenty years. More recent work has changed our perspective. Some jobs may disappear, but most jobs are impacted and reshaped by technology (but not extinguished). And lots of new jobs are created. Digital technology is reinventing the workplace. It's changing how we work, what we do and what we need to learn. Australia's employment environment over the next 10 years is likely to emphasise adaptability, flexibility, people skills, technical skills and the ability to learn.

People will create the jobs of the future, not simply train for them, and technology is already central. It will undoubtedly play a greater role in the years ahead.

– JONATHAN GRUDIN, PRINCIPAL RESEARCHER AT MICROSOFT
(CITED BY THE PEW RESEARCH CENTER)

Seminal studies on computerisation and automation published around five years ago focused on the risks of job loss/replacement. These findings were associated with much concern and fear about job loss. Newspapers were filled with images and headlines about robots coming to take people's jobs. However, unemployment rates have not changed markedly over the past ten years. The forecasts of widespread job loss and unemployment have not happened. At the same time we are seeing high demand, relative to supply, for a wide range of jobs in data science, artificial intelligence and related fields of digital technology.

Since our report last year, several studies have been published which identify the job opportunities in a digital economy. Economists studying the issue at the International Monetary Fund [58] find that in the long run automation brings economic benefits and newer, better jobs. However, they also note that in the short term the consequences can be quite disruptive; especially to people finding themselves suddenly out of work. Overall the digitisation of our economy represents a challenge and opportunity for workers. It will be associated with the need for early, proactive and targeted reskilling and upskilling. The education and training imperative applies to all life stages from infancy to adulthood. There are great career opportunities, and good salaries, for people with the right skills mix which includes both hard/technical and soft/human skills. There are also opportunities to change the way we work involving the introduction of new cultures and flexible arrangements supported by digital technologies.

This megatrend is about the new world of work associated with the rising use of digital technology. It captures both the risks and opportunities for current and future workers.

A seminal study of the United States labour market. In 2013 University of Oxford academics, Carl Benedikt Frey and Michael Osborne, published a landmark study [59] examining the impacts of automation on 702 unique occupation types in the United States economy. They found 47% were at high risk of being replaced by a robot or computer. They also found a strong negative relationship between automation risks and wages (i.e. lower pay for jobs with a higher chance of being automated). This led to a huge amount of concern around the world about the possibilities of higher rates of unemployment and under-employment.

Replicated in other jurisdictions. The University of Oxford study was replicated in multiple jurisdictions. The Committee for the Economic Development of Australia (CEDA) commissioned a study [60] of the Australian economy and found a similar result with 44% of the workforce at risk of automation [61]. A more recent meta-level study by the OECD [62] published in 2018 found that 14% of jobs have a "high risk" of automation and another 32% will be substantially changed; meaning that 46% of all jobs will be significantly impacted. All these studies have understandably been associated with anxiety and concern in society about job insecurity.

But jobs typically don't disappear, they just change. However, the risks may have been overstated and incorrectly characterised. Typically, automation will apply to tasks within a job but not the entire job. For example, spreadsheets did not see the end of the accounting profession. Accountants learned how to use them and became more productive. Likewise, the forthcoming era of workforce automation will create new jobs and new career pathways with improved salaries for skilled workers. Automation reduces the amount of boring, repetitive and unsafe tasks for human workers. Automation can free-up a worker's time for tasks involving higher levels of creativity, logic, judgement, social interaction and emotional intelligence. Automation creates new career opportunities in entirely new industries, often with high salaries, for workers who have the right mix of technical and human skills. The impact of automation will range from job replacement to no-impact with most jobs somewhere in the middle.

An explosion of job opportunities. People with the right skills mix are likely to get good jobs. And well paid jobs. Australia had an estimated 301,000 data scientists in 2017 and that figure is expected to grow by 2.4% each year until 2022. This contrasts with average job growth of 1.5%. Data Science workers with postgraduate IT qualifications are expected to see average annual salaries rise from approximately AU$111,634 to AU$130,176 in this period [34]. According to a recent report from the World Economic Forum [63] artificial intelligence will displace 75 million jobs and create 133 million new jobs leading to a net increase of 58 million new jobs by the year 2022 in the world economy.

What jobs are in demand? According to the World Economic Forum report [63] jobs likely to grow in demand include technical jobs such as "AI and Machine Learning Specialists, Big Data Specialists, Process Automation Experts, Information Security Analysts, User Experience and Human-Machine Interaction Designers, Robotics Engineers, and Blockchain Specialists". They also include human jobs such as "Customer Service Workers, Sales and Marketing Professionals, Training and Development, People and Culture, and Organizational Development Specialists as well as Innovation Managers".

Data specialists are hard to find. At present, not nearly enough data specialists are being trained to meet vacancies requiring advanced skills [35], with the very real possibility that skills shortages will slow down growth of the sector. Over half of the managers polled in recent global surveys indicated that data analytics roles were the hardest to fill [64]. Already, multinationals seek to poach talent from across borders, and wages for specialists working in machine learning remain attractive, driven by aggressive recruiting of specialists with experience. Tech giants and auto companies are both locked in fierce competition to recruit cutting edge artificial intelligence researchers to work on AV technology [65]. As artificial intelligence and IoT advances are incorporated into more technologies, demand for people with the right skills is likely to grow.

Not just technical skills. Whilst there will be huge demand for technical skills many of the new jobs need human-centred skills such as judgement, reasoning, creativity, communication and emotional intelligence. There will be strong demand for "soft" skills alongside hard skills. A survey by the Economist Corporate Network [66] of 500 staff working in companies across the Asia- Pacific region identified strong demand for soft skills such as communication, teamwork and creativity in addition to hard and/or technical skills.

Further evidence from the United States Labour market. With deeper penetration of digital technology, the United States labour market gives us an insight to the future. A study by researchers at Harvard University found that: "Between 1980 and 2012, jobs requiring high levels of social interaction grew by nearly 12 percentage points as a share of the U.S. labor force. Math-intensive but less social jobs—including many STEM occupations—shrank by 3.3 percentage points over the same period" [67]. Another study by researchers at Indiana University in the United States found that "in an increasingly data-driven economy, the demand for soft social skills, like teamwork and communication, increase with greater demand for hard technical skills and tools" [68].

A lifelong retraining and reskilling imperative. The World Economic Forum report [63] also finds that by 2022 around 54% of all workers will require significant reskilling and upskilling. Of these people one-third will need additional training of six-months duration. A recent study by Google and consulting firm AlphaBeta [69] finds Australian workers will, on average, need to increase time spent learning new skills by 33% over their lifetime and that job tasks will change 18% per decade.

BURNING PLATFORMS

Online platforms provide a clearinghouse for buyers (providers) and sellers (consumers) of goods, services and information to make efficient exchanges. Companies such as Amazon, Freelancer, Uber and Facebook have been hugely successful and have disrupted existing marketplaces. The next decade is likely to see the continued expansion and diversification of online platforms into new areas. Blockchain and distributed ledger technology provide unprecedented potential for disintermediation as they allow two parties to exchange not only information but value (money, contracts, property rights...) without an intermediary. Many well established firms are standing on a burning platform for change.

While competitors poured flames on our market share, what happened at Nokia? We fell behind, we missed big trends, and we lost time. At that time, we thought we were making the right decisions; but, with the benefit of hindsight, we now find ourselves years behind.

– STEPHEN ELOP, FORMER NOKIA CEO AND CURRENT EXECUTIVE STRATEGIST AT TELSTRA, WRITING IN HIS INDUSTRY-DEFINING BURNING PLATFORMS MEMO.

In 2011, Nokia CEO Stephen Elop coined the phrase "burning platforms" in a memo when he recounted the tale of an oil rig worker forced to jump into icy waters as flames engulfed his oil platform—it was an analogy for Nokia's loss of market share against Apple and Android, and Nokia's failure to keep up with change.

When the term "platform" is used in the digital context, in the broadest sense it refers to software that allows users to interact with each other [70], generally via the uploading and sharing of data. Whether it's Ebay, Facebook or a file-sharing torrent site, their existence depends on this data being shared.

Platforms are increasingly central to the way modern economies operate. However, in a world where the methods used to share data are always changing, companies can rise and fall faster than ever before. Elop's flames are lapping at the edges of digital platforms, and the ways in which they respond will affect much more than just the digital and corporate ecosystems of the next decade.

This megatrend is about the rise and evolution of the digital platform including new enabling technologies such as blockchain and artificial intelligence along with the socio economic response by governments, industries and communities.

Digital companies dominate global markets. In a world that is rapidly becoming digitised, it is no surprise that digitally-driven companies have increasingly come to dominate global industry. The 2018 list of top 12 firms worldwide (by market capitalisation) was led by digital companies. The top four companies by market value were Apple, Alphabet (Google), Microsoft and Amazon. This is compared to the 2000 list which was made up almost entirely of industry leaders topped by General Electric, ExxonMobil, Pfizer and Citigroup [71].

Platform companies. Online platforms represent a significant force of creative destruction. Companies such as Amazon, Freelancer, Uber and Facebook have been hugely successful in disrupting existing marketplaces. The next decade is likely to see the continued expansion and diversification of online platforms into new areas. Internet platforms exploit the network effects of global connectivity online, and therefore, have experienced massive growth in the last 2 decades in step with internet adoption. In 1995, the top 15 internet companies were cumulatively worth around US$16.752 billion. By 2015, the cumulative market capitalisation of the top 15 public platform companies was around US$2,560,902 billion (around US$2.6 trillion) [72].

Disruption to the status quo. The rise of data and digital technology companies is accelerating the churn of S&P 500 companies. The 33-year average tenure of companies on the S&P 500 index in 1964 had shrunk to 24 years by 2016, and is forecast to shrink to 12 years by 2027 [71]. At the current rate, about half of S&P 500 companies will be replaced in the next decade [71].

Australia's tech sector performed strongly in 2018. In the year leading up to September 2018, Australia's ASX-listed tech companies performed, on average, twice as well as US NASDAQ index, which is primarily a tech sector listing. The Australian tech ASX rose by 20% in that time, compared to just 9% for the NASDAQ. The preceding year was also impressive for Australia's tech businesses, with 25% growth on the ASX [73]. Australia's tech sector is small but growing rapidly. In in recent years the Australian tech sector created its first billionaires ever, the duo behind tech company Atlassian [74].

