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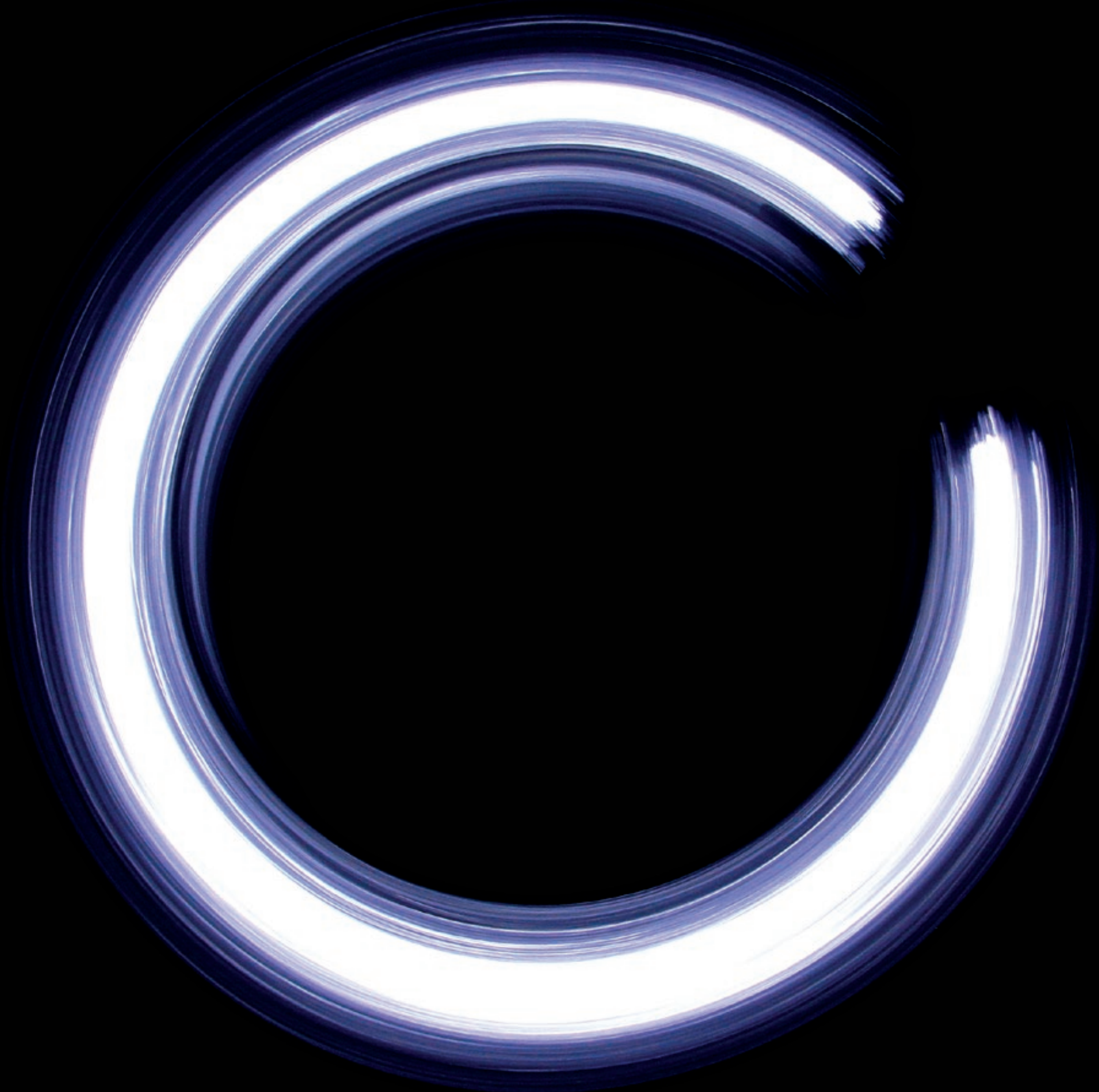

ACS Australia’s Digital Pulse

Driving Australia’s international ICT competitiveness and digital growth

2018

Foreword

Australia has historically been a net importer of technology. Large global platforms that have scaled offer an affordable entry price. As a result, for Australia to remain a country offering higher paying jobs, we have needed to be focused higher up the supply chain, creating added value.

Over the last 12 months, there has been much to be optimistic about. In the 2017 *Australia's Digital Pulse* report there was evidence of a digital boom occurring in Australia, with 40,000 tech jobs created in the previous two years, and IT services exports up 12% to $2.8 billion. In this year's report that growth has continued. IT service exports have grown to $3.2 billion and there were 22,300 new jobs created in just the past year.

At the same time, technological advancement has seen the world shrink. Digitisation and automation mean geography isn't the cost inhibitor it once was. Australians can buy goods from all over the world via online supply channels such as Amazon, Alibaba and eBay. Even the nature of technology investment too is no longer just about productivity gains – it's about meeting the expectations of more connected and empowered customers.

If you are delivering a digital product or service using technology, your prospective customer base will always compare the user experience to that of YouTube, Google and Facebook.

In last year's edition of *Australia's Digital Pulse*, we asked which policy priorities were needed to fuel Australia's digital workforce boom. These included the need to build digital communities to facilitate collaboration and innovation, the enablers required to build a highly skilled talent pipeline for Australia, and new factors of production, such as data being the fuel for new business models.

This year, we investigated Australia's performance in terms of international competitiveness and looked at ways we can find new sources of economic growth.

Rather than identify the skills required for Australia to continue its record 27 years of economic growth, we have applied a different lens, questioning what it would take to be a world leader in an age of emerging technologies such as artificial intelligence, machine learning, blockchain, IoT, drones and autonomous vehicles.

And then, what would be required to ensure that all Australians can maximise their ability to participate in the fourth industrial revolution? How do we avoid what the Governor of the Reserve Bank, Philip Lowe, has described as a two-speed scenario emerging through the structural effects of technology?

Finally, we take a look at where we might find the game-changing ideas that could unlock the next wave of economic growth for Australia. Where can our businesses and financial institutions find their next sources of significant growth? Could it be an industry standard for valuing data on balance sheets? Do intangible assets afford a way to unlock capital and investment? How can tax reform incentivise technology investment while recognising that government budgets need to live within their means? How can government technology procurement processes be enhanced to better diffuse technology throughout our economy, give our startups their demonstrated success, and have knowledge transfer disseminate via the public sector?

It is ACS' aspiration for Australia to be successful in a changing world by becoming a world leader in technology talent and a nation that fosters innovation and creates new forms of value. We feel confident that *ACS Australia's Digital Pulse* will inform public debate and lead to the realisation of game changing ideas that will fuel our living standards over the next decade.

Yohan Ramasundara
President

Andrew Johnson
Chief Executive Officer

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Glossary

ABS	Australian Bureau of Statistics
ACS	Australian Computer Society
AI	Artificial intelligence
ANZSCO	Australian and New Zealand Standard Classification of Occupations
ANZSIC	Australian and New Zealand Standard Industrial Classification
CfBA	Centre for Business Analytics
ASEAN	Association of Southeast Asian Nations
DAE	Deloitte Access Economics
ESIC	Early-stage innovation company
ICT	Information and communications technology
IMT	Information, Media and Telecommunications (industry)
IoT	Internet of Things
GDP	Gross domestic product
OECD	Organisation for Economic Co-operation and Development
PISA	Program for International Student Assessment
R&D	Research and development
STEM	Science, technology, engineering and mathematics
UK	United Kingdom
UN	United Nations
US	United States
WEF	World Economic Forum
WTO	World Trade Organization

Executive summary

For Australia to succeed as an economy in the coming decades of the 21st century, it will need to successfully participate in the next waves of the digital revolution. This means using the creativity and skills of the Australian people; supporting the entrepreneurship and innovation of our businesses; and applying emerging technologies such as artificial intelligence (AI), machine learning and the Internet of Things (IoT). Digital success will enable growth and innovation across industries as diverse as manufacturing, agriculture and professional services. It will generate new jobs and help address a variety of social challenges, from reducing traffic congestion to delivering health services more efficiently.

By some measures, Australia is taking advantage of the opportunities offered by the digital revolution. Information and communications technology (ICT) services exports increased by more than 60% over the past five years to reach $3.2 billion in 2016-17. Business ICT R&D increased by almost 50% to $6.6 billion in the five years to 2015-16. But there are also early warning signs that Australia could end up a passenger in the digital journey, with other countries in the driver's seat. As an economy grappling with the transition away from its mining boom, Australia risks falling behind our international peers, which could have flow-on effects on productivity and living standards.

This edition of *ACS Australia's Digital Pulse* is the fourth annual stocktake of the health of Australia's digital economy, produced by Deloitte Access Economics for the Australian Computer Society (ACS). It's the most detailed examination of digital workforce trends, aimed at informing public debate about this important area of our economy. But this edition is more than just an annual update. For the first time, we directly benchmark Australia's digital performance with that of its peers, and contemplate the magnitude of the benefits on the table if we can become a global leader in digital activity. We identify what success looks like in terms of Australia's workforce and businesses, and some of the policies needed to support this digital activity.

How does Australia perform on the international stage? We looked at 15 indicators of digital performance across four themes: consumers, businesses, ICT sector and workforce skills. We gathered data from a range of international sources such as the Organisation for Economic Co-operation and Development (OECD), the World Trade Organization (WTO), the United Nations (UN) and other research institutions. Overall, our average relative ranking is seventh out of 16 developed economies. So we're ahead of the laggards, but lagging behind the leaders. Moreover, the past five years have seen almost no relative improvement. Others have matched our efforts.

But first, the good news. Our ICT workforce grew to 663,100 workers in 2017, an increase of 3.5% from the 640,800 workers reported in last year's report. Two-thirds of current ICT workers currently in Australia are in technical, professional, management and operational roles, and 51% are employed in industries outside of ICT. Demand for ICT workers is set to grow by almost 100,000 to 758,700 workers by 2023, by which time almost 3 million Australian workers will be employed in occupations that regularly use technology.

Scratch beneath the surface and it's a different story. With fewer than 5,000 domestic ICT graduates a year, the only way we'll reach workforce targets is by importing labour, much as we've done for the past five years. We need more ICT workers with skills in artificial intelligence, data science, cyber security and blockchain, and filling these positions with migrants suggests a missed opportunity to provide rewarding employment for the next generation of Australian workers. Furthermore, our existing workforce has diversity issues: only 28% of ICT workers are women and only 12% are aged over 55, compared with 45% and 15% respectively in all professional industries.

The biggest worry is that we are performing worst on the measures of future capability. We're falling behind other countries like the US, the UK and Singapore in being able to supply ICT skills, both from a current workforce perspective and based on STEM performance in schools, which is a key determinant of future skills supply. We also have relatively low investment ICT R&D today. Does this mean we're likely to see our relative position in digital decline over time, especially regarding tech startups? We don't ask such a question to portend doom and gloom, but rather to provoke a less complacent attitude about our place in the global digital economy.

What can Australia do to improve our international competitiveness in ICT and become a leading digital economy? Developing and attracting highly skilled ICT workers continues to be one of the most important drivers of growth and innovation, which requires an agile workforce and education system to support digital transformation across the economy. This edition of *Australia's Digital Pulse* provides some workforce policy ideas. It also discusses four additional key policy issues that could accelerate technology investment and digital business activity in Australia:

- **Reassessing the tax landscape for digital investment overall.** Some governments around the world are introducing favourable settings for digital and innovation activities, while the 2018-19 budget achieved savings by narrowing the R&D tax incentive. This suggests there may be value in taking another look at incentives to encourage digital growth.
- **Valuing and accounting for data as a company asset.** Developing Australian accounting standards for data assets could facilitate more investment by enabling businesses to leverage data assets to access external financing. Currently 35% of innovation-active business in the ICT industry cite funding difficulties as a barrier to business activity. While the productivity benefits for companies adopting data-driven decision making are up to 6%, almost half of company data and other intangible assets of ASX200-listed companies are not properly accounted for.
- **Using data as a tool for policy development.** Australia performs poorly compared to other countries when it comes to the availability of open government data overall. This limits the potential to create value by using this data for other applications. And it must change, because the aggregate direct and indirect value of government data in Australia is up to $25 billion per annum. State governments in Victoria, New South Wales and South Australia are already using data to improve the effectiveness and efficiency of policy making, and they continue to work at overcoming challenges such as data quality and data literacy in the public service.
- **Positive spillovers and collaboration in technology procurement.** The Australian Government's annual ICT spend is around $6 billion. A more collaborative procurement process would enable more innovation, technology transfer and digital capability development. While data is the most important factor of production in the digital economy, many government procurement processes are still stuck in the 20th century. Moving towards digital procurement would improve efficiency.

Emerging from the middle of the digital pack to digital leadership is not just to please the technology community – it's what's going to drive innovation and productivity growth in business over the coming decades. And economists often say, productivity growth is the key to higher living standards and better quality of life. Based on previous productivity gains from technology uptake, further adoption of digital technologies has the potential to add an extra $66 billion to Australia's GDP over the next five years alone. Becoming an international leader in digital skills and employment would involve an extra 100,000 ICT jobs – in addition to the 100,000 already forecast.

Introduction

ACS Australia's Digital Pulse provides a snapshot of Australia's digital economy, workforce and policy landscape, prepared by Deloitte Access Economics on behalf of the Australian Computer Society. Its analysis of Australia's ICT sector – including the increasing use of digital technologies across the economy, and key enablers of future growth and innovation – provides an evidence base for the broader public discussion on digital issues.

Previous editions of the *Australia's Digital Pulse* have examined digital technology education in Australian schools, ICT workforce development and training, and policy priorities to enable Australia's future digital growth. The series has also highlighted how emerging technologies are being applied to transform business operations in a diverse range of Australian industries, such as agriculture, health, manufacturing and financial services.

This 2018 report is the fourth edition of the *Digital Pulse* series. The underlying themes are the international competitiveness of Australia's ICT sector and digital economy, and strategies for positioning Australia to reap the benefits of technological change and progress. Our research is based on information from a range of sources, including:

- Data from the Australian Bureau of Statistics, drawing on publicly available tables and a customised data request regarding the ICT workforce
- Data and reports published by various Australian sources, particularly the Australian Government departments of Education; Immigration and Border Protection; and Industry, Innovation and Science
- Information collected from various international sources, including the OECD, the WTO, the UN and other research institutions
- Customised data from LinkedIn, providing a more granular and real-time picture of Australia's ICT workforce and skills
- Consultations with industry, academic and government experts, including those from Property Exchange Australia (PEXA), Origin Energy, the Melbourne Business School, AustCyber, the NSW Government and the Victorian Centre for Data Insights.

The report is structured as follows:

- Section 1 provides an overview of Australia's international competitiveness in ICT relative to other developed countries, across the four themes of consumers, businesses, the ICT sector and workforce skills
- Section 2 is a snapshot of Australia's current ICT workforce and skills, including analysis of diversity among ICT workers and forecasts of future employer demand for ICT workers
- Section 3 describes the importance of Australia developing and attracting ICT talent, and outlines recent developments among ICT-related university graduates and skilled migration flows
- Section 4 evaluates the economic dimensions of digital leadership, and what this could look like in Australia
- Section 5 discusses some key policy issues that could affect Australia's digital landscape in the future, including introducing tax incentives, valuing data as an asset, using data for policymaking, and pursuing government technology procurement.

As Australian households, businesses and governments increase their use of digital technologies, it is important that we have a robust and informed conversation about Australia's digital economy in a way that drives growth and innovation for the future.

1 Australia's international competitiveness in ICT

Key findings

- Australia's ICT performance is relatively 'middle of the pack' compared with other developed countries, with an average relative ranking of seven out of 16 countries across indicators relating to consumers, businesses, workforce skills and the ICT sector.
- Our performance on some indicators of ICT economic activity (such as ICT exports and R&D) has improved over recent years, but other developed countries have also seen significant growth in digital activity and technological advances. Given the competitive global environment, Australia is only standing still compared to our international peers, despite these recent developments.
- While ICT skills and technological competencies are a critical driver of digital growth, many other developed countries outperform us on measures such as ICT employment and STEM skills in schools, and Australia has shown no signs of improvement over recent years.

A highly skilled workforce and sophisticated technological capabilities that enable the production of innovative and high-quality goods and services are key drivers of Australia's success in the global economy. This is particularly relevant when considering the international competitiveness[1] of Australia's (ICT) sector. The rapid pace of digital change – with advances in technologies such as AI, augmented and virtual reality, 3D printing and robotics – make it is essential for Australian businesses and industries to remain competitive and reap the benefits of digitally-enabled growth.

Innovative and productivity-enhancing applications of emerging technologies are not only limited to the ICT industry itself. The 2017 edition of *Australia's Digital Pulse* highlighted examples of potential applications such as IoT in agriculture, 3D printing in manufacturing, robotics in healthcare and AI in financial services (DAE, 2017a). Australia continues to transition towards a services- and knowledge-based economy (RBA, 2017), so developing the digital skills to operate new technologies and understand their commercial applications will be an important driver of this growth.

With technology being a key enabler of globalisation and productivity improvements, it is no surprise that many countries focus on international competitiveness in ICT to facilitate broader economic growth (Dahlman, 2008). This involves developing a competitive local ICT industry while effectively utilising digital technologies in wider applications across the economy.

Several international organisations have sought to measure the relative international competitiveness of different economies by capturing a range of relevant factors, as discussed in the box on the following page. While these various indexes are based on different metrics, they all tell a similar story: compared with all other countries, Australia performs near the top on indicators of ICT competitiveness. And yet when comparing Australia with other developed countries, it typically falls around the middle of the rankings.

