

02

INDUSTRY INSIGHTS Future productivity





How digital are Australian industries?

The Four Revolutions

1

Water and steam power are used to create mechanical production facilities.



1784: First mechanical loom

2

Mass production assembly lines are developed using electrical power.



1870: First assembly line

3

IT Systems automate production lines further.



1969: First programmable logic controller

4

Advanced digital technology begins to blur the cyber and physical divide



Today: Digital Revolution

Rapid developments in technology and science and the transition to a digital economy are changing the way we live, work and do business (Box 2.1). These changes come with challenges, but they also present opportunities to increase productivity and Australia's competitiveness in a globalised economy.

Box 2.1: The Digital Economy

The term 'digital economy' describes the range of economic and social activities that are enabled by information and communications technologies. 'Digitisation' is the use of digital technologies to change a business model with the intent to provide new revenue and value-producing opportunities.

The digital economy is not separate to the economy. It affects all industries and business types, and influences the way we interact with each other every day. It includes activities like banking, buying and selling, and accessing education or entertainment using the internet and connected devices.

Sources: Department of Industry, Innovation and Science (2017) *Digital Economy Consultation Paper*, DIIS, Canberra, p. 9; Gartner (2018) IT Glossary, viewed 31 July 2018, <https://www.gartner.com/it-glossary/>

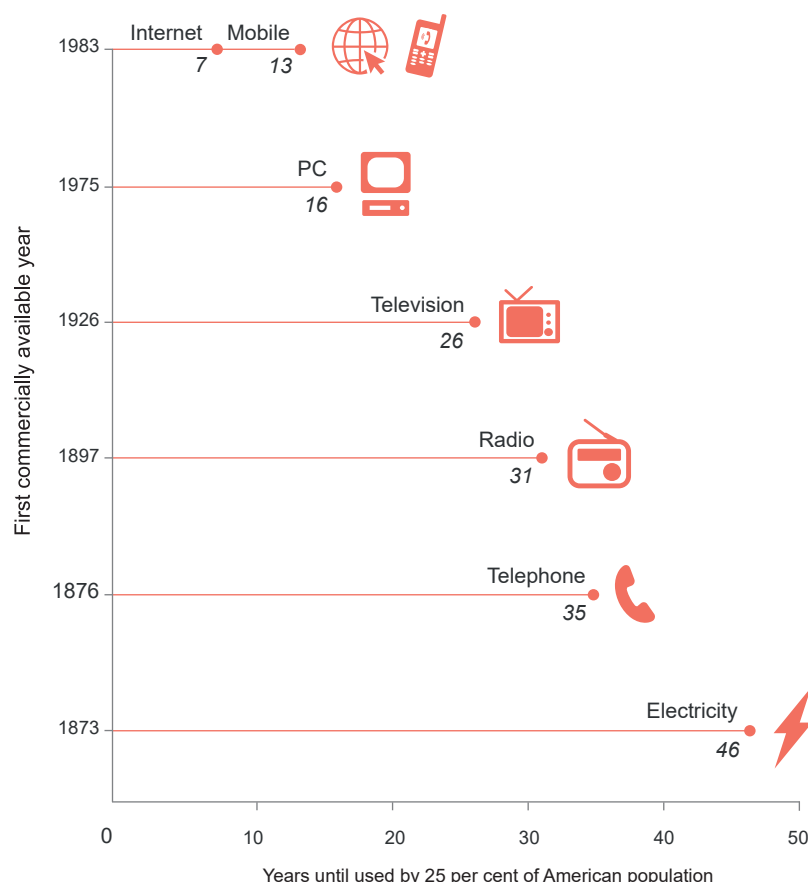
Over the past 10 years, Australia has experienced significant economy-wide change. From the ubiquity of smartphones (with the iPhone developed in 2007), to the rise of global technology companies, the digital economy is profoundly affecting how we work and play, and the speed of digital uptake has increased significantly (Figure 2.1). This change is being seen globally, with the top five global companies by market capitalisation all digital giants: Apple, Alphabet, Microsoft, Amazon and Tencent.⁴⁹ In August 2018, Apple became the world's first trillion dollar company, Amazon followed shortly after reaching a trillion dollars in September 2018.⁵⁰ The emergence of new digital technologies is so significant, it underpins the Fourth Industrial Revolution (4IR).⁵¹

49 PwC (2018) *Global Top 100 companies by market capitalisation*, PwC, UK, p 39

50 Thomson Reuters (2018) *Amazon touches \$1 trillion, on pace to overtake Apple*, 5 September 2018, viewed 21 September 2018, <https://www.reuters.com/article/us-usa-stocks-amazon-com-trillion/amazon-joins-1-trillion-club-on-pace-to-overtake-apple-idUSKCN1LK1ZJ>

51 McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, McKinsey & Company, Australia, p. 6. The first industrial revolution was mechanisation with water and steam power. The second was mass production with the assembly line and electricity, and the third was the introduction of computers and automation.

Figure 2.1: Speed of digital adoption



Source: US Census Bureau (2000) *Home Computers and Internet Use in the United States: August 2000* (2000), viewed 7 November 2018, <https://www.census.gov/prod/2001pubs/p23-207.pdf> and Kurzweil R (2005) *The Singularity is Near*, Viking Press, New York

The rapid adoption of digital technology over the past 10 years is expected to continue, offering substantial benefits to the Australian economy. *The Australian Industry Report 2016* found that business investment in digital technologies results in higher productivity.⁵² It is estimated that the adoption of digital technologies could see Australia's gross domestic product (GDP) increase by \$140–250 billion by 2025.⁵³

Despite the potential gains, productivity growth has been low in Australia since 2004 (see Chapter 1). However, we see a slightly more positive picture when comparing 'digital' and 'physical' industries. Digital industries are those where the main output is usually provided in digital form and readily delivered anywhere in the world. These include information, media and telecommunications; financial and insurance services; professional, scientific and technical services; and administrative and support services. These industries perform consistently higher across various measures of digitisation than other industries (Table 2.1 and Table 2.2). The remaining sectors, representing the bulk of the economy, fall into the physical industries category. This is defined as those industries where the output is mainly in physical form.⁵⁴

⁵² Department of Industry, Innovation and Science (2016) *Australian Industry Report*, DIIS, Canberra, p. 89

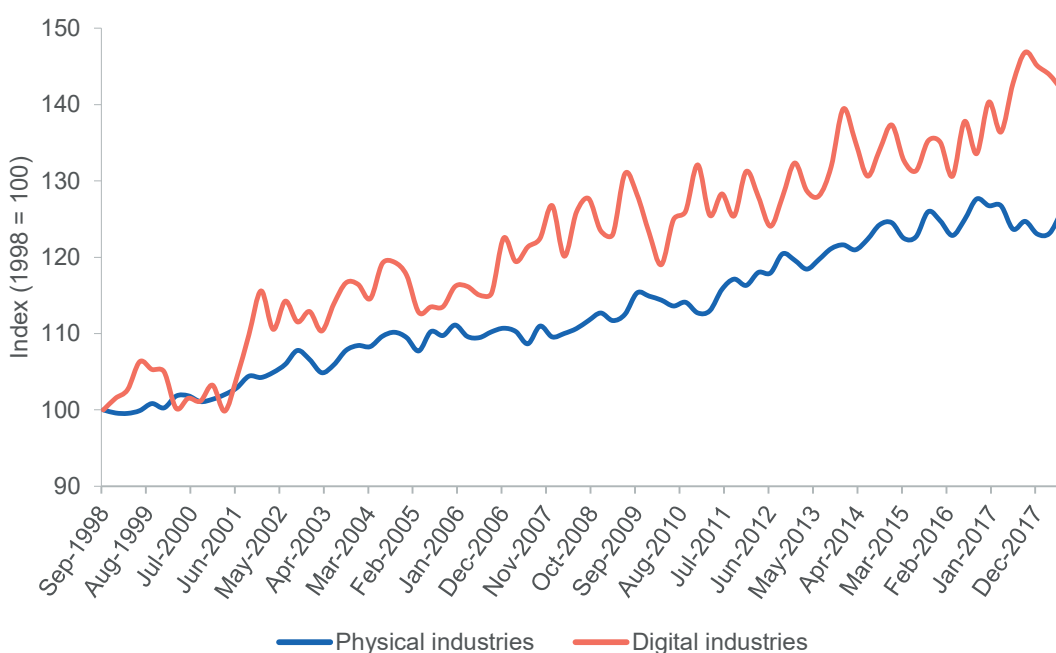
⁵³ McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, McKinsey & Company, Australia, p. 13

⁵⁴ Mandel M and Swanson B (2017) *The Coming Productivity Boom*, viewed 06 November 2018, <http://www.techcouncil.org/clientuploads/reports/TCC%20Productivity%20Boom%20FINAL.pdf>

Over the past 20 years, growth in productivity (Figure 2.2), employment (Figure 2.3) and output (Figure 2.4) has been much faster for digital industries. For example, productivity in digital industries grew by an average of 2.1 per cent a year, compared to 1.3 per cent in physical industries.