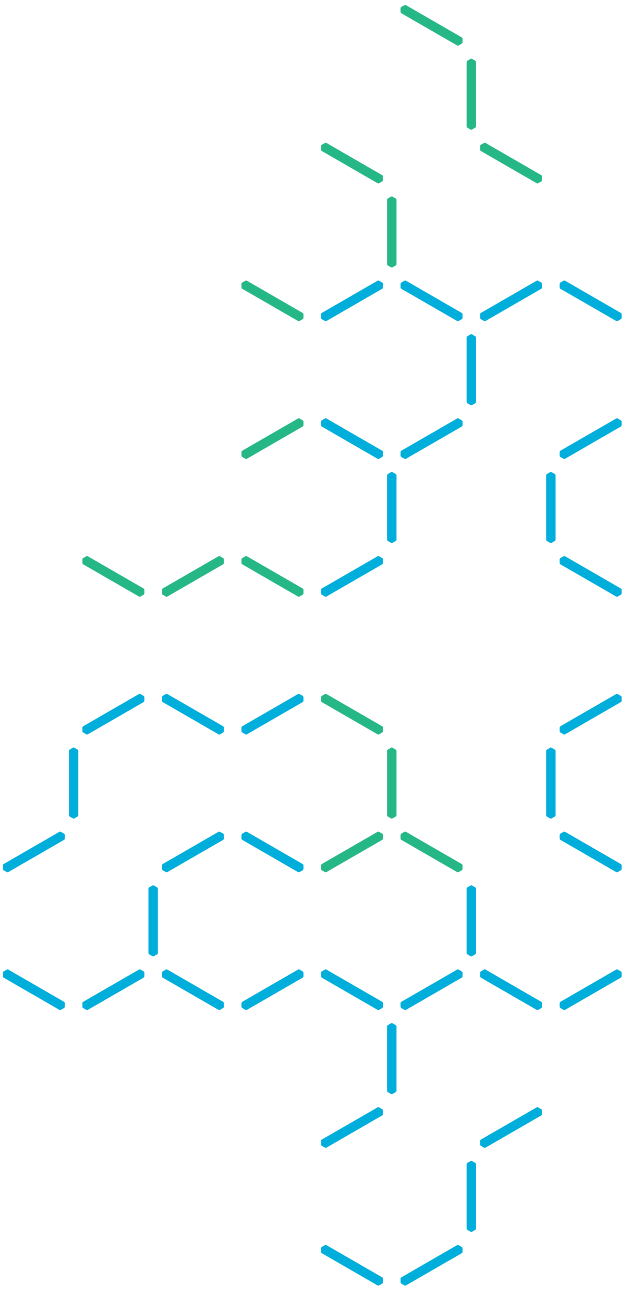
But it had its own fly-by-night operators. Australia's recent tech sector success has also brought its own fly-by-night operations, with the stratospheric rise of video company Big Un proving to be an illusory success that preceded a downfall into administration [75]. Silicon Valley has long had its share of startups that collapse under their own weight or even fraudulent behaviour, such as the recent scandal surrounding Theranos and its founder Elizabeth Holmes [76], but as Australia moves into the tech sector big leagues, it is likely to replicate the downsides of Silicon Valley along with the positives.

The role of digital platforms moving into the future. The Australian Competition and Consumer Commission (ACCC) is currently examining the role of digital platforms. In a world-first investigation of this type, the ACCC plans to liaise with international agencies in determining ways to address the problems posed by digital platforms in terms of diversity in media, competition policy, concentration of advertising revenue and other problems. Its preliminary report suggests that changes to merger laws may be needed [77].

More regulation on the horizon for digital platforms? The ACCC preliminary report states: "Despite digital platforms increasingly performing similar functions to media businesses, virtually no media regulation applies to digital platforms in comparison with some other media businesses. The regulation of media sectors supplying news and journalistic content varies by sector and different regulatory models and obligations apply for TV, radio, print and online publishers"[77]. With digital platforms facing renewed scrutiny after the spread of viral videos showing the March 2019 shootings in Christchurch, digital platform companies are increasingly coming under pressure to self-regulate or be regulated.

Decentralisation of databases. A blockchain platform works differently to the centralised databases that form the backbone of most digital operations. While most companies put their data on a centralised database, cryptocurrencies typically rely on a blockchain instead. The key difference is that there is no one individual or company that controls the database—all the information (in the case of cryptocurrencies, the transaction information) is stored on a "ledger" and governed democratically by users who can see all of the information on the ledger. This makes it more transparent, and also harder for any one individual to make any significant change without the approval of the community.

Blockchain in governance. Blockchain can be used for a variety of applications beyond cryptocurrency. Already, the CSIRO has explored using blockchain to verify food provenance, so consumers can know exactly where their food came from and what has happened to it at each step of the chain [78]. An Australian National Blockchain project has also been launched, with both government and private partners, to create a public blockchain database that could be used to facilitate cooperation among Australian businesses and organisations [79]. Data61 has identified 34 various blockchain projects across Australia that had been launched as of 2017 [80]. Figure 8 shows the relative levels of blockchain activity across specific sectors.



DIGITAL DILEMMAS

As our economy and society become more deeply immersed in digital technology the risks, challenges and emerging ethical dilemmas are becoming increasingly visible. Social media has been linked to higher levels of stress and anxiety. Governments are grappling with ways to prevent harmful and extremist material being circulated online. People are concerned about privacy and the cybersecurity threat continues to grow and morph as technology advances. This megatrend is about the rise of new digital dilemmas and the innovative efforts by governments, companies and communities to protect people from the risks whilst still capturing all benefits.

All tools can be used for good or ill. Even a broom can be used to sweep the floor or hit someone over the head. The more powerful the tool, the greater the benefit or damage it can cause.

– MICROSOFT PRESIDENT BRAD SMITH

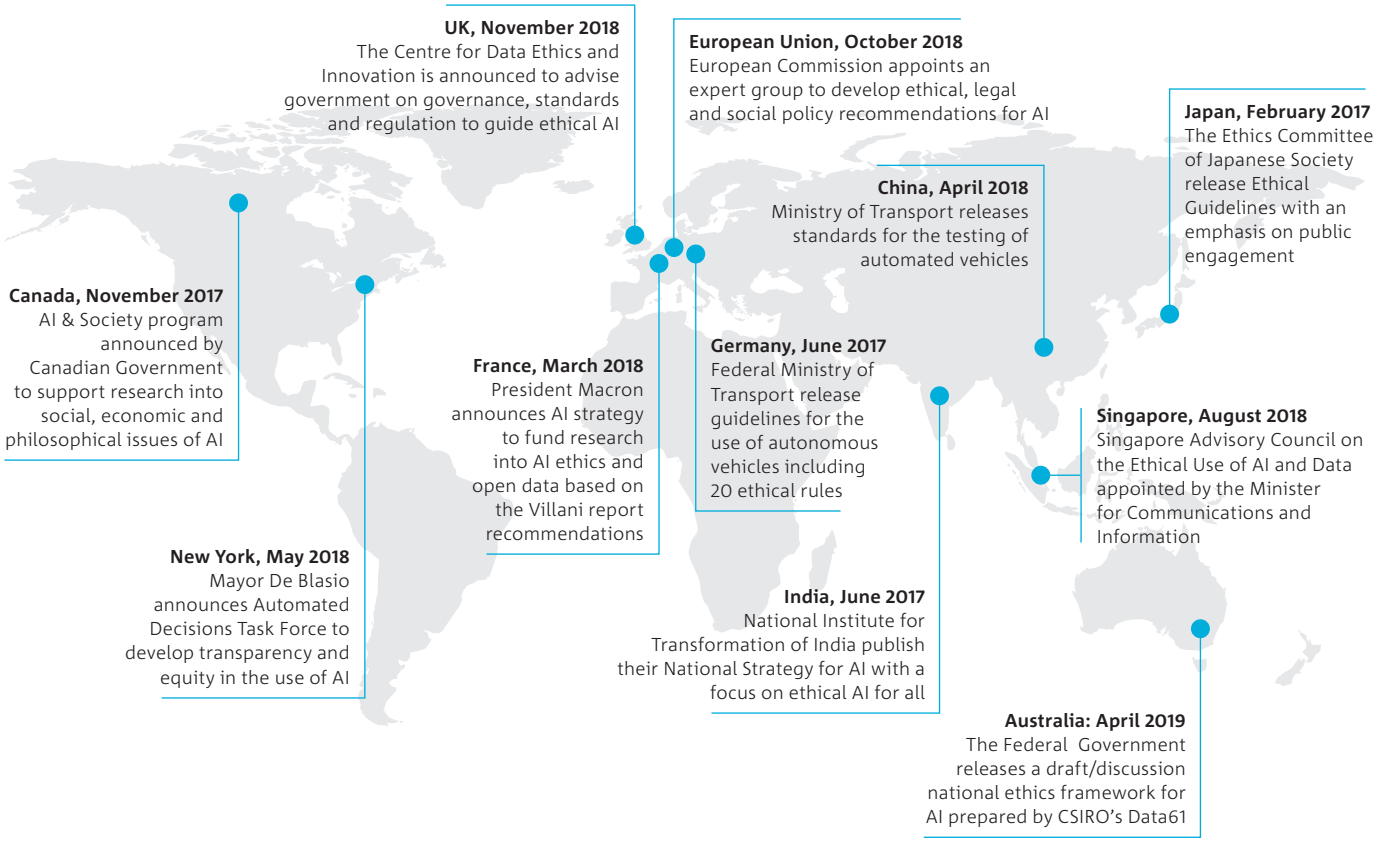


Figure 4. Recent developments in artificial intelligence ethics worldwide.