[1] A country's international competitiveness depends on factors such as the productivity and efficiency of its local businesses and industries, and their capabilities in devloping and producing new and valuable goods and services to meet global demand (Porter, Ketels and Delgado, 2007). The ability to compete on price has always been a significant driver of international competitiveness, particularly as the trend towards e-commerce allows businesses to reach new markets overseas and enables consumers to conveniently access lower prices around the world (StarTrack, 2017). But international competitiveness is a multidimensional concept, and other considerations such as the quality and design of goods and services are also important determinants of the international competitiveness of a country's businesses and industries (Adriana and Anca, 2009).

Measures and cross-country comparisons of international competitiveness in ICT

Global organisations have published a number of indexes that measure the growth and development of a country's ICT sector and overall digital economy.

The World Economic Forum (WEF) Networked Readiness Index is a measure of how ready countries are to benefit from digital technologies, based on the drivers of infrastructure, affordability and skills, and from the perspective of individuals, businesses and governments (WEF, 2016). In 2016, Australia ranked 18th out of 139 countries in this index. Our ranking has remained relatively stable in recent times, rising by only one place since 2012.

The UN's Global ICT Development Index measures the evolution of countries towards becoming an information society. It compares the digital landscape of different countries based on their general readiness to access and use digital technology, their recent progress in ICT development and the broader potential for technology to enhance growth (UN, 2017). In 2017, Australia ranked 14th of 176 countries in this index.

The World Digital Competitiveness Rankings, collated by the global business school IMD, considers whether a country's regulatory framework encourages business innovation, the development level of its talent pool, its investment risks associated with technology-related activities and its future-readiness (IMD, 2017). Australia ranked 15th out of 63 countries in 2017.

For the 2018 *Digital Pulse*, we analysed how Australia performs on indicators that contribute towards our international competitiveness in ICT. Many factors can influence or indicate ICT competitiveness – including the workforce, business use, general consumer uptake and other aggregate activity-based measures. Of these, Deloitte Access Economics examined four relevant themes to inform an assessment of Australia's ICT competitiveness:

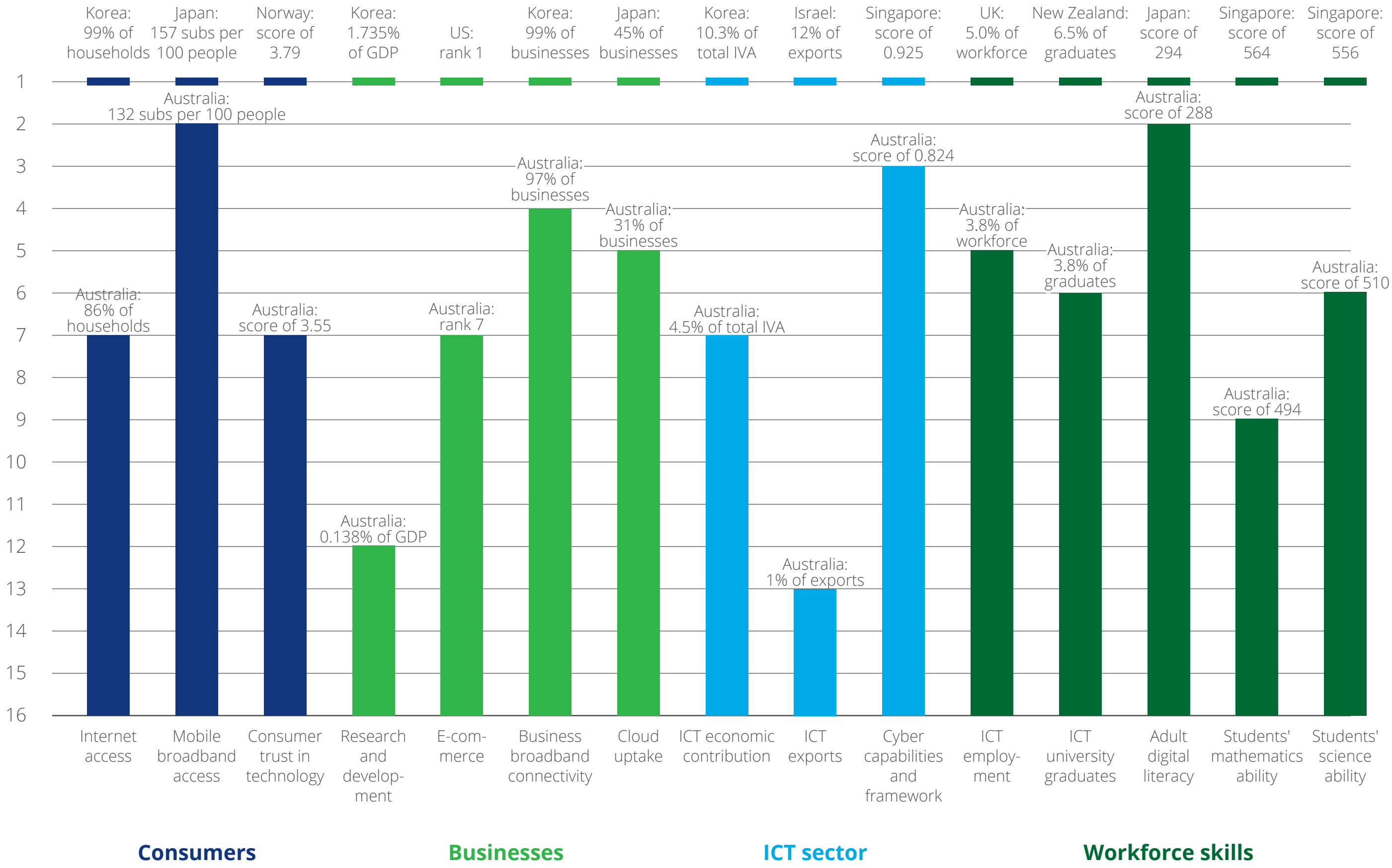
Consumers | ICT sector | Businesses | Workforce skills

Deloitte analysed a total of 15 indicators across these four themes to rank Australia's performance out of 16 developed countries[2]. These indicators have come from a range of international sources, including the OECD, the WTO, the UN and other research institutions.

[2] Given that most sources examine different sets of countries when conducting a global analysis, our assessment uses a common pool of 16 countries across all indicators to ensure a standardised comparison. In addition to Australia, our list comprises: Canada, Denmark, France, Germany, Israel, Italy, Japan, Korea, New Zealand, Norway, Singapore, Spain, Turkey, the United Kingdom (UK) and the United States (US). While some of the indicators look at a much larger set of countries, the rankings that we discuss in the analysis that follows only considers this subset of 16 countries. If a particular indicator does not include a measure for one or more of these specified countries we have noted this in the analysis.

Chart 1.1 provides an overview of Australia's relative performance across the four ICT competitiveness themes and the 15 indicators. The evidence suggests that Australia's performance is relatively 'middle of the pack' compared with other developed countries, with an average relative ranking of seventh out of the 16 countries.[3] Each theme and indicator is discussed in further detail below.

Chart 1.1: Summary of Australia's relative performance in ICT competitiveness indicators



Sources: ABS (2017a, 2017b, 2018); A.T. Kearney (2015); IBISWorld (2018); IEA (2017); ITU (2017); OECD (2012a, 2017a, 2017b, 2018a, 2018b, 2018c); Tufts University (2017); WTO (2018)

[3] Australia's ranking on individual indicators has been scaled to relative rankings for this average, to account for the fact that not all indicators include all 16 countries. This average places equal weight on each of the four themes.

Consumers

The ability of individuals to access and connect to basic technologies is widely viewed as a critical driver of increased economic development and reduced social disadvantage (AHRC, 2018). Narrowing the 'digital divide' – the gap between individuals with no or inadequate access to digital infrastructure, and those with effective access – is an important focus for governments around the world. Widespread uptake of basic technology – such as the internet and mobile devices – can also contribute to developing the digital literacy and ICT skills of the general population.

Internet access

Australia ranks seventh out of 15 countries[4] for internet access, with 86% of the population connected to the internet in 2017 (OECD, 2018a and ABS, 2018). While this represents a significant increase in internet access over the past decade (only 60% of households had internet access in 2005), the proportion of the population with access to a basic internet connection is lower than in countries such as Korea (99% in 2017), Denmark (97% in 2017) and the UK (94% in 2017). In particular, there is a digital divide between Australia's urban and rural areas when it comes to accessing the internet. Reducing this gap will be important in improving digital inclusion more broadly across the country (Roy Morgan Research, 2017).

Mobile broadband access

On access to mobile broadband, Australia ranks second out of 15 countries[5], with 132 wireless mobile broadband subscriptions for every 100 inhabitants across the country in 2017, compared to around 157 subscriptions per 100 inhabitants in the highest-ranked country, Japan (OECD, 2018b). Australia's international ranking has remained unchanged since 2012, though mobile broadband access has increased from around 98 subscriptions per 100 inhabitants since then. Deloitte Access Economics previously estimated that mobile technologies contributed $43 billion to the Australian economy in productivity and participation benefits in 2015, and these benefits are expected to grow with the upgrade from 4G to 5G mobile networks (DAE, 2017b).

Consumer trust in technology

Consumer trust in the digital economy and new technologies is essential for driving general uptake. On this measure, Australia ranks seventh out of the 16 countries in the 2017 Digital Evolution Index. This index examines the evolving nature of cyber security risks that result from our increasing use of and reliance on digital technology, and assesses the trustworthiness of each country's digital environment (Tufts University, 2017). Norway, Denmark and Sweden rank at the top for this indicator, while Australia is noted as a country with a 'trust deficit' – that is, our technology users have significant digital experience but their behaviour suggests that they are less patient when they encounter issues online.

4 Data for the international comparison of internet access was unavailable for Singapore.
5 Data for the international comparison of mobile broadband subscriptions was unavailable for Singapore.

Businesses

As industries within and outside the ICT sector expand their use of new and existing technologies, their ability to effectively use digital tools becomes more important. Digital technologies are 'a platform for innovation and growth' that provide a foundation for business transformation and positive disruption throughout the broader economy (BCR, 2016a). The extent to which a country's businesses use and invest in technology illustrates how developed and sophisticated their digital activities are, and whether they are building current and future capacity for ICT economic activity.

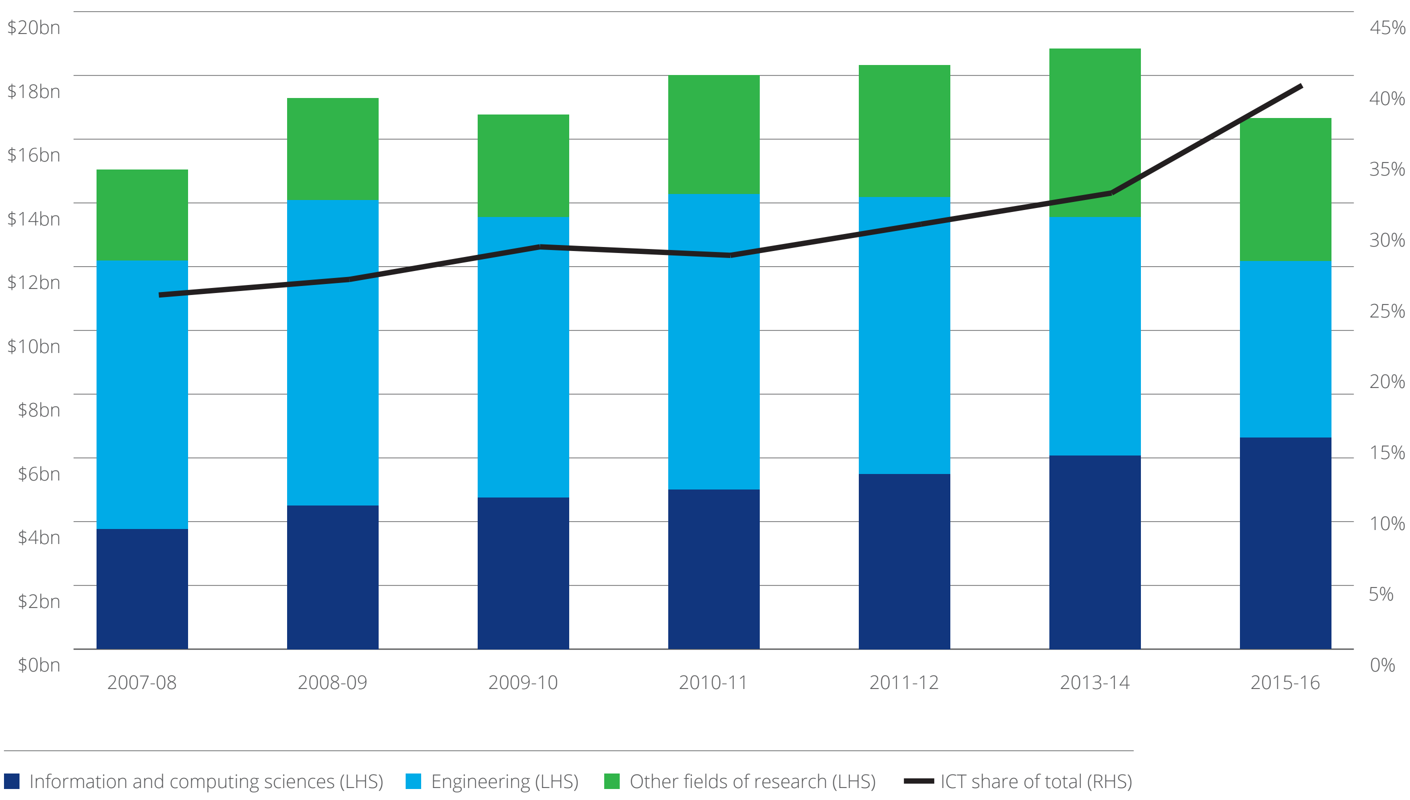
Research and development

Australia ranks 12th out of the 16 countries on business expenditure on research and development (R&D) in ICT, when this R&D is examined as a share of a country's overall GDP. Australian businesses' investment in ICT R&D amounted to 0.14% of GDP in 2015, compared to 1.7% in Korea and 1.6% in Israel (OECD, 2017a). Nonetheless, this spending has increased over the past decade, to $6.6 billion in 2015-16 (Chart 1.2). This represents 40% of total business R&D expenditure in Australia.

E-commerce

Growth in e-commerce is enabling businesses to reach customers in new markets both within their own countries and around the world, while potentially lowering the costs associated with physical store operations. The Global Retail E-commerce Index assesses countries based on current online sales, predicted growth and other e-commerce factors, and places Australia ranks seventh out of 14 countries[6] for the development and potential of our businesses in the e-commerce market (A.T. Kearney, 2015). Australia's ranking has been relatively unchanged since 2013, during which time the US, the UK and Japan have ranked among the top countries on e-commerce activity.

Chart 1.2: Australian businesses' R&D expenditure, FY2008–16



Source: ABS catalogue 8104.0 (2017)

[6] Data for the international comparison of e-commerce activity was unavailable for Israel and Turkey.

Broadband connectivity

Easy and reliable internet access can enable businesses to maximise their growth potential in the digital age. On the indicator of businesses' broadband connectivity, Australia ranks fourth out of 13 countries;[7] 97% of all businesses had access to broadband internet in 2016, up from around 94% in 2010 (OECD, 2017a). The top-ranking country on this indicator was Korea, where more than 99% of all businesses have a broadband connection.

Cloud uptake

Businesses' use of cloud technology is another access and adoption measure involving a more advanced category of digital tools. Australia is ranked fifth out of 12 countries[8] on our uptake of cloud services across all industries, with 30.7% of Australian businesses using of cloud computing services in 2016 (OECD, 2017b and ABS, 2017a). This measure of cloud computing includes server access, storage, network components and software applications.

ICT sector

The size and development of the ICT sector indicates the strength of the technological core underpinning a country's digital economy. A domestic ICT sector with comparatively strong economic performance indicates that a country is better equipped to capture a larger share of the growth in global consumer and business demand for ICT goods and services – growth that carries on apace as digital disruption continues to affect households and industries around the world (Acker, Gröne and Schröder, 2012). Furthermore, a country with substantial ICT economic activity can experience positive spillovers that lead other industries to digitise. Depending on the relative strengths of the country this may set the 'global tech standard' for what digital development looks like (*The Economist*, 2018).

ICT economic contribution

The definition of the ICT sector can vary across countries and may include businesses that deliver a mix of ICT goods (such as the manufacturing of computers and communications equipment) and services (such as software publishing and information services) (ITU, 2007). Analysis of the ICT sector's contribution to economic activity finds that Australia ranks seventh out of 13 countries[9], with our ICT sector representing around 4.5% of total industry value add in 2015 (OECD, 2017a; ABS, 2017b and IBISWorld, 2018). By comparison, the ICT sector's economic contribution is 10.3% of total value add in the top-ranking Korean economy, where there is a large ICT manufacturing industry that makes up 7.2% of overall economic activity.

ICT exports

ICT exports are a measure of the extent to which a country's production of ICT goods and services are competitive at a global scale and demanded by consumers around the world. The available international comparison data examines exports of ICT services[10] as a share of total exports, ranking Australia 13th out of the 16 countries on exporting ICT services in 2016 (WTO, 2018). Australia's exports of ICT services made up 1.03% of total exports or US$2.5 billion, compared to 12.02% of exports in Israel and 3.23% in the UK.