One reason for this may be the difference in IT investment of the digital and physical sectors. Over the last 10 years, investment in computers and software in the digital industries has grown by 37 per cent, from \$19.2 billion in 1998 to \$26.3 billion in 2018. Conversely, IT investment in the physical industries has only increased by 18.9 per cent over the same period.⁵⁵

Figure 2.2: Productivity in digital and physical industries, 1998 to 2018

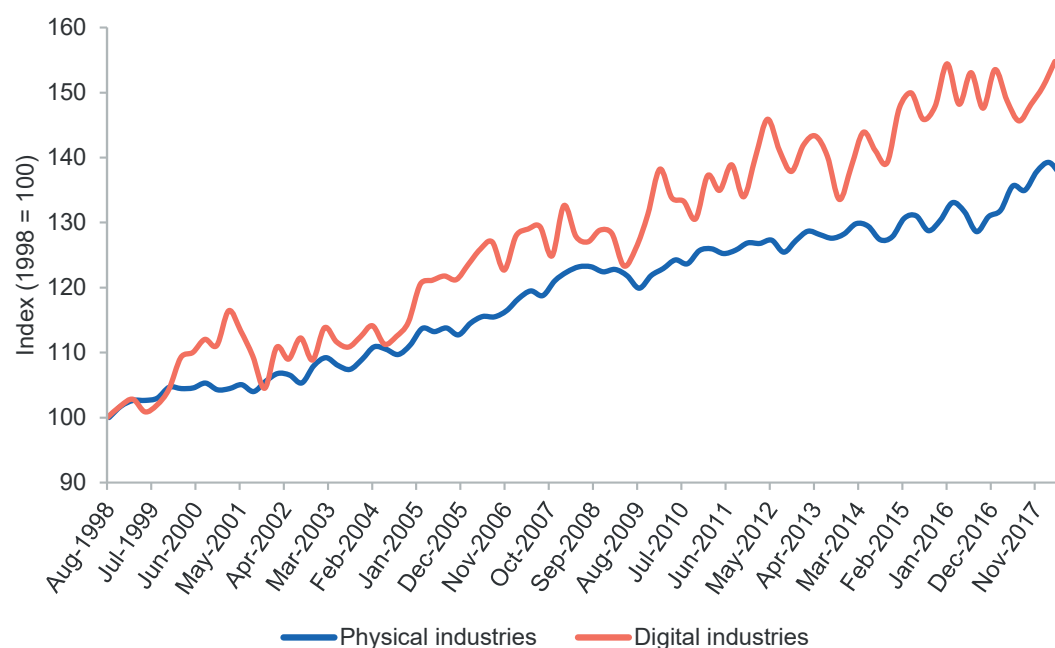


Notes: Methodology is based on Mandel M and Swanson B (2017), *The Productivity Boom*, productivity is calculated as total output divided by total hours worked

Source: ABS, Labour Force, Australia, Detailed, Quarterly, cat. no. 6291.0.55.003, table 11 and ABS, Australian System of National Accounts, cat. no. 5206, table 6

55 ABS, Australian System of National Accounts, cat. no 5206 table 69

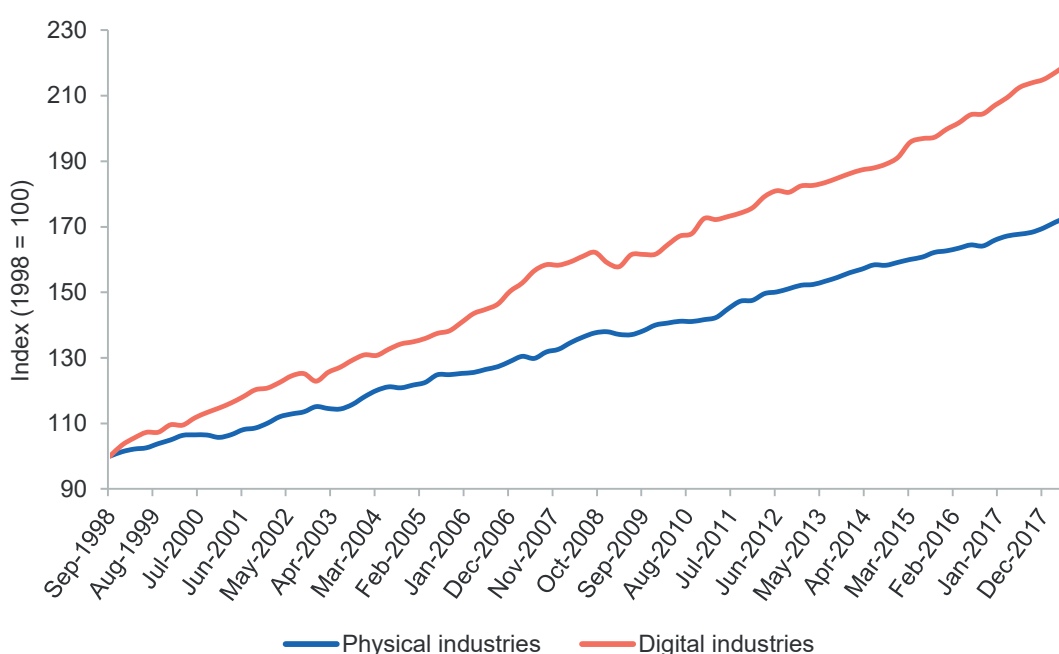
Figure 2.3: Employment in digital and physical industries, 1998 to 2018



Notes: Methodology is based on Mandel M and Swanson B (2017), *The Productivity Boom*

Source: ABS, ABS, Labour Force, Australia, Detailed, Quarterly, cat. no. 6291.0.55.003, table 11

Figure 2.4: Output in digital and physical industries, 1998 to 2018



Notes: Methodology is based on Mandel M and Swanson B (2017), *The Productivity Boom*

Source: ABS, Australian System of National Accounts, cat. no. 5206, table 6

This chapter examines the current adoption, and potential economic impacts, of four digital technologies (Box 2.2) on five Australian industries — agriculture; mining; manufacturing; health care; and retail. These technologies have been included in the analysis as they have been identified among the most promising and potentially disruptive by the Organisation for Economic Co-operation and Development (OECD).⁵⁶

⁵⁶ Organisation for Economic Co-operation and Development (OECD) (2016) *Science, Technology and Innovation Outlook*, OECD, p79

Box 2.2: Four digital technologies

Digital sensors and wearable devices — Digital sensors and wearables are devices that detect and respond to electrical or optical signals. They are used to monitor a range of activities from a person's stress level and fitness tracking, to the health of crops on farms.

Big data and advanced analytics — Big data is a term to describe large volumes of complex data. Advanced analytics is the analysis of data using sophisticated tools to discover insights, make predications or generate recommendations.

The Internet of Things (IoT) — IoT is a large network of connected objects. It enables the connection of devices such as mobiles, wearable devices, industrial equipment and sensors on roads to the internet at all times to allow for real time data analysis.

Automation — Automation involves the use of technology to monitor and control the production and delivery of products and services. That is, the use of machines and technology to make processes run on their own.

Source: World Economic Forum (WEF) (2015) *Deep shift: Technology Tipping Points and Societal Impacts*, WEF Publishing, Geneva, p5; Gartner (2018) *IT Glossary*, viewed 31 July 2018, <https://www.gartner.com/it-glossary/>

Measuring digital adoption

There is no universally agreed measure to determine the level of digitisation of an industry. This chapter draws on several measures including: data from the Australian Bureau of Statistics (ABS) Business Characteristics Survey (Business Use of Information Technology, 'BUILT indicators'),⁵⁷ the McKinsey Global Institute Digitisation Index (Digitisation Index), and work undertaken by the Brookings Institution to determine the level of digital content (referred to as 'Digital Scores') of occupations (Box 2.3).