Data sources: Pan-Canadian artificial intelligence Strategy [81], Australian Federal Budget 2018-2019 [82] German Ministry of Transport and Digital Infrastructure [83], National Institute for Transformation of India [84], The Villani Report [85], Reuters [86], Japanese Society for Artificial Intelligence [87], European Commission [88] UK Parliament [89], Singapore Government [90] China's State Council [91] New York City Hall [92]

In the past few years the world has seen significant activity in emerging areas of digital science such as artificial intelligence, machine learning, human language technologies and computer vision. These are powerful tools that deliver transformative benefits to humanity. However, they are unfamiliar tools. These emerging technologies carry both risk and opportunity for breaches or improvements to ethical conduct. They are taking us into new and unchartered ethical territory. Innovations within the fields of digital/data science and ethics will help Australia manage the risks and harness the opportunities.

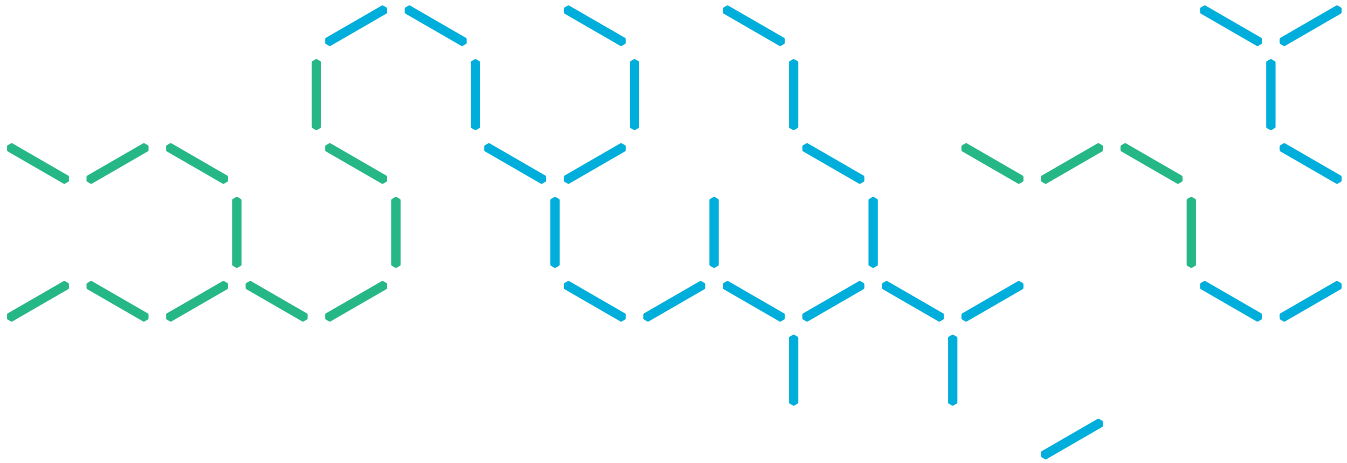
In addition to emerging and unfamiliar technologies, longstanding tools such as social media and computerised face recognition are coming under increased scrutiny. Recent times have seen governments take action to manage the challenging issue of extremist material being distributed online. Parents and schools continue to be challenged with protecting children from harmful aspects of social media and internet use. Office workers are challenged with managing information overload and online distractions which harm productivity. Cybercrime continues to grow and morph with increased cross-jurisdictional issues spanning the globe.

This megatrend is about the emerging risks and opportunities for ethical outcomes associated with digital technology. It covers the issues being encountered by governments, communities and companies. It also captures the innovations within the physical/technical sciences and the social sciences that will lead to improved outcomes for Australia.

Australia's ethics framework for artificial intelligence. In April 2019 the Australian Government published a draft national framework for the ethical development and application of artificial intelligence technologies. The document was prepared by the Data61 Insights team and has been released by the Australian Government as a discussion paper. This framework notes both the risks and opportunities for artificial intelligence to enhance or compromise ethical integrity [5]. The framework contains a set of principles and toolkit for ethical application and development of artificial intelligence. The document is on the website for the Australian Government Department of Industry Innovation and Science.

Other countries are moving on artificial intelligence ethics. Significant artificial ethics documents, strategies and policies have been published by governments in Canada [81], Germany [83], India [84], France [85], Japan [87], the European Commission [88], the United Kingdom [89], Singapore [90] China [91] and the United States of America [92]. These initiatives all aim to improve and ensure the ethical development and application of various aspects of artificial intelligence technologies. They are likely to be developed and improved over time.

Society will struggle with trust online. Two thirds of Australian youth aged 8 to 16 struggle to differentiate fake news from real [93]. Between 2017 and 2018, overall public levels of trust in NGOs, business, government and media all declined in Australia [94]. On the international Edelman Trust Barometer, Australia had the third lowest score out of all countries for trust in social media and search engines in the 2017 to 2018 period [94]. In a rapidly changing digital landscape, the ability of organisations to maintain their credibility will be a core issue that determines success – and this does not just apply to media outlets.



Privacy will be breached. Over 300 000 Australians were caught up in the 2018 Facebook data breach [95], but it was just one privacy breach among many, with roughly one in 20 Australian internet users reporting in 2017 that they were aware of an incident in which their personal information had been abused [96]. The issue is compounded by the fact that leaks can occur from almost anywhere: banks, hospitals and government departments are among the many organisations which hold sensitive personal information and can be ripe targets for malicious attacks [97].

With financial repercussions. An IBM report which looked at the cost of data breaches found that worldwide, companies are losing more customers as a result of data breaches. There are positive signs in this area though—in Australia in 2017, the average cost per data breach declined by 2% to AU$139, when compared to the previous year. Part of this was driven by a decrease in the amount of time it took to locate where and how the data breach had occurred, from an average of 201 days to 191 days [98].

Governments will respond. In response to the growing threat of data breaches, the Office of the Australian Information Commissioner (OAIC) in February began collecting and reporting on data breaches experienced by organisations, as part of its obligations under the Privacy Act. Already, the figures reveal that breaches occur across a range of sectors, with the healthcare industry topping the first quarter's figures [98]. Almost half of the 63 breaches were classed as malicious or criminal attacks [98]. The EU is currently rolling out its strictest privacy protection legislation in decades and that will have implications for Australian businesses [99], and the CSIRO's Data61 unit will develop Consumer Data Right technical standards over the next four years [100].

Social media has downsides (as well as upsides). Studies have shown that in many cases, social media usage is associated with declines in well-being [101]. Part of the reason is that it's easy to fall into the habit of comparing one's own appearance and lifestyle to the glamorised, curated lifestyles shown on the Facebook profiles of peers, with results that can damage self-esteem, particularly among teenagers [102]. Norwegian researchers have even developed a psychological scale for measuring Facebook addiction [103].

Digital will distract. When a market research company installed software to track every swipe, touch or tap on 94 people's smartphones, they found that on average, they touched their phones 2,617 times a day, with the heaviest users at well over 5,000 [104]. The ubiquity of smartphones and social media, combined with a global 24/7 news cycle, have made it harder than ever to resist these distractions.

Leading to productivity concerns. The connection between productivity and digital interruptions is not yet well understood, but some companies have already banned social media in order to keep employees focused on their work [105]. Two key concerns are regularly expressed—do the distractions have an immediate effect on worker productivity, and in the longer term, do they create more distracted minds that are unable to focus?[106] The debate over digital interruptions, productivity and the gains brought by digital technology will continue to play out over the coming years.

How addictive are computer games? The jury is still out on this question and there is some question over the specific diagnosis of a video-game addiction, but the World Health Organisation has added video game addiction to its list of psychological disorders [107]. It states "For gaming disorder to be diagnosed, the behaviour pattern must be of sufficient severity to result in significant impairment in personal, family, social, educational, occupational or other important areas of functioning and would normally have been evident for at least 12 months."

Tracking technology holds risks. At the opening event of a world-first anti-stalking unit in London, police suggested a measure which would involve tracking stalkers and notifying their victims when they are in close proximity [108]. Tracking was the suggested solution to a problem also exacerbated by the ease of tracking. Services already exist to mask caller IDs, there are bots that can swarm a victim with online threats, and GPS services and child-tracking apps can be repurposed by stalkers to hunt their victims [109]. Around 19% of women and 7% of men in Australia are stalked at some point in their lifetime [110], and as digital technologies become more widely available to the public, it is likely that they will be increasingly used for harassment or physical violence.

All things in moderation. When Facebook's internal moderation requirements were leaked to the media last year, it became clear that the social media platform was struggling to define comments that constitute unacceptable behaviour [111]. Separating "credible threats" from violent hyperbole is a difficult enough task for police, but it's even more difficult when operating on a global level. Although they may help or harm, technological solutions will not be able to resolve many of the social issues associated with the need to balance free speech with illegal or discriminatory material, even as they have ramifications in terms of making censorship easier.

Online threats are always changing. The cybersecurity landscape in 2017 included incidents on a scale and frequency never seen before and involved new and evolving malware techniques [112], such as the global spread of the Wannacry ransomware worm which exploited outdated Windows XP systems and caused over 6900 health appointments to be rescheduled or cancelled in the UK [113]. It is almost certain that threats related to breaches of private data and malicious hacking attacks will grow over the coming decade.

INVISIBLE TECHNOLOGY

For most of us there's no unplug option. However, as we become immersed in digital the marginal value of the physical world will rise. We will increasingly crave activities involving objects we can touch and feel along with nature-based experiences and real social interaction experiences. The necessity of visiting a shop, office or university campus will be diminished. But necessity will be replaced by choice. People will visit places they choose to visit. Architects and town planners will need to design buildings and urban environments which attract visitors due to their amenity and beauty. One of the major drawcards for people will be other people. Therefore, successful innovations will be human centred. The best technology of the future will be invisible. Human centred design will be at the forefront of successful digital technologies.

Science and technology revolutionize our lives, but memory, tradition and myth frame our response

– HARVARD HISTORIAN ARTHUR M. SCHLESINGER

Despite the arrival of streaming services like Netflix – and the advent of binge-watching as a pastime – movie theatres aren't struggling to survive. Visitor numbers have remained reasonably stable over the last decade and box office profits have risen even amid slight declines in numbers of theatres [114]. A digitally connected world does not mean everything will migrate to the cloud, because consumers are still in the market for in-person experiences and hand-crafted products. The experience economy offers new areas for growth, even as certain types of consumption decline. This megatrend runs counter-directional to the other digital megatrends. It's about the human being at the centre of all the advanced technology and the experiences they are seeking. The implication is that digital technology solutions which take a human centric approach are likely to be more successful in the long term.