Australia's international position for ICT services exports (as a share of total exports) has remained relatively unchanged over recent years; we were ranked 12th out of the 16 countries in 2011. At the same time, Australia's exports of ICT services has grown significantly, increasing by more than 60% over this period to reach A$3.2 billion in 2016-17 (Chart 1.3). This suggests that while Australia's ICT service export activity has been strengthening over time, the pace of growth has only enabled us to keep up with the performance of other countries. Indeed, Chart 1.3 illustrates that over this same period, Australia's ICT services imports (that is, the exports of other countries) has also increased significantly.

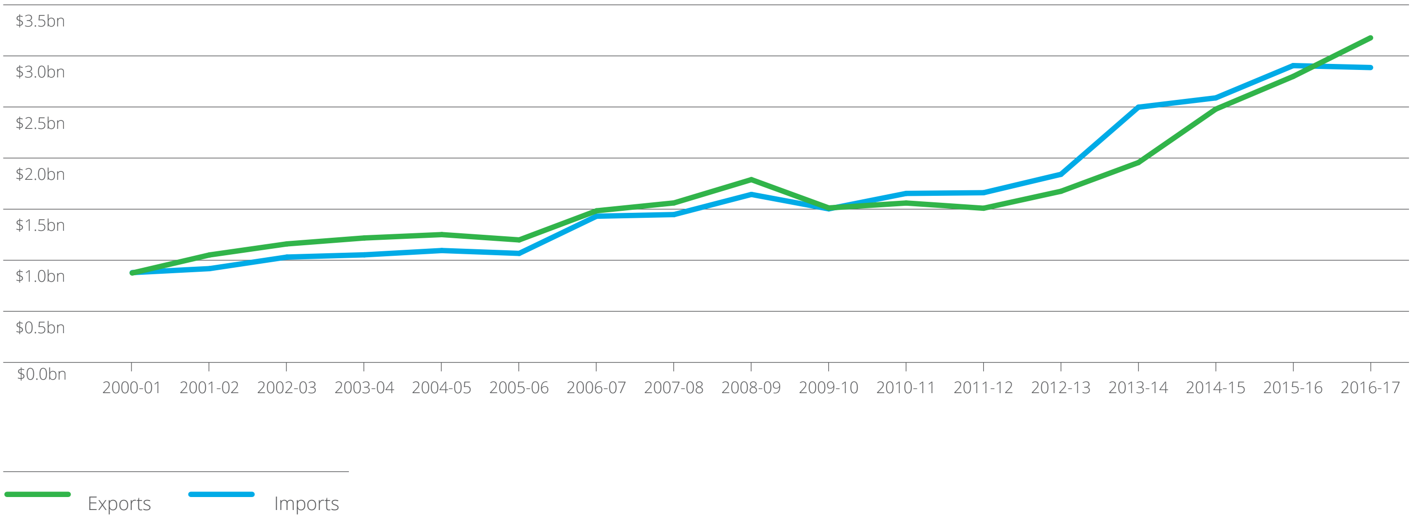
[7] Data for the international comparison of businesses' broadband connectivity was unavailable for Israel, Singapore and the US.

[8] Data for the international comparison of cloud technology use was unavailable for Israel, New Zealand, Singapore and the US.

[9] Data for the international comparison of ICT economic contribution was unavailable for Israel, New Zealand and Singapore.

[10] Examining ICT services exports in isolation is likely to understate the contribution of digital technology to a country's international trade, as services exports do not capture the ICT inputs embedded in goods exports. For example, the 2017 *Australia's Digital Pulse* reported that the ICT input share of Australia's exports had increased from 4% in 2013 to 7% in 2016, reflecting the growing uptake of new technologies across economically significant industries in Australia (DAE, 2017a).

Chart 1.3: Australia's trade in ICT services, FY2001–17



Source: ABS catalogue 5368.0 (2018)

Cyber capabilities and framework

The increasing use of ICT across all sectors of the economy means there is increased focus on individuals' trust in the security of information stored and transferred digitally, especially in relation to personal or financial data. Malicious activity such as online fraud, cyber espionage and other cyber crime can substantially damage the reputation of a business (*The Economist*, 2016). Assessing the cyber security skills and infrastructure of a country's ICT sector provides an indication of its capabilities in defending against cyber attacks and managing cyber-related risk, as well as its resilience in recovering from such activities should a significant cyber security incident arise.

Australia ranks third of the 16 countries on its cyber-related capabilities and framework in the 2017 Global Cybersecurity Index (ITU, 2017), a ranking that has remained relatively unchanged over the past few years. Singapore and the US ranked above Australia on this index. Within this assessment, Australia performed relatively well on technical information security skills, as well as having a strong cyber crime legal framework and capacity building through research and education. However, our performance was relatively poor on cooperation and the existence of information-sharing networks, potentially reflecting challenges in collaborating between Australia's states and territories – as discussed in the box on the following page.

Global leadership in cyber security represents a significant economic opportunity. Previous research has found that a greater focus on cyber security across the Australian economy could lead to a 5.5% uplift in business investment, a 2% increase in wages and an additional 60,000 people employed by 2030 (Deloitte, 2017c). This includes benefits to the ICT industry and in sectors of the economy with higher 'cyber value at risk'; for example, banking, defence, health and education.

A secure approach to addressing cyber risks will be important for enabling future growth in the digital economy, and this will require proactively addressing cyber threats. The first annual update to the Australian Government's *Cyber Security Strategy* notes progress on a number of cyber initiatives (Australian Government, 2017). These include the opening of the Joint Cyber Security Centre in Brisbane; $30 million funding for AustCyber to take advantage of global cyber opportunities; and establishing Academic Centres of Cyber Security Excellence to fill demand for cyber security professionals (with 11,000 additional cyber workers required over the next decade). Given the potential economic gains to be had from greater investment in cyber, Australian businesses and governments should seize these growth opportunities to become a global leader in this area.

Developing Australia as a global leader in cyber security

Cyber security is an area where Australia can take a leading role. The continued increase in digital economic activity and international connectivity means that cyber security risks pose an ongoing challenge for governments, businesses and individuals. At the same time, investing in our cyber-related capabilities will raise our overall security levels and create new opportunities for innovation, job creation and economic growth.

AustCyber (the Australian Cyber Security Growth Network) was created in 2017 in recognition of the critical importance of cyber security. This industry-led government initiative supports growth in Australia's cyber industry, and AustCyber builds on the distinct strengths that will help Australia capitalise on the economic opportunities of cyber security and become a global leader in this field. According to Mike Bareja, National Network Program Manager at AustCyber, Australia's strengths include "a leading research and academic sector in cyber-related technologies such as crypto, quantum, IoT and smart cities; Australia's reputation as a trusted and secure country in terms of our government and business environment; and our existing education exports which can be leveraged to become a global cyber education provider".

But there are also barriers that may slow or limit Australia's potential for growth in this field. Mike suggests we can improve the "coordination between different states and territories on cyber capabilities, innovation and policy. Since many initiatives are at the state level, a disconnect between jurisdictions leads to inefficiencies and undercuts Australia's strength of having an agreed, strategic national approach to cyber security." AustCyber is a national initiative that is helping to break down these barriers and improve collaboration between states and territories. It is currently establishing and maintaining a network of cyber security innovation nodes through bilateral agreements with each of the state and territory governments, which will improve national connectivity, commercialisation, and research and development.

Australia also needs to develop a sustainable pipeline of cyber-related skills to facilitate future growth. This ranges from increasing school students' participation and performance in STEM subjects and earlier development of logic and critical-thinking skills, through to offering and improving courses in cyber security in the tertiary and vocational education sectors. The latter is particularly important, as many of the worker shortages in cyber security roles could be filled by vocationally trained and job-ready workers. AustCyber has worked with industry partners and TAFEs around Australia to develop national cyber security qualifications (at Certificate IV and Advanced Diploma levels) which provide technical and practical training in cyber skills. These qualifications will help develop the 11,000 additional technical cyber security workers that AustCyber estimates Australia will require over the next decade.

Workforce skills

It is increasingly recognised that developing technological competencies across the wider population – and integrating ICT into broader learning and skills development – is an important driver of success in the digital age (Pineida, 2011). The digital capabilities and ICT skills of individuals within a country – across students, workers and the general population – is an important theme in this analysis.

ICT employment

The size of the ICT workforce is an important indicator of an economy's core base of technical ICT skills. Although Section 2 discusses Australia's ICT workforce in greater detail using the definition of ICT workers applied in previous editions of *Australia's Digital Pulse*, the international comparison of relative workforce sizes uses the narrower OECD definition of 'ICT specialists'. On this measure, 3.8% of Australia's workforce was comprised of ICT workers in 2016, placing us fifth out of 11 countries[11] (OECD, 2017a). By comparison, ICT employment represented around 5% of total employment in the top-ranking country, the UK.

ICT university graduates

Graduates from ICT degrees provides a pipeline of talent to meet employer demands for ICT skills and digital capabilities. In 2015, Australia ranked sixth out of 14 countries based on the share of information science graduates as a proportion of all tertiary-educated graduates (OECD, 2018c).[12] 3.77% of all graduates in Australia had completed studies in information science, compared to the top-ranking New Zealand where 6.54% of graduates had studied information science. Section 3 of this report provides a more detailed discussion around ICT graduates in Australia and forecasts the qualifications required by future ICT workers.

[11] Data for the international comparison of ICT employment was unavailable for Israel, Japan, Korea, New Zealand and Singapore.

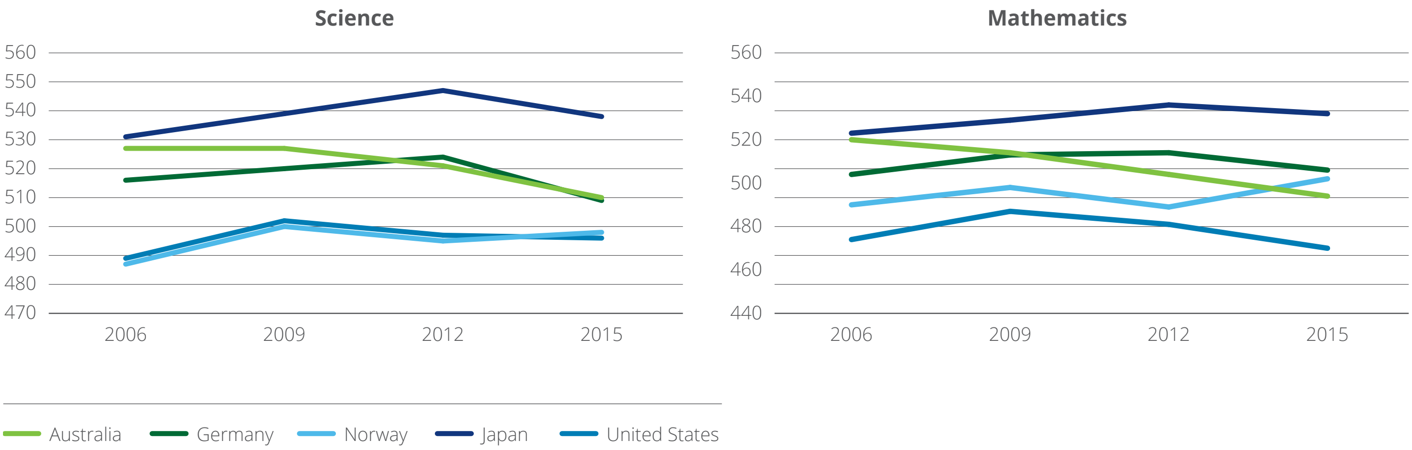
[12] Data for the international comparison of university graduates was unavailable for Japan and Singapore.

Adult digital literacy
Australia ranks second out of 13 countries on the ability of our adult population to solve problems in technology-rich environments, second only to Japan (OECD, 2012a).[13] This indicator of adult digital literacy – that is, for individuals aged 16 years and older – is assessed in the Programme for the International Assessment of Adult Competencies (PIAAC), and indicates the proficiency of adults in different countries in information-processing skills for personal, work and civic purposes. General digital literacy across the population provides a foundation for understanding how to work and live in an increasingly digital society. This has important implications for addressing socioeconomic disadvantage, as poor digital literacy can be associated with lower employment and income outcomes (Pew Research Centre, 2018).

Students' mathematics and science ability
Having strong capabilities in school-level STEM subjects continues to grow in importance. This is the case both from a technical viewpoint – in developing a country's future STEM-related workforce – and from a broader perspective as STEM skills are strongly related to the critical thinking, problem solving and logic competencies that are essential for success in any future role (Education Council, 2015).

In 2015, Australia ranked ninth out of 16 countries on student achievement in mathematics and sixth of 16 countries in science achievement for students aged 15 (OECD, 2018d). These indicators are based on the OECD's Programme for International Student Assessment (PISA). Australia's performance in science and mathematics has declined over the past decade (Chart 1.4). The relatively lacklustre performance in mathematics and science scores could be partly attributable to the proportion of Australian schools experiencing difficulty finding science and mathematics teachers, which is double that of the international average of 19% (OCS, 2017).

Chart 1.4: International performance in PISA, 2006-15



Source: OECD (2018d)

[13] Data for the international comparison of adult digital literacy was unavailable for France, Italy and Spain.

Australia's overall performance in ICT

Overall, these indicators provide evidence that with an average relative ranking of seventh out of the 16 developed countries, **Australia's performance is relatively middling** across measures of international ICT competitiveness.

While our digital activity in areas like exports and R&D has increased in dollar terms over recent years, there has also been significant growth in ICT economic activity overseas. This competitive global environment means that **Australia is only standing still compared to our international peers** in terms of the performance of our digital economy. At the same time, we're falling behind other countries like the US, UK and Singapore in the supply of ICT skills, both from a current workforce perspective and when factoring in STEM performance in schools, which is a key determinant of future skills supply.

It can be difficult to definitively identify the reasons for being 'middle of the pack', instead of a global leader. In Australia's case, our economy has traditionally focused on goods-producing industries such as manufacturing, construction and mining, which were historically less ICT-intensive industries. The shift towards more knowledge- and service-based sectors has been a recent trend (RBA, 2017), so Australia could still be playing catch-up on the technological capabilities and digital activities required to accelerate growth in these areas.

Regarding education and skills, previous research has identified several potential factors contributing to Australia's poor performance in STEM subjects. These include school factors such as insufficient resources or qualified teachers; home factors such as poor awareness and understanding of STEM careers among parents; and personal factors such as a lack of interest and engagement (University of Canberra, 2017). This suggests that some systemic and cultural issues could be improved to better develop the required skills and capabilities in Australia's future workforce.

What can be done to address these areas? Although the conversation around technological change and innovation has been picking up in Australia over recent years, **businesses can still do better and we could have a policy environment that better facilitates digital activity**. Section 5 explores these themes in more detail.

2 Snapshot and forecasts of Australia's ICT workforce and skills

Key findings

- Australia's ICT workforce grew from 640,800 workers in 2016 to 663,100 workers in 2017, an increase of 3.5%.
- The ICT workforce is forecast to grow by almost 100,000 over the coming years, to around 758,700 workers in 2023. This is an average annual growth rate of 2.3%, compared to 1.4% in the overall workforce over this period.
- Women currently represent only 28% of ICT workers (compared to 45% in all professional industries), and workers aged over 55 make up only 12% of the ICT workforce (compared to 15% in all professional industries).

Australia's ICT workforce: occupations, industries and skills

The ICT workforce grew to an estimated 663,100 workers in 2017, increasing by around 3.5% over the past year from the 640,800 workers reported in 2016 (DAE, 2017a).[14] This reflects strong demand for ICT skills among Australian employers and continued growth more generally in the labour market. The increase of around 22,300 ICT workers between 2016 and 2017 was significantly stronger than we had previously forecast in last year's *Australia's Digital Pulse*, at which time employment projections indicated that Australia's ICT workforce would grow by around 10,700 workers between 2016 and 2017.

ICT occupations relating to technical, professional, management and operational roles continue to account for around two-thirds of all ICT workers (Chart 2.1). The size of the ICT workforce in these occupational groupings increased particularly strongly between 2016 and 2017, by around 7%. The share of Australia's overall labour force comprising ICT workers remained at 5.4% in 2017, relatively unchanged compared to the previous year.

An analysis of LinkedIn data on the most in-demand skills possessed by ICT workers in Australia suggests that employers are seeking a range of skills.[15] Although ICT workers that have recently moved jobs most commonly possess general enterprise skills such as customer service, management and leadership, technical skills such as SQL, Java and HTML also feature on the list of top 20 skills (Table 2.1).

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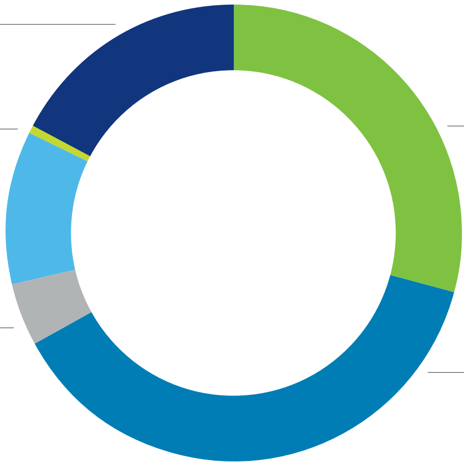
[14] ABS industry classifications include an 'Information Media and Telecommunications' (IMT) industry. However, in practice there are a large number of ICT workers outside the IMT industry (for example, software developers working in the banking industry) and there are some employees in the IMT industry who are not ICT workers (for example, publishers of print newspapers). In this study, employment figures for ICT workers have been calculated using ABS occupation and industry classifications, based on the methodology used in previous editions of *Australia's Digital Pulse*. This methodology draws on definitions and nomenclature developed by Centre for Innovative Industries Economic Research (CIIER) lead researcher, Ian Dennis FACS, and used in the ACS's 2008–13 statistical compendiums and other CIIER analysis. For a list of the occupations and industries classified as ICT workers, see Table A.3.

