Industry Insights

Future productivity

3/2018
From the Chief Economist

Imagine you were born in Australia in 1887. You would have been born into one of the most prosperous nations on earth, enjoying a mining and agricultural boom that had lasted for decades.

You would likely have been born in a small town and been bought home in a two wheeled horse drawn vehicle called a sulky. The sulky was a major advance for its time as its cost made passenger transport vastly cheaper and light weight made it easy to use.

In the first decade of your life, telephones and running water became common in homes. Rail lines were snaking out over the continent, suddenly you could travel hundreds of kilometres in a day.

In your teens, internal combustion engines replaced steam power. Your house was electrified by a diesel generator in the shed, allowing you to listen to your first radio program.

As you blew out the candles on your 50th birthday cake in 1937, you could reflect on a time of technological marvels that had transformed your life beyond the imaginings of your parents. Of buying your first car and the service stations that sprang up in every town.

But Australia's real GDP per capita was exactly the same as three decades ago.

Robert Solow famously quipped in 1987 that you can see the computer age everywhere but in the productivity statistics. He could well have made a similar remark about mechanisation and electrification in 1937

Yet if you had been born in Australia in 1967, GDP per capita would have gone up by about 250 per cent by your 50th birthday. So why the difference? This conundrum is a reminder that technology does not always increase productivity in the way and at the time we expect.

In this third edition of Industry Insights we unpack the conundrum by looking at Australia’s recent productivity performance. We then look at how digital technologies and management capability may affect productivity in the years ahead.

The opening chapter explores a possible explanation for low productivity growth — the slower pace of change in the economy. For an economy to grow, it must change. Workers must shift to the more productive roles created by new technologies. Entrepreneurs must bring better ideas to market, forcing out inefficient incumbents.

Yet rates of entrepreneurship are falling, occupations within the economy are changing more slowly, and the spread of innovation has slowed.

Guest author Robert Atkinson of the Information Technology and Innovation Foundation suggests that industrial revolutions proceed in waves. Conditions must be in place before economies take full advantage of the productivity-enhancing impact of technology.
Viewed this way, the current low productivity environment can be explained as being at the tail end of the ICT revolution and the beginning of the digital revolution.

It’s undeniable that digital technologies are an opportunity to escape the productivity slump. The second chapter explores digital in Australia, with technologies like the internet of things and big data being rolled out across industries, boosting output and lowering costs.

Examples of digital technology adoption are typically in an infancy or trial stage, suggesting we sit at the start of that wave.

The digital revolution has transformed some industries more than others. Australia’s mining industry has been at the global forefront of innovation and adoption of digital technology. Digitisation can be increased across the economy with some barriers to overcome.

In their guest chapter, the Australian Cyber Security Growth Centre suggests a more dynamic, scalable and responsive cyber security sector will enhance Australia’s global reputation as a secure business environment and trusted trade partner.

Looking ahead, Australia can improve its productivity performance. Up to half the productivity gap between Australia and the US is explained by differences in management capability.

Productivity is typically described as the way that labour and capital are used together in production. Clearly managers, and their capabilities, sit at the heart of productivity.

The third chapter uses an Australian-first survey of management practices to explore the relationship with productivity. Our best managed firms are about 20 per cent more productive than firms with the least structured management practices. Better managed firms also innovate and collaborate more frequently.

Companies systematically overestimating their management practices suggests a role for government in improving management capability. Tailored advice is available through the Entrepreneurs’ Programme, which pairs firms with experienced business advisers and facilitators. The Industry Growth Centres Initiative supports firms in selected sectors with the development of management and practical skills, and identifying skills gaps.

Guest author Annette Cairnduff from the Foundation for Young Australians highlights the importance of enterprise skills — such as teamwork, problem solving, and emotional judgement — in readying the workforce for future challenges.

Governments don’t have much influence on whether digital technologies will be more or less transformative than past revolutions. But they can help people ride the wave of change.

Policies that boost competition, increase global integration, and remove barriers to investment help shift workers and investment to their best use. Exposing services to more competition is important as the sector is the largest in the economy and an important input to exports.

Future productivity will depend on the capability of people and continual change in the economy. These factors will help us embrace the digital economy and allow Australia to take advantage of the significant opportunities presented for future prosperity.

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INDUSTRY INSIGHTS Future Productivity
Declining economic dynamism: implications for productivity

A slower pace of change could be driving the weak productivity growth in Australia and advanced economies.

The entry and exit of businesses has been declining in Australia, the United States and Canada over the past decade. The fall is mostly due to lower rates of start-ups, meaning fewer new firms entering with transformative innovations.

Globally, the productivity gap between firms at the technological frontier and non-frontier firms is widening. The innovations of leading firms are not spreading to others, lowering productivity as most businesses adopt existing technologies rather than invent new ones.

Job turnover and the rate of people moving interstate has been falling in Australia and the United States. Slowing turnover and mobility means people are not shifting jobs as quickly to productive areas of the economy.
Productivity reflects the ability to produce more output by better combining inputs, technological innovations and management practices (see Box 1.1: Multifactor productivity). Continued productivity growth matters for the economy and society as it supports ongoing improvements in incomes and living standards.

However, productivity growth has fallen in Australia and across advanced economies since around 2004. This slump has been broad across industries and has coincided with a period of advances in digital technologies.

There is little consensus on the cause of the productivity slowdown. Traditional explanations for the slowdown in Australia include a slowing pace of microeconomic reforms and the rapid increase in mining-led capital investment during the mining boom that resulted in input usage, outpacing output growth. Another less common, but plausible, explanation of low productivity growth is that the pace of change in the economy has declined. Measures of the pace of change (or economic dynamism) include business churn, job turnover, labour mobility and technology diffusion. Lower dynamism is not just apparent in Australia but in other advanced economies, including the United States (US).

This chapter will explore Australia’s productivity growth since the 1990s and identify domestic and international trends of economic dynamism that have implications for productivity growth. It concludes with a summary of the arguments about future productivity given the rise in digital technologies.

### Box 1.1: Multifactor productivity

There are numerous measures of productivity of which multifactor productivity (MFP) is one. In this chapter, discussions are based on MFP and the terms MFP and productivity are used interchangeably.

MFP growth is the increase in output beyond that stemming from changes in inputs used in production processes. It can be thought of as the efficiency with which inputs such as labour and capital are combined to produce goods and services.

### Earlier growth in productivity

Australia’s productivity growth accelerated during the 1990s, playing a vital role in lifting Australia’s economic performance during that decade and into the early 2000s. Yet, growth has stalled since around 2004, raising concerns as low productivity growth has implications for incomes and living standards. This section provides an overview of productivity growth over the past three decades.

### Productivity growth prior to 2004

Productivity growth over the last 30 years averaged one per cent per year. Between 1993 and 2004, productivity growth exceeded the average following a slump in the 1980s (Figure 1.1). Average yearly growth was 2.6 per cent between 1994 and 1999 and 1.2 per cent between 1999 and 2004.

The period of strong productivity growth in the 1990s was mostly attributed to a series of microeconomic and macroeconomic reforms introduced since the 1970s. In 2005, the Productivity Commission estimated that productivity improvements and price reductions
flowing from the National Competition Policy and related reforms raised GDP by 2.5 per cent.\(^1\) The International Monetary Fund estimated that these reforms helped boost Australia’s annual productivity growth in the 1990s by 0.5 to 0.9 of a percentage point.\(^2\)

The acceleration in productivity during the 1990s was common across industries in Australia but was mostly led by services — especially information and telecommunications — and utilities.