Good technology is invisible: The inventor of the mobile phone, Marty Cooper, is among many technology developers who thinks good technology should be invisible [115]. This theme regularly crops up in innovation discussions, and essentially means that the technology should be so intuitive, users shouldn't even need to think about how to use the technology when finishing tasks with it. With this design principle in mind, new advancements may barely be noticed even as they change the technological landscape.

The Cloud. 'The Cloud' is a unique business and technical model for enabling ubiquitous, convenient, on demand access to a shared pool of computing resources that is a necessity in modern times. Invisible but always available, The Cloud assists businesses to overcome economic, technical and geographical limitations, and offers a multitude of benefits – agile systems, reduced costs, device and location independence, low maintenance, multi-tenancy, enhanced performance monitoring, increased productivity, reliability, scalability and elasticity. By 2021, 94% of workloads and compute instances will be processed by cloud data centres and only 6% will be processed by traditional data centres [116].

The hidden sensors driving cost savings. If you drive across the Sydney Harbour Bridge, you probably won't notice the thousands of small sensors gathering data on the health of the structure. A CSIRO-led project involved the installation of 2,400 sensors across the bridge, which monitor where stresses occur and maintenance may be needed [51]. These kinds of monitoring projects have a great deal of potential to help more accurately target maintenance work and dramatically cut down on the costs of infrastructure.

Is it just $C_8H_{10}N_4O_2$ or is there more to coffee? In theory baristas should have been automated. It's a rules based, structured and repetitive job with a well-defined end product. And there are plenty of advanced robotic options that make coffee with little or no human input. But baristas haven't gone anywhere. In fact it's a growing profession. Data from the Australian Bureau of Statistics indicate that between 2011 and 2016 there was a 23% rise in the number of people employed as bar attendants or baristas [117]. So is a cup of coffee at a coffee shop just about getting a drink? Is convenience the priority? Is it the experience? The ambience? A quick conversation? A joke? A smile to brighten the morning? As prices of personal coffee machines have come down it would be reasonable to expect a reduction in coffee shops as people bought more coffee to stay at home. But anyone who regularly travels through urban areas can see that this isn't the case. Making a coffee is a process that can be automated, but if barista employment is an indicator, customers don't necessarily want machines. Customers want human experiences that go beyond $C_8H_{10}N_4O_2$ (caffeine).

Peak stuff? Global furniture retailer Ikea is one of the most powerful symbols of modern capitalism, yet in 2016 its head of sustainability told a conference that the West had probably hit "peak stuff" [118]. He was indicating that affluent consumers are no longer driven as much by a need to buy physical products, and said that the company would pursue growth through recycling and repair initiatives. Could there be a future where the majority of Ikea sales are for experiences (e.g. entertainment, information, culture and food) rather than furniture products?

Reflected in an experience economy. Twenty years after academics in the Harvard Business Review coined the term "the experience economy"[119], their analysis remains as relevant as ever. Their description of the experience economy began by tracking investment in a birthday cake over the decades—from mere cents for ingredients, through to cake mixes for a few dollars, before entirely catered parties with cakes thrown in for free [119]. It was a demonstration of how customers will pay much more for value-adding through services, and how the quality of the "experience" determines what people will pay.

Digital versus experience. In the digital era, that lesson is particularly important. More recent analyses have focused on the difference between experiences and services, as well as the nature of interactions between customers and businesses [120]. Key questions relate to the "emotion" component—businesses that offer face to face, personalised service that makes every customer feel like they had a unique experience have advantages. These advantages are unlikely to be replaced by an increased presence online. Big data offers ways to understand customer needs—up to a point. Beyond that point, face to face interactions are crucial.

Craft resurgence. Boutique or artisanal offerings have carved out market niches in recent years, and this is reflected in the craft beer market. According to the Independent Brewers Association, in 2008 there were 81 craft breweries that were "small and traditional", meeting their criteria for craft beer operations, but by 2016, that figure had risen to 387 [121]. Independent brewers represented just 3% of total

beer production, but provided 73% of the employment in the beer industry—with microbrewers and small craft beer pubs representing a significant share. The market for a "beer experience" is growing.

Cultural participation holds steady. In 2005 and 2006, 85% of Australians attended cultural venues [122]. When the ABS checked attendance at the same types of cultural venues for the year leading up to the 2013-2014 period, they found that figure had moved to 86% [123,124]. Regardless of the changes brought about by technology, roughly the same proportion of people wanted a day out. Cinemas were the most popular venues to attract Australians, along with libraries, botanical gardens, zoos and aquariums. These categories remained the key categories across the decade, with only slight variations in attendance.

Digital and physical museums. Australian museums now have more digital viewers than physical ones—online catalogues and exhibitions attract more views than people walking through the doors. Amid this growth in digital visitors, however, there has been growth in physical visitors as well. The 62 museums included in the Council of Australasian Museum Directors recorded 13% growth in the years between 2008 and 2013 [125].

Complementing, not replacing. This means that people are going digital when they want to see museums, but they also want to walk through those museum doors for a day out. Digital services are complementing brick-and-mortar offerings across a range of sectors and experiencing rapid uptake. Fast food outlets regularly offer consumers the chance to order ahead of time via an app so their food will be ready when they arrive, but this doesn't fundamentally change the nature of those fast food restaurants, just as Uber Eats may grow and expand where and how it delivers food, but the food offerings themselves can remain the same.

Libraries aren't going anywhere. Contrary to rumours of their demise, libraries are adapting to the digital era, generally either holding their position or thriving. While there has been a slight decrease in book loans, the number of customers has risen slightly, albeit at a slightly slower pace than overall population growth [126,127]. Libraries are also expanding alternative offerings, like book depots, kiosks and vending machines. Libraries will have a role in Australia's digital future, though they are already shifting from being stewards of books to stewards of knowledge and entertainment.

Skills shortages affect uptake. The skill levels of users and their familiarity with technology is a key consideration of any good technology developer. What good is an advanced piece of technology if users can't or won't learn to use it? In the US, the agriculture sector has some of the widest gaps between the technology available and the skills of the people who are actually meant to use it [128]. In Australia, the agriculture sector is seeing skills shortages as farmers struggle to locate specialists that can work with digital agriculture tools [129]. These kinds of skills shortages will affect the extent to which the digital revolution changes Australia, because if workers can't use new technologies, the old technologies will continue to dominate.

Offline relationships, online. Tinder may have made the term "hookup app" part of the modern digital lexicon, but Tinder wouldn't have found such success if humans didn't have a strong desire for in-person relationships, however brief those relationships may be. Estimates in 2015 indicated that around one in 10 Australians aged 18 to 24 had used Tinder in the month before the poll [130]. While digital technology will transform the ways in which people communicate, that desire for intimacy will remain and be a driver of technological development, instead of being replaced by it.

What can be monetised? Another key consideration that will determine digital uptake relates to how well technologies can be leveraged for profit. Blockchain, for example, has been enormously successful in cryptocurrencies, which by their very nature can facilitate investment and returns. But at the same time, much of the transformative potential of blockchain lies in the fact it is a radical new form of transparency. Some of its applications are already being monetised and more will be in future, but efforts to unlock some of its disruptive potential could find obstacles if there are already existing, more readily monetised forms of data sharing.

Startups can stop. The vast majority of tech startups fail, with some reports indicating a failure rate of 90% [131]. Sometimes these failures are easy to predict, like the spectacular collapse of IoT startup Juicero, whose US$399 juicers had one key function: to squeeze juice packets that could just as effectively be squeezed by hand. While the Juicero collapse caused mirth among commentators [132], other startup failures had more severe consequences. The long-burn downfall of blood testing startup Theranos was an exercise in dogged determination by journalists and whistleblowers who spent months chipping away at the façade of a Silicon Valley icon once valued at US$9 billion, to reveal that its finger-prick blood testing service did not work as advertised [133].

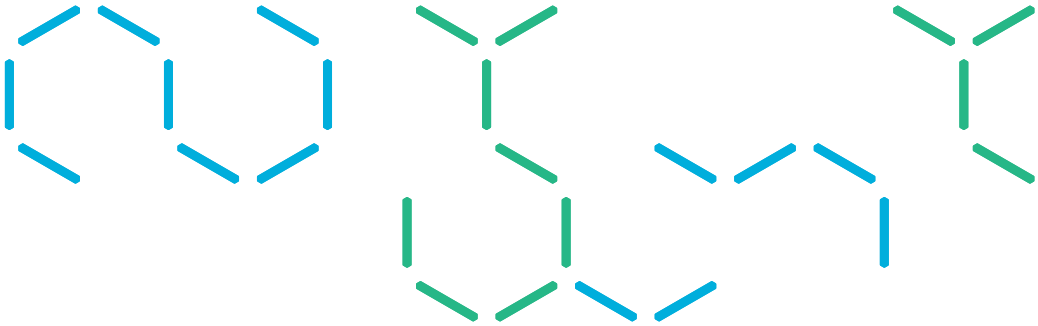
And that affects development. As fraud charges were brought against Theranos founder Elizabeth Holmes, authorities told media, "Innovators who seek to revolutionize and disrupt an industry must tell investors the truth about what their technology can do today, not just what they hope it might do someday" [133]. When plotting scenarios for strategic foresight purposes, a frequently used "axis of uncertainty" relates to technological development or uptake. A key consideration here is whether startups can actually deliver on their promises.

EFFECTIVE DIGITAL STRATEGY – EIGHT INGREDIENTS

The extent of forthcoming change driven by digital transformation is staggering. Just about every geographic region, jurisdiction, industry sector, demography and profession will be impacted. Millions of workers will need to retrain and reposition their careers as digital technology reshapes the labour market. Governments will need to design and implement new policies, regulations and services as society is reshaped. Companies will need to redesign business processes and open new product offerings for different types of customers. There is much opportunity and risk.