[15] LinkedIn provided ACS with the data for this analysis in a customised report. Note that the LinkedIn data includes both ICT and digital skills, and these terms have been used interchangeably throughout the discussion. This data is based on information entered into LinkedIn by its members. As such, the data is influenced by how members choose to use the site, which can vary based on professional, social and regional culture, as well as overall site availability and accessibility. For example, LinkedIn users tend to be professional or knowledge workers and the data is therefore likely to be skewed towards office-related jobs and skills rather than, for example, builders or chefs. These variances have not been accounted for in the analysis that follows.

Chart 2.1: ICT workers by CIIER occupation groupings, 2017



Source: ABS customised report (2018)

Table 2.1: Top 20 skills possessed by ICT workers who moved jobs, 2017

Rank	Occupation
1	Customer service
2	Management
3	Leadership
4	Project management
5	Social media
6	Public speaking
7	Marketing
8	Sales
9	Team leadership
10	Business development
11	Negotiation
12	Business strategy
13	Adobe Photoshop
14	Marketing strategy
15	Training
16	Team building
17	SQL
18	Java
19	HTML
20	Communications

Source: LinkedIn customised report (2018)

The LinkedIn data also highlights that the most in-demand ICT occupations are roles that combine technical ICT requirements with broader business needs. Similar to the findings in last year's *Australia's Digital Pulse*, the top three occupations with the largest number of job advertisements in 2017 were project manager, business analyst and business development manager. Technical ICT occupations such as software engineer and various developer roles are also in relatively high demand (Table 2.2).

Table 2.2: ICT occupations with the most job advertisements, 2017

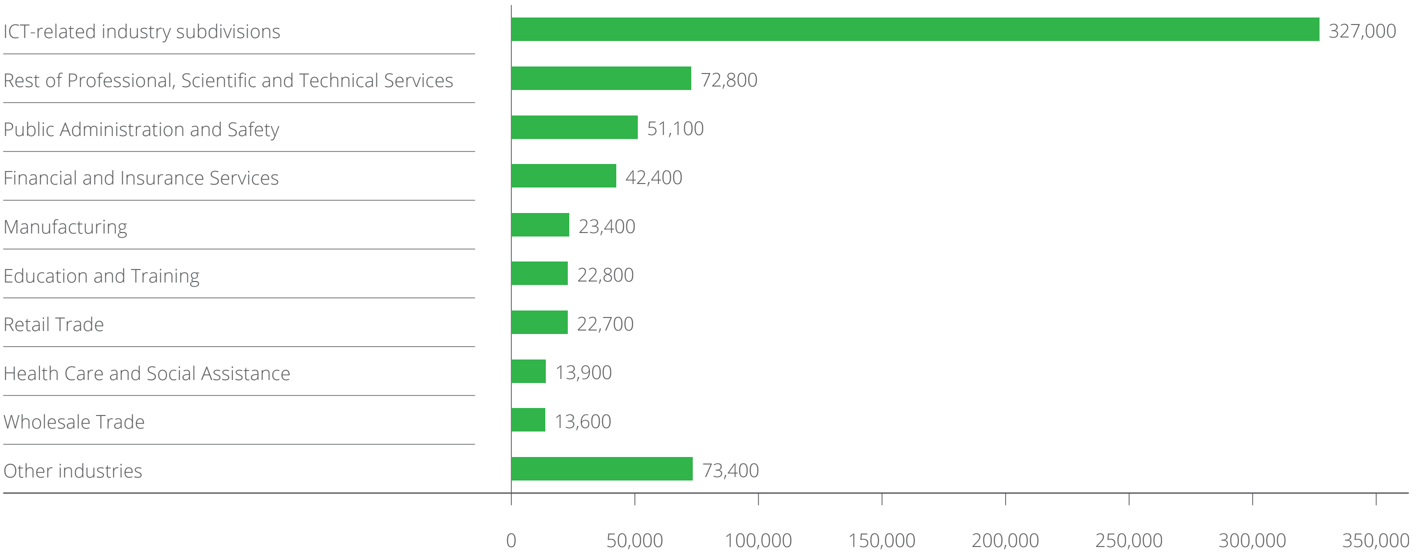
Rank	Occupation
1	Project manager
2	Business analyst
3	Business development manager
4	Software engineer
5	Senior business analyst
6	Account manager
7	Front-end developer
8	Web developer
9	Software developer
10	Senior project manager

Source: LinkedIn customised report (2018)

Almost half (49%) of all ICT workers in Australia are directly employed in ICT-related industries such as computer system design, telecommunication services and internet service provision. The remaining 51% of ICT workers are employed in other industries throughout the Australian economy (Chart 2.2). Similar to previous editions of *Australia's Digital Pulse,* the largest employer of ICT workers outside of ICT-related industries continues to be the professional, scientific and technical services, which employs 72,800 ICT workers. But there has been significant growth in the number of ICT workers in the public administration and safety industry (an increase of 10% between 2016 and 2017), and in the health and manufacturing industries (each increasing by 9% between 2016 and 2017).

Consistent with this aggregate picture of sectoral diversity across Australia's ICT workforce, the LinkedIn data suggests that recent demand for ICT workers extends beyond traditional ICT industries such as information technology and computer software (Table 2.3). In 2017, financial services, marketing and construction were all amongst the top 10 industries based on share of ICT job advertisements.

Chart 2.2: ICT workers by industry, 2017



Source: ABS customised report (2018)

Table 2.3: Industries with the largest share of ICT job advertisements, 2017

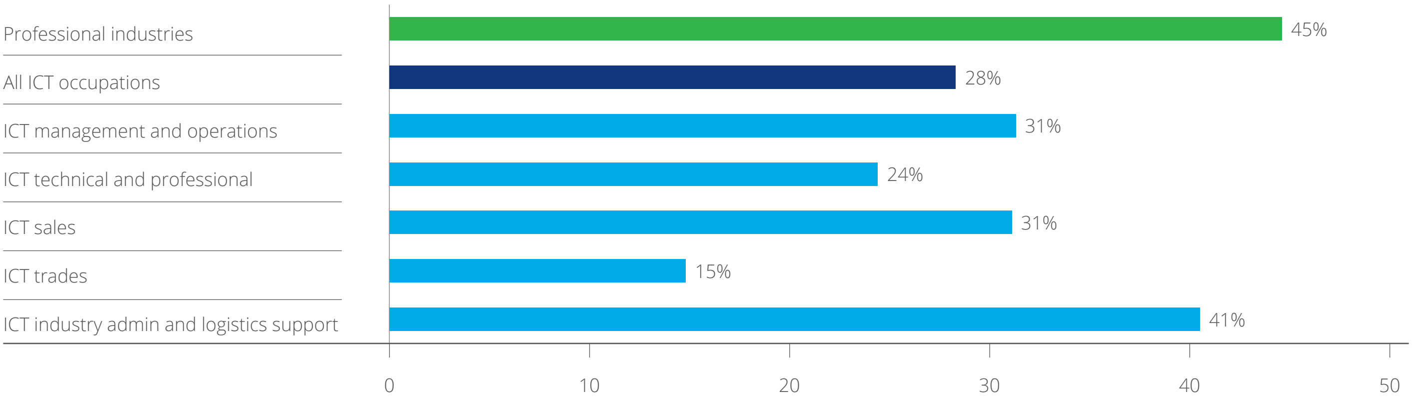
Rank	Occupation
1	Information technology and services
2	Computer software
3	Financial services
4	Marketing and advertising
5	Construction
6	Staffing and recruiting
7	Internet
8	Online media
9	Telecommunications
10	Banking

Source: LinkedIn customised report (2018)

Diversity in Australia's ICT workforce

The ICT workforce in Australia continues to see underrepresentation of key demographic segments. In particular, the participation of women in ICT roles remains significantly lower than it is in professional occupations more broadly. Women comprised only 28% of all ICT workers in 2017, a figure which remains unchanged since *Australia's Digital Pulse* was first published in 2015. This compares to a 45% female representation across all professional industries (Chart 2.3). Furthermore, there continues to be a significant difference in the average earnings of male and female ICT workers in Australia, with an average pay gap of around 20% across all ICT occupations – similar to the gender pay gap reported in previous editions of *Australia's Digital Pulse* (DAE, 2017a).

Chart 2.3: Share of women in ICT occupations, 2017*



* Data was unavailable for the electronic trades and professional grouping.

Source: ABS customised report (2018)

The low share of female ICT workers could be holding Australian businesses back, particularly where this gender gap exists at senior levels. For example, previous research has found that women in the Chief Information Officer role tend to outperform their male counterparts in interpersonal skills, persuasiveness and networking ability, all of which can improve a business's financial performance (Deloitte, 2018a). More generally, it's been estimated that having equal representation of women in leadership roles could lift labour force participation and add up to $10.8 billion to the Australian economy every year (DAE, 2017c).

Improving female participation in Australia's ICT workforce requires greater efforts in engaging and maintaining their interest in digital technology and computing-related skills. As discussed in the box below, this engagement needs to be developed from a relatively young age, such as by addressing the gender imbalance in the number of girls that are studying STEM subjects in schools across Australia.

Older workers are another demographic that continues to be underrepresented in Australia's ICT workforce. In 2017, only 12% of Australia's ICT workforce was aged 55 or older, compared to 15% of workers across all professional industries (Chart 2.4). Research in the US has found that older workers face systemic discrimination in the ICT job market, and that the tech industry hires a much smaller proportion of 'baby boomers' than non-tech industries, despite experience and maturity being of relatively greater value in the tech industry (Visier, 2017).

Girls studying STEM and computing in Australian schools

One contributing factor to the underrepresentation of women in ICT occupations is likely to be the relatively low share of young girls studying STEM subjects in schools across Australia. The ratio of male to female students studying advanced mathematics at the Year 12 level is around 2:1, and the ratio is 3:1 for Year 12 physics (OCS, 2016). But this imbalance has been found to begin at an even earlier age; for example, around 30% of girls in Grade 4 were confident in maths abilities compared to 42% of boys (OCS, 2016).

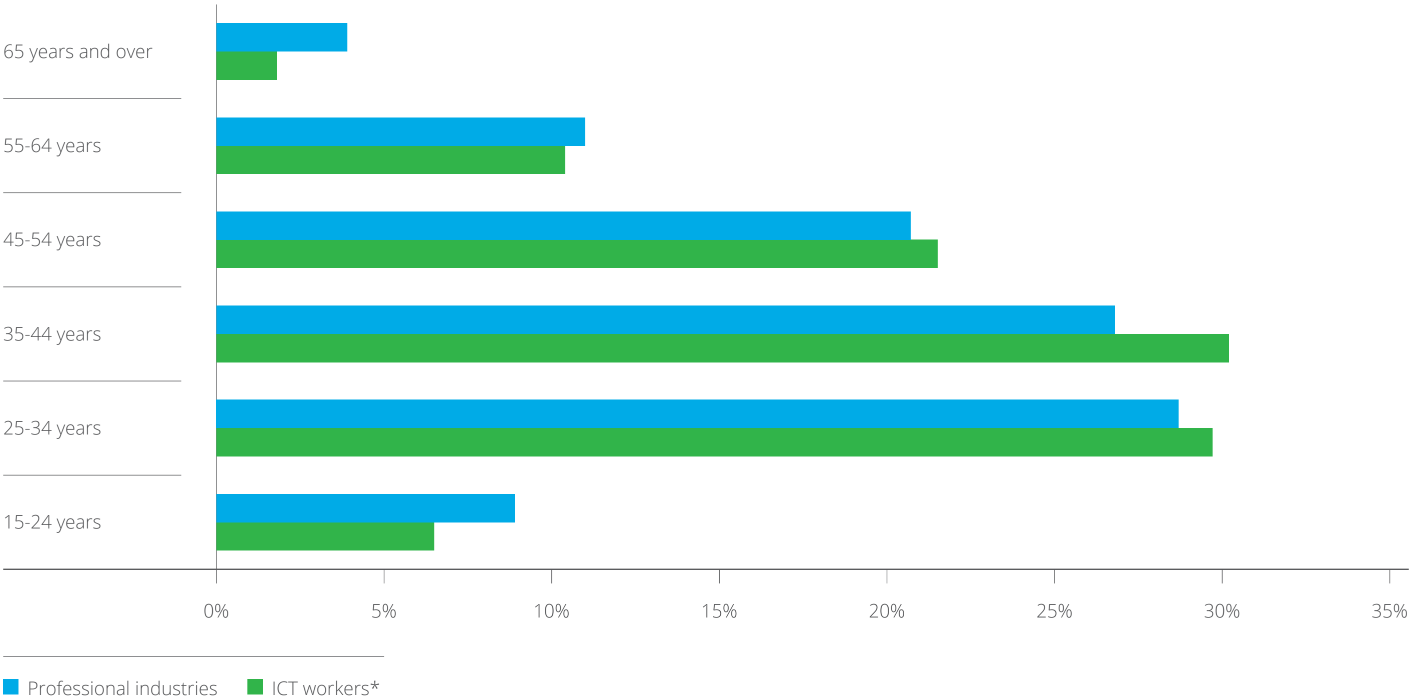
This narrowing of school students participating in STEM subjects could be contributing to Australia's relatively modest international performance in science and mathematics in PISA, as discussed in Section 1. Previous research has found that maintaining girls' interest in computing is particularly critical in Years 7 and 8, as this is where female participation in computing subjects starts to decline significantly (Zagami et al., 2016).

State and territory governments have begun implementing the Digital Technologies Curriculum, which will be mandatory in Australian schools from Foundation to Year 8. Topics in the curriculum include programming and coding as well as more general competencies such as computational thinking, digital citizenship and literacy, and data representation (Digital Technologies Hub, 2018). However, unlike other countries such as the UK – where coding is a mandatory subject for all school students aged five to 16 – the Digital Technologies Curriculum will only be an optional elective for Australian students in Years 9 and 10.

A recent study has found that addressing unconscious bias and teacher competence in STEM in primary education – along with better career advice on STEM-based possibilities and partnerships with local communities and industries – could encourage more girls to study STEM at school (Hobbs et al., 2017).

A number of other Australian programs aimed at encouraging girls to develop and improve their coding skills. For instance, Code Like a Girl is a social enterprise that runs tech-focused workshops for girls and women across Australia, seeking to connect like-minded females across the IT community and provide opportunities to learn more about coding. The Australian Government has allocated $8 million over the four years to 2019-20 to provide Women in STEM and Entrepreneurship grants, with the objective of increasing the awareness, participation and success of girls and women in STEM-related education and careers.

Chart 2.4: Age profile of ICT workers, 2017



* Excludes ICT industry administration and logistic support, for which breakdowns are unavailable; data for electronic trades and professional roles relate to all industries

Source: ABS customised report (2018)

Future demand for ICT workers

Australia's ICT workforce is forecast to grow by almost 100,000 workers over the coming years, increasing from 663,100 workers in 2017 to around 758,700 workers in 2023. Around one-third of this employment growth is forecast to be in ICT management and operations roles (projected to increase by 31,300 workers), while a further 27% will be in ICT technical and professional roles (26,200 workers) (Table 2.4 and Chart 2.5).

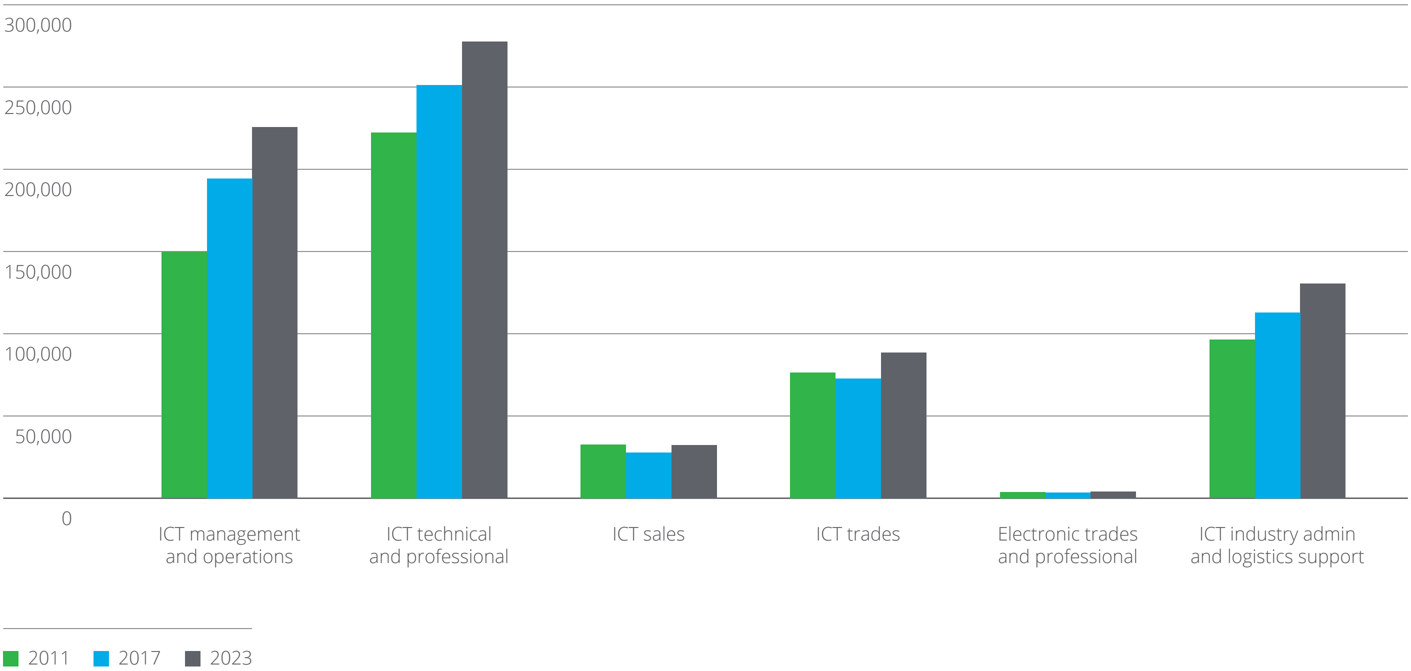
Table 2.4: Employment forecasts by CIIER occupation groupings, 2017-23

Occupational grouping	2017	2023	Average annual growth, 2017-23
ICT management and operations	194,400	225,700	2.5%
ICT technical and professional	251,300	277,500	1.7%
ICT sales	27,900	32,400	2.5%
ICT trades	72,900	88,500	3.3%
Electronic trades and professional*	3,600	4,000	1.6%
ICT industry admin and logistics support*	113,000	130,600	2.4%
Total ICT workers	**663,100**	**758,700**	**2.3%**

* Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.