Deregulation of the airline and financial industries, injecting more commercial focus into government-owned enterprises, and privatisation resulted in greater price competition, lower production costs and improved services. Competition reforms that increased competitive forces helped raise productivity by moving resources to more successful and higher productivity firms. In more competitive economies, average productivity tends to be higher as there is a smaller tail of low-productivity firms.\(^3\)

Compared to policy reforms, broad adoption of information and communications technology (ICT) played a supplementary role with a smaller contribution to productivity growth — estimated at a tenth of a percentage point per year between 1992 and 1997.\(^4\)

ICT adoption may have even been a by-product of the reforms: the liberalisation of trade and capital markets and increased labour market flexibility created a platform for greater investment — particularly in ICT — and innovation. Trade liberalisation also stimulated competition, inducing Australian firms to adopt better business practices to compete


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![Figure 1.1: Aggregate market sector productivity growth, 1982 to 2017](image_url)
with foreign producers. Services industries — including wholesale trade and finance — transformed business operations using new ICT. Once opened to competition, productivity levels in these industries rose towards the international technological frontier as Australia became a world leader in ICT usage during the 1990s.

Productivity growth since 2004

Productivity growth in Australia and other advanced countries declined from about 2004 (Figure 1.2) and across most industries. The fall was sharper in Australia than other advanced countries, with the mining boom likely to be a major reason for the difference.

The impact of the mining boom helps explain the downturn in some industries in Australia. The mining boom had three distinct but connected stages (Figure 1.3).

- The price phase (2004 to 2012): high economic growth and investment from Asia drove commodity prices to record levels.
- The investment phase (2007 to 2017): mining responded with unprecedented investment to increase production capacity.
- The production phase (2011 to 2019): investment projects were completed and began to generate massive increases in production.

During the price and investment phases, mining firms employed more workers and invested in capital to unlock bottlenecks and open new mines. Given the long lead times from investment to production in the sector, growth in output did not match the acceleration in inputs, lowering productivity. Prior to the mining boom, productivity growth in the industry averaged 0.7 per cent per year. Yet, during the price and investment phases, annual productivity fell sharply and averaged about -5 per cent per year in both phases.

Productivity in mining is recovering with the transition from the investment to the production phase. Since 2014, production has increased as new capacity has come online and productivity growth has averaged 3.1 per cent per year.

Yet, falling mining productivity does not entirely explain the slow economy-wide productivity growth as mining comprises only 7 per cent of output. Low productivity growth since 2004 was common across most industries (Figure 1.4).

Figure 1.3: The three phases of the mining boom

Figure 1.4: Difference between pre- and post-2004 annual average productivity growth, by industry

Notes: Pre-2004 average productivity growth refers to the average annual growth between 1991 and 2004, while post-2004 average productivity growth refers to the average annual growth between 2005 and 2017.

Since 2004, productivity growth in productivity enabling industries like utilities, construction, transport, information and telecommunications, and finance and professional services has remained at or below the pre-2004 long-term average. These industries comprise a large share of output (around 45 per cent) and also affected aggregate productivity given their roles as inputs into production process.  

Numerous factors contributed to the low productivity growth in productivity-enabling sectors. In utilities, heavy but lumpy investment in infrastructure, technology and alternative generation have resulted in higher input requirements per unit of output, reducing productivity. Services are one of the least reformed and trade exposed parts of the economy. The lack of reforms and competition in services could be dragging down aggregate productivity growth given its size, importance as inputs to other industries and impact on productive capacity such as on health and education levels.

A declining momentum of large-scale policy reform could be contributing to lower productivity growth. The fading of the one-off effects of past reforms could also be exacerbating the problem. Beyond the introduction of the Goods and Services Tax in 2000 and changes made as part of A New Taxation System reforms, there have been few large tax policy changes. Fewer regulation reforms, and rises in productivity-stifling regulation and legislation, have also been suggested as contributing to the productivity decline.

The implications for living standards of declining productivity growth is concerning. Yet, the slowdown is not completely explained by causes explored above. It is worth examining underlying factors driving low productivity growth and the slowing pace at which technology is adopted and spread.

The status of underlying drivers of productivity growth

Productivity is intricately linked to the pace of change in the economy, also known as economic dynamism. Dynamism is a productivity-enhancing mechanism that helps allocate resources and spread ideas and innovation in the economy. A slowdown in dynamism is a trend that has been observed in Australia and some major economies.

This section explores whether lower dynamism contributed to the productivity slowdown using three measures: business churn, labour dynamism — including occupation churn and interstate migration — and technology diffusion.

Business dynamism

A healthy flow of business entries and exits — business churn — is important for economic growth. New firms that enter and succeed are likely to have uncovered a new or better quality product, service or process. New entries can increase competitive pressures on existing firms, forcing them to become more competitive or exit the market. This dynamic, known as creative destruction, increases productivity.

10 Productivity Commission (PC) Shifting the Dial: 5 Year Productivity Review, Inquiry Report, PC, Canberra
Business churn has been declining in Australia, the US and Canada over the past decade. Lower business churn is primarily the consequence of decreasing rates of entrepreneurship (Figure 1.5).\(^{14}\) The decline is broad across industries, including the productivity-enabling sectors. Entrepreneurship has also declined in professional and technical services, which is associated with advanced technology use and entrepreneurs that transform markets and create jobs.\(^ {15}\)

**Figure 1.5: Business entry rates, 2003 to 2015**

![Graph showing business entry rates from 2003 to 2015 for Australia, United States, and United Kingdom.](image)


A key significance of entrepreneurs and young firms is their contribution to job creation and labour reallocation.\(^ {16}\) In Australia, the fall in entrepreneurship is being matched by lower job creation rates (Figure 1.6). Between 2004 and 2014, the job creation rate fell from 20 per cent to 14 per cent, while the job destruction rate was stable at around 14 per cent.\(^ {17}\)

Given the key role that new entrants have in employment and output growth,\(^ {18}\) declining entry may slow the creative destruction process which underpins productivity growth.

Since research on business entry and job creation was published in 2017, new data shows business entry rates rose 1.7 percentage points in the two years to 2016-17,\(^ {19}\) coinciding with strong employment growth. Yet, even factoring in these new observations, there is still a longer term downward trend.

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15 Ibid.
18 Ibid.
Turnover high-growth firms (business that grow their turnover by 20 per cent or more for three years running) are also becoming less prominent in Australia. These firms contribute significantly to sales growth, net value-added, productivity and capital investment. Since the mid-2000s, both the magnitude of the growth rates of these firms and the proportion that experience high growth episodes have been declining.\(^{20}\)

In Europe, productivity growth during the 2000s was weaker in industries with larger declines in the share of young firms and in start-ups.\(^{21}\)

There is also evidence of falling business exits. Total company insolvency per 100,000 companies rose temporarily leading up to and during the height of the Global Financial Crises (GFC) but has since declined (Figure 1.7). Further, average annual change in company insolvency has been trending downwards since the early-2000s. The pattern is similar for total personal insolvencies per 100,000 working-age persons, which includes bankruptcies of small businesses.

Falling insolvencies could increase the likelihood that labour and capital remain locked in inefficient firms or “zombie firms”, slowing the productivity-enhancing reallocation of resources as well as the spread of ideas and know-how. Insolvency or bankruptcy laws that penalise failure are negatively associated with productivity growth and the share of high growth firms in capital-intensive industries.\(^{22}\)

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Labour dynamism

A fast changing labour market can allocate labour to where they will add most value. By transitioning labour efficiently to the most productive jobs and regions, a changing labour market helps increase productivity. This section explores labour dynamism looking at two proxies, occupation churn and regional mobility.

Occupation churn — a measure of the rate of labour reallocation in the economy — has been falling in Australia and the US, despite perceptions that technological change is increasing the pace of change (Figure 1.8). This period of slower labour market dynamism has negative implications for productivity.