In response to these challenges the Data61 Insight team has been working with numerous large and small organisations across our nation and the world on digital strategy problems. Through this work, we've identified elements of successful digital strategy that transcend industries, geographies and policy-sectors. In this section of the report we describe eight high-level strategic responses to digital disruption that will help Australian governments, companies, communities and individuals achieve better outcomes.

Figure 5. Ingredients for effective digital strategy



1. Accelerate. This involves removing barriers, reducing friction and increasing the cadence of organisational change to match the fast paced digital world. Many digital technologies are following exponential and/or geometric (as opposed to linear) growth curves both in terms of capability and user adoption/uptake. This means that each year, or month, sees markedly more change than the preceding time period. Platform based models such as Uber, Airbnb, Amazon and others are capable of transforming a marketplace within months and existing companies or industries may not have catch-up time. Australia needs organisational structures, cultures and governance models with increased agility and flexibility.

2. Automate. The costs of high powered artificial intelligence, robotics and sensory systems are continuing to decline. These represent more cost efficient, more effective and often safer business processes. For the most part Australia is/organisations are adopting automated systems too slowly given their benefits. The coming decades will see a relentless push by businesses to design, test and implement automated systems. Artificial intelligence can provide more than just an improved way of doing an old process; it can also completely replace the need for entire business functions or operations.

3. Migrate. Despite a few decades of digital, a significant number of government and business processes are still conducted via analogue means. Transferring these to digital format can be costly and risky. However, there are many long term benefits and society, especially younger people, have heightened expectation for user-friendly delivery of seamless and often invisible digital services. Organisations need to identify and prioritise business processes which can be converted from analogue to digital. This can be challenging due to the unfamiliar nature of many new technologies (e.g. blockchain). Improved decision support and appraisal frameworks are needed to identify what processes are migrated to digital. The migration strategy also involves a transfer of human skills and aptitudes suited to the digital economy.

4. Mitigate. The downsides of digital are well known. These include privacy breaches, cybercrime, online manipulation, fake news, information overload, sedentary behaviours associated with excessive screen time and productivity issues for office workers with numerous interrupts. Many of these problems, especially cybercrime, are worsening at accelerating rates. Any digital strategy needs solutions to these downsides. This includes the replacement of human workers with digital solutions and social equality impacts of digital. The aim is to ensure everyone benefits from the digital transformation.

5. Navigate. Theories of recombinant innovation indicate that technological inventions have a multiplicative effect. One technological innovation creates a platform for numerous further technological innovations which in turn enable new platforms for a multitude of technological innovations. This means company boards and policy makers are facing a continually shifting landscape. This calls for improved capacity for anticipatory governance; seeing what lies ahead and taking proactive action. Foresight and digital strategy are two sides of the same coin.

6. Innovate. The digital economy lowers the barriers to marketplace entry and decreases the costs associated with designing and testing new business models. This environment is favourable to entrepreneurs. Large organisations in the public and private sector need a changed risk profile and an appetite for experimentation with new technologies and business models. The biggest risk is taking no risk at all.

7. Cogitate. The world's largest companies today such as Alphabet (Google), Microsoft, Amazon and Facebook are set aside from traditional large companies by the amount they invest in research and development which lies in the vicinity of 10-30 percent of total revenue. Governments across the OECD are also ramping up digital research and development. There's no brute force solution to the digital economy and hard work alone won't be sufficient. A deeper, new or transformative digital capability can place a company beyond the reach of competitors and quickly consume the bulk of market share. It's about working smarter not harder in the digital economy.

8. Gravitate. As the digital world engulfs everything the marginal value of the physical world rises. Consumers and citizens are likely to place greater emphasis on real human experiences involving social interaction, nature and physical spaces. In this last strategy the importance of gravitating towards the all-important human experience-factor in a digitally immersed economy is emphasised. Often the best digital technologies are invisible and a digital strategy should be wrapped around what people want and need, not the technology itself.

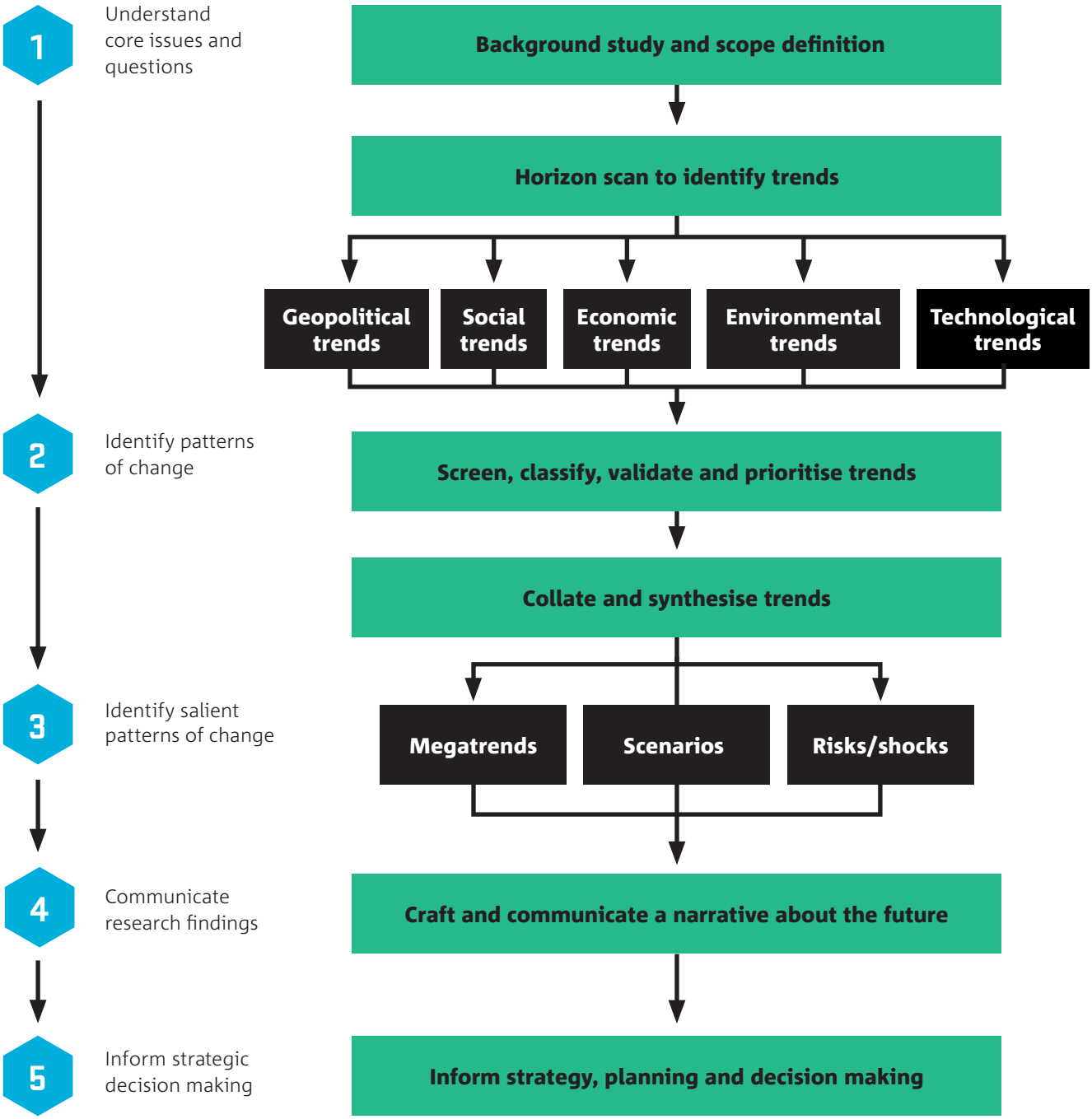


Figure 5. Strategic foresight process applied by Data61 Insights.

OUR METHODS – STRATEGIC FORESIGHT

Strategic foresight is an emerging research field and profession which aims to explore plausible futures and help people make wiser choices. It occurs at the intersection of multiple disciplines including geography, economics, management science, operations research and planning theory. The field of strategic foresight attracts regular conferences, university courses and dedicated research and professional journals.

Concepts of strategic foresight emerged after World War II with an early focus on technology forecasting. In the 1960s and 1970s the field was given a boost by the formation of the Royal Dutch Shell (an energy company) scenario-planning team. Over the decades that followed, thousands of scholarly articles, professional guides and books have been published on methods and applications of strategic foresight. Cutting-edge research is developing processes via which future scenarios can be combined with decision making.

Over the past several years the *Insights* team housed within one of CSIRO's Data61 business unit has developed a generic strategic-foresight process pioneered through multiple megatrends, scenario planning and strategy projects delivered in diverse industry sectors. It draws upon numerous theories developed by researchers worldwide and on our own practical experience in delivering many strategic-foresight projects to private and public-sector clients. This process for identifying megatrends and scenarios has been applied in the current study. There are five main phases of strategic foresight using this process.

In the first stage, the process commences with a background study and scope definition. The background study documents the current conditions, size, structure, opportunities and challenges within the industry, region or societal grouping being studied. Unlike the forthcoming stages, the background study is concerned with the current status and historic conditions. It does not attempt to look into the future. The scope defines the stakeholder groups, timeframe and issues to be considered throughout the remainder of the project.