Source: Deloitte Access Economics (2018)

Chart 2.5: Historical and forecast ICT employment, 2011-23



Source: Deloitte Access Economics (2018)

Digital capabilities and technology-driven change at Origin Energy

The Australian energy industry is undergoing significant change as largely centralised power generation moves towards a more decentralised value chain where energy production, consumption and interpretation increasingly occurs at the local household or business level. This means that energy companies are now managing a distributed network of assets and different types of customer interactions to deliver value.

Rod van Onselen, Chief Digital Officer at Origin Energy, believes that digital will play a multilayered role in this new value chain. "The first layer involves nailing the digital experience for our customers," he says. "We recently launched our Good Energy brand, underpinned by a new Origin.com.au website and a variety of compelling digital experiences. These experiences include more granular insights on when and how customers are consuming energy, which supports our key brand propositions of ease, innovative services and affordability."

"We've trialled and are planning to launch disaggregation technology in collaboration with [California-based tech startup] Bidgely, that enables customers to understand their energy bills at the appliance level, such as the fridge, lighting, pool pump, and so on. This will provide customers with the information to make choices about their energy usage, in a way that balances affordability and lifestyle."

Enhancing Origin's ability to deliver compelling new digital experiences has required the company to grow its internal ICT capabilities – including building new technology platforms and architecture, and growing its team of digital specialists. In a competitive environment for ICT talent, the ability for companies such as Origin to offer meaningful projects, learning and development opportunities, and the autonomy to drive change are important contributors to their overall employee value proposition.

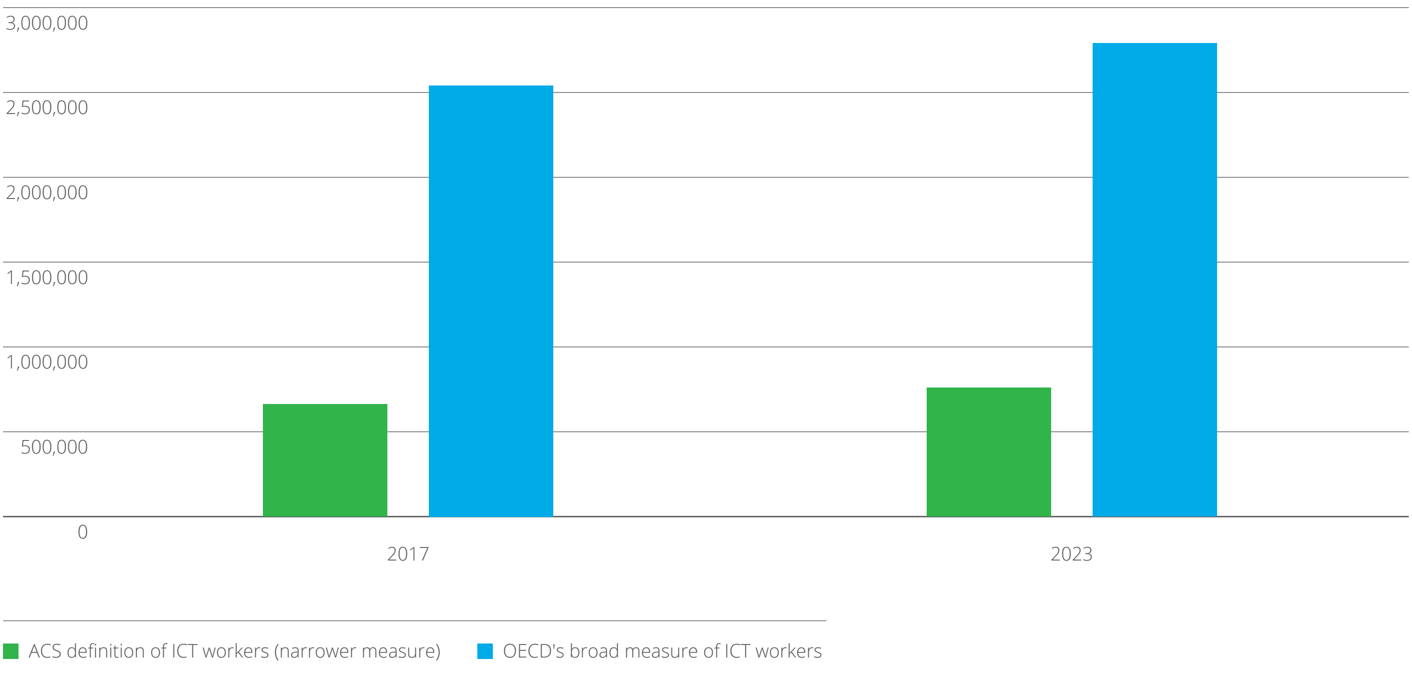
In addition, Origin partners with a range of innovative startups through its 'O Hub' accelerator program and a presence in Silicon Valley, which sees the company collaborate with technology startups to create innovative energy solutions. The collaboration with Bidgely is one such solution developed as an O Hub project. "O Hub enables us to work with the startup community to identify new propositions and experiences that can be developed, tested, validated and brought to market," van Onselen says. "The program also demonstrates our commitment to and focus on innovation to improve the customer experience."

Consistent with rising employer demand for digital skills across the Australian economy, the average annual growth rate of the ICT workforce, at 2.3%, is significantly higher than the forecast growth of the overall Australian workforce over the same period (1.4% per annum). Businesses in all industries are increasingly relying on digital solutions to reach new markets, improve customer experiences, and offer innovative new products and services. This in turn requires increased digital capabilities, as highlighted in the box on the previous page describing the digital changes occurring at Origin Energy.

Moreover, because of the increased use of technology across Australian industries, most members of the Australian workforce will also be required to have digital capabilities even if they are not employed in ICT occupations. That is, if ICT workers are defined as a relatively narrow group of ICT specialists who develop, operate and maintain ICT systems, we can also consider a broader measure of employees who use ICT regularly as a part of their jobs, and rely on ICT skills to perform their work. This is consistent with the OECD's framework for distinguishing between different types of ICT workers and skills (OECD, 2012b).

This broader group of workers that regularly use ICT includes occupations such as accountants, solicitors and environmental scientists. Table A.4 contains a full list of occupations included in this definition. Workforce forecasts suggest that the broader ICT workforce will increase from around 2,541,000 workers in 2017 to 2,794,000 in 2023 (Chart 2.6). This represents an average annual growth rate of 1.6% and is equivalent to a projected gain of 252,900 jobs over this period.

Chart 2.6: ICT workforce growth under narrow and broad measures, 2017-23



Source: Deloitte Access Economics (2018)

3 The importance of developing and attracting ICT talent

Key findings

- Australia must have a highly skilled ICT workforce to drive economic growth and innovation in the digital age. However, we are currently a middling country in international comparisons on ICT employment and skills.
- Our education system plays an important role in developing Australia's ICT talent. Demand for qualifications held by ICT workers is projected to increase by an annual average growth rate of 2.7%, up to 1.13 million qualifications by 2023.
- Attracting ICT talent through skilled migration to Australia enables knowledge and technology transfer. The top source countries for ICT worker inflows in 2017 were the UK (18% of ICT inflows to Australia) and India (17%).
- A growing digital economy, vibrant innovation precincts and global leadership in emerging technologies are required to ensure Australia can attract and retain highly skilled ICT workers.

A highly skilled workforce is an important enabler of growth and innovation, particularly as the Australian economy shifts towards more knowledge-based industries. At the same time, increasing globalisation and technological developments are affecting the broader labour market environment. This is resulting in greater employee mobility across international borders; new workforce models such as offshoring, outsourcing and automating alongside local employees; and requiring workers to upskill and reskill throughout their careers to ensure their skills remain relevant in a changing world (CAANZ, 2016).

It is particularly important that Australia is able to develop and attract highly skilled ICT workers. Because digital capabilities are becoming a critical driver of business growth – not just in the technology sector, but in all industries across the economy – the global competition for ICT talent is becoming increasingly intense (Vickery, 2018). Businesses and governments around the world are recognising that advanced technology skills are required to become a global digital and innovation leader.

As such, in order for Australia to reap the benefits of digital leadership, we should aim to build a highly skilled and appropriately sized ICT workforce. However, as highlighted in Section 1, Australia ranks towards the middle of the pack compared to other countries on the ICT employment indicator, at number five of 11 countries on the share of workers employed as ICT specialists.

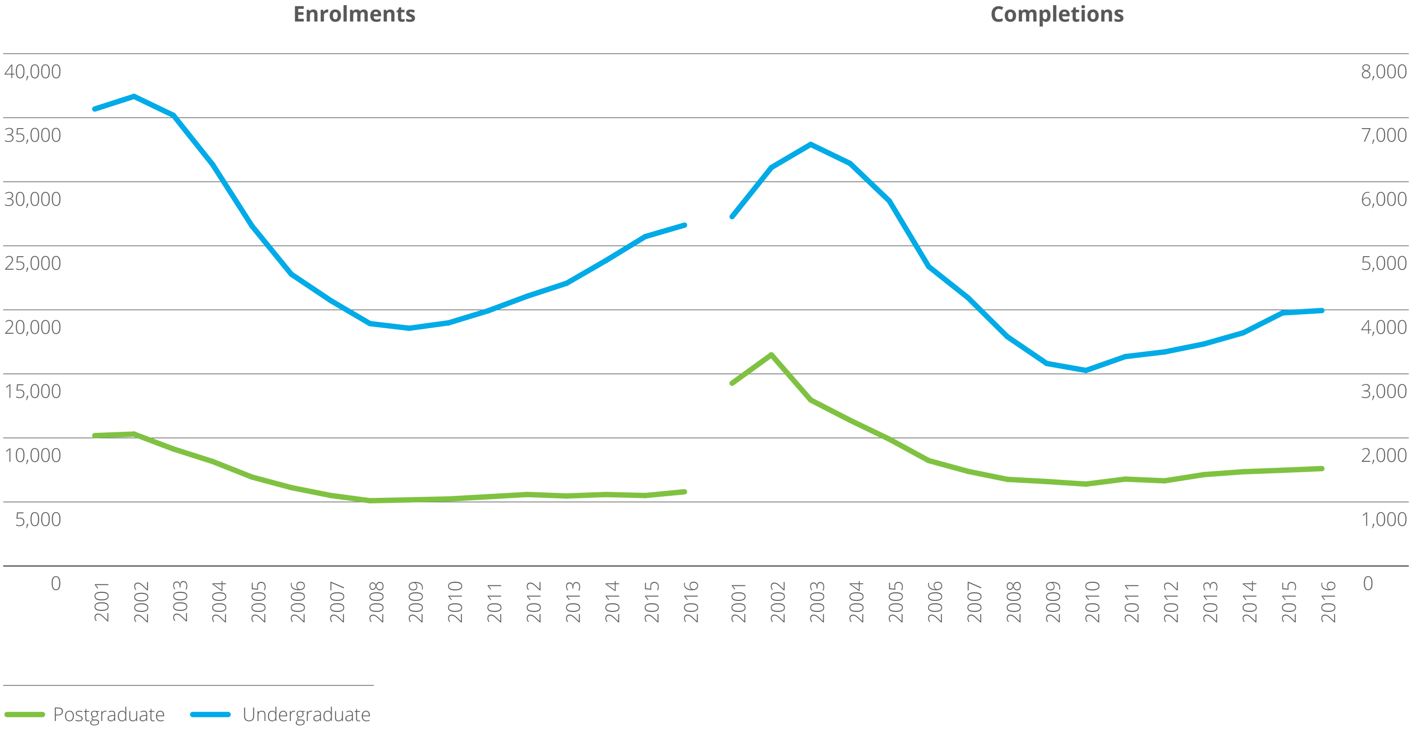
Developing Australia's ICT talent: education and ICT skills

Within the Australian economy, workers can develop the skills demanded by employers via formal education and training programs. More than 30% of Australians now hold a tertiary qualification such as a Bachelor degree or above (ABS, 2017c), and previous research has estimated that Australia's economy is 8.5% larger because of the workforce's increased productive capacity resulting from university education – worth $140 billion in 2014 (DAE, 2015a). Broader employment experience and 'on-the-job' learning represents another channel for Australian workers to develop, update and refine their skills and capabilities.

A significant component of the local development of ICT skills is the number of Australian university students who are studying and graduating with degrees in ICT. In 2016, there were around 26,600 domestic enrolments in undergraduate IT degrees at Australian universities, and almost 5,800 enrolments in postgraduate IT degrees. Total enrolments in IT degrees increased by 3.8% between 2015 and 2016 and continue to pick up from the low levels reached in the late 2000s, with growth in recent years driven by rising undergraduate enrolments (Chart 3.1). There were almost 4,000 completions of undergraduate IT degrees and around 1,500 completions of postgraduate IT degrees in 2016.

Moreover, international students who enrol in and complete IT degrees at Australian universities could also represent a potential pipeline of skilled workers to meet employer demands for ICT skills and digital capabilities – should they choose to remain in Australia and seek employment opportunities after graduation. As discussed in the box on the following page, international students represent a significant proportion of the overall student population in IT degrees (38% of total undergraduate IT enrolments and 76% of postgraduate). They therefore also make an important broader contribution to the Australian economy through their tuition fees and living expenses.

Chart 3.1: Domestic enrolments in and completions of IT degrees, 2001-16



Source: Department of Education U-Cube (2018)

International students studying IT in Australian universities

In 2016, there were 16,000 international students studying undergraduate IT degrees in Australia, and almost 18,000 studying postgraduate IT degrees. Students from overseas therefore make up a substantial proportion of the overall population of university students in IT degrees, representing 38% of total enrolments at the undergraduate level and 76% at the postgraduate level. This is higher than the share of international students across other fields of study; on average, across all degrees offered by Australian universities, 22% of undergraduate enrolments and 40% of postgraduate enrolments represent students from overseas.

Education is Australia's largest service export and the third-largest export overall, behind iron ore and coal (Dodd, 2017). Previous research has found that international students make a significant contribution to the Australian economy, not only through their tuition fees but also through their living expenses such as on accommodation, food, transport and entertainment. The economic contribution of international education was estimated to be $16.8 billion in the 2014-15 financial year (equivalent to $17.4 billion in 2016-17 Australian dollar terms), supporting around 128,000 full-time equivalent jobs (DAE, 2015b).

While some international students return to their home country or move elsewhere after completing their studies in Australia, others may choose to remain in the country and seek employment opportunities here through temporary or permanent migration pathways. For example, it has previously been estimated that "Australia's current stock of international students will contribute 130,000 skilled migrants to our workforce after they graduate" (DAE, 2015b). This suggests that international students who are currently enrolled in IT degrees across Australia could represent a valuable pipeline of relevant digital capabilities that may assist in meeting employer demands for highly skilled ICT workers in the future.

Developing Australia's future workforce means having schools that cultivate the digital competencies required in an increasingly technological business environment, as well as universities and vocational education providers working with industry to provide teaching and experiences which are relevant to businesses' needs (AI Group, 2018). The box on the following page describes how one tertiary education institution, the Melbourne Business School (MBS), is adapting its course offerings to better align with industry requirements and position graduates to succeed in the future workplace.

There will be increased demand for qualifications held by ICT workers over the coming years, consistent with the projected growth in the ICT workforce. The demand for qualifications depends not only on the forecasts for employment growth, but also on other skill and labour market considerations, such as the propensity for different occupations to hold particular types and levels of education. Total qualifications held by ICT workers are projected to increase by an annual average growth rate of 2.7%, up to more than 1.1 million qualifications by 2023 (Table 3.2).

Importantly, there are many potential study and career pathways for developing ICT talent, and these could include studying non-IT degrees. Data from LinkedIn reveals that some of the most common areas of study for ICT workers in Australia are business-related areas, such as business administration, marketing and accounting (Table 3.1). As expected, technical areas of study such as IT and computer science also rank highly on the list.