Notes:
Company insolvency is the proportion of total companies registered with the Australian Securities & Investments Commission entering external administration and total registered companies multiplied by 100,000. Growth represents the three-year moving average in the annual change in company insolvency.
Source: Australian Securities & Investments Commission

Labour dynamism

A fast changing labour market can allocate labour to where they will add most value. By transitioning labour efficiently to the most productive jobs and regions, a changing labour market helps increase productivity. This section explores labour dynamism looking at two proxies, occupation churn and regional mobility.

Occupation churn is equal to the absolute value of the sum of jobs created and jobs lost in a particular period as a share of total jobs in the economy in the base period.
Figure 1.8: Occupation churn, Australia and the United States, 1960 to 2018

Notes: The level of occupation churn rates for Australia and the United States are not directly comparable due to differences in classifications and type of data sources used to estimate the rates. Data for Australia for decades prior to 1980 was not available.


In the US, occupation churn has fallen from over 30 per cent in the 1960s to less than 10 per cent in 2015. A similar trend is observed in Australia where occupation churn has fallen by 20 percentage points over the past 40 years.

There is no clear answer why occupation churn has slowed in Australia and other advanced economies. The impact of the GFC on firm capacity use has been posited as contributing to the declining churn after 2008: firms may have responded to the deterioration in demand during the GFC by underutilising labour.24 In Australia, the underutilisation rate rose over 3.5 percentage points to 13.6 per cent.25 Ten years on, underutilisation has remained stubbornly high at slightly under 14 per cent.26

The movement of labour across regions signals that labour supply is responding to the changes in the location of jobs, an aspect of labour market flexibility that facilitates productivity growth. More efficient job matching has been linked to residential reallocation.27

25 The labour force underutilisation rate is the sum of the number of persons unemployed and underemployed expressed as a percentage of the labour force. It is an indicator of unused capacity of labour.
However, the proportion of working-age population migrating between states has declined steadily from 2.3 per cent in 2002 to around 1.8 in 2016 (Figure 1.9). The fall was despite the mining boom, which increased mining wages and encouraged workers to relocate to mining-intensive states like Western Australia and Queensland. The decline is apparent among all working-age group cohorts, but largest for the younger and the prime-working age.28

Figure 1.9: Interstate mobility, proportion of working age population, 1998 to 2016

Notes: Working age population refers to those between 15 and 64 years of age.
Source: ABS.Stat: Estimated resident population, Interstate migration: Arrivals, departures and net

The experience of lower regional migration is not unique to Australia. Internal migration within the US has fallen continuously since the 1980s. Similar to Australia, the decline — from a peak of 3.8 per cent in 1990 to 2.1 per cent in 2017 — predates the GFC.29

A slowdown in job turnover and population ageing may be driving the steady drop in interstate labour migration. Taxation policy — particularly stamp duty — housing costs and state-based occupational licensing can also create barriers to labour flows across regions.30

Technology diffusion
An additional measure of a dynamic economy is the rate of technology diffusion. Diffusion spreads the benefits of productivity-enhancing technology from frontier firms to others.

New, frontier technologies do not diffuse to all firms straightaway. Evidence suggests firms below the technology frontier only receive the benefits of new technologies after they have been diffused to national frontier firms, and tested and adapted to country specific circumstances by them.31

28 Department of Industry, Innovation and Science calculations
Moreover, adoption and diffusion of technology matters more for the majority of firms than direct investment in research and development.\textsuperscript{32} This finding resonates with the innovation traits of Australian businesses: the vast majority of Australian businesses adopt technologies, products or processes already introduced by other businesses and few introduce new-to-market technologies or innovations (Figure 1.10).

Figure 1.10: Proportion of Australian firms introducing innovation, by novelty status, 2016–17

![Figure 1.10: Proportion of Australian firms introducing innovation, by novelty status, 2016–17](image)

Studies on cross-country firm-level data show that declining global productivity could be the result of the slower pace of technology diffusion across firms.\textsuperscript{33} Productivity growth in firms that are at the global frontier of technological change has remained robust over time, but has stagnated for firms below the frontier. Consequently, the productivity gap between frontier and non-frontier firms has widened (Figure 1.11).

The widening productivity gap has been found to be more pronounced in ICT intensive services and information-based industries — industries that are an important source of productivity growth.\textsuperscript{34} Widening dispersion in firm-level productivity is potentially a sign that firms are facing increasing friction in adopting the technologies of firms on the productivity frontier.


In Australia, there is some evidence of slower technology diffusion. Small and medium-sized businesses in Australia appear to have difficulties and high costs of imitating larger businesses.\textsuperscript{35} Imitation refers to the ability of an individual business to grow by mimicking the success of others. Lack of access to skilled labour appears to be a barrier to growth for both small and mid-sized businesses, with around 22 per cent of small business and a quarter of mid-sized businesses reporting this factor as a barrier.\textsuperscript{36} Further, almost 20 per cent of small businesses reported lack of access to funding as being a barrier to growth.\textsuperscript{37}

The ability of small and medium-sized businesses to grow is further constrained by the most capable business owners and managers gravitating towards large businesses. Of note is that Australia has a high concentration of small firms. In addition, most of Australia’s innovation activity is concentrated in larger businesses, with a long tail of small firms that tend not to be innovative (Figure 1.12).

\footnotesize{\textsuperscript{35} Cully M (2017) \textit{Stuck in the middle? Mid-sized enterprises in the Australian economy}, Department of Industry, Innovation and Science, Office of the Chief Economist presentation}


\footnotesize{\textsuperscript{37} ibid.}
Future productivity: the uncertain road

Whether future productivity growth will return to the high levels of the 1990s or remain low is unclear.

Two fields of thought dominate the discussion about the future of global productivity growth. The techno-pessimists argue that emerging advances are less revolutionary than past changes and will only lead to low productivity growth. Techno-optimists argue that the wave of technologies will be substantial and will generate high growth. But future productivity growth may also follow a third path, where high productivity growth proceeds as waves — history suggests it does.

Techno-pessimists and a low growth future

The techno-pessimist arguments are best characterised by the works of Robert Gordon and Tyler Cowan. They argue that each successive industrial revolution has resulted in a smaller and smaller impact on the economy.

The Fourth Industrial Revolution (4IR) is the 4th major industrial era since the initial industrial revolution of the 18th century. The pessimist view proposes that the impact of 4IR technologies will be less revolutionary and general purpose compared to past major advances such as the motor vehicle, electricity, radio, antibiotics and commercial air travel.

Understanding the 4IR requires some historical context. The First Industrial Revolution used water and steam power to mechanise production processes. The second used electric power to create mass production. The third used electronics and ICT to automate

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production and improve communication. The fourth has been marked by the emergence of robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, the Internet of Things, 3D printing and autonomous vehicles.

Arguments of the techno-pessimists are based on the declining productivity impact of each of the first three revolutions. Between 1920 and 2016, most of the productivity growth in Australia and the US occurred in the five decades between 1920 and 1970 — primarily a product of the second revolution (Figure 1.13). In Australia, the impact was lagged, with productivity growth accelerating between 1950 and 1970. In the US, between 1920 and 1950 and between 1950 and 1970, average annual growth was 2.4 per cent and 2.2 per cent respectively. The US productivity spike associated with the third revolution manifested between 1996 and 2004 and averaged 1.9 per cent per year. In Australia, a similar pattern is observed: productivity growth associated with the third revolution (1.7 per cent per year) was lower compared to the second (2.2 per cent per year).

The observations suggest that improvements in computing power and the widespread adoption of internet technologies have facilitated a smaller and shorter-duration of productivity spike than past revolutions.