This chapter also draws on case studies of businesses that have implemented one or more of the four digital technologies analysed. These case studies illustrate how these technologies are applied and their reported benefits.

57 The Business Characteristics Survey (BCS) is conducted annually by the ABS. Approximately 7,000 businesses are randomly sampled using an online questionnaire. Note that some of the indicators used in this chapter are only released bi-annually and are presented as the proportion of firms.

More information can be found at the ABS website:
<http://www.abs.gov.au/ausstats/abs@.nsf/products/8DF4417273266B0ACA25707C0078D6C4?OpenDocument>.

Box 2.3: McKinsey Digitisation Index and Brookings Digital Scores

McKinsey Digitisation Index (Digitisation Index)

The Digitisation Index ranks industries according to the level of digital adoption in the Australian economy using three broad categories: digital usage; digital assets; and digital labour. It looks at how businesses invest in digital skills, deploy digital technologies to interact with customers, digitise their supply chains and processes, and digitise work. It ranks industries on a scale of relatively high digitisation to relatively low digitisation.

Brookings Digital Scores

The Brookings Institution ranked American occupations based on digital knowledge and activity for each occupation. Brookings used data from the Occupational Information Network (O*NET) database to determine the Digital Scores of 545 occupations (covering 90 per cent of the American Workforce). The scores are used to determine American industry level scores (Table 2.2).

Notes: The Office of the Chief Economist (OCE) is currently undertaking analysis using a similar methodology to the Brookings Institution to develop occupation specific digital scores for Australia.

Source: McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, McKinsey & Company, Australia, p. 16, and Brookings Institution (2017) *Digitalization and the American Workforce*, Metropolitan Policy Program, Washington, p.11

Table 2.1 provides a snapshot of the use of IT, as well as the importance of digital technology to Australian businesses by industry. This data is drawn from the ABS as a part of their annual Business Characteristics Survey (BCS). The questions include indicators of current adoption (e.g. business with web presence, social media presence, etc.) as well as potential future adoption (e.g. businesses that introduced or changed a digital business strategy). These will be referred to as 'BUILT indicators' throughout this chapter.

We have used the industry average⁵⁸ for each BUILT indicator to determine rankings for low, medium and high. Industries that ranked lower than the 25th percentile are ranked low (orange cells), industries that ranked in the highest 25th percentile are ranked high (green cells), and industries in-between are ranked medium (amber cells). These rankings are relative to the average Australian industry performance as there is no global comparison available.

Table 2.2 provides a snapshot of digitisation by industry according to the analysis undertaken by McKinsey and the Brookings Institution. For most industries, the BUILT indicators in Table 2.1 are consistent with the analysis by McKinsey and Brookings (Table 2.2). Some differences will occur as different indicators have been used to determine industry rankings. This is because the BUILT indicators include measures of current adoption, as well as indicators of the perceived importance of new digital technologies. Whereas McKinsey and Brookings have constructed the Digital Index and Digital Scores using indicators that reflect the current use, and the importance of digital technologies.

The sections below will draw on the analysis in Tables 2.1 and 2.2, as well as case studies, to look at the current levels of digital technology adoption across five industries.

58 This is the average of all firm sizes within the industry. Further analysis of uptake of digital technologies at the firm level is under consideration by the department.

Table 2.1: Business use of digital technology by industry (BUIT indicators)

Indicators of current adoption					Indicators of future adoption						
	Firms with web presence (per cent)	Firms with social media presence (per cent)	Firms that received orders via the internet (per cent)	Firms that used paid cloud computing (per cent)	Introduced or changed a digital business strategy (per cent)	Approved investment in new digital tech / infrastructure (per cent)	Introduced new training programs (per cent)	Indicated data analytics is important (per cent)	Indicated AI is important (per cent)	Indicated IoT is important (per cent)	Indicated cyber security is important (per cent)
Agriculture	11.6	10.9	18.7	16.2	4.1	5.0	3.5	10.7	9.1	16.1	21.2
Mining	63.0	27.8	24.2	34.2	4.4	13.7	5.8	36.0	30.2	28.6	45.9
Manufacturing	65.1	40.0	57.8	29.5	5.2	8.0	8.2	10.1	14.7	15.0	26.7
Utilities	57.2	26.7	38.7	32.7	11.0	9.7	9.2	15.6	21.3	17.1	34.7
Construction	39.5	23.2	36.2	22.5	3.3	5.1	4.7	7.9	9.1	12.3	20.2
Wholesale trade	70.4	42.6	62.9	35.3	6.9	7.6	8.9	15.7	22.8	16.0	29.4
Retail	45.5	53.3	42.0	23.7	9.4	6.6	11.4	13.4	21.2	21.1	27.8
Accom & food	53.0	56.0	34.0	35.0	6.3	10.6	8.9	18.0	20.0	16.5	25.1
Transport	26.7	20.1	21.6	17.5	6.1	6.0	4.5	5.3	10.3	15.0	23.7
IMT	74.2	63.7	47.8	57.3	12.8	17.1	8.2	21.6	22.6	27.5	51.5
Finance	67.4	46.4	36.2	49.4	9.0	13.8	14.7	27.8	30.3	32.7	54.0
Real estate services	66.2	47.1	27.8	34.4	5.7	8.1	11.7	12.6	24.3	17.8	36.7
PST	58.4	41.4	37.0	46.3	6.8	12.0	11.3	18.9	17.7	20.9	34.7
Admin	47.1	39.0	36.3	36.4	7.3	10.5	12.3	8.4	13.2	19.7	28.7
Health care	57.5	38.4	27.8	30.6	7.8	6.5	14.3	9.5	19.1	13.3	39.7
Arts and rec	75.9	69.9	47.7	31.1	8.5	11.7	8.8	8.8	15.5	16.0	30.5
Average	54.9	40.6	37.3	32.7	7.3	9.1	9.3	14.3	18.4	18.9	32.5

Notes: Rankings have been calculated by the OCE relative to the total industry average. Industries that scored 25 per cent more than the average are ranked high (indicated in green), industries that scored 25 per cent lower than the average are ranked low (indicated in red), industries that scored in between are ranked medium (indicated in amber). Other services have also been included in the overall average

Notes: Rankings have been calculated by the OCE relative to the total industry average. Industries that scored 25 per cent more than the average are ranked high (indicated in green), industries that scored 25 per cent lower than the average are ranked low (indicated in orange), industries that scored in between are ranked medium (indicated in amber). Other services have also been included in the overall average calculation. PST refers to professional, scientific and technical and IMT refers to Information media and telecommunications. Data is weighted by the size distribution of firms, not by industry contribution to GVA. Industries with many small businesses (e.g. agriculture) will score worse than those with fewer small businesses (e.g. health).

Source: ABS, Business Use of Information Technology, 2015–16 cat. no. 8129.0, table 12 and table 18; DIIS analysis (2018)

Table 2.2: Brookings Digital Score and McKinsey Digital Index

	Ag	Mining	Manufacturing	Utilities	Construction	Wholesale	Retail	Accom & food	Transport	IMT	Finance	Real estate	PST	Admin	Health care	Arts & rec
Brookings mean Score	16	30	33	44	33	44	41	30	33	52	55	45	55	32	46	33
McKinsey Digital Index	Low	Low	Medium	Low	Low	Medium	High	Low	Low	High	High	Medium	High	High	Low	Medium

Notes: Brookings Digital Score is out of 100. Scores are included for the equivalent American Industries: Agriculture, Forestry, Fishing and Hunting; Mining (except Oil and Gas); Basic Goods Manufacturing; Health Care Services and Hospitals; and Retail Trade. Industry scores have been aggregated from occupation scores.