Table 3.1: Most common areas studied by ICT workers, 2017

Rank	Occupation
1	Business administration and management
2	Marketing
3	Accounting
4	Information technology
5	Computer science
6	Business and commerce
7	Electrical and electronics engineering
8	Economics
9	Finance
10	Project management

Source: LinkedIn customised report (2018)

Table 3.2: Forecasts of total qualifications held by ICT workers, 2017-23*

Qualification	2017	2023	Average annual growth, 2017-23
Postgraduate	196,000	236,000	3.1%
Undergraduate	420,500	498,600	2.9%
Diploma or advanced diploma	170,800	192,600	2.0%
Certificate III or IV	123,700	144,300	2.6%
Certificate I or II	53,800	57,900	1.2%
Total	964,800	1,129,300	2.7%

* One person may hold multiple qualifications

Source: Deloitte Access Economics (2018)

Educating the future workforce at Melbourne Business School

As one of Australia's leading graduate schools in business and economics, Melbourne Business School (MBS) – part of the University of Melbourne – plays an important role in developing and educating our current and future workforce.

Recognising that the nature of professional education and student demand for qualifications is changing, the University of Melbourne is currently undertaking a strategic review of its business education offerings. The new strategy will respond to issues raised in an environmental scan in 2017, which found that the business courses the university offers could be better tailored to suit employer requirements and the needs of potential students. Although the university is still developing its strategy, in recent years MBS has introduced changes to ensure that its course offerings are better aligned with industry requirements and position graduates to succeed in the workplace.

For example, MBS founded its Centre for Business Analytics (CfBA) in 2014 in response to the increasing demand for data analytics skills and research. The CfBA emphasises collaboration with industry, and is guided by an advisory board of business leaders from companies across a range of sectors that employ analytics professionals (including ICT, banking, retail and professional services). According to Professor Ian Harper, Dean of MBS, "Advisory Board members co-design course content with the school – such as for the Master of Business Analytics – and provide critical industry linkages for students, including networking and employment opportunities." Following the success of the Master of Business Analytics, MBS is now seeking to collaborate more closely with industry in designing and delivering other courses, including in marketing and business administration.

MBS is also working to enhance the student experience by combining on-campus teaching with course delivery. Some courses have been configured for a blended or 'adaptive learning' delivery model, with video lectures and small assessments delivered online, and face-to-face classroom time devoted to interactive discussions, problem-solving and addressing student questions. This enables instructors to monitor students' learning progress in real time online, and ensure that on-campus teaching is tailored to address individual needs. "MBS creates an environment for students to learn and grow, and we aim to use technology to complement the classroom experience," Professor Harper noted. "This requires a mix of classroom study to enable students to collaborate and learn from one another and their instructors, and digital platforms to improve the effectiveness and accessibility of our teaching."

Attracting ICT talent to Australia: skilled migration of ICT workers

Australian companies can also source the required skills from overseas, such as through the skilled migration program: the skilled stream accounted for 67% of total migration to Australia in 2016-17 (DIBP, 2017). Apart from filling immediate skills shortages, the benefits of skilled migration include cross-border knowledge transfers, which can see leading capabilities and technologies brought to Australia from overseas, and relationship establishment, which can lead to new economic activity such as cross-border trade and investment (Liu, Gao, Lu and Wei, 2015). Enabling companies to attract skilled workers from overseas can also create new domestic opportunities as Australian industries grow, invest and innovate using a mix of overseas and local workers.

In a competitive global environment for digital talent, Australia also needs to position itself to attract ICT workers from overseas. Over recent years, Australia has received net migration inflows of around 20,000 ICT workers per year (DAE, 2017a).[16] Data from LinkedIn reveals that ICT workers moving to Australia are employed in a range of sectors across the economy, including traditional technology and communications industries, as well as industries with broader digital skill needs such as financial services, marketing and construction (Table 3.3).

Table 3.3: Top 20 industries employing ICT workers who moved to Australia, 2017

Rank	Occupation
1	Information technology and services
2	Computer software
3	Financial services
4	Marketing and advertising
5	Telecommunications
6	Construction
7	Management consulting
8	Banking
9	Internet
10	Retail
11	Oil and energy
12	Staffing and recruiting
13	Civil engineering
14	Higher education
15	Accounting
16	Government administration
17	Design
18	Hospitality
19	Healthcare
20	Electrical and electronic manufacturing

Source: LinkedIn customised report (2018)

A growing and vibrant digital economy is required to attract ICT talent from overseas. Australia's rankings on the digital indicators, discussed in Section 1, suggests that while our relative performance is solid across most areas, more could be done to strengthen our local digital environment. One factor that can help attract and develop this is the presence of a supportive and growing startup environment, which provides mentoring, training and funding opportunities for new technology businesses. Accelerator programs can facilitate these activities, as discussed in the box on the following page.

The financial rewards Australian businesses offer to ICT workers is another channel for attracting digital talent. Previous research has found that the average annual salary paid to software developers in Australia was US$53,721 in February 2018, compared to US$92,240 in the United States. It also ranked below many other countries such as Switzerland (US$85,709), Israel (US$70,290) and the United Kingdom (US$59,268) (Daxx, 2018). Poor financial rewards may compound the scarcity of digital talent in Australia, by making international labour markets more attractive to highly skilled ICT workers.

Attracting ICT skills to Australia is important, as knowledge and technology transfer from international inflows of ICT workers can enhance the skills of the broader Australian workforce. LinkedIn data suggests that ICT workers moving to Australia from overseas possessed technical skills such as SQL, requirements analysis, Java and software development (Table 3.4). It also finds that the top source countries for ICT workers from overseas were the UK and India, which respectively comprised 18% and 17% of total ICT worker inflows in 2017 (Table 3.5). These workers from overseas can equip Australian companies to fill skills shortages, while also supplementing and enhancing the technical capabilities of the local ICT workforce.

[16] Due to changes in the methodology for collecting overseas arrivals and departures data, a detailed occupational breakdown of this data is no longer published. As such, updated figures for the net migration of ICT workers are unavailable for this year's *ACS Australia's Digital Pulse report.*

Table 3.4: Top 10 individual skills possessed by ICT workers who moved to Australia, 2017

Rank	Skill
1	Project management
2	SQL
3	Business analysis
4	Requirement analysis
5	Customer service
6	Java
7	Team leadership
8	Software development life cycle (SDLC)
9	Agile methodologies
10	JavaScript

Source: LinkedIn customised report (2018)

Table 3.5: Top 10 source countries for ICT workers who moved to Australia, 2017

Country	Share of ICT worker inflows
United Kingdom	18%
India	17%
United States	8%
New Zealand	6%
Singapore	4%
China	3%
Brazil	3%
United Arab Emirates	3%
Canada	2%
South Africa	2%

Source: LinkedIn customised report (2018)

The LinkedIn data also provides an indication of the skills most commonly possessed by Australian ICT workers who moved overseas. In contrast to the technical capabilities featured in the top skills for ICT worker inflows, these top outflows are primarily broader enterprise skills such as management, leadership and marketing (Table 3.6). The data finds that the top countries that Australian ICT workers moved to were the UK and US, which respectively comprised 22% and 13% of total ICT worker outflows in 2017 (Table 3.7).

The role of accelerators in attracting and developing digital talent

Accelerators are an important part of the technology startup landscape, as their programs provide start-ups with opportunities to build connections, receive mentoring, participate in education and training, and source investment. Recent research has found that the number of Australian accelerators has increased over the past few years, with the most active accelerators being Slingshot (processing 118 startups since its launch in 2013) and BlueChilli (103 startups since 2012) (Artesian, 2017).

Having a strong startup environment facilitated by the activities of local accelerators can be a contributing factor in attracting and developing digital talent. The global competition for ICT workers is intensifying across technology firms and traditional industries that are experiencing digital disruption (including finance, health, retail and energy). This makes it important to take a creative approach when building and acquiring ICT skills that are in high demand – such as in cyber security, data science and mobile development. Investing in accelerator programs to indicate a focus on innovative startup activity represents one such channel (Musti, 2017). An accelerator environment where local businesses and industries participate in spaces and programs that support startups can lead to greater access to digital talent overall (Aron and Davies, 2017).

Some countries also have accelerator programs with an explicit emphasis on developing digital talent. For example, Singapore's TechSkills Accelerator is designed to connect companies requiring ICT skills with new ICT graduates and existing professionals. It also provides funding for businesses to support training programs and for individuals to attain relevant skills and certification to take on specific technical roles (SkillsFuture, 2017). Such initiatives use the accelerator program format to strengthen the local pool of talent.

Table 3.6: Top 10 individual skills possessed by ICT workers who moved overseas, 2017

Rank	Skill
1	Management
2	Project management
3	Customer service
4	Leadership
5	Sales
6	Marketing
7	Design
8	Company research
9	Analytical skills
10	Training

Source: LinkedIn customised report (2018)

Table 3.7: Top 10 countries that Australian ICT workers moved to, 2017

Country	Share of ICT worker outflows
United Kingdom	22%
United States	13%
New Zealand	8%
India	6%
Canada	4%
Singapore	4%
France	3%
Germany	3%
Ireland	3%
China	2%

Source: LinkedIn customised report (2018)

Around 32% of Australian ICT workers who moved overseas in 2017 were in relatively senior roles (at a manager, director or owner level). This compares to around 30% of overseas ICT workers coming to Australia being at these relatively senior levels. Australia's ability to retain highly skilled and experienced ICT workers will be an important driver of future digital success. An attractive environment for ICT workers in Australia requires a growing digital economy, vibrant innovation precincts and global leadership in emerging technologies.

ICT workers from overseas may come to Australia via the temporary skilled migration program. In March 2018, the Australian Government replaced the Temporary Work (Skilled) visa (subclass 457 visa) with the new Temporary Skill Shortage (TSS) visa. Data on this new scheme is not yet available. Information on the previous 457 visas shows that there were around 13,400 visas granted to ICT workers in 2016-17, which represented 15% of total 457 visas granted and was equivalent to around 2% of Australia's total ICT workforce (Chart 3.2). While this was relatively unchanged compared to the previous financial year, the latest data on 457 visas reveals that there were only 4,500 visas granted to ICT workers in the six months to December 2017.

It remains to be seen how the new TSS visa will affect temporary skilled migration inflows to Australia. The new visa includes a short-term stream of up to two years, which includes ICT occupations such as ICT project managers, support engineers and trainers; and a medium-term stream of up to four years, which includes ICT occupations such as ICT business analysts and security specialists (Department of Home Affairs, 2018). The TSS visa scheme also introduces new requirements such as tightened English prerequisites, mandatory labour market testing and employer contributions to training Australian workers.

Recognising the particularly strong international competition for ICT talent, from 1 July 2018 the Australian Government is also conducting a 12-month pilot of the *Global Talent Scheme* enabling workers with tech-related skills to come to Australia on a four-year TSS visa. The scheme consists of two components: an established business component for large Australian businesses to sponsor highly skilled and experienced workers in senior tech roles; and a startup component for technology and STEM-related startups to sponsor workers with specialised technology skills (DIIS, 2018a). This supplementary scheme to the broader TSS occupations list could help businesses to attract highly skilled ICT workers and address digital skills shortages in Australia, providing more opportunities for skills transfer, growth and innovation.

Chart 3.2: Subclass 457 (Temporary Work (Skilled)) visas granted to ICT workers, FY2009-17

* Excludes ICT industry administative and logistics support, for which breakdowns are unavailable; data for electronic trades and professional roles is for all industries
Source: Department of Immigration and Border Protection Subclass 457 Visa Statistics (2018)

4 Economic dimensions of digital leadership

Key findings

- There would be significant economic benefits associated with global digital leadership: more rapid adoption of new technologies could add an extra $54 billion to Australia's GDP over the next five years. However, Australia is a relatively middling country compared to other developed economies when it comes to measures of international ICT competitiveness.
- Becoming a global digital leader would require an additional 200,000 ICT workers in Australia, double the current forecast growth over the next five years. While our IMT industry is forecast to grow by almost $10 billion in this period, most digital economic activity now occurs outside of this industry.
- Given the large economic gains to be had from global digital leadership, Australia needs to do more to improve our international performance in ICT and strengthen our digital economy. A supportive digital policy environment will be an important driver of future growth and development.

The analysis of Australia's performance on measures of ICT competitiveness suggests that we are currently a middling country in terms of digital economy development, relative to other developed countries. While Australian businesses, consumers and policymakers have increasingly embraced a technology- and innovation-led approach to growth over the past five to 10 years, the size and development of Australia's digital economy is still less advanced than that of some other developed countries around the world.

It is important that Australia accelerates our ICT performance and competitiveness so we can fully realise the economic gains from digitally enabled growth. There would be significant benefits associated with becoming a global digital leader.

Recent research has found that technological progress has been fundamental in increasing living standards in Australia in recent years. The productivity enhancements associated with greater adoption of digital technologies across the Australian economy contributed to a 6.6% increase in Australia's GDP per capita over the decade to 2014 (Qu, Simes and O'Mahony, 2017). Based on these previous productivity gains and Deloitte Access Economics' *Business Outlook* forecasts, further adoption of digital technologies could add an extra $66 billion to Australia's GDP in 2015-16 Australian dollar terms over the next five years (DAE, 2018a).

Given the potential for these significant economic benefits, we must consider what would be required for Australia to become a global digital leader. For example, there needs to be ongoing innovation and digital transformation in industries across the Australian economy that have not traditionally been heavy technology users, through new applications of technology by both startups and existing businesses. The box on the following page describes how one technology business, PEXA, has taken a leading role in driving digital change and productivity benefits in Australia's property sector.

Global digital leadership will also require significant growth in Australia's ICT workforce, given the highly skilled nature of current and future jobs in our digital economy. For Australia to be a world leader in this area, employment of ICT workers in our economy would need to grow by more than 30% to be comparable in size to the top-ranked country on the ICT workforce indicator (the UK, Chart 4.1). Based on a current ICT workforce of 663,100, this would be equivalent to an increase of more than 200,000 workers, up to around 870,600 ICT workers.

Efficiency gains from digitising property transactions across Australia

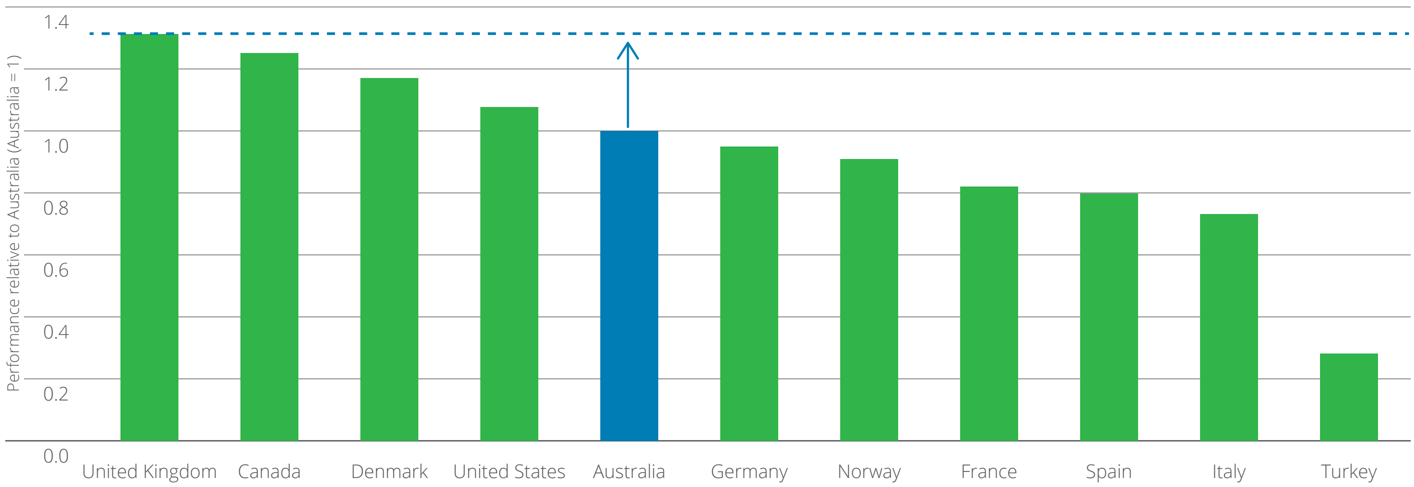
PEXA has developed and implemented a national electronic platform for settling and lodging documents for property transactions, leading to digital transformation across the legal, financial and conveyancing industries involved in Australia's $7.3 trillion residential property market.

Traditionally, property settlements have required the physical exchange of documents between representatives of the buyer and seller – an error-prone and outdated process. However, in 2008 the Council of Australian Governments proposed the delivery of a national e-conveyancing solution as a vital initiative for improving the efficiency and accuracy of settling property transactions. PEXA was formed in 2010, and the platform has settled more than 1 million property transactions, representing $121 billion in property value. PEXA was recognised as the fifth fastest growing technology company in the Asia-Pacific region in the 2016 Technology Fast 500 rankings (Deloitte, 2016a).

It has been estimated that using PEXA's digital platform for property transactions saves 60-70% of time taken in the conveyancing process after the contract has been written and exchanged (KPMG, 2018). It also provides vendors with faster access to the proceeds of sale, and purchasers' interests are recognised on title in real time, not weeks later as in the manual world. Change management and upskilling the workforce in the legal, financial and conveyancing industries has been a critical driver of the property sector's increasing adoption of PEXA for settling transactions. "We have provided face-to-face training as well as online support for practitioners to ease the transition to the new technology," says David Hentschke, Group Executive of Corporate Development at PEXA. "On-the-ground professional development has been important, particularly for teaching conveyancers and lawyers how to complete transactions on the digital platform. As the network matures, we're beginning to see excellent examples of peer-to-peer support come to life."