Figure 1.13: Average long term productivity growth during the industrial revolutions, Australia and the United States, 1890 to 2016


Techno-optimists and a high-growth future

The second field of thought, the techno-optimists such as Andrew McAfee and Erik Brynjolfsson, argue the opposite. The optimists argue that the scale, scope and complexity of current and future technologies will dramatically transform economies. They propose that the current 4IR wave of technological developments holds significant promise for productivity growth.

Glimpses of the potential of the effect of 4IR technologies are present globally and in Australia. For example, in Australia, over the past 20 years, productivity in digital-intensive
industries39 grew by an average of about 2 per cent a year, compared to marginally above zero per cent in the rest of the economy.39 These digital intensive industries currently account for only about 20 per cent of the Australian workforce and less than a quarter of output. Digital catch-up in the rest of the economy has the potential to significantly bolster productivity.

Chapter 2 further highlights the current and potential effects on output, sustainability and productivity growth of digital technology penetration in Australian industries.

In terms of households, the adoption rate of new technological devices has been increasing for some time, with smartphones and internet diffusing rapidly (Figure 1.14). Electricity took 30 years to achieve a 10 per cent adoption rate, while smart phones reached 40 per cent penetration in just 10 years.

Figure 1.14: Household diffusion of selected technologies

![Figure 1.14: Household diffusion of selected technologies](source: Michael Felton, New York Times)

**The third path**

History suggests productivity improvements from general-purpose technologies (GPT) — technologies that shape economies and lead to protracted increases in aggregate productivity — appear in an S-shaped curve. The curve has three phases:

- low productivity growth as GPTs are invented and trialled but without widespread adoption
- high productivity growth as GPTs become cheaper and more effective, leading to wide adoption (Figure 1.14) and business practices transforming to better incorporate new technologies
- slowing productivity growth as take-up rates near saturation and the transformational benefits of the GPT peak.

Some argue the current slow growth may simply be the result of economies worldwide being at the last phase of the third revolution and the early phase of the fourth. Like previous revolutions, there will be a long lag before current 4IR technologies diffuse throughout the economy. Organisational know-how — particularly managerial capability — is needed as it enables business to absorb, adapt and reap the full benefits of new technologies (see Chapter 3). There can be costly and time-consuming adjustments before productivity.

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39 Digital-intensive industries include information and telecommunications and financial, professional and administrative services. The main output in these industries can be provided easily in a digital form and readily delivered worldwide.

40 Department of Industry, Innovation and Science calculations.
gains come through.\textsuperscript{41} Gains are unlikely to arise until new technologies and business practices are fully embedded within firms and across the entire supply chain, including in how businesses connect with customers.

What next for Australia?

Techno-optimist and pessimist arguments attract much attention because their views on future productivity growth are polarising. While the impact of coming technology advances is likely to be significant, history suggests that extreme outcomes are unlikely.

The productivity trajectory in Australia and advanced economies worldwide could follow the typical S-bend as they move into the 4IR. Productivity is expected to grow as digital technologies become cheaper, better, and diffused in production processes. Yet, the full effects of emerging technologies are unlikely to be realised without improving economic dynamism in Australia. Prolonged periods of weak dynamism will hamper the adjustment process, making the transition to the 4IR more time consuming and less beneficial.

Waning dynamism in Australia has implications for government policy that shape productivity. Reforms that increase the pace of dynamism will be consistent with the government’s role in removing barriers to the economy adjusting to structural change.

Government policies encouraging competition, global integration, and removing barriers to investment and experimentation will create better conditions for reallocating labour and capital through the entry of productive firms.

In Australia, competition is not uniformly strong across the economy.\textsuperscript{42} Competitive pressure can be enhanced through policies preventing the misuse of market power and reducing entry barriers across sectors — particularly in the productivity-enabling sectors such as financial, information and telecommunications and logistics and distribution. Increased information and ease for consumers to switch between providers and control their own data will further boost competition.\textsuperscript{43}

Well-designed insolvency laws encourage entrepreneurship and sharpen firm incentive to experiment with and adopt technologies and alternative business practices. Business churn in Australia may increase as a result of the changes made through the Bankruptcy Amendments Bill 2017, introduced in October 2017, which aims to reduce the costs of closing a business.

Greater reforms in services and exposing the sector to more competition is likely to boost productivity. This is especially so given the industry is the largest in the economy and growing. Further, services are an important input into production processes of other industries. Research suggests that regulations in retail trade and professional services have remained relatively stringent in OECD countries. Reforms equivalent to that experienced in telecommunications would reduce the productivity gap between frontier and other firms by up to 50 per cent,\textsuperscript{44} increasing aggregate productivity growth.

Tax arrangements, such as stamp duties, can add to the costs of individuals or firms relocating. Occupational licensing can constrain the flow of skilled labour and exacerbate skills mismatches. Further reforms to taxation, employment and workplace relations laws could reduce impediments to labour relocation and occupation churn.


\textsuperscript{43} Ibid.

The productivity outlook

Dr Robert D. Atkinson
President, Information Technology and Innovation Foundation

Productivity growth rates have fallen for most nations over the past decade. In this sense Australia is not unique. What does appear to separate Australia from at least some nations, including the United States (US), is that Australian policymakers are having a conversation about the problem and potential solutions; as evidenced in this chapter. This is critical because productivity growth is the main determinant of long-term improvements in living standards.

However, effectively delving into productivity policy is like traveling to a new and strange land; many of the landmarks that guide conventional neoclassical economics are of less use here. Unlike understanding the dynamics of a recession, for example, understanding the causes of a productivity slowdown are much more difficult, and require an analysis and understanding of at least two key factors: organisations and technology, neither of which are the speciality of most macroeconomists.

This is particularly important because most conventional recommendations to improve productivity are usually focused on improving the business climate (trade, competition, tax, monetary policy, regulation, etc.) and firm factor inputs (e.g. skills, infrastructure, research). But these are no longer enough to significantly move the needle on productivity. To be sure, nations need to get them right, but given that many already do, they are now table stakes in the productivity game.

Moreover, some conventional recommendations may be misguided. A case in point is the view that reviving firm start-ups will drive productivity growth. As Michael Lind and I highlight in Big is Beautiful: Debunking the Myth of Small Business, not only are large firms more productive than small firms in virtually every nation, but the decline in firm start-ups, at least

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in the US, does not appear to be the cause of declining productivity. If anything, the decline, at least in traditional ‘mom-and-pop’ small businesses, has spurred productivity growth. Case in point is the retail industry where the expansion of more efficient ‘big box’ and ‘big internet’ retailers has made it harder for less productive small retailers to enter.

Formulating more effective productivity policy requires deeper enterprise and industry-level analysis than traditional macroeconomic analysis is used to engaging in. Fundamentally, productivity slowdowns occur in organisations (firms, non-profits and governments), and it is there that solutions must be found. As such, nations need to understand and craft sectoral productivity policies that reflect the unique differences between industries. This is important because when it comes to productivity, industries differ in significant ways and broad-based business climate and factor input policies generally do not reflect these differences. Case in point is the construction industry, an industry with negative measured productivity growth in the US. Many aspects of the industry impede productivity: lack of scale, weak incentives to improve productivity, variations in building codes making it hard to achieve scale economies. Moreover, many of the new technologies that could boost productivity, such as building information modelling and information technology (IT) enabled integrated supply chains, suffer from chicken-or-egg challenges where firms don’t adopt them because other firms in the supply chain don’t adopt. Broad-based tax, regulatory and trade policies will do little to address these challenges. But a national construction strategy, as I discuss in the report Think like an enterprise: Why nations need comprehensive productivity strategy, could help. Likewise, strategies for other industries, including health care, financial services, and state and local government services, can also help.