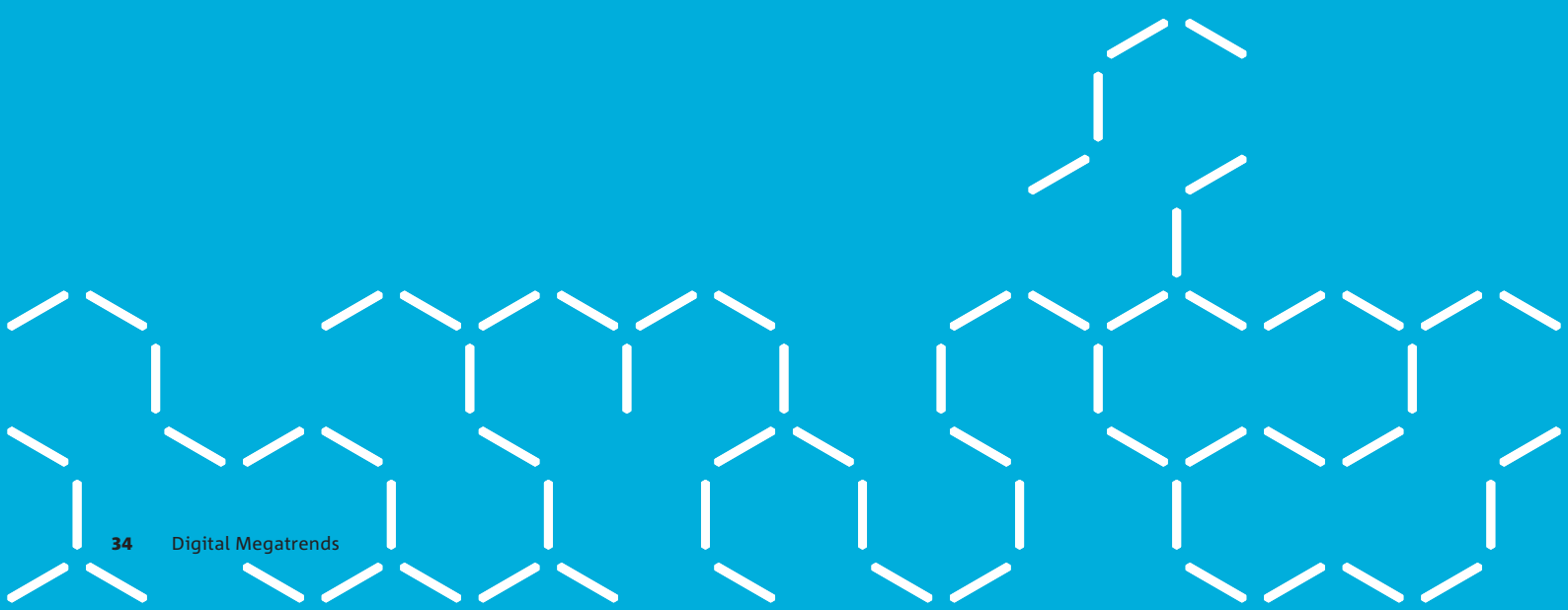
In the second stage, trends are identified by a horizon scanning process. This casts a wide net over all patterns of change which are potentially relevant to the organisation. The horizon scan errs on the side of being overly inclusive rather than exclusive. The trends are typically grouped as geopolitical, social, economic, environmental and technological. However, an alternative and tailored nomenclature can be designed to classify the trends based on the unique needs of the organisation. We sometimes build statistical, mathematical and econometric models to forecast quantitative trends. However, much lies beyond the scope of quantification and is handled via qualitative analysis.

Processes of validation and screening are used at a secondary stage to remove any 'by-catch'; trends which are unsubstantiated or irrelevant. The screening and validation process checks to ensure trends pass two tests: (a) evidence that the pattern of change is actually occurring and likely to continue occurring into the future; and (b) evidence that it matters to the organisation.

The process of validation often involves checking the proposed trend against datasets, expert opinions and research findings published in journals to ensure accuracy. Sometimes evidence is found both supporting and undermining the trend and the foresight team need to make a difficult judgement call about where the weight of evidence lies and whether the trend should be included.

In the third stage, the trends are collated and synthesised to identify more salient patterns of change and possible future events which hold significant implications for decision makers. These are captured as building blocks – scenarios, megatrends and risks. These building blocks are not necessarily mutually exclusive and a foresight study may use one, some or all in developing a narrative about the future.

The final two stages involve crafting and communicating a narrative about the future and then injecting that narrative into strategic decision-making processes. The narrative captures all of the relevant building blocks and describes the methods and information sources so that the audience has confidence in the results. This description ends at "decision making" but we note an entirely new set of theories, tools and techniques come into play at this point.



REFERENCES

1. ISA. 2017. Australia 2030: Prosperity through Innovation. Innovation and Science Australia (ISA), Australian Government. Canberra, Australia.
2. AlphaBeta. 2018. Digital innovation: Australia's $315B opportunity. AlphaBeta. Sydney.
3. McKinsey. 2017. Digital Australia: Seizing the opportunity from the Fourth Industrial Revolution. McKinsey and Company. Sydney.
4. PwC. 2019. Sizing the prize: PwC's Global Artificial Intelligence Study: Exploiting the AI Revolution. Price Waterhouse Coopers. London.
5. Dawson D, Schleiger E, Horton J et al. 2019. Artificial Intelligence: Australia's Ethics Framework. Data61 CSIRO. Australia.
6. Hajkowicz S, Evans M, Karimi S et al. 2019. Artificial intelligence: Australia's year 2030 roadmap (In Preparation). CSIRO Data61 (Not Yet Published). Brisbane.
7. CSIRO. 2018. CSIRO invests $35M in future of space and AI for Australia. Media Release 19 November. CSIRO. Canberra.
8. Australian Government. 2019. Australian Research Council grants dataset. Australian Research Council.
9. University of Adelaide. New research institute for machine learning [press release]. 9 December 2017. Available from: https://www.adelaide.edu.au/news/news97022.html.
10. Palaszczuk A, Jones K. 2018. Government announces state-of-the-art artificial intelligence hub. Queensland Government - Media Statements.
11. Singh S, Okun A, Jackson A. 2017. Artificial intelligence: Learning to play Go from scratch. Nature, 550(7676): 336-337.
12. Chan D. 2017. The AI That Has Nothing to Learn from Humans. The Atlantic (www.theatlantic.com).
13. Danni F. 2018. Top Go Player Ke Jie Loses to Made-in-China AI. Sixth Tone (www.sixthtone.com/news).
14. Zoph B, Vasudevan V, Shlens J et al. 2017. AutoML for large scale image classification and object detection (Google Blog). Google. Mountain View, California, United States.
15. Hauert S. 2016. Building a Startup Ecosystem for Robotics in Europe. IEEE Robotics & Automation Magazine, 23(3): Online Article.
16. Graetz G, Michaels G. 2015. Robots at Work. London School of Economics and Political Science Centre for Economic Performance. London.
17. Lu C, Tang X. Surpassing human-level face verification performance on LFW with gaussian face. Proceedings of the Twenty-Ninth AAAI Conference on Artificial Intelligence; 2888245: AAAI Press; 2015. p. 3811-3819.
18. Bargal S A, Barsoum E, Ferrer C C et al. Emotion recognition in the wild from videos using images. Proceedings of the 18th ACM International Conference on Multimodal Interaction; 2997627: ACM; 2016. p. 433-436.
19. Kołakowska A, Landowska A, Szwoch M et al. 2014. "Emotion Recognition and Its Applications" In: Hippe Zdzisław S. et al. Human-Computer Systems Interaction: Backgrounds and Applications. Chapter 3. Springer International Publishing.
20. Linn A. 2016. Historic Achievement: Microsoft researchers reach human parity in conversational speech recognition (https://blogs.microsoft.com). Microsoft Blog.
21. Xiong W D, J. & Huang, X. & Seide, F. & Seltzer, M. & Stolke, A. & Yu, D. & Zweig, G. 2016. Acheiving Human Parity in Conversational Speech Recognition. Microsoft Research Technical Report MSR-TR-2016-71. Microsoft, United States.
22. Youyou W, Kosinski M, Stillwell D. 2015. Computer-based personality judgments are more accurate than those made by humans. Proceedings of the National Academy of Sciences, 112(4): 1036-1040.
23. Cellan-Jones R. 2017. The robot lawyers are here - and they're winning. BBC News.
24. Whyte C. 2019. AI can diagnose childhood illnesses better than some doctors (11 February 2019). New Scientist. United States.
25. Ravven W. 2016. Deep learning—a giant step for robots. TechXplore
26. Bughin J, Hazan E, Ramaswamy S et al. 2017. Artificial Intelligence: The Next Digital Frontier? McKinsey Global Institute. United States.
27. Bughin J, McCarthy B, Chui M. 2017. A Survey of 3,000 Executives Reveals How Businesses Succeed with AI. Harvard Business Review, United States.
28. Clinch M, Turak N. 2018. Microsoft CEO Satya Nadella on the rise of artificial intelligence – "The future we will invent is a choice we make". CNBC News Online.

29. ABS. 2018. Internet Activity, Australia, December 2017 (Catalogue Number 8153.0). Australian Bureau of Statistics, Canberra.

30. ABS. 2016. Internet Activity, Australia (Catalogue Number 8153.0). Australian Bureau of Statistics, Canberra.

31. NBN. How much data does streaming video, movies and TV use? (2018 edition) NBN Company Website (www.nbnco.com.au), Australia.

32. OECD. 2015. Data-Driven Innovation: Big data for Growth and Well-Being. Organisation for Economic Cooperation and Development, Paris.

33. Foulkes P. 2017. The intelligent use of big data on an industrial scale. Portland, United States.

34. Deloitte. 2018. The future of work: Occupational and education trends in data science in Australia, Deloitte, Sydney.

35. Miller S, Hughes D. 2017. The Quant Crunch: How the demand for data science skills is disrupting the job market. IBM, United States.

36. Cisco. 2015. Cisco Visual Networking Index: Forecast and Methodology 2015-2020, Cisco United States.

37. ACMA. 2016. 5G and mobile network developments—Emerging issues. Australian Communications and Media Authority. Australia.

38. Duke J. 2018. Australians first in the world to try 5G network. Sydney Morning Herald, Business News (www.smh.com.au).

39. DCA. 2017. 5G-Enabling the future economy. Australian Government, Australian Government Department of Communications and the Arts, Canberra.

40. Morrow B. 2018. nbn-the challenges of transforming an industry. NBN Co, Australia.

41. Rabaey J. 2018. What is 5G? The next generation of wireless, explained. The Conversation, Australia.

42. Gregory M. Explainer: what is 5G? The Conversation, Australia.

43. Thomas J, Barraket J, Wilson C et al. 2017. Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2017. Research Roy Morgan: Melbourne.

44. Thomas J, Barraket J, Ewing S et al. 2016. Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2016. Swinburne University of Technology. Melbourne.

45. Grijpink F, Ménard A, Sigurdsson H et al. 2018. The road to 5G: The inevitable growth of infrastructure cost. McKinsey, United States.