Source: McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, McKinsey & Company, Australia, p. 19, and Brookings Institution (2017) *Digitalization and the American Workforce*, Metropolitan Policy Program, Washington, p26

Agriculture

Digital technologies offer substantial benefits to agriculture compared to other industries for two main reasons. First, digital technologies are expected to significantly improve productivity and sustainability in agriculture, due in part to the benefits technologies such as sensors can have on crop and livestock management. Second, the current take-up of digital technology in the industry is very low compared with other industries, so there is greater scope for productivity improvement compared with other industries that have a higher level of adoption.⁵⁹

Case studies — digital technology in agriculture

Sensors and the IoT

Digital technologies such as sensors have been used on farms for the last two decades. A range of farm machinery and equipment use digital sensors that record and transmit detailed information about their operations. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is currently adapting and applying sensor systems that cheaply and accurately monitor the state of environmental factors, including plants, animals and soils, and transmitting the data wirelessly using the IoT. The data generated from these systems will assist farmers in managing their inputs to maximise production in the most cost effective and sustainable way.⁶⁰ For example, farmers can use this information to reduce irrigation by only turning sprinklers on when required rather than using a generic timing system.

Drones

Drone technology is used across a number of areas within agriculture. At the beginning of the crop life cycle, farmers can use drones with sensors for soil analysis to develop seed-planting patterns. Once seed-planting patterns are determined, drones then plant trees and monitor their health.⁶¹ They assist farmers in determining the health of crops by pinpointing dry areas or assessing plant health. Improved monitoring allows for quick reactions to issues, so farmers can address issues as they arise and potentially avoid the spread of bacterial or fungal infections.

Farmers are also using drones to spray crops, with estimates suggesting that aerial spraying is five times faster than spraying with traditional machinery.⁶²

Adoption of digital technology in agriculture

The adoption of digital technologies in agriculture has led to productivity gains across the industry — studies show productivity gains of 10 to 15 per cent in the cropping sector alone.⁶³ Despite this, uptake of digital technologies is low, with the industry ranking low across all BUIT indicators, the Digitisation Index and a low Digital Score (Table 2.1 and Table 2.2).

59 Keogh M and Henry M (2016) *The Implications of Digital Agriculture and Big Data for Australian Agriculture*, Research Report, Australian Farm Institute, Sydney, Australia, p. iii

60 CSIRO (2018) *Digital Agriculture* viewed 31 July 2018, <https://www.csiro.au/en/Research/AF/Areas/Digital-agriculture>

61 Biocarbon Engineering (2018) Our Story, viewed 31 July 2018, <https://www.biocarbonengineering.com/technologies>

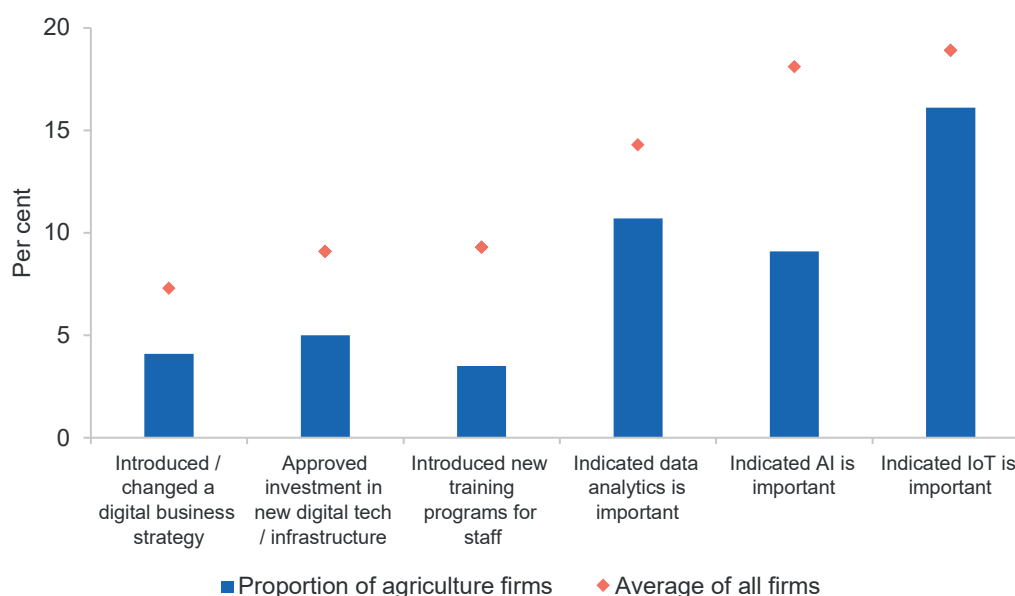
62 PwC (2016) *Clarity from above; PwC global report on the commercial applications of drone technology*, PwC, Poland, p. 4

63 Keogh M and Henry M (2016) *The Implications of Digital Agriculture and Big Data for Australian Agriculture*, Research Report, Australian Farm Institute, Sydney, Australia, p. 24

Figure 2.5 shows the BUIT indicators of future adoption in agriculture. Only five per cent of surveyed firms approved investment into new digital technologies or infrastructure, and only 3.5 per cent introduced new training programs to upskill staff. This indicates that in the short to medium term, adoption of digital technology in agriculture is unlikely to increase much, as the majority of firms are not investing in technology.⁶⁴

McKinsey and Brookings have similar findings. Agriculture ranked the lowest across 11 of the 14 fields of the Digitisation Index and had the lowest Digital Score in 2002 and 2016.⁶⁵

Figure 2.5: Indicators of future adoption of digital technology in agriculture, 2015–16



Notes: Firms that indicated a digital technology as important is calculated as the total proportion of firms that indicated digital technology important to a moderate extent and to a major extent.

Source: ABS, *Business Use of Information Technology, 2015–16*, cat. no. 8129.0, table 12 and table 18

Low digital uptake may be due to a number of factors — a lack of understanding of the productivity potential, a lack of infrastructure (fast internet and widespread mobile coverage), lower payoffs for small operators, and concerns about privacy and storage of sensitive information in the cloud.⁶⁶

Farmers in Australia operate in one of the riskiest environments globally, due to the variability of weather in Australia.⁶⁷ Adoption of digital technologies will help farmers to better navigate in a challenging environment, and may also lead to productivity improvements similar to those outlined in the case studies above.

64 Data is weighted by size distribution of firms, not their contribution to industry value added. As such, industries with lots of very small business (e.g agriculture) will score worse than those with fewer businesses (e.g health)

65 McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, McKinsey & Company, Australia, p. 19; Brookings Institution (2017), *Digitalization and the American Workforce*, Metropolitan Policy Program, Washington, p.20

66 Farming Ahead (2017), *Modest use of sensor technology only half the problem*, 4 August 2017, viewed 31 July 2018, <https://www.farmingahead.com.au/future-of-farming/news/1330807/modest-use-of-sensor-technology-only-half-the-problem>

67 Bureau of Meteorology, *Weather and Climate Risks in Agriculture*, viewed 31 July 2018, <http://www.bom.gov.au/watl/about-weather-and-climate/risk/index.shtml>

Health care

Advances in digital technology can change the way health care is delivered. Mobile technology enables patients to receive services such as telehealth, and access health apps such as fitness, medical reference and wellness apps. The case studies below include examples of productivity improvements, and social impacts such as improvements in patient experience and wellness.

Case studies — digital technology in health care

IoT and sensors

Medical sensors gather and share information so that data is accessible in real time. Better connectivity between providers and patients improves prevention, medical diagnostics, monitoring of patients and medical delivery methods. This supports people to stay healthier and reduces the number of clinical visits required.

Technology applications such as wearable technologies and sensors (e.g. Fitbit™) encourage healthier behaviour, and help with proactive management of a healthy lifestyle by allowing people to monitor their own health and wellness.

Sensors and interconnected technologies can improve the functionality of medical equipment, such as life-supporting implants, and can enable bedside and remote monitoring of vital signs and other health factors. They can provide clinicians with real time, reliable and accurate diagnostic results wherever the patient is located which supports patients staying in their own homes for longer.

Big data and advanced analytics

Big data and advanced analytics have the potential to substantially improve health care, from reducing hospital waiting times to supporting clinicians in diagnoses and treatment decisions.

The Patient Admission and Prediction Tool (PAPT) has been developed to predict emergency departments' expected patient load, their medical urgency and specialty, and admissions and discharges. The tool is used in over 30 Queensland hospitals and results show 90 per cent accuracy in forecasting bed demand. An estimated \$23 million in annual savings could be achieved if adoption were to occur across Australia.⁶⁸

AI has enabled doctors to review and interpret mammograms 30 times faster, with 99 per cent accuracy. In addition, wearable technology integrated with AI enables clinicians to monitor early-stage heart disease and predict potentially fatal episodes well in advance.⁶⁹

Adoption of digital technology in health care

Despite advances in medical technologies, the industry has been slow to innovate and adopt new technologies, with low scores across most BUIT indicators, the Digitisation Index and a low Digital Score.