Better understanding of the process and trajectory of technology innovation, particularly the current state and evolution of general purpose technologies, is the second key component. Making this difficult is the fact that duelling ‘pundits’ now proffer completely contradictory visions of where technology is going, from the overly pessimistic end-of-growth prediction from Robert Gordon to the exaggerated and breathless forecast of a massive Fourth Industrial Revolution from World Economic Forum head Klaus Schwab.46

A better model for understanding technological change is the neo-Schumpeterian model that holds that technological innovation, at least with regard to powerful general-purpose technologies (like the steam engine, steel, electricity, and IT), proceeds in waves.47 The conventional view of innovation is that the process is linear and is exogenous to economic models. But in fact, technological innovation appears to follow a pattern of repeating S-curves with waves of new technology systems emerging, powering growth and then stagnating before the emergence of the next wave. This is what Joseph Schumpeter was referring to when he wrote that ‘each of the long waves in economic activity consists of an “industrial revolution” and the absorption of its effects.’48 Perhaps the most important question today is where are we on the current 5th wave information and communications technology (ICT) technology S-curve. If we are in the middle, then we could likely enjoy at least a decade or two of robust growth before the expected slow-growth intervening period before the next big technology wave. But I believe we are closer to the end, which explains today’s slow productivity growth. But it is likely that a 6th wave, grounded in general purpose technologies of machine learning, robotics and autonomous systems, will emerge and drive a productivity increase. But despite the claims of countless enthusiasts who say we are already in this new wave, I believe that we are not, because for a general purpose technology to truly take off and power productivity, prices have to fall dramatically and functionalities increase significantly, a point we are not at yet. For example, truly self-driving cars at a price point people can afford are likely at least 15 years off.

This suggests that nations have two tasks when it comes to technology. The first is to ensure that most organisations are adopting and effectively using best-in-class technologies. This means keeping capital input prices low (e.g. eliminating tariffs on ICT goods and services and expanding tax incentives for businesses to invest in machines) while also raising the price of labour (e.g. setting a higher minimum wage). The second is to help accelerate the innovation and adoption of new, risky next-wave technologies, in part by having government be a lead adopter, encouraging organisations to coordinate where there are ‘chicken-or-egg’ adoption challenges, and spurring more research and development (R&D) through tools like R&D tax incentives.

It may very well be that the productivity frontier for most developed nations, including Australia, will be lower than optimal over the next decade or so. But that doesn’t mean that nations should not develop national productivity strategies and work to increase growth levels. The first steps to doing this are to admit there is a challenge, and to begin the analysis and dialogue around potential solutions.
INDUSTRY INSIGHTS: Future productivity
How digital are Australian industries?

The Four Revolutions

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

2. Mass production assembly lines are developed using electrical power.

3. IT Systems automate production lines further.

4. Advanced digital technology begins to blur the cyber and physical divide

1784: First mechanical loom

1870: First assembly line

1969: First programmable logic controller

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.


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. In August 2018, Apple became the world’s first trillion dollar company, Amazon followed shortly after reaching a trillion dollars in September 2018. The emergence of new digital technologies is so significant, it underpins the Fourth Industrial Revolution (4IR).

49 PwC (2018) Global Top 100 companies by market capitalisation, PwC, UK, p 39
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.
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. It is estimated that the adoption of digital technologies could see Australia’s gross domestic product (GDP) increase by $140–250 billion by 2025. 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.


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


55 ABS, Australian System of National Accounts, cat. no 5206 table 69
CHAPTER 2  How digital are Australian industries?

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

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, ‘BUIT 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.

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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.

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.


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 ‘BUIT indicators’ throughout this chapter.

We have used the industry average\(^{58}\) for each BUIT 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 BUIT 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 BUIT 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.

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\(^{58}\) 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)

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

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 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

<table>
<thead>
<tr>
<th>Industry</th>
<th>Brookings mean Score</th>
<th>McKinsey Digital Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>16</td>
<td>Low</td>
</tr>
<tr>
<td>Mining</td>
<td>30</td>
<td>Low</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>33</td>
<td>Medium</td>
</tr>
<tr>
<td>Utilities</td>
<td>44</td>
<td>Low</td>
</tr>
<tr>
<td>Construction</td>
<td>33</td>
<td>Low</td>
</tr>
<tr>
<td>Wholesale</td>
<td>44</td>
<td>Medium</td>
</tr>
<tr>
<td>Retail</td>
<td>41</td>
<td>High</td>
</tr>
<tr>
<td>Accom &amp; food</td>
<td>30</td>
<td>Low</td>
</tr>
<tr>
<td>Transport</td>
<td>33</td>
<td>Low</td>
</tr>
<tr>
<td>IMT</td>
<td>52</td>
<td>High</td>
</tr>
<tr>
<td>Finance</td>
<td>55</td>
<td>High</td>
</tr>
<tr>
<td>Real estate</td>
<td>45</td>
<td>Medium</td>
</tr>
<tr>
<td>PST</td>
<td>55</td>
<td>High</td>
</tr>
<tr>
<td>Health care</td>
<td>32</td>
<td>High</td>
</tr>
<tr>
<td>Admin</td>
<td>46</td>
<td>High</td>
</tr>
<tr>
<td>Arts &amp; rec</td>
<td>33</td>
<td>Medium</td>
</tr>
</tbody>
</table>

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.

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.\(^\text{59}\)

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.\(^\text{60}\) 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.\(^\text{61}\) 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.\(^\text{62}\)

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.\(^\text{63}\) 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


\(^{62}\) 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.  

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.

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.

Farmers in Australia operate in one of the riskiest environments globally, due to the variability of weather in Australia. 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.

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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)


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

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.  

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

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.

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. 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.

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

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.\(^\text{74}\)

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.\(^\text{75}\)

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.\(^\text{76}\)

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


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](image)

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. Digital technologies will play a key role in accessing global supply chains and creating high-value products.

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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. The industry has developed world-first technologies that have improved productivity and been used globally.

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’). 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.

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.

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, scientists have developed insights into how mineral deposits change over time, which can be used to predict the location of new deposits. 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 evaluation, reducing the risk of injury for workers.

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79 DIIS (2018) Australian resources – providing prosperity for future generations, Resources 2030 Taskforce, Canberra, p 23
83 Network theory refers to the analysis of complex connections and interactions between different objects.
inspections, and conduct surveys and mapping at the beginning of 2017. Initial results have provided a more accurate picture of the company’s activities.\footnote{South32 Limited (2017) Environment at South32, viewed 31 July 2018, https://www.south32.net/investors-media/annual-report-suite}

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.\footnote{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}

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

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.\(^\text{91}\) Fashion and beauty retailers are using chatbots to allow customers to get fashion advice and mimic the social aspect of shopping.\(^\text{92}\)

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.

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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.

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**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.

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

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
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.
Delivering economic growth: cyber security as a vertical and horizontal enabler
Management practices and productivity

Australian management practices trail international peers such as United States, Germany, Canada, the United Kingdom and France.

Roughly half the gap between Australia’s and the United States’ productivity can be explained by management practices.

Firms lack information on how their management practices compare with others.
In the early 1980s, the General Motors’ Fremont, California, automotive assembly site was the most unproductive plant operated by the company. It was described by a manager as “one of the worst in the world”, and following ongoing disputes, low rates of production and high rates of product defects, the plant closed in 1982. At the same time, Toyota’s Takaoka assembly site in Japan was among the most productive in the world. The Takaoka plant had a highly structured production system with standardised work, just-in-time inventory, preventative maintenance and quality control processes.