46. OECD. 2015. Working Party on Communication Infrastructures and Services Policy. Development of high speed networks and the role of municipal networks. Organisation for Economic Cooperation and Development, Paris.

47. Scott J. 2018. You should be paid for your Facebook data. Quartz Online Magazine (website: https://qz.com).

48. Tapscott A, Gifford K. 2017. Globalization failed too many people. Here's the technology that could help it work for everyone. Quartz Online Magazine (website: https://qz.com).

49. Huawei. Huawei Creates a Smart City Nervous System for More Than 100 Cities with Leading New ICT [press release]. Huawei, 14 November 2017.

50. Wroe D. 2018 Australia takes over Solomon Islands internet cable amid spies' concerns about China. Sydney Morning Herald, Australia.

51. Data61. Monitoring the health of structures. Available from: https://www.data61.csiro.au/en/Our-Work/Future-Cities/Planning-sustainable-infrastructure/Structural-health-monitoring.

52. Roy Morgan Research. 2016. Second wind lifts Netflix over 5.75 million Australians – but not everyone actually watches it (December 1). Available from: http://www.roymorgan.com.

53. Duke J. 2018. Data downloads more than double since Netflix arrival. Sydney Morning Herald, Australia.

54. Haselton M, Nettle D, Murray D. 2015. The Evolution of Cognitive Bias. The Handbook of Evolutionary Psychology. Wiley, New York.

55. Pannucci C, Wilkins E. 2011. Identifying and Avoiding Bias in Research. National Institutes of Health, United States.

56. Lohr S. Facial Recognition Is Accurate, if You're a White Guy. New York Times, United States.

57. Amos Tversky D K. 1973. Availability: A heuristic for judging frequency and probability. Cognitive Psychology, 5(2): 207-232.

58. Berg A, Buffie E, Zanna L-F. 2018. Should we fear the robot revolution? International Monetary Fund, Washington DC.

59. Frey C B, Osborne M A. 2013. The future of employment: How susceptible are jobs to computerisation. Technology Oxford Martin Programme on the Impacts of Future, Oxford, United Kingdom.

60. Durrant-Whyte H, McCalman L, O'Callaghan S et al. 2015 'The impact of computerisation and automation on future employment' In: Australia's future workforce? Committee for Economic Development of Australia, Melbourne.

61. Nedelkoska L, Quintini G. 2018. Automation, skills use and training (working paper number 202) Organisation for Economic Cooperation and Development. Paris.

62. OECD. 2018. Transformative technologies and jobs of the future. Organisation for Economic Cooperation and Development, Paris.

63. WEF. 2018. The future of jobs report. World Economic Forum. Geneva.

64. McKinsey. 2016. The age of analytics: competing in a data-driven world. McKinsey, New York.

65. Metz C. 2017. Tech Giants Are Paying Huge Salaries for Scarce A.I. Talent. New York Times, United States.

66. Kohlbacher F. 2017. Skills 4.0: How CEOs shape the future of work in Asia. Asian Management Insights, 4(1): 40-47.

67. Deming D. 2017. The Growing Importance of Social Skills in the Labor Market. Quarterly Journal of Economics, 132(4): 1593-1640.

68. Börner K, Scrivner O, Gallant M et al. 2018. Skill discrepancies between research, education, and jobs reveal the critical need to supply soft skills for the data economy. Proceedings of the National Academy of Sciences of the United States of America, 115(50): 12630-12637.

69. AlphaBeta. 2019. Future Skills - To adapt to the future of work, Australians will undertake a third more education and training and change what, when and how we learn. Prepared by AlphaBeta for Google Australia. Sydney.

70. Bram Klievink M J, Yao-Hua Tan. 2012. A Stakeholder Analysis of Business-to-Government Information Sharing: The Governance of a Public-Private Platform. International Journal of Electronic Government Research

71. Anthony S, Viguerie P, Schwartz E et al. 2018. 2018 Corporate Longevity Forecast: Creative Destruction is Accelerating. Lexington, United States.

72. Accenture. 2016. Platform Economy: Technology-driven Business Model Innovation from the Outside In. Accenture Website, Australia.

73. Clarke C. 2018. Australia's tiny tech sector has outgunned the US digital giants this year. ABC News 27 September, Australia.

74. Bowles N. 2019. The Strange Experience of Being Australia's First Tech Billionaires. New York Times. United States.

75. Powell D. 2018. Hooked on a Big Un: How the listed tech company went from all-star to administration in less than a year. Smartcompany 24 September (www.smartcompany.com.au), Australia.

76. Bilton N. 2019. As Theranos burned, Elizabeth Holmes was partying - at Burning Man. Vanity Fair, New York.

77. ACCC. 2018. Digital Platforms Inquiry: preliminary report. Australian Competition and Consumer Commission. Canberra, Australia.

78. Galovic N. 2018. Is your honey faking it? CSIROscope, CSIRO, Australia.

79. ANB. 2018. Australian National Blockchain Home Page (cited 2 May, 2019).

80. Bratanova A, Devaraj D, Horton J et al. 2019. Towards the blockchain plateau of productivity. A Data61 Consultancy Report for the Australian Computer Society, Brisbane.

81. Canadian Institute for Advanced Research. 2017. Pan-Canadian artificial intelligence strategy. Government of Canada.

82. Australian Government. 2018. 2018-2019 Budget overview. Australian Treasury. Canberra.

83. Ethics Commission Federal Ministry of Transport and Digital Infrastructure. 2017. Automated and connected driving. German Government. Berlin.

84. National Institute for Transforming India. 2018. National strategy for artificial intelligence. Government of India.

85. Villani C. 2018. For a Meaningful Artificial Intelligence. Government of France, Paris.

86. Rosemain M and Rose M. 2018. France to spend $1.8 billion on AI to compete with U.S., China. Reuters Online News 29 March.

87. JSAL. 2017. Artificial intelligence ethical guidelines. The Japanese society for artificial intelligence, Tokyo, Japan.

88. EC. 2018. High-level expert group on artificial intelligence. European Commission, Brussels.

89. UK Parliament. 2018. World first Centre for Data Ethics and Innovation: Government statement. United Kingdom Government, London.

90. Infocomm Media Development Authority. 2018. Composition of the Advisory Council on the Ethical Use of Artificial Intelligence and Data. Minister for Communications and Information. Singapore.

91. The State Council: The People's Republic of China. 2018. Guidelines to ensure safe self-driving vehicle tests. The State Council: The People's Republic of China. The People's Republic of China.

92. New York City Hall. 2018. Mayor de Blasio announces first-in-nation Task Force to examine automated decision systems used by the city. Mayor's Office.

93. Notley T, Dezuanni M, Zhong H et al. 2017. News and Australian children: how young people access, perceive and are affected by the news. Western Sydney University, Queensland University of Technology and Crinkling News 2017, Sydney Australia.

94. Edelman. 2018. 2018 Edelman Trust Barometer - Australia Results. Edelman.

95. Schroepfer M. An Update on Our Plans to Restrict Data Access on Facebook. Facebook Press Release 04 April 2018 (Available from: https://newsroom.fb.com).

96. ABS. 2018. Household Use of Information Technology. Catalogue Number 8146.0, Australian Bureau of Statistics, Canberra.

97. OAIC. 2018. Quarterly Statistics Report: January 2018 – March 2018. Office of the Australian Information Commissioner.

98. Ponemon Institute. 2017. Ponemon Institute's 2017 Cost of Data Breach Study: Australia.

99. OAIC. 2017. General Data Protection Regulation guidance for Australian businesses. Office of the Australian Information Commissioner, 31 May. Office of the Australian Information Commissioner, Australian Government, Canberra.

100. Australian Competition and Consumer Commission. 2018. ACCC Welcomes Consumer Data Right [press release]. Australian Competition and Consumer Commission, Available from: https://www.accc.gov.au/media-release/accc-welcomes-consumer-data-right.

101. Shakya H, Christakis N. 2017. Association of Facebook Use With Compromised Well-Being: A Longitudinal Study. Am J Epidemiol. 2017 Feb 1;185(3):203-211.

102. Jan M, Soomro S A, Ahmad N. 2017. Impact of Social Media on Self Esteem. European Scientific Journal, DOI: http://dx.doi.org/10.19044/esj.2017.v13n23p329.

103. Andreassen C S, Torsheim T, Brunborg G S et al. 2012. Development of a Facebook Addiction Scale. Psychol Rep. 2012 Apr;110(2):501-17.

104. Winnick M, Zolna R. 2016. Putting a Finger on Our Phone Obsession. Dscout Website (https://blog.dscout.com/mobile-touches).

105. Lucas C. Social media facing bans in workplace agreements. Sydney Morning Herald [Internet]. 2012 Available from: https://www.smh.com.au/technology/social-media-facing-bans-in-workplace-agreements-20121214-2bfbl.html.

106. Nixon D. Is the economy suffering from the crisis of attention? Bank Underground [Internet]. 2017 Available from: https://bankunderground.co.uk/2017/11/24/is-the-economy-suffering-from-the-crisis-of-attention/.

107. WHO. 2018. Gaming disorder: Online Q&A. World Health Organisation, Geneva.

108. Dodd V. 2018. Stalkers may be tagged to alert victims to proximity, police say. The Guardian Newspaper (2018 Available from: https://www.theguardian.com/uk-news).

109. Valention-DeVries J. 2018. Hundreds of Apps Can Empower Stalkers to Track Their Victims. New York Times, United States.

110. ABS. 2012. Personal Safety, Australia, 2012. Catalogue Number 4906.0. Australian Bureau of Statistics. Canberra.

111. Sulleyman A. 2017. Facebook's leaked threat guidance for moderators makes more sense than people think (https://www.independent.co.uk).

112. Cisco. 2018. Annual Cybersecurity Report. Cisco Systems, San Jose California, United States.

113. Smart W. 2018. Lessons learned review of the WannaCry Ransomware Cyber Attack. Department of Health and Social Care, United Kingdom Government, London.

114. Australia S. 2018. Number of Australian cinema admissions and gross box office, 1976-2017. Screen Australia, Australian Government, Canberra.