PEXA employs around 250 staff members across Australia, around half of whom are in technology-related roles. All of the core technical functions – such as product design and testing – are performed in-house. Given the company's rapid growth, it is expected that demand for technical ICT skills will continue to remain strong in the future. "We are currently looking for a range of ICT workers including java developers, cloud and DevOps engineers and IT security specialists," said Hentschke. "Demand for these latter two roles in particular is likely to increase in the coming years, and having talented employees with these skills will be necessary to build on PEXA's current success."

Chart 4.1: Australia's relative performance for size of ICT workforce, 2016



Sources: OECD (2017a) and Deloitte Access Economics (2018)

Deloitte Access Economics' employment projections in this year's report, presented in Section 2, suggest that Australia's current economic trajectory will see demand for ICT workers increase by almost 100,000 over the coming years. While this is a substantial number, it is still less than half of the 200,000 increase required for Australia to become a global leader in the ICT workforce measure. Given the significant ICT employment growth required for Australia's performance to exceed that of other countries, it is important that we continue to work towards attracting and retaining highly skilled ICT workers.

In terms of the size of ICT economic activity, Deloitte Access Economics' macroeconomic forecasts suggest that the IMT industry will grow from around $45 billion in 2016-17 to almost $55 billion in 2022-23 in 2015-16 Australian dollar terms (DAE, 2018a). However, it is clear that a large share of digital economic activity now takes place outside of the IMT industry, particularly as emerging technologies become increasingly integrated into the operations of other industries across Australia, as discussed in Section 1.

Given the size, diversity and growth potential of these other industries in the Australian economy, there are likely to be significant economic gains associated with becoming a digital leader in a range of technologies and industries outside of the IMT sector alone. This will be an important channel through which the $54 billion in potential economic benefits of global digital leadership could be realised across the Australian economy and population. For example, the box on the following page describes how AI technology can generate large efficiency benefits across a range of business applications and industries.

An internationally competitive ICT sector and digital economy will require Australia to make the most of the new opportunities provided by AI and other growing technologies such as machine learning, blockchain and cyber security. This in turn requires a highly skilled workforce that can support current and future digital transformation across the Australian economy. As a result, many of the additional 200,000 ICT workers that Australia needs to become a global digital leader should be targeted or specialised in these growth areas and new opportunities.

In many cases, Australian businesses and industries are already recognising the importance of sourcing these skills to drive future growth. For example, the Indeed job search website reports that employer demand for AI-related jobs in Australia has doubled since 2015 and was 50% higher in January 2018 compared to a year earlier, with many of these involving data science roles (Pickering, 2018). More broadly, it has been forecast that Australia will need almost 38,000 more data science workers in the next five years (DAE, 2018b). And in other areas, Australia will likely need 11,000 more cyber security workers over the next decade (AustCyber, 2017), while demand for blockchain development skills was recently identified as the fastest-growing skill on the online platform Upwork (Mearian, 2018).

Ensuring that Australia continues to grow its ICT workforce and that these new workers are suitably skilled in growth areas will enable us to make the most of new opportunities created by emerging technologies, particularly in a globally competitive environment for ICT talent. As discussed in Section 5, this will require Australia to develop a more agile workforce and education system, which can quickly and effectively respond to these growth opportunities and new demand for skills as they arise.

Overall, there are significant economic benefits to be gained through global digital leadership; however, we must improve our ICT competitiveness across a range of areas to advance our international position and realise these benefits. Further developing our core ICT workforce and broader digital skills, generating greater efficiencies by using digital tools, and creating new innovations with emerging technologies will enable Australia to fully realise the economic benefits of digitally led growth. A supportive digital policy environment, as highlighted in the next section, will be an important driver of future investment, growth and development in our technological capabilities.

Applying artificial intelligence to improve business efficiency

AI refers to technologies involving 'intelligent' machines that can operate and react like humans, using computer systems that rely on data to learn about the environment and adapt to solve problems. While the concept of AI has been around for many decades, it is only now beginning to revolutionise mainstream business practices. Increased processing power at lower cost, and growing bandwidth availability in remote locations, has seen the potential business applications of AI grow significantly (Sallomi, 2015).

The use of AI enables routine tasks to be automated, freeing up time for workers to complete higher-value tasks. Previous research has found that over the 15 years to 2030, the productivity gains resulting from increased automation could boost the Australian economy by $2.2 trillion, and reduce the amount of manual work performed by the average Australian by two hours per week (AlphaBeta, 2017).

In response to the growing importance of AI, Australian education institutions are investing in upskilling the future workforce in understanding and finding commercial applications for this new technology. The Australian Institute of Machine Learning (AIML) in Adelaide provides one such example, working directly with local businesses to develop new products based on AI technology (University of Adelaide, 2018). The South Australian Government has invested $7.1 million towards establishing this institution (University of Adelaide, 2017).

There are examples of Australian companies integrating AI into their operations to improve efficiency in a range of industries. For example, in the legal sector, AI has been used to provide clients with legal advice, including on wills, tax issues, business structuring and asset protection, improving the accessibility and affordability of basic legal services for the general population (Marks, 2017). In the marketing industry, AI-powered services have automated many manual tasks associated with digital marketing such as keyword identification, campaign testing and targeting personalised audiences (Cameron, 2017). This enables businesses to focus their efforts on the strategic and creative elements of marketing decisions.

However, across the entire economy the number of Australian businesses that have adopted AI technology is low, and there are opportunities for increased uptake to facilitate greater productivity gains. The progress of AI will likely be exponential, so businesses need to consider the time frame of any potential AI investments and where the greatest value lies in applying predictive AI, thus positioning themselves for future success in employing these technologies (McKinsey, 2018).

5 Policy to support an internationally competitive ICT sector

Key findings

- Australia's digital policy environment must encourage businesses to invest in new technologies, innovation and skills development. It is this business investment and activity that will accelerate digitally led economic growth and improve Australia's overall international ICT competitiveness.
- Using taxation policy to support this investment is one way for the government to enable more activity by Australian businesses and drive future growth in the digital economy. Another measure to encourage greater technology investment is to improve the accounting treatment of digital assets such as company data.
- The government's own activities, such as using data in policy development and its technology procurement practices, can also contribute to a strong digital environment and economy that attracts ICT businesses and workers to Australia.
- Developing an agile workforce and education system will enable Australian businesses to respond to technological change and move into new opportunities as required, positioning us to maximise the future economic benefits of digital growth.

Government policy interacts with the digital landscape many ways. Taxation settings and other financial standards can affect the way businesses invest in developing digital capabilities and building digital assets. The government also directly contributes to digital economic activity, such as through its technology procurement and internal uses of ICT for policymaking purposes. Considering how policy can support the international competitiveness of Australia's ICT sector can therefore enable future growth in the broader digital economy.

There has been much activity in the Australian policy landscape around ICT development, digital growth and innovation in the past 12 months – at the federal and state and territory levels. As discussed in the box on the following page, the Australian Government is currently developing a Digital Economy Strategy to maximise Australia's growth potential from new technologies and digital change.

The Prime Minister has also commissioned an independent review of the Australian Public Service, the terms of which include examining how the public service can more effectively use data and technology to innovate, collaborate and improve the delivery of core responsibilities and functions (Australian Government, 2018). A number of state and territory governments have released their own digital strategies and policy priorities in the past year, including the NSW Government's *Digital Government Strategy*; the Queensland Government's *DIGITAL1ST: Advancing our digital future*; and the Northern Territory Government's ongoing development of the *Digital Territory Strategy*. This adds to the Victorian Government's 2016 *Information Technology Strategy* and the South Australia Government's *Digital Transformation Strategy*.

With regards to recent policy actions, the Australian Government's 2018-19 Budget contained a range of technology initiatives, including almost $30 million in funding over four years to develop Australia's artificial intelligence and machine learning capabilities (DIIS, 2018b). The Budget also included investments in satellite navigation technology and infrastructure, funding for national research infrastructure, and adjustments to the R&D Tax Incentive (discussed in further detail later in this section). Other digital policy actions over the past 12 months have included the release of the government's policy paper on the rollout of 5G mobile technology (Department of Communications and the Arts, 2017), and changes to the temporary migration program, as discussed in Section 3.

Digital Economy Strategy: enabling Australia's digital growth

In 2017, the Australian Government announced that it will develop a new Digital Economy Strategy, which will provide a plan for Australia to maximise the economic and social benefits to be gained from digital change and new technologies. The strategy will cover a broad range of topics including productivity, innovation, inclusion and global competitiveness, and is being developed in consultation with Australian businesses and communities. The Department of Industry, Innovation and Science is leading the development of this strategy.

There is currently significant international focus on the themes of the digital economy and technology-led growth. The OECD has a 'Going Digital' project to examine how technological change affects policymaking. 'Digital Economy' is a workstream of the 2018 G20 meetings in Argentina, which will seek to provide recommendations for inclusive development in the context of digital transformation. The Association of Southeast Asian Nations (ASEAN) has recently discussed the topic, and in the last few years various countries (including the UK, Denmark, New Zealand, Singapore and Germany) have released digital strategies, covering themes such as digital infrastructure and connectivity, inclusivity in digital skills, strengthening the digital business ecosystem, and a more secure cyberspace. The international competitiveness of Australia's digital economy is a key focus of the Digital Economy Strategy and the government is drawing on this existing work from around the world as part of its work in developing the strategy.

While Australia's strategy will not be tied to particular technologies or industries, there are clear examples of emerging technologies that businesses across the country are piloting and exploring. For example, both Optus and Telstra showcased their 5G capabilities on the Gold Coast around the 2018 Commonwealth Games, and the Australian Securities Exchange is moving towards a blockchain system for settling securities trades. The strategy will consider the role of government in supporting these technological developments, such as whether regulatory settings are suitable or if intervention may be required to address market failures.

The Digital Economy Strategy will be released later in 2018, and will provide a forward-looking plan for Australia's digitally enabled growth and development.

The digital economic landscape is complex and continuously evolving, and ongoing policy improvements will be required to ensure that Australia can leverage the opportunities created by technological change. In particular, data and investment are key policy issues that could significantly affect the Australian digital landscape over the coming years. More specific policy issues include:

- **Reassessing the tax landscape for digital investment overall.** Investment in digital projects and businesses is a key driver of growth and innovation. Australia needs a tax policy environment that encourages increased investment in new technologies.
- **Valuing and accounting for data as a company asset.** Greater recognition of the strategic value of information assets – and the changing nature of business investment towards intangible assets – means this is becoming an increasingly important policy question.
- **Using data as a tool for policy development.** Data analytics is a powerful tool to assist governments in complex decision making, and has the potential to improve the efficiency and effectiveness of developing policy.
- **Positive spillovers and collaboration in technology procurement. T**he Australian Government's annual ICT expenditure totals more than $6 billion, so improved procurement processes can generate more positive outcomes in technology projects.

Finally, while this section focuses on how government policy can support business investment and activity in the digital economy, a critical enabler of this activity is an appropriate supply of highly skilled ICT workers in Australia. In a world of rapid technological change and digital disruption, this means **having an agile workforce and education system that can support digital transformation** across the economy by adapting to new developments and seizing new opportunities as they arise.

Previous editions of *Australia's Digital Pulse* have examined how Australia's National Curriculum develops digital capabilities in school students, and the importance of ongoing workforce development in ICT skills. In the 2017 report, we recommended that Australia continue to support digital skills development in school and tertiary education, and respond to technology-related workforce disruption through greater flexibility and transferability in education and training.

More recently, a key priority identified in the Australian Government's *Review to Achieve Educational Excellence in Australian Schools* was to "equip every child to be a creative, connected and engaged learner in a rapidly changing world", particularly as jobs and industries are reshaped by new technologies such as AI and automation (Gonski et al., 2018). However, at the same time, the report highlighted that the performance of Australian school students has declined since the early 2000s. This suggests that "Australian education has failed a generation of Australian school children by not enabling them to reach their full learning potential" (Gonski et al., 2018).

Australia must work towards developing an education system that effectively responds to technological change and builds the skills required for our workforce to drive growth and innovation. As discussed in Section 4, this includes increasing the pipeline of ICT workers in emerging technologies and growth areas, such as AI and cyber security. While some progress has been made in individual schools and universities, there needs to be a more consistent and holistic approach to an agile education system across the nation. Combined with the policies discussed below, this will position Australia to make the most of new technologically driven opportunities, thanks to greater business investment and activity in the growing digital economy.

Reassessing the tax landscape for digital investment overall

As highlighted in Section 1, Australia is a middling country with regards to our ICT competitiveness in the international domain. And yet a strong and competitive digital sector is an important driver of broader growth and innovation throughout the economy. For example, recent research has found that technological progress has been fundamental to increasing living standards in Australia, with higher uptake of digital technology leading to a 6.6% increase in Australia's GDP per capita over the past decade (Qu, Simes and O'Mahony, 2017). This is the result of greater worker and business productivity, better quality products and services, and reduced prices.

Investing in Australia's ICT capabilities and development will therefore enable future economic growth. In doing so, the Australian Government needs to be mindful of potential market failures relating to technology investment (including the risk of information asymmetry around innovation) and positive spillovers associated with the wider benefits of a digitally advanced economy and society. Government policy may have a role in levelling the playing field here, and the tax system is a policy tool which it can use to create an environment that supports technology investment. Importantly, the purpose of policy and regulation should be to facilitate a fair and competitive environment where companies can operate, rather than to 'pick winners.'

Various tax policies can create a more supportive environment for growing digital businesses and investment. These might differ based on who receives the benefits – such as the company itself or individual investors – or the timing of the benefits, whether it's an upfront concession compared to a benefit after the investment, or a concession that is only available for a limited time.

The nature of a specific tax policy influences the type of digital investment and business activity that policy affects. For example, a limited-time tax concession for companies that make digital investments would encourage immediate investment in new technologies earlier than would otherwise have been planned (such as the 'Hyper Depreciation' allowance implemented in Italy, discussed below). Meanwhile, having a mix of upfront and ongoing tax benefits for investors in new technology companies would incentivise the deployment of capital to growing digital businesses in the longer term (such as the UK's Seed Enterprise Investment Scheme, discussed below).

The policy debate around Australia's tax system is currently focused on broader initiatives such as the overall corporate tax rate and the R&D Tax Incentive. The reduced corporate tax rate is intended to encourage companies to invest in Australia, and to attract more foreign investment in an internationally competitive corporate tax environment, where Australia's corporate tax rate is currently amongst the highest in the OECD (Jericho, 2017). By 2019-20, Australia's corporate tax rate will be reduced from 30% to 27.5% for companies with annual turnover of up to $50 million. But the proposed reduction in the corporate tax rate paid by all Australian companies, from 30% to 25% by 2026-27, is currently stalled in the Senate (Taylor, 2018).

Meanwhile, the R&D Tax Incentive aims to encourage innovative activity by Australian companies. Following the 2016 *Review of the R&D Tax Incentive* (Ferris, Finkel and Fraser, 2016), the government announced several changes to this scheme in its 2018-19 Budget. These include implementing a tiered R&D intensity threshold for businesses with more than $20 million in annual turnover, with higher R&D intensities leading to greater non-refundable tax offsets; and a $4 million annual cap on refundable tax offsets paid in cash for businesses with less than $20 million in annual turnover (Deloitte, 2018b). The purpose of these changes is to better target government support for R&D towards additional investment, and to improve the integrity of the incentive scheme.

Overall, expenditure on the R&D Tax Incentive will be $2.4 billion lower than previous estimates over the next four years. While it remains to be seen how these changes will affect R&D activity by Australian businesses, stability and certainty in these policy settings will be required to enable businesses to make long-term innovation investment decisions, confident in the relevant tax scheme.

There are other parts of the Australian economy where the structure of the tax system recognises the different roles and impacts of tax on different industries. For example, the Australian Government's Junior Mineral Exploration Tax Credit is designed to encourage investment in greenfield mineral exploration in Australia, by allowing companies to give up a proportion of their losses and issue tax credits. Although such exploration activities are vital for driving future mineral discoveries, they are also high risk and involve large upfront costs with potential returns only realised decades later; the purpose of the tax incentive is to level these factors (DIIS, 2018c). This enables companies with limited access to funding to pass future tax deductions to Australian investors who acquire newly issued shares, increasing the attractiveness of these shares to potential investors (ATO, 2018).

Another example is the fuel tax credits scheme, which provides a rebate to Australian businesses for the excise they have paid on petrol and diesel. This policy is designed to reduce or eliminate an input tax on businesses that are heavy users of fuel – such as in the transport and agriculture industries – as input taxes generally reduce output and living standards (Webb, 2012).

Many overseas jurisdictions have tax policies targeted towards ICT-related businesses and broader economic activity relating to innovation and new technologies. For example:

- In Canada, federal and provincial tax credits are available to companies operating in high-tech industries, such as those involved in producing climate change technologies and interactive digital media development. These tax incentives are in addition to Canada's general Scientific Research and Experimental Development tax benefits (Deloitte, 2017a).
- In the United States, a number of state governments provide tax concessions for companies investing in developing a data centre within the state, with the aim of attracting these large investments. The range of incentives include sales and property tax abatements and exemptions, and investment tax credits (Chernicoff, 2016).
- In Italy, the government has set a 'Hyper Depreciation' allowance for particular types of tangible high-tech investments, allowing a 150% notional increase in the purchase cost of specified assets acquired for technological transformation (such as digitally controlled equipment or smart sensors) for the 2017 calendar year. This means that companies can depreciate up to 250% of the value of these digital assets, and these higher tax deductions lower their taxable income and therefore the effective cost of the high-tech investment (Fisco Oggi, 2017). The effect of the allowance is to encourage companies to invest in new technologies earlier than they otherwise might have planned.
- In the United Kingdom, the government's Seed Enterprise Investment Scheme (SEIS) enables investors in early-stage startups to claim tax benefits on their investment. Startups can raise up to £150,000 under the scheme, and investors receive concessions such as an upfront tax credit of 45% of their investment, as well as a capital gains tax exemption. Examples of startup activities that qualify for the scheme include biotechnology, online marketplaces and mobile app development (SEIS, 2018).
- In Singapore, the government's Productivity and Innovation Credit Scheme grants tax concessions for innovation investments, including product design activities, acquisition and registration of intellectual property, purchases of automation equipment, and training. A 400% tax allowance or deduction is available on the first S$400,000 spent each year, with additional support for small- and medium-sized enterprises (Deloitte, 2017b).