The industry also scores below most of the BUIT indicators for future adoption (Figure 2.6). While the industry scores above average for introduction of new training programs, only 6.5 per cent of firms approved investment in new technologies and 7.8 per cent introduced or

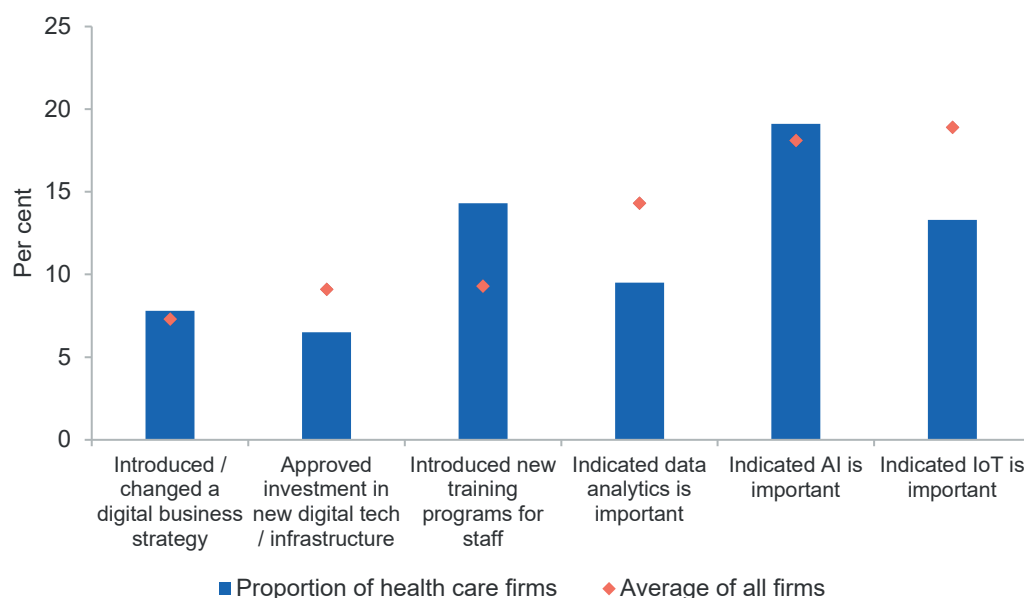
68 RO (2017) *Cutting hospital waiting times*, Digital Health, viewed 31 July 2018, <http://www.csiro.au/en/Research/BF/Areas/Digital-health/Waiting-times>

69 PwC Digital Pulse (2017) *What doctor? Why AI and robotics will define New Health*, June 2017, viewed 31 July 2018, <http://www.pwc.com/gx/en/industries/healthcare/publications/ai-robotics-new-health.html>

changed a digital strategy. This may indicate adoption in the industry will remain low in the short-term as a very small proportion of firms are investing in new technology.

Similarly, health care scored lower than most other service industries in the Digitisation Index, with a score of 45 in 2016. Overall growth in digitisation of the industry has only been 1.1 per cent between 2011 and 2016, the lowest growth of any industry analysed.⁷⁰

Figure 2.6 Indicators of future adoption of digital technology in health care, 2015–16



Notes: Firms that indicated a digital technology as important is calculated as the total proportion of firms that indicated digital technology important to a moderate extent and to a major extent.

Source: ABS, *Business Use of Information Technology, 2015–16*, cat. no. 8129.0, table 12 and table 18

There are a number of reasons why adoption may be low. First, the capital investment required for digital technologies, such as network infrastructure and new devices, is significant. If providers do not see the benefit of digital technology, they may not be willing to invest.

Second, concerns about personal data being susceptible to cyberattacks and breaches may be preventing adoption. An example of this is the public response to the My Health Record. Despite the safeguards in place to protect patient data, there were high levels of public concern about data security and significant media coverage of the issue.⁷¹

Health care costs are expected to rise rapidly due to an ageing population and the costs associated with advances in medical treatments. The 2015 Intergenerational Report identified rising health costs as the major pressure on government budgets to 2050.⁷² Digital technologies can improve patient outcomes, experience and access to care, and can reduce health care costs. McKinsey estimated that Australia's annual health care costs could be reduced by 8 to 12 per cent from digitisation.⁷³

70 McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution* McKinsey & Company, Australia, p. 22

71 ABC News (2018) *My Health Record opt-out period begins, but privacy concerns remain*, 16 July 2018, viewed 31 July 2018, <http://www.abc.net.au/news/science/2018-07-16/my-health-record-experts-say-its-safe-privacy-concerns-remain/9981658>

72 Australian Treasury (2015) *2015 Intergenerational Report: Australia in 2055*, Australian Treasury, Canberra, p. ii

73 McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, McKinsey & Company, Australia, p. 3

Manufacturing

Digital technologies have had a significant impact on the manufacturing industry — from how employees work, to the monitoring and optimisation of processes and the management of supply chains. Manufacturers that have incorporated digital technologies into processes are more responsive to changing external factors, such as consumer demand than non-digital manufacturers as they have access to real time analytics on consumer behaviour.

Case studies — digital technology in manufacturing

Sensors and advanced analytics

The integration of IoT, analytics, sensors, wearables and 3D printing can shorten the length of product development and factory production cycles. Advanced analytics can improve manufacturing operations by optimising the movement of supplies, machinery and labour around complex worksites.

Sensors and data analytics are primarily used during production to measure single attributes. Yet sensors and advanced analytics can be used across the entire value chain, including real time monitoring, predictive maintenance, and quality control. The global market for sensors in manufacturing was estimated at US\$ 8.7 billion in 2016, with rapid growth expected in the next decade.⁷⁴

Automation

There are many examples of advances in autonomous technologies occurring in Australia. Swinburne University has established an Industry 4.0 TestLab in collaboration with the Advanced Manufacturing Growth Centre. TestLabs enable businesses to work with researchers to develop prototypes, allowing faster adoption of digital technologies.

Urban Art Projects is collaborating with Queensland University of Technology and RMIT University to use robotic vision and software user interfaces to reduce the integration time between design and custom manufacturing. This innovation will increase the company's ability to manufacture high-value products and reduce time and cost to manufacture.⁷⁵

IoT

The IoT can significantly improve productivity in the manufacturing production process and supply chain. Imagine Intelligent Materials has developed a conductive geo-material that can report on real time stress, temperature and moisture using the IoT. This information can reduce the cost of structural failures by improving preventative maintenance for critical infrastructure such as roads, airports, tunnels, buildings, landfill sites and dams.⁷⁶

Adoption of digital technology in manufacturing

The adoption of digital technologies in manufacturing is mixed across the BUIT indicators, the Digitisation Index and the Digital Scores. Manufacturing performs below the total industry average across each of the BUIT indicators for future adoption (Figure 2.7). Manufacturing performs particularly poorly in the proportion of firms who indicated digital technology is important to business operations, with only 10.1, 14.7 and 15 per cent of firms indicating that data analytics, AI and IoT (respectively) are important to business operations. This is a

74 CSIRO Futures (2016) *Advanced Manufacturing. A Roadmap for unlocking future growth opportunities for Australia*, CSIRO Publishing, p. 38