In 1984, General Motors and Toyota embarked on a joint venture to repurpose the defunct Fremont plant and create the New United Motors Manufacturing, Inc. (NUMMI). General Motors was to incorporate aspects of Japanese manufacturing management techniques into its production, whilst Toyota was to side-step import restrictions by building cars in the United States (US). Around 450 General Motors’ workers were sent to Takaoka for classroom and on the job training and around 35 Toyota managers and production coordinators were sent to Fremont to staff the venture. Approximately 85 per cent of staff hired by NUMMI were former employees of the Fremont plant.

In its early years, the NUMMI venture was a success. By 1986, the productivity and product quality of the NUMMI planted exceeded that of any other General Motors plant and approached levels observed in Toyota’s Takaoka plant. The key ingredient in this successful transformation was the implementation of effective management practices.

Case studies illustrating the importance of management — such as NUMMI — are common, and management has long been considered crucial to firms’ success. However, until recently, systematic evidence of the impact of management has been limited. Over the last decade, innovative approaches to producing large-scale datasets on management practices have emerged, shining light on management practices of firms around the world (Box 3.1). Interest in management practices has grown as new data has produced fresh insights, with growing evidence that management practices have a substantial impact on firms’ productivity and profits.

These large-scale studies confirm that there is room for improvement in the management practices of Australian firms. As early as 1995, the Karpin report99 identified a need for Australian managers to improve in several areas, including strategic management. More recently, in a 2017 paper, roughly 50 per cent of the gap between Australia’s and the United States’ total factor productivity (TFP) was found to be explained by differences in management practices.100

This chapter presents evidence of the impact of management practices on firms’ performance. It examines how Australian management practices compare with world standards, how they vary according to firm characteristics and behaviours, and considers implications for policy. The chapter provides an overview of the international literature on management practices and presents some evidence of an association between management and measures of firm performance in Australia. It suggests that this relationship may be driven, in part, by the higher likelihood of well-managed firms engaging in innovation, seeking out collaborative opportunities and responding to skill and supply chain issues.


Box 3.1: Measuring and evaluating management practices

Measurement

The term “management practices” encompasses a broad array of activities in a firm, ranging from human resource management to tracking of key performance indicators. Whilst management practices are difficult to measure, substantial steps have been taken in recent years toward gaining an understanding of how firms manage their business and how this differs across countries.

Two key data collections on management practices are the World Management Survey (WMS) and the US Census Bureau Management and Organizational Practices (MOP) Survey. The former is collected via an interview-based approach, whilst the latter uses questionnaires. The interview approach applied by the WMS involves a trained interviewer discussing management practices with firms, and scoring these practices according to pre-defined criteria. The questionnaire approach requires participants to respond to closed questions on their management practices. The Australian Management and Organisational Capability (MOC) Survey of Australian Businesses is another questionnaire-based survey of management practices.

Evaluation

Data on individual management practices are often aggregated to produce an overall score of a firm’s management. To calculate these scores, individual management practices are assigned weights, which are then then aggregated. An alternative approach to characterising management practices used by the Office of the Chief Economist (OCE) involves creating categories of management. This involves categorising firms according to what combination of management practices they employ. Analysis based on the approach is presented in Section 3.3.

Firms that engage in more management practices are generally described as employing more active or structured management. Firms’ performance on these scores is also often considered a measure of management capability.


Management practices affect firm performance

Management practices cover a broad array of firms’ activities. For example, firms’ development of strategy, use of data, measurement of performance and relations with staff are all separate aspects of management. Given this, there is clearly scope for it to influence firm performance in many ways. Broadly, management practices standardise processes, shape the flow of information throughout the firm, guide how this information is used, align incentives of members of the firm and encourage the adoption of a longer-term perspective.
Evidence of the link between management and firm performance

Much of the evidence that structured management practices improve firm outcomes — including productivity — has emerged in the manufacturing sector. One seminal study in the mid-90s examined 26 steel plants and found that the adoption of coherent systems of new work practices — such as flexible job assignments, training, incentive pay, and employment security — produced substantially higher levels of productivity.\(^{101}\)

These findings have been reinforced by a series of subsequent, larger-scale examinations of management practices in manufacturing. For example, Bloom et al\(^{102}\) found that a 1 point increase in management practices (on a scale of 1 to 4) had an equivalent impact on output to a 25 per cent increase in the labour force and a 65 per cent increase in invested capital. Additionally, whilst the measurement of management practices has tended to focus on manufacturing firms, there is evidence that management practices are crucial in other sectors such as health care and education.

Management practices appear to explain not only differences in performance across firms, but also across countries. Bloom, Sadun and Van Reenen\(^{103}\) estimate that differences in management capability account for about 30 per cent of the differences in TFP between countries and roughly 50 per cent of the gap between Australia’s TFP and that of the US (Figure 3.1).

Figure 3.1: Share of TFP gap with US explained by management

Source: Data were digitally extracted from Bloom, Sadun and Van Reenen (2017).

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In addition to large-scale quantitative studies of manufacturing, a wealth of case-studies also highlight the importance of active management practices in a range of other industries. For example, the success of Amazon, the United State's largest online retailer, has been partly attributed its focus on performance indicators.

**Box 3.2: Amazon’s “culture of metrics”**

Amazon was founded in 1994 and has since grown to become the largest internet retailer in the world. Among US online retailers, Amazon has led customer satisfaction since 2010. Underpinning this success has been continual innovation, as the company has shifted from reliance on books sales to hosting a vast online marketplace and production of ebook readers and tablets, and a strong focus on performance indicators. Amazon reportedly tracks its performance against approximately 500 metrics. This focus has lead to critical insights — for example, that a 0.1 second delay in page rendering can result in a 1 per cent decline in customer activity. Data and use of metrics have also driven the personalised online shopping experience and speed of deliver that has continued to separate Amazon from its competitors.


**How do Australian management practices compare internationally?**

International comparisons suggest that Australian firms have substantial scope for improvement in their management practices. In the World Management Survey, Australian firms have demonstrated less structured management — for example, in their use of key performance indicators (KPIs) and human resource management — than firms in comparable countries.

As early as 1995, the Karpin report found that good managers were key to job creation and a more competitive economy and that Australian managers needed to improve performance. It noted that customers of Australian firms rated Australian managers behind those of Germany, Japan, Taiwan, the United Kingdom and the US with respect to entrepreneurial expertise and management. The report found that few Australian managers were matching the best internationally and that Australian management must change substantially over the next decade to meet world best practice.

Despite the issue being highlighted, relatively poor management has persisted in Australia. Data from external administrators’ reports lodged with the Australian Securities and Investments Commission have revealed that a substantial proportion of firms cite poor strategic management as a reason for failure (between 17 and 19 per cent of firms from 2009–10 to 2016–17).

Internationally, data from the WMS indicates that Australia continues to trail international peers — such as the US, Germany, Canada, the United Kingdom and France — in terms of management practices (Figure 3.2).

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Manufacturing management in Australia and the United States

Whilst the WMS provides a useful basis for benchmarking Australia’s management performance against a range of countries, recent survey data allows for a more up-to-date comparison of manufacturing management practices between Australia and the US.

This data shows stark differences in the use of KPIs and promotion of staff. For example, 91 per cent of American manufacturing firms use KPIs compared with only around half of Australian firms (Figure 3.3). American manufacturing firms also more often report that promotion decisions for both managers and non–managers are based solely on performance and ability compared with Australian firms (Figure 3.3). These differences may be partly due to systematic differences in characteristics, such as size and industry subdivision, between firms in Australia and the US.
Figure 3.3: Manufacturing management in Australia and the United States, 2015–16

(a) Number of key performance indicators monitored

(b) Frequency of key performance monitoring

(c) Promotion of managers and non-managers

Notes: In panel (a), firms reporting “don’t know” have been removed from the Australian sample. In panel (b), firms responding “other review period(s)” have been removed from the sample. In panel (c), responses that “managers are normally not promoted” in the US MOP Survey is compared with the response “staff were not promoted” in the Australian MOC Survey of Australian Businesses.