115. Cooper M. 2017. Marty Cooper, inventor of the cellphone: The next step is implantables.

116. Cisco. 2017. Global Cloud Index (GCI). Cisco Systems: San Jose, United States.

117. ABS. Community and Personal Service Workers on the rise [press release]. Australian Bureau of Statistics, 23 October 2017, Australian Government, Canberra.

118. Farrell S. We've hit peak home furnishings, says Ikea boss. The Guardian Newspaper.

119. Pine J, Gilmore J. 1998. Welcome to the experience economy. Harvard Business Review, United States.

120. Ferreira H, Teixeira A A. 2013. 'Welcome to the experience economy': assessing the influence of customer experience literature through bibliometric analysis. FEP Working Papers481): 1-26.

121. IBA 2019. The rise of craft beer: opportunities and challenges for the malting industry [press release]. Independent Brewer's Association. Available from: http://iba.org.au/rise-craft-beer/.

122. ABS. 2007. Attendance at Selected Cultural Venues and Events, Australia, 2005-06. Catalogue Number: 4114.0. Australian Bureau of Statics, Canberra.

123. ABS. 2015. Attendance at Selected Cultural Venues and Events, Australia, 2013-14. Catalogue number 4114.0.

124. ABS. 2015. Attendance at Selected Cultural Venues and Events, Australia, 2013-14. Available from: Catalogue Number: 4114.0. Australian Bureau of Statics, Canberra.

125. Greene P. 2014. Visits to Australia's museums rise on the back of a digital experience. The Conversation, Australia.

126. State Library of Queensland. 2012. Australian public libraries statistical report 2011-2012.

127. State Library of Queensland. 2016. Australian public libraries statistical report 2015-2016.

128. James Manyika S R, Somesh Khanna, Hugo Sarrazin, Gary Pinkus, Guru Sethupathy, Andrew Yaffe. 2015. Digital America: A tale of the haves and have-mores.

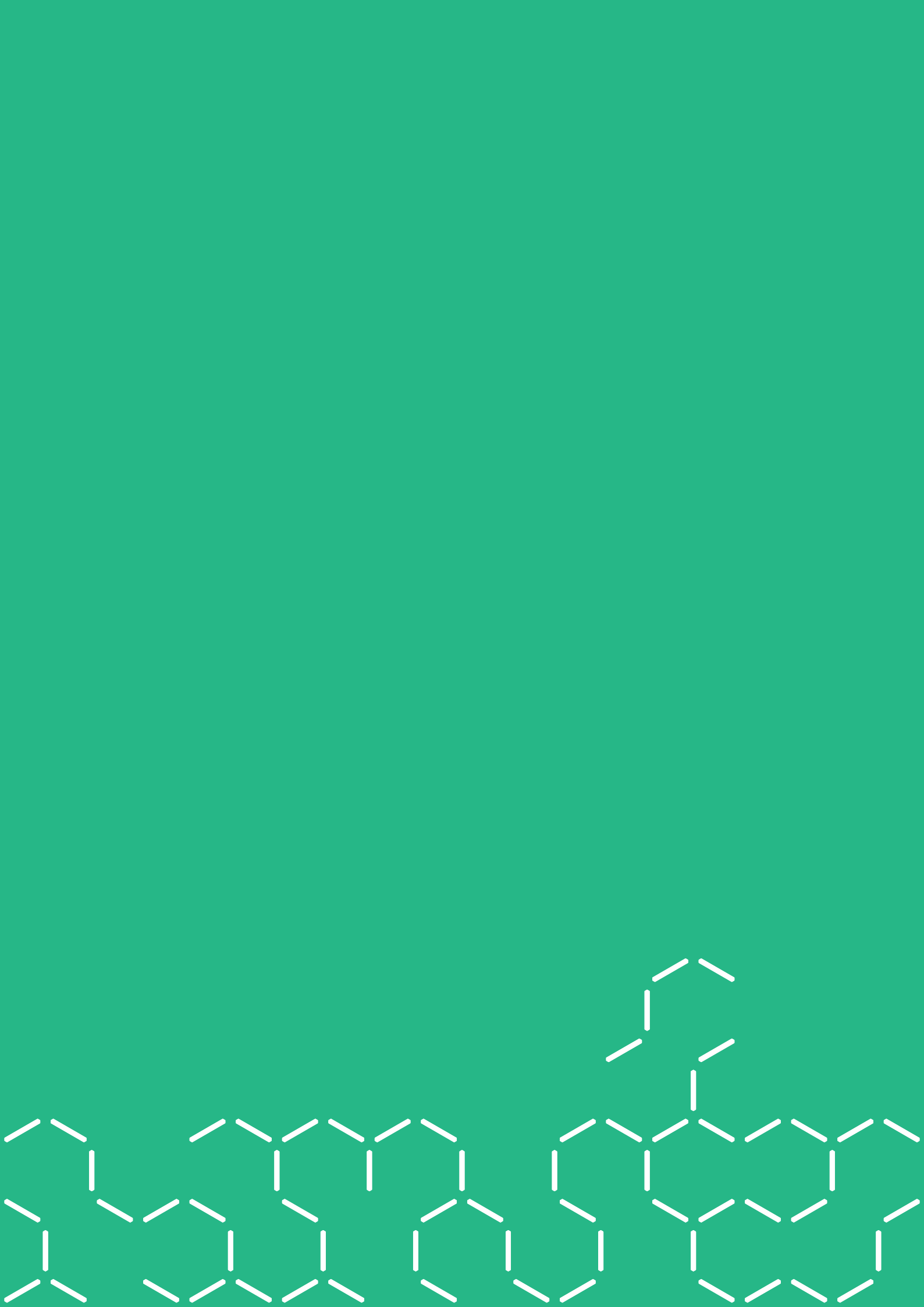
129. Johnson R. High technology in agriculture creates changing trends in recruitment. Agricultural Appointments blog, Available from: https://www.agri.com.au/high-technology-in-agriculture-creates-changing-trends-in-recruitment/

130. Roy Morgan Research. 2015. Nearly 1 in 10 young Aussie singles use Tinder. Roy Morgan, Australia.

131. Marmer M, Herrmann B, Dogrultan E et al. 2011. Startup Genome Report Extra on Premature Scaling Genome Startup. Stanford University, United States.

132. Levin S. 2017. Squeezed out: widely mocked startup Juicero is shutting down. The Guardian Newspaper, London.

133. Securities and Investment Commission. 2018. Theranos, CEO Holmes, and Former President Balwani Charged with Massive Fraud. US Securities and Exchange Commission. United States Government, Washington DC.



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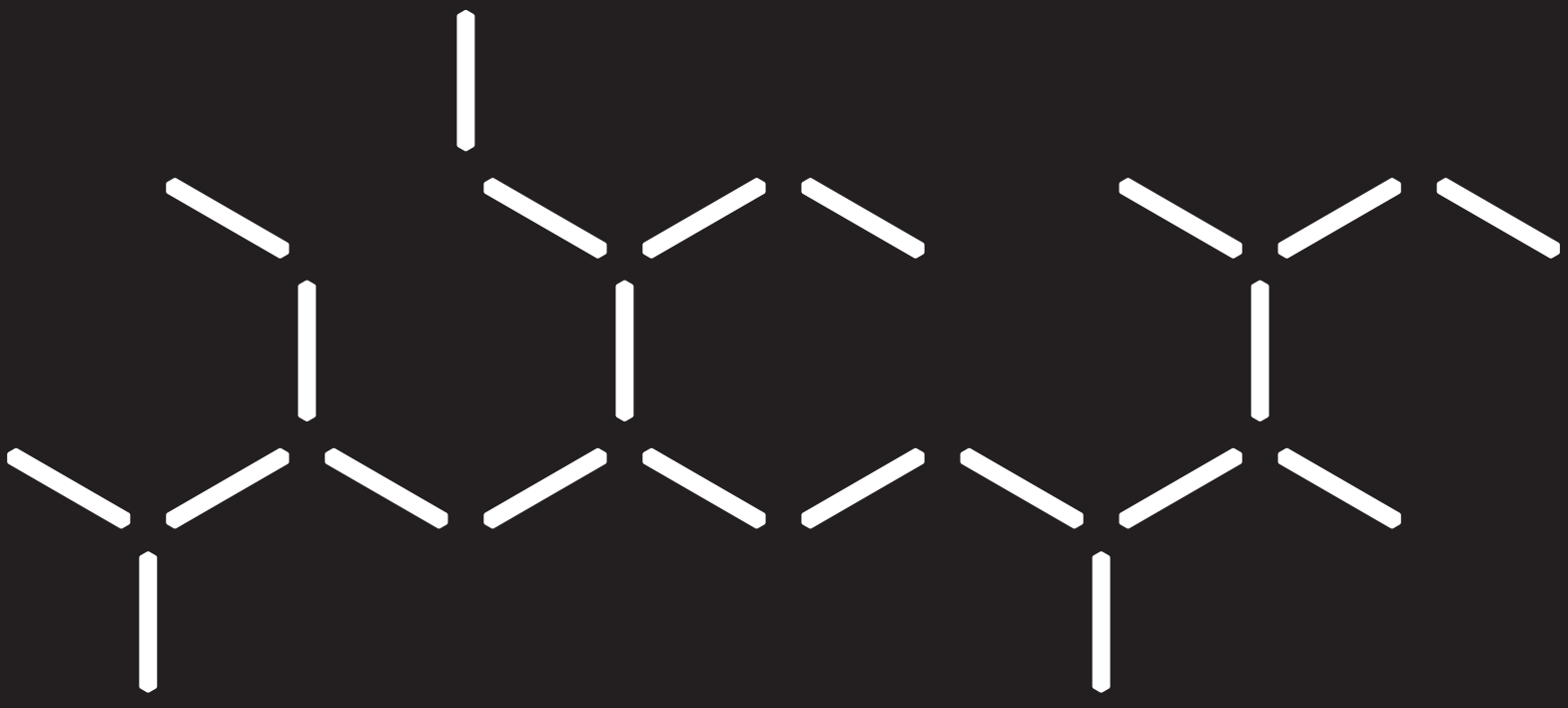

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