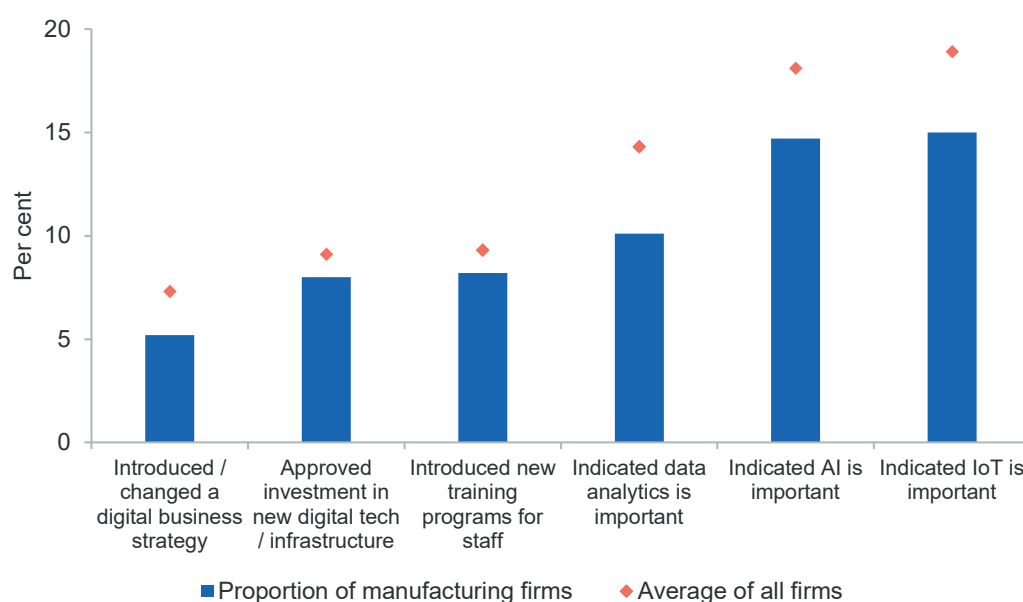
75 IMRC (2018) *Design robotics for mass customisation Manufacturing*, viewed 31 July 2018, <https://imrcr.org/2017/07/12/design-robotics-for-mass-customisation-manufacturing/>

76 Imagine Intelligent Materials (2018) *Creating Conductive Materials*, viewed 31 July 2018, <http://imgne.com/innovation/conductivity/>

concerning trend, as businesses that do not see the importance of digital technologies are unlikely to invest in them.

Brookings also ranked manufacturing relatively low, with a Digital Score of 33 out of 100 in 2016. Yet, McKinsey ranked manufacturing as the highest of all asset-intensive industries in the Digitisation Index. This may be because McKinsey have looked at indicators of current adoption, for example, current use of digital technology scored relatively high. Low digital spending is consistent across McKinsey work and the BUIT indicators, only 8 per cent of manufacturing firms approved investment in new digital technology or infrastructure (Figure 2.7).

Figure 2.7 Indicators of future adoption of digital technology in manufacturing, 2015–16



Notes: Firms that indicated a digital technology as important is calculated as the total proportion of firms that indicated digital technology important to a moderate extent and to a major extent.

Source: ABS, Business Use of Information Technology, 2015–16, cat. no. 8129.0, table 12 and table 18

Manufacturing is transforming due to long-term trends, including globalisation, technological changes and changing consumer demands. To remain competitive against low-cost countries, the Australian industry must move up the value chain into high value-added manufacturing services in the global supply chains of multinational companies.⁷⁷ Digital technologies will play a key role in accessing global supply chains and creating high-value products.

77 DIIS (2018) *Industry Insights 2/2018 – Globalising Australia*, DIIS, Canberra, pp 46-47

Mining

Mining in Australia has been at the forefront of innovation and adoption of digital technology, leading to benefits such as increased efficiency, enhanced safety and workforce diversification.⁷⁸ The industry has developed world-first technologies that have improved productivity and been used globally.⁷⁹

Mining firms are increasingly using digital technologies to improve productivity in exploration, extraction and processing. At the exploration stage, digital technologies help firms explore beyond easily discoverable near-surface resources (known as 'exploration under cover').⁸⁰ At the extraction and processing stages, digital technologies improve the efficiency of operations, enable preventative maintenance, reduce environmental effects and improve worker safety.

Case studies — digital technology in mining

Sensors and wearables

Sensors are being embedded in equipment and machinery. This enables the collection of high-resolution and multidimensional datasets. Analysis of these datasets allows for better forecasting in areas like processing, and enables predictive maintenance and reduction in operational costs.⁸¹

Wearables can improve productivity and worker safety by transmitting information in real time to remote operations sensors, tracking worker location and monitoring air quality. Wearables could save 500 lives and prevent over 20,000 injuries globally over the next 10 years.⁸²

Big data and advanced analytics

Big data on mineral deposits include information on 5,200 different known minerals in hundreds of thousands of different locations around the world. Combining this data with network theory,⁸³ scientists have developed insights into how mineral deposits change over time, which can be used to predict the location of new deposits.⁸⁴ This analysis has helped reduce both the cost and negative environmental effects of mineral exploration as miners can limit their search for minerals to areas based on scientific prediction.

Automation

Robotics and autonomous systems are improving productivity and increasing safety by removing humans from dangerous environments. South32, a metals and coal mining company, began trialling the use of autonomous drones to carry out stockpile and equipment

78 Australian Treasury (2018) Speech by Mr Philip Gaetjens, Secretary to the Treasury, viewed 6 September 2018 <https://treasury.gov.au/speech/bateman-lecture/>

79 DIIS (2018) *Australian resources – providing prosperity for future generations*, Resources 2030 Taskforce, Canberra, p 23

80 CSIRO (2016) The under cover mission, *Resourceful*, 9, viewed 31 July 2018, <https://www.csiro.au/en/Research/MRF/Areas/Resourceful-magazine/Issue-09/The-undercover-mission>

81 CSIRO Futures (2017) *Mining Equipment, Technology and Services. A Roadmap for unlocking future growth opportunities for Australia*, CSIRO Publishing, p. 23

82 World Economic Forum (WEF) in collaboration with Accenture (2017) Digital Transformation Initiative. Mining and Metals Industry, WEF, Geneva, p. 17

83 Network theory refers to the analysis of complex connections and interactions between different objects.

84 COSMOS (2017), 'Data Mining: How digging through big data can turn up new mineral deposits' in *The Science of Everything*, 2 August 2017, viewed 31 July 2018, <https://cosmosmagazine.com/geoscience/data-mining-how-digging-through-big-data-can-turn-up-new-mineral-deposits>

inspections, and conduct surveys and mapping at the beginning of 2017. Initial results have provided a more accurate picture of the company's activities.⁸⁵

Mining companies are leading the way in use of autonomous vehicles. For example, Rio Tinto has been using autonomous haulage system trucks since 2008, with approximately 20 per cent of its existing fleet now autonomous. Autonomous trucks allow mining firms to move more material efficiently and safely as they are fitted with predefined GPS courses to automatically navigate roads and know the actual locations, speeds and directions of other vehicles at all times.⁸⁶

Adoption of digital technology in mining

Despite high-profile examples, the adoption of digital technologies in mining is mixed, with high scores across the BUIT indicators, but low in the Digitisation Index and the Digital Scores.

Mining ranks relatively well across most of the BUIT indicators of future adoption (Figure 2.8). A large number of firms surveyed have recognised that new digital technologies are important to the business, particularly data analytics. The number of firms that have approved investment in new digital technologies or infrastructures is above the industry average which may indicate an increase in future adoption.

In contrast, mining ranks low in the Digitisation Index and Digital Scores. Mining sits in the bottom quarter of Australian industries in the Digitisation Index, with the industry scoring particularly low in its use of digital assets.

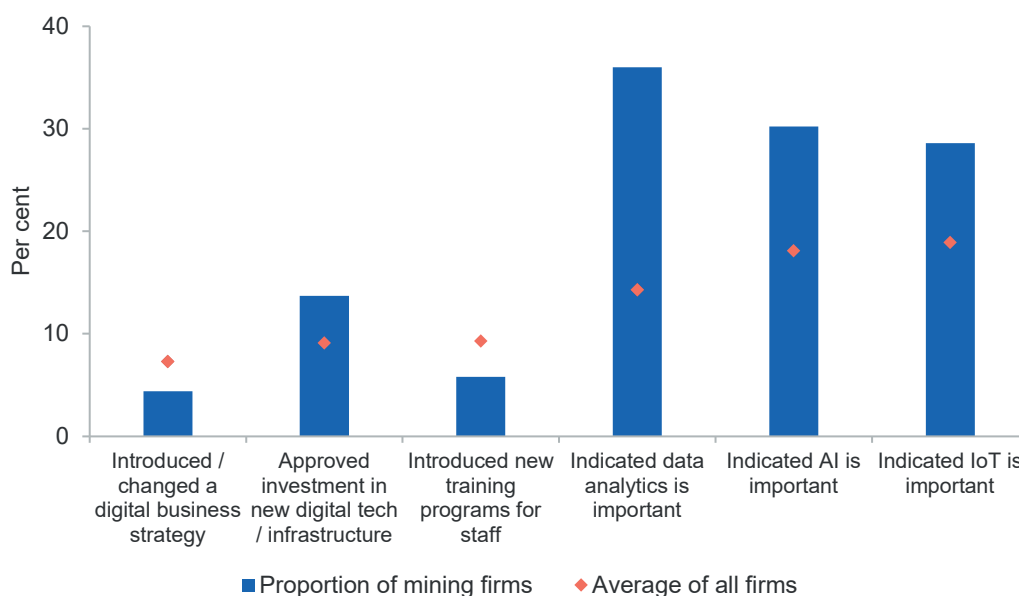
The mixed results are partly due to the nature of the industry. The long-term and risky nature of mining project investment can slow the adoption of digital technologies as firms are unlikely to make large upfront investments in risky projects.⁸⁷ In addition, new technologies are more likely to be implemented in new projects, as the cost of retrofitting existing mines is higher than the cost of including digital technologies in a new mine. Technologies require careful assessment around safety and risk to ensure they are ready for implementation.