A closer look at management in Australia

Whilst the overall differences in management practices between Australian and US firms are stark, there is also substantial variation in management practices among Australian firms. Information on management practices across a range of sectors is collected by the ABS MOC Survey of Australian Businesses. This near-economy-wide survey is unique among management data collections because its broad scope enables comparison of management practices across most Australian industries.

The ABS MOC Survey of Australian Businesses reveals substantial variation in management practices across Australian industries. For example, financial and insurance services firms are more than six times as likely to have a written strategic plan than firms in the construction industry (Figure 3.4a), and almost twice as likely to monitor at least one KPI (Figure 3.4c). Yet it is difficult to compare management practices across the broad range of individual measures available. Combining measures to construct a single classification of management capability enables a more holistic comparison of management capability across Australian firms.

To summarise differences in general approaches to management, the OCE has constructed four categories of management which range from more to less structured (Box 3.2). They highlight significant variation in management practices. In particular, firm size has a strong positive relationship with management practices, which may be driven by necessity, highlighting the importance of comparing management practices of similarly sized firms.
Box 3.3: Categorising management of Australian firms

The OCE has identified four different approaches to strategic management, based on firms strategic planning, the number of KPIs monitored and the number of topics covered by these KPIs. The four categories include:

- **Strategic management** — the firm has active management practices, reporting structured planning and performance monitoring across a range of indicators;
- **Narrow-focus management** — the firm may demonstrate active management in one area but lack either formal strategic planning or comprehensive monitoring;
- **Ad hoc management** — the firm has a reactive approach to management with limited strategic planning and managerial practices occurring on an ad hoc basis; and
- **Low engagement management** — the firm does not undertake strategic planning and does not monitor performance.

The four facets of management contributing to these categories broadly correspond to the Business Scorecard (BSC) framework, which focusses on aligning firms operations with overall strategy. The framework was developed by Kaplan and Norton and — in addition to focussing on the development of strategic plans and corresponding KPIs — emphasises the importance of monitoring a variety of indicators to counter overreliance on financial measures. This prompts firms to not only consider indicators of previous performance (financial measures) but also drivers of future performance.

The BSC framework is widely used by management consultants. Bain and Company (2015) list the BSC approach as one of 25 popular tools included in its survey of Management Tools and Trends. The most recent international survey of around 14,000 executives found that approximately 30 per cent of firms were using this tool. In addition, several studies have found this tool to be associated with improved firm outcomes. For example, a survey of 76 business units found BSC to have a positive impact on firm performance through increased translation of strategy into operations.\(^{105}\) A quasi-experimental study found superior financial performance among bank branches implementing the BSC approach compared with other branches within the same organisation.\(^{106}\)


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3.4: Management practices of Australian firms by industry, 2015–16

(a) Strategic Planning

(b) Monitoring of KPIs
Modes of management and firm characteristics, behaviours and outcomes

Classifying firms according to the four levels of management outlined in Box 3.2 reveals a surprising number of firms with limited structure in their management practices. Across all employing firms, only 6 per cent meet the criteria for Strategic Management (Figure 3.5). At the other end of the spectrum, a surprisingly large share of Australian firms or 58 per cent are classed as having Low Engagement, and the Narrow-Focus and Ad hoc categories include 23 and 12 per cent of firms, respectively.

Source: ABS MOC of Australian Business, 2015-16 Cat. No. 8172.0.55; Author’s calculations.
Figure 3.5: Distributions of the management modes, 2015–16

Notes: Weights have been applied to provide nationally representative estimates.
Source: ABS MOC of Australian Business Microdata, 2015-16 Cat. No. 8172.0.55.001

Firm characteristics, including size and industry, vary substantially with respect to management capability. In Australia, firms employing more than 100 employees are over six times more likely to engage in Strategic Management than firms with 5 to 19 employees (Figure 3.6b). This may reflect the need for larger firms to more proactively manage information (for example, through the use of KPIs) or that the costs associated with formal planning, which have a fixed component, become more manageable at scale. With respect to industry, no clear pattern emerges. The output of some industries, for example, finance and mining lend themselves to the identification and tracking of KPIs, and these industries are more engaged in management practices generally (see Figure 3.6a). However, the drivers of higher rates of structured management in other industries, such as Arts and Recreation Services, are less clear.
Management practices also vary with respect to firm behaviours. For example, firms with higher levels of strategic capability report higher rates of innovation and consider themselves more active in seeking out collaborative opportunities (Figure 3.7). This relationship holds across all levels of firm size, suggesting that this relationship is not driven by the confounding influence of scale. In addition, the OCE has also found that firms with more structured management are more likely to be responsive to skill and supply chain issues (Moran et al. 2018).

Consistent with the substantial number of studies outlined in Section 3.1, higher levels of management structure correspond with higher levels of labour productivity, a relationship that holds across firm sizes from 10 to 1000 employees (Figure 3.8). For large firms, the difference in estimates of average productivity between the lowest and highest level of productivity is just under 20 per cent, whilst the difference between the second highest and highest level of management capability is just under 8 per cent.

The mechanisms behind the relationship between management and productivity have not been examined in depth. The findings above suggest collaboration, innovation and responsiveness may contribute, however alignment of incentives and increased use of digital technology are examples of other potential mechanisms. Further research into what accounts for the relationship between management and productivity is required.
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**What role can policy play?**

How firms determine which management practices to implement is an important consideration for public policy makers. The most appropriate set of management practices will vary according to each firm’s unique operating environment and characteristics and in many cases, firms will have the best information to determine which management practices are most appropriate to their needs. Indeed, firms may opt for less structured management to promote performance.
However, it is also possible that firms lack information on management practices and forgo implementing more structured management practices despite net benefits. Indeed, there is evidence that firms systematically overestimate how structured their management practices are with respect to others. Between countries, self-assessment of management capability is negatively related to external assessments (Figure 3.9). Moreover, firms’ self-assessed management scores have been found to poorly correlate with externally assessed management scores and firm performance in several countries.109

**Figure 3.9: External and internal assessed management practices scores**

![Graph showing external and internal assessed management practices scores](image)

Notes: Scores represent unweighted means of management scores by companies belonging to foreign multinationals vs. domestic firms

Source: Data were digitally extracted from Maloney (2017, p.5).

These informational issues and the potential positive spillovers associated with good management suggests a role for government in encouraging firms to introduce more active management practices, invest in management training or access managerial advice.

### Measures to improve management practices

Evidence that intervention can improve management practices and produce benefits is emerging. For example, randomised management interventions in US schools have demonstrated gains in teaching practices and student outcomes. Similarly, a randomised control trial demonstrated that improved management practices in Indian textiles firms increased TFP by 17 per cent and profits per plant by around $325,000 per year. In a follow up study 7 years later these performance benefits were found to persist.110

A government initiative that offers tailored advice to firms on management practices and strategy is the Department of Industry, Innovation and Science’s Entrepreneurs’ Programme Business Management stream which pairs firms with experienced business advisers and facilitators (Box 3.3). The Industry Growth Centres Initiative also supports firms in selected sectors and can assist with the development of management and practical skills, and identifying skills gaps. As data becomes available on program outcomes, new insights on the effectiveness of government assistance with management practices will emerge.


An OCE study that assessed the impact of participation in the Enterprise Connect (EC) program (a forerunner of the Entrepreneurs' Programme) on firm performance found that EC participant firms had higher performance than non-participants firms, in terms of growth in turnover, employment, capital expenditure and survival rates.