85 South32 Limited (2017) *Environment at South32*, viewed 31 July 2018, <https://www.south32.net/investors-media/annual-report-suite>

86 Rio Tinto (2018) *Rio Tinto's autonomous haul trucks achieve one billion tonne milestone*, 30 January 2018, viewed 14 September 2018, http://www.riotinto.com/media/media-releases-237_23991.aspx

87 CSIRO (2016) Mining evolution, *Resourceful*, 10, viewed 06 November 2018, <https://www.csiro.au/en/Research/MRF/Areas/Resourceful-magazine/Issue-10/Mining-evolution>

Figure 2.8 Indicators of future adoption of digital technology in mining, 2015–16



Notes: Firms that indicated a digital technology as important is calculated as the total proportion of firms that indicated digital technology important to a moderate extent and to a major extent.

Source: ABS, Business Use of Information Technology, 2015–16, cat. no. 8129.0, table 12 and table 18

With lower commodity prices and increasing competition from emerging economies, maintaining Australia's competitive advantage in mining is especially important. Further adoption of digital technologies will allow the industry to improve productivity and maintain Australia's competitive advantage in the sector. McKinsey estimates the value of digital technology to the mining sector at \$40 to \$80 billion in annual sector profit by 2025.⁸⁸

Retail

Retail has been one of the industries most affected by digital technology. McKinsey estimated that approximately 12 per cent of global goods trade is e-commerce, driven by online retail and wholesale platforms, such as Alibaba, Amazon and eBay.⁸⁹ Online sales in Australia continues to grow faster and outperform store-based retailing, as consumers favour the convenience offered by online retail.⁹⁰

Digital technology has the potential to transform each step of the retail value chain. The IoT is driving greater connectivity as data, knowledge and information flows between assets and digital platforms at all stages of the supply chain.

Sensors, AI and machine learning allow retailers and wholesalers to manage their inventories, develop e-commerce strategies, including pricing, manage activities across the network of physical and virtual stores and storage facilities, and carry out trend and volume forecasting.

88 McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, McKinsey & Company, Australia, p. 19

89 McKinsey Global Institute (2016) *Digital Globalization: The new era of global flows*, McKinsey & Company, p. 7

90 Australia Post (2017) *Inside Australian Online Shopping*, viewed 22 August 2018, <https://acquire.starttrack.com.au/pdf/Inside%20Australian%20Online%20Shopping%202017.pdf>

Case studies — digital technology in retail

IoT and sensors

The IoT has dramatically changed the in-store shopping experience — customers can use a smart phone app or digital shopping trolley to locate and find information on an item. These smart apps and trolleys can link customers' profiles, social media accounts and shopping history to tailor shopping advice and promotions, such as providing enticing loyalty deals for frequent shoppers. Sensors can monitor the condition of perishable goods and trigger automated restocking, freeing up staff to spend more time interacting with customers.

At home, IoT enabled sensors can monitor pantries, fridges and medicine cabinets to create shopping lists and place orders, and monitor appliances to pre-empt maintenance requirements.

Automation

Automated customer service can improve the experience of gathering information and placing orders. For example, Starbucks has a 'conversational' ordering system powered by AI and accessed through the Starbucks app.⁹¹ Fashion and beauty retailers are using chatbots to allow customers to get fashion advice and mimic the social aspect of shopping.⁹²

Contactless checkouts allow customers to leave the store without lining up to pay. For example, in 2016 Amazon introduced Amazon Go in Seattle, where customers can purchase products by scanning the product barcode with an app and walk out of the store without going through checkouts.

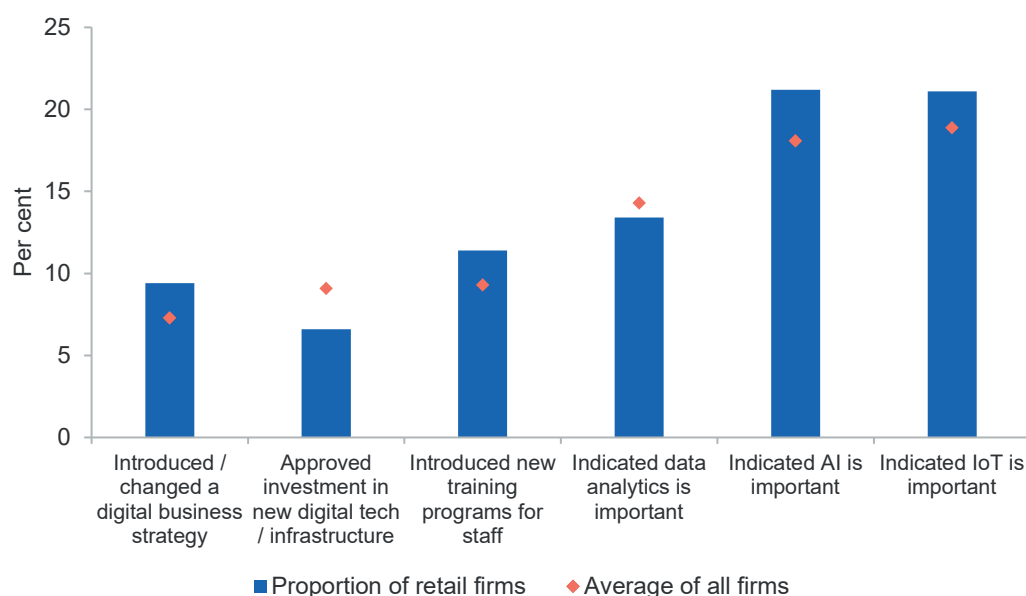
Adoption of digital technology in retail

The retail industry scores relatively well across BUIT indicators, the Digitisation Index and Digital Scores. Retail ranks above the Australian average in BUIT indicators when looking at the number of firms that have introduced or changed their digital strategy, and in the number of firms that have introduced new training programs to upskill staff (Figure 2.9). However, only 6.6 per cent of firms indicated that they have approved investment in new digital technologies or infrastructure, which may be an indicator of slow adoption in the short-term as the majority of retailers are not currently investing in technology.

91 Starbucks Newsroom (2016), *Starbucks Presents its Five-Year Plan for Strong Global Growth*, 7 December 2016, viewed 31 July 2018, <https://news.starbucks.com/news/investor-day-2016-press-release>

92 Retaildive (2018), *H&M, Sephora nab early entry into Kik's fashion bot shop*, viewed 31 July 2018, <http://www.Retaildive.com/ex/mobilecommercedaily/hm-sephora-nab-early-entry-into-kiks-fashion-bot-shop>

Figure 2.9: Indicators of future adoption of digital technology in retail, 2015–16



Notes: Firms that indicated a digital technology as important is calculated as the total proportion of firms that indicated digital technology important to a moderate extent and to a major extent.

Source: ABS, *Business Use of Information Technology*, 2015–16, cat. no. 8129.0, table 12 and table 18

McKinsey found similar results, with the sector scoring the highest of all service industries in the Digitisation Index. Interestingly, Brookings found that the retail industry ranked middle of the range, with a Digital Score of 41 (out of 100) in 2016. This may be because the Brookings Institution used indicators that focused on knowledge and use of digital technologies by employees, rather than looking at digitisation of processes.

Although the industry scores highly relative to other Australian industries, internationally Australia is lagging behind most developed countries, particularly the US and the UK.⁹³

Globally, e-commerce is expected to grow from 10 per cent to greater than 40 per cent of retail sales in 2026.⁹⁴ The entry of low-cost retailers like Amazon into Australia means that many bricks-and-mortar retailers will need to embrace digital technologies to offer greater choices and better experiences to remain competitive.

93 McKinsey (2017) *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, McKinsey & Company, p. 58

94 WEF (2017) *Shaping the Future of Retail for Consumer Industries*, WEF, Geneva p. 4

Conclusion

Despite the potential benefits, the rate of adoption of digital technologies across Australian industries is uneven. Businesses across all industries have a significant way to go in adopting technology to realise the full potential these technologies can bring.

Adoption of digital technology is key to Australia's international competitiveness. Australia currently ranks 13 out of 63 countries in the Institute for Management Development digital competitiveness ranking, lagging behind countries such as the US, Canada and Singapore.⁹⁵

As outlined in Chapter 1, productivity growth has been flat in Australia and across many developed economies since 2004. The past wave of digital technologies led to productivity improvements and economic growth in both Australia and the US.⁹⁶

Digital uptake will be critical to addressing slow productivity. Uptake is also key to global competitiveness in traditional industries like mining and advanced manufacturing as well as emerging priorities in services industries.⁹⁷

A recent joint report by the OECD and the Department of Foreign Affairs and Trade⁹⁸ emphasised the importance of digital technologies to enabling services trade. In particular, secure cross-border data sharing helps to facilitate trade in digital form. One prominent example is the digital transformation of higher education in the form of e-learning and digital education materials, enhanced information sharing through cloud services, and more efficient course scheduling, among others.

The technologies explored in this chapter have potential for future productivity growth. New technologies transform cost structures, enable the creation of new business models and methods of production, and bring entirely new products and services to market.

Some of the technologies discussed in this chapter are still in their infancy, and require further development before they diffuse more broadly. Adoption may increase overtime, as the technologies continue to be trialled, and as their costs decrease. Productivity growth will be improved with broader adoption across all industries

95 The IMD digital competitiveness ranking assesses the extent to which a country adopts and explores digital technologies leading to a transformation in government practices, business models and society in general.

Institute of Management Development World Competitiveness Centre (2018) The IMD World Digital Competitiveness Ranking 2019 results, viewed 8 November 2018, <https://www.imd.org/wcc/world-competitiveness-center-rankings/world-digital-competitiveness-rankings-2018/>

96 For further information about previous trends in productivity, refer to Chapter 1

97 For further information on emerging priorities, see *Industry Insights 2/2018 – Globalising Australia*

98 OECD (2018), *Australian Services Trade in the Global Economy*, OECD Publishing, Paris, <https://doi.org/10.1787/9789264303911-en>

Delivering economic growth: cyber security as a vertical and horizontal enabler

AustCyber — Cyber Security Growth Centre

The global economy relies on cyber resilient digital technologies, making cyber security critical to the growth of today's economy and societies — and for all future generations.

The Australian cyber security sector is an essential part of securing Australia's online environment and expanding into the burgeoning global cyber security market.

Having a more dynamic, scalable and responsive cyber security sector will enhance Australia's global reputation as a trusted and secure business environment and trade partner — while significantly contributing to Australia's own cyber resilience. This could increase demand for the export of other Australian goods and services, and over time will mitigate costs related to data breaches and malicious cyber activity for Australian organisations.

While every sector of the economy is affected by technological change and the need to leverage the power of data science, perhaps none is impacted more than the cyber security sector. Several major trends are likely to unfold in coming years, shaping the structure and nature of cyber security markets. For some organisations, many of the technological changes will be disruptive; with positive and/or negative impacts depending on how change is embraced.

AustCyber — the Australian Cyber Security Growth Centre — was established as an industry-led entity by the Australian Government's Industry Growth Centres Initiative to help our domestic cyber security sector to grow and become globally competitive. This will deliver Australia significant economic benefit, while enabling public and private sector organisations alike to source solutions closer to home.

Part of the Government's National Innovation and Science Agenda and Australia's Cyber Security Strategy, AustCyber brings together governments, businesses and researchers to provide a foundation for the development of next generation solutions required to live and work securely in our increasingly connected world.

The global opportunity

Cyber resilience adds economic and social value to all sectors of the economy. Australian organisations with cyber security front of mind will be best placed to maximise the benefits of the digital age and realise the long-term growth potential of cyber-physical systems.

The Internet of Things, Cloud Computing and the convergence of IT and operational technology are some of the current disruptive technological trends that may provide opportunities for Australian industry and increase the future demand of cyber security solutions.

They could increase demand for all forms of cyber security, including non-technical areas such as education, business development, legal services and policy implementation. These disruptive technological trends will continue to evolve, and as they do, they will likely bring demand for new cyber security solutions.

The global cyber security market is currently valued at around US\$126 billion and is projected to increase to US\$251 billion over the next decade. Around three-quarters of the global expenditure on cyber security comes from cyber security 'users' (organisations and individuals seeking to defend themselves against malicious cyber activity) who purchase solutions from external cyber security 'providers' (both specialist cyber security firms and IT or telecommunications firms with cyber security offerings).

Australia's potential

Cyber security in Australia is a rapidly growing industry. Currently, the sector employs approximately 19,000 people in technical roles — either as part of an organisation's internal cyber security workforce or through external cyber security providers. Total expenditure on cyber security in 2016 was approximately A\$4.3 billion, which equates to around five per cent of the Australian information technology sector.

Australian demand and employment are dominated by outsourced cyber security services, and more than three-quarters of this market is controlled by foreign firms — mostly operating from local bases and employing Australians. Software and hardware markets are also dominated by imports.

There are however, opportunities for local firms to penetrate the market — and this is now happening at pace across the country and across capability strengths. Australia can concentrate its limited resources on parts of the cyber security sector that are experiencing growth in local demand and where Australia can compete most effectively.

Analysis suggests that this includes software in areas of distinctive research capability, services in the cyber protection stack and in underlying processes. While these segments will be the initial focus of industry development, many of the actions of government, AustCyber and others will also support the competitiveness of the sector as whole.

Over the next decade, the current demand pattern is set to intensify as organisations are expected to make even greater use of outsourced services to manage growing security needs and a proliferation of security threats.

This means that cyber security services will likely experience a much stronger growth in demand than cyber security hardware and software. This basic trend applies to both Australia and the world, but in Australia the additional demand for cyber security solutions

is expected to bolster a broad spectrum of different security services — from the protection stack to underlying processes — whereas globally demand is expected to strengthen most notably for security operations services.

Despite the economic potential, there are structural and cultural factors that challenge the growth outlook for Australia's cyber security sector. Fortunately, AustCyber provides the Australian economy with a dedicated focus on addressing these; acting as a multiplier and connector across governments, academia and industry.

AustCyber's contribution

Since AustCyber was established in January 2017, a foundation has been built to grow Australia's cyber security sector by delivering practical support to Australian cyber security entrepreneurs and activated buyers at home and abroad. AustCyber has quickly established itself as a visible independent advocate for the competitive and comparative advantages of Australian technical and non-technical cyber security capabilities and has re-shaped cyber education in Australia. In a previously austere environment, AustCyber has marshalled passionate Australian cyber businesses, academics and governments into a genuine community.

AustCyber operates independently at the nexus of national and jurisdictional policies that span economic growth, national security, education, innovation, law enforcement and more. These diverse areas reflect the diverse opportunities for the cyber security sector. AustCyber operates across government, industry and academic stakeholder groups to identify and, where possible, remove barriers to the growth and success of the sector.

AustCyber's decade-long value proposition is stated in Australia's inaugural Cyber Security Sector Competitiveness Plan (April 2017). Three strategic objectives underpin AustCyber's operating model, business plan and all its activities:

- Grow an Australian cyber security ecosystem.
- Export Australia's cyber security to the world.
- Make Australia the leading centre for cyber education.

An update to the Cyber Security Sector Competitiveness Plan was released in November 2018. It explores AustCyber's progress, confirms ever-growing market demand and provides new data on sector growth.

The Australian Cyber Security Industry Roadmap, developed by AustCyber in partnership with CSIRO Futures, was also released in November 2018 and shows how AustCyber will amplify growth in other sectors by embedding cyber security as a requirement for success.

By working with public and private partners across the ecosystem, AustCyber is providing Australian cyber security companies with the foundation to grow and scale, which creates the step-change required to help Australia transform into a true and trusted knowledge economy.