Box 3.4: The Entrepreneurs' Programme

The Department of Industry, Innovation and Science’s Entrepreneurs’ Programme Business Management stream pairs firms with experienced business advisers and facilitators. The advisors and facilitators provide:

- **Business evaluation**, which involves developing a business evaluation action plan with recommended strategies for business improvement or growth. The evaluation includes up to 12 months of mentoring to help implement the strategies.

- **Growth services**, which develops their unique growth plan. Advisers/facilitators mentor the business through the implementation of their plan, facilitating access to knowledge and expertise, research, funding and other assistance.

- **Supply chain facilitation**, which works with firms to strengthen their supply chain and improve their ability to access new markets.

- **Tourism partnerships**, which provides groups of tourism businesses in northern Australia with access to an experienced business facilitator for over 12 months to create a tourism partnerships action plan and opportunities and strategies for common business interests.

Business growth grants are also available under the program. These grants provide matched funding of up to $20,000 to hire an expert to help implement advice and strategies recommended in the one of the above services.

*Source: Department of Industry, Innovation and Science (2018).*

In addition to bespoke advice and facilitated management interventions, information provision can also benefit firms. Diagnostics tools are currently used to guide business evaluation in the Entrepreneurs’ Programme and there is potential to explore additional benchmarking tools to provide further information for Australian firms looking to build management capability. The WMS currently offers a benchmarking tool that allows manufacturing firms to compare their management practices with those of other firms. For other industries, data from the Australia MOC Survey could provide additional information and raise awareness of the opportunities associated with better management.

Overall, management is an important driver of economic outcomes and an important consideration for policymakers. As understanding of what interventions best improve management capability develops, there is potential for substantial economy-wide gains.

Overall, management is an important driver of economic outcomes and an important consideration for policymakers. As understanding of what interventions best improve management capability develops, there is potential for substantial economy-wide gains.
The future of work — the next 25 years

Annette Cairnduff, Director Research and Policy, Foundation for Young Australians

The future of work is changing. It’s a reality governments, industry and communities are all grappling with. The Reserve Bank of Australia has raised concerns regarding fewer taxpayers as the baby boomers retire. We will need an innovative and entrepreneurial generation of young people to maintain our standard of living and quality of life in Australia.

The Foundation for Young Australians (FYA), have sought to understand through our New Work Order report series the dimensions of this change, the implications for young people — and thereby, the future of this country — and what we need to do to prepare young people to thrive in this future.

Our first report, launched in August 2015, explored the three economic forces — automation, globalisation and collaboration — shaping the future of work. It revealed that young Australians entering the workforce today might have as many as 17 jobs in five different industries over their working lives.111

Our six subsequent reports have examined how young Australians are faring in this new reality and what needs to change. In the New Work Order, the types of skills that young people will need to thrive are changing, and formal qualifications and technical skills are only part of the requirements for modern employees. Enterprise skills and personal attributes are already seen as equally important to success, with 10 of the 16 ‘crucial proficiencies in the 21st century’ identified by the World Economic Forum being non-technical skills or capabilities.112

Enterprise skills include communication, teamwork and problem solving, as well as emotional judgement, professional ethics and global citizenship, perceived as generally transferable between industries and occupations - will enable young people to prosper in a

radically altered economy. Yet our research shows that young people are not being prepared or equipped for the significant changes ahead. Recent results from the Programme for International Student Assessment (PISA) showed that of Australian 15-year-olds, 30 per cent are not financially literate and 35 per cent aren’t proficient in problem solving. Other Australian data shows that 35 per cent of 15-year-olds aren’t proficient in digital literacy.

Our report, The New Basics, showed that these capabilities are being actively sought by employers. Demand for an enterprising skill set is increasing across the economy. Since 2013 demand for employees with digital literacy has increased by 212 per cent, critical thinking skills by 158 per cent and creativity by 65 per cent. What were once thought of as ‘soft skills’ are now being prioritised by policymakers and education systems and sought after by employers as necessary skills for the 21st century. We also know employers will pay more for people with these skills, with employees with capabilities in critical thinking and problem solving likely to receive up to $8,000 more per year.

Research in The New Work Mindset report, found that jobs are more related than we think. Not all jobs require the acquisition of an entirely new qualification to become proficient, the skill sets of many jobs are in fact ‘portable’ to other jobs. This is because, for many jobs, employers demand very similar skills. By understanding this, there is an opportunity for young people to be more strategic in planning for, and navigating, working lives that are likely to be dynamic and changing. Rather than seeing learning as a one-off process before our first job or as a necessary for repurposing careers, young people can build a portfolio of skills within a job cluster and target the acquisition of capabilities in key learning areas related to job and career opportunities throughout their life.


On average, when a person trains or works in 1 job, they acquire skills for 13 other jobs. See FYA (2016) New work order, Foundation for Young Australians.
The New Work Smarts report, the fifth in our series investigates what we do at work and how this is going to undergo profound changes in every job over the next decade.\footnote{FYA (2017), The New Work Smarts. Accessed via: https://www.fya.org.au/wp-content/uploads/2017/07/FYA_TheNewWorkSmarts_July2017.pdf} For example, on average, workers will spend 30 per cent more time per week learning skills on the job; 100 per cent more time at work solving problems, over 40 per cent more time on critical thinking and judgment, and over 70 per cent more time using STEM (science, technology, engineering and mathematics) skills.

Workers will use written and verbal communication and interpersonal skills for 29 hours each week (up 14 per cent); and activate an entrepreneurial mindset due to having less management (down 26 per cent), less organisational coordination (down 16 per cent) and less teaching (down 10 per cent).

By 2030, young people will need to be able to deploy foundational and technical capabilities in increasingly enterprising and creative ways, as well as requiring a thirst for ongoing learning.

Our sixth and most recent report, The New Work Reality confirms that now and into the future young people will increasingly need support to develop their cognitive and emotional skills to a much higher level.

By following the journeys of 14,000 young people over a decade from 15-25 years old, we were able to identify a number of key factors that help young people make a smoother transition from full time education to full-time work.
The four most significant factors supporting young people to secure full-time work faster are:

- Courses teaching enterprise skills like problem solving, teamwork and communication. This can increase the speed of entry to working full-time hours by 17 months.
- Relevant paid work experience. This can speed up the transition to full-time work by up to 12 months.
- Employment within an area of work which has strong growth future prospects can speed up the transition by 5 months.
- An optimistic mindset and strong well-being by age 18. This can accelerate the transition by up to two months faster than a young person who is unhappy or not confident with their career prospects before leaving school.

More than ever before young people need access to a relevant, high quality education and learning systems that reflect and respond to their changing and diverse needs, and those of the economy.

If the education system is to meet the challenge of equipping young people with the skills to navigate the future of work and a rapidly changing world, a substantial shift in current approaches is needed. This understanding is growing in import and driving curriculum reform and redesign across the world. How do we design a life of learning that builds flexibility and resilience in the face of rapid change? How do we build skills that enable people to anticipate and respond to changing environments? We need to develop adaptability in young people, as well as enterprise skills that can be applied across a wide range of contexts. Learning needs to be distributed across an entire lifetime. But this concept demands a focus and society-wide commitment that is not yet in place.

While the demand from employers is clear, more needs to be done, with students, parents, educators, industry and government working together to ensure our children and young people will be equipped with the skills they need in work and life.

So how can we help young people achieve stronger results to ensure they’re prepared for the challenges of the future?
We must urgently invest in:

- redesigning the learning system from preschool through higher education (and beyond)
- immersive enterprise education and careers management strategies where the ‘new work smart’ skills are core to teaching, learning and assessment across all school and higher education systems
- a real jobs commitment to young Australians
- a promise and plan for the equitable intergenerational transfer of knowledge, resources and power in the new economy.
FEATURE ARTICLE The future of work – the next 25 years