These schemes have supported the economic environment for technology investment in these countries, both by established companies and new startup businesses.

For instance, in Singapore the government's tax incentives have attracted high-value technology investment, including by research and manufacturing companies in the semiconductor industry, which makes chips used for high-tech purposes such as robotics, autonomous vehicles and IT security. A number of global chipmakers have set up hubs in Singapore, incentivised by the government's proactive and long-term vision for technological innovation and growth (Kitano and Aravindan, 2017). In another example, the UK SEIS saw 2,360 startup companies raise £180 million of funding in 2015-16, a similar amount to the previous year. Of this investment, 68% was targeted towards the high-tech and business services sectors (HMRC, 2017).

Recent research published by the European Commission has sought to highlight the role of tax incentives in startup investment. It found that these policy settings play an important role in supporting venture capital investment, as tax incentives lower the effective marginal cost of investing in startup companies, which may otherwise be relatively costly due to information asymmetries of higher-risk activities (EC, 2017). The research also identified best-practice features of successful tax incentives, such as offering upfront tax concessions to address investor risk aversion; targeting incentives to entrepreneurial activity based on factors like business size, age and sector; and a stable policy design that encourages investors and businesses to commit to decisions.

The Australian Government introduced tax incentives for investing in early-stage innovation companies (ESICs) in 2016 (ATO, 2017). Similar to the UK's SEIS, the incentives include a 20% tax credit up to A$200,000 per year and concessions on capital gains tax for investments in companies that meet the ESIC definition. There is a flexible range of qualifying criteria Australian startups may fulfil to be eligible as an ESIC, such as enrolling in an accelerator program, partnering with universities to commercialise innovations and investing in research and development activities (Bailey, 2016).

Some state- and territory-specific initiatives also provide direct support for innovation and digital activity by local businesses and industries. These include Victoria's Future Industries Fund, which supports new technologies in a range of high-growth sectors; NSW's TechVouchers for small- and medium-sized businesses; and Queensland's Platform Technology Program for large-scale industry projects.

Based on overseas experiences, there are other tax policies that Australia could consider to create a more supportive environment for ICT investment and digital business activity. Doing so will require consideration of related policy questions such as what types of activity are relevant (including overall technology investment, growth in ICT businesses and specific innovation categories) and how to structure incentives in a manner that encourages additional investment beyond what would have otherwise happened.

Nonetheless, with the international evidence suggesting a range of potential policy options, governments in Australia need to think about whether introducing similar schemes could better facilitate growth and innovation. While the ESIC scheme provides incentives for individual investors, Australia as a whole could consider whether more targeted policies would encourage greater innovative investments by Australian companies, as has happened in other countries. To remain internationally competitive and take a leading role in the global digital economy, Australia needs to ensure continued investment in technology and innovation.

Valuing and accounting for data as a company asset

Businesses across the economy are recognising that information is a key asset with significant strategic value. Companies with data-driven strategies have been found to have above-average productivity and profits (Steers, 2018). In the US, the output and productivity benefits of adopting data-driven decision making have previously been estimated at 5% to 6% above baseline, and improving data quality and access by 10% could increase labour productivity by an average of 14% (OECD, 2018e). In Australia, companies are increasingly recognising the value of customer and product data in driving and targeting demand growth; designing innovative new goods and services; improving pricing and other business strategies; and realising efficiency gains.

Data is no longer only valued by technology companies. Businesses in all industries are realising opportunities to use data to create corporate value and competitive advantage (Disparte and Wagner, 2016). For example, companies in financial services use data to improve risk assessment and pricing; retail businesses use data to target marketing and customer loyalty campaigns; and patient data analytics has the potential to deliver significant public benefits in the health sector. Across all industries, using data on customers, prices and products to inform decision making can result in more specific solutions and efficient outcomes.

Consistent with this, the nature of business investment in Australia is changing. Investment in physical equipment is becoming a lower priority while investment in technology is rising in importance. According to the Reserve Bank of Australia, since 2000 investment by non-mining businesses in intellectual property has grown faster and more consistently than investment in buildings, structures, machinery and equipment (Lowe, 2018). There has been almost no growth in tangible asset investment since 2010, while investment in intellectual property has increased by 5% per year over the same period.

However, most information-rich companies cannot currently include the value of their data as an asset on the balance sheet. This is because existing accounting models and standards generally prevent the capitalisation of data and information assets on financial statements, even though these meet the established definition of a business asset: a resource being used to generate company value (Gartner, 2017).

As a result, the value of internally generated data produced by the company's own activities typically does not appear on the balance sheet – even though the size, quality and variety of these data assets can all play a significant role in optimising overall performance and driving future growth. Furthermore, the ability to formally account for data on the balance sheet can facilitate greater investment by enabling businesses to leverage the value of their data assets to access external financing. In Australia, 21% of all innovation-active businesses cite lack of access to funds as a barrier to business activities, and it is the most commonly identified barrier for innovation-active businesses in the IMT industry – of which 35% state that accessing funding is a barrier (ABS, 2017d).

Previous research has found that US companies could own more than US$8 trillion in largely unmeasured intangible value, despite increasing company investment in information- and brand-building assets such as customer databases, and declining investment in traditional physical assets such as factories (Monga, 2016). In Australia, a recent study found that 37% of the enterprise value of ASX200-listed companies is in tangible assets, and 15% is in intangible assets that are currently measured and reported. As discussed in the box on the following page, this means that almost half of company value is not being accurately captured.

This policy issue is currently being considered around the world. For example, in 2016, the US Financial Accounting Standards Board investigated the potential for updating its accounting rules to require data to be recorded as an asset on the balance sheet (D'Onofrio, 2017). However, this research had trouble answering questions around how a company should estimate the fair value of its data assets, and how to measure and depreciate the value of information over time. A more formal accounting treatment of data assets would also require the costs of collecting, developing, refining and storing information to be accurately captured in financial statements, which may be challenging for companies to calculate (Shacklett, 2016).

Reporting the value of data assets is a difficult task in existing accounting and financial reporting frameworks. Australia's accounting standards are based on the International Financial Reporting Standards and were implemented in 2005, when technology and data assets were considered less important. Although data assets gained by acquiring another company can show up on the balance sheet in some capacity (depending on whether they are considered to be 'identifiable intangible assets'), investing in the internal development of a digital asset is typically treated as an expense without being capitalised on the balance sheet (Akred and Samani, 2018). Balance sheets have become an increasingly inaccurate representation of a company's asset base in the digital age.

Recent research by Deloitte found that only 37% of the enterprise value of ASX200-listed companies is captured by net tangible assets, and a further 15% is represented by intangible assets that are accounted for on the balance sheet. According to Tim Heberden, a specialist in intellectual property valuation and a partner at Deloitte, "this means that up to half of a company's value is invisible to investors. The other 48% of enterprise value typically comes from internally generated assets such as data. Unfortunately, management visibility of the commercial strength and value of data and other intangible assets is little better than that of investors. Poor data metrics means that companies can't optimise their decision making and strategy to best leverage these assets."

Better visibility of companies' data assets and appropriate recognition of the current and potential value can encourage greater investment in systems that extract, collate and analyse data to generate more sales, efficiency and innovation. These developments can also have financial implications, such as for tax obligations or as a means for early-stage loss-making companies to demonstrate a solid asset base.

"The starting point is to clearly define the asset, which might consist of an organisational structure, different categories of data and analysis," Heberden says. "The next step is to rate the utility and earnings potential of the data asset. This includes as assessment of factors such as uniqueness, depth, breadth, quality and commercial relevance. Once the characteristics of the asset have been assessed, an informed decision can be made on the most appropriate valuation method; alternatives include incremental earnings, replacement cost and market comparisons. Value mapping can be used to gauge and illustrate the current and potential contribution of intangible assets to organisational performance, and articulate the value impact of a coherent data management strategy."

Overcoming these challenges in Australia could lead to significant benefits for digitally enabled businesses across all industries throughout the economy. With data becoming an increasingly important determinant of growth and success, greater visibility of information assets enables greater investment in data-related capabilities and more opportunities to seek financing against the value of these assets to fund business operations. Ensuring that policy settings are appropriately calibrated to encourage companies to actively manage and invest in their data assets will therefore create future opportunities to leverage data and facilitate broader growth (Osborn, 2016).

Using data as a tool for policy development

Government policy development is a complex process that must factor in a range of evidence to inform decision making. In this context, data analytics is a powerful tool that can enable governments to more efficiently and effectively allocate public resources including staff, assets and funding, while also providing public services that are more relevant and responsive to citizens' needs. Countries around the world are developing the data analysis capabilities and general digital literacy of their government agencies, to improve the quality of their policy decisions.

The technological advances enabling data analytics to be feasibly used as a sophisticated policy making tool have only been developed over the past decade or so. Prior to this, the paper-based world of information gathering meant that collecting and analysing the required data to inform policy decisions represented too large a cost and administrative burden (Etsy and Rushing, 2007). But recent developments in IT provide governments with new opportunities to exchange data, monitor changes, conduct policy evaluations and compare performance – in a way that closes many of the data gaps that previously impeded effective policy design and implementation. Previous research has found that the aggregate direct and indirect value of government data in Australia is up to $25 billion per annum (Gruen, Houghton and Tooth, 2014).

It can be challenging for an organisation as large and complex as a government to adapt its operations and culture to be more data-centric. Previous research suggests that effective organisational change needs to be underpinned by a purpose or mission, and the data gathering and analysis process to make decisions based on this mission (Figure 5.1).

For government, this could mean considering what outcomes citizens value (such as improved child welfare and safety), then linking this to a range of relevant and measurable factors (such as case worker visits, number of children reunited with families, attendance at core health and education services). The final step is to use data on these factors to define and answer important questions. In this manner, data analytics is a tool for generating relevant insights and then translating them into tailored and timely policy decisions that are consistent with the government's underlying purpose (Deloitte, 2016b).

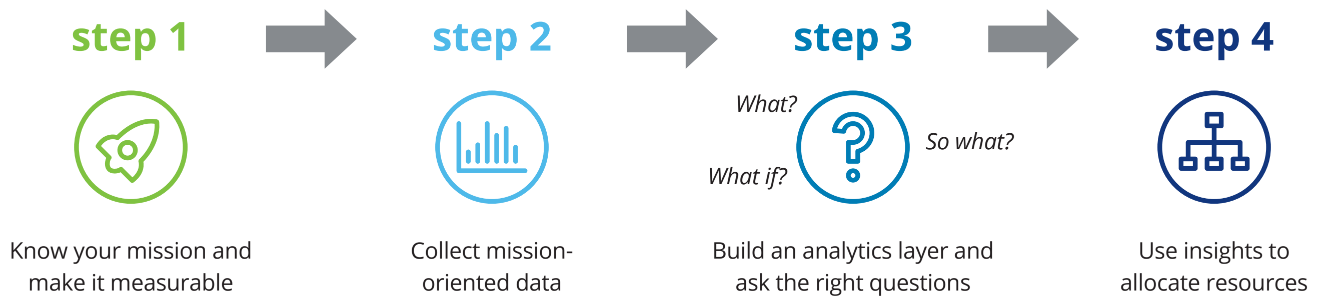
Previous research has found significant net economic benefits associated with having an open government data policy. For example, it enables new data-driven products and services, improves operational efficiencies, enables more informed decision making and facilitates better public engagement (BCR, 2016b). There are many overseas examples of governments beginning to use data to inform policy development across a range of sectors and applications.

The benefits of open government data for policymaking have also led to concerted efforts to improve access to this data in other countries. The OECD's Open Government Data initiative promotes various national policies aimed at improving transparency, accountability and value creation associated with greater availability of government data. The Government Data Index measures the level of open data across OECD countries according to three criteria: availability, accessibility and government support for reuse (OECD, 2018e). According to these measures, Australia performs moderately compared to our international peers, with particularly poor performance on the availability of government data (Chart 5.1).

Open data can also have benefits for the private sector. The Australian Productivity Commission's draft report on open data in banking found that data-related reforms could encourage greater involvement by smaller industry players, reducing borrowing costs when mortgages and personal loan data become products that can be traded in 2020 (Productivity Commission, 2018). The banking sector will be the first Australian industry to be subject to the government's Consumer Data Right framework, which will also be rolled out in the energy and telecommunications industries (Eyers, 2018).

There can be a variety of challenges for governments embarking on the journey towards more open data and using data to inform policy decisions. These include the need to clean data due to poor quality of the raw information; legacy 'stovepipe' systems that cannot communicate with each other; privacy concerns and citizens' expectations regarding government use of data; and complexities in managing data and determining where data responsibility lies (IBM, 2015). Overcoming these challenges in Australia and around the world will facilitate more efficient and effective government decision making in the long term.

Figure 5.1: Potential roadmap for becoming a data-centric organisation



Source: Deloitte (2016b)

Data-driven policymaking in the Victorian Government

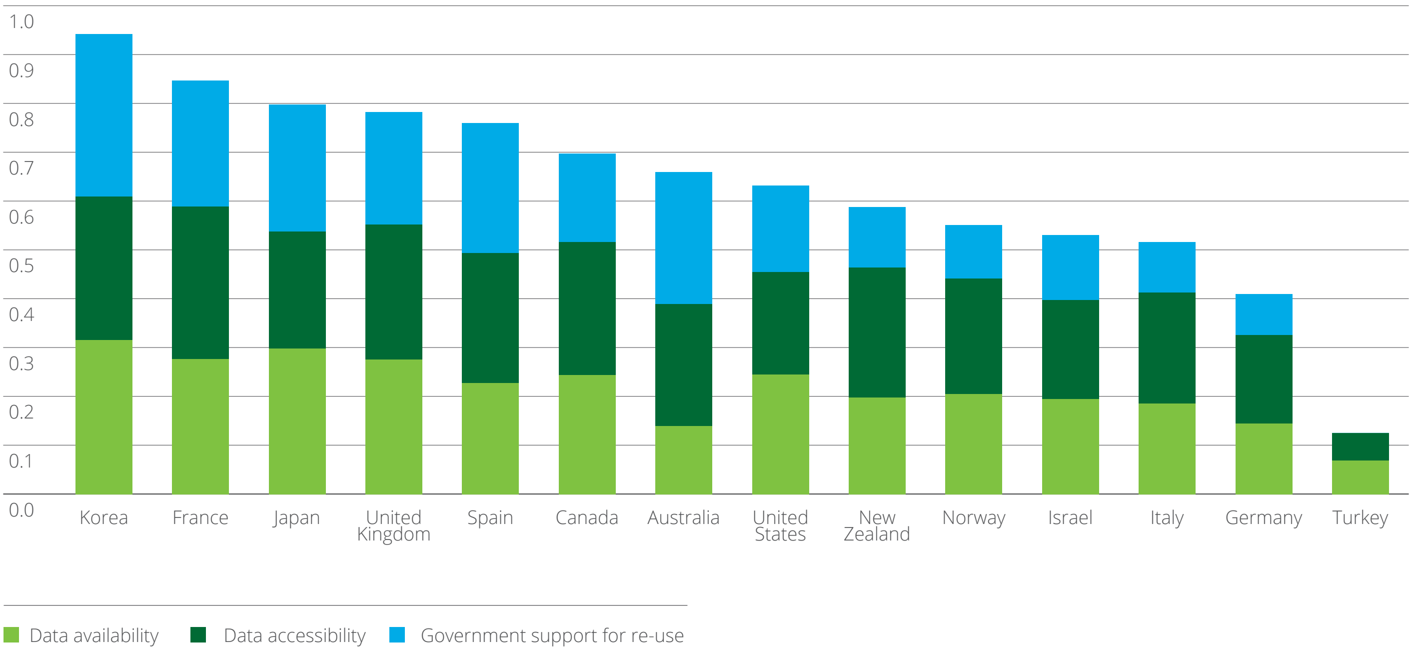
The Victorian Centre for Data Insights (VCDI) was formed in 2017 within the Department of Premier and Cabinet, to build data analytics capabilities across the Victorian Government and lead the development of Victoria's data reform agenda. The purpose of the VCDI is to make better use of data to inform policymaking, while also working to improve data standards, quality and management across government departments and agencies. The VCDI is led by Victoria's Chief Data Officer and consists of a team of around 30 policy and analytics specialists.

A rich data set can provide the evidence base to improve government operations in a number of ways. For example, predictive analytics can be used to prioritise limited public resources. According to Ryan Batchelor, Executive Director of Public Sector Reform in the Department of Premier and Cabinet: "In a project following the 2017 Grenfell Tower fire in London, the VCDI developed models to identify at-risk buildings in Victoria, which enabled more targeted building inspections based on the use of flammable cladding. As a result, the Victorian Building Authority inspected around 1,300 priority buildings, rather than the full list of 10,000 potential inspections."

Data analytics can also help to deliver better social outcomes from government policy. Recent work has been conducted with Ambulance Victoria to help improve quality and understanding of data used to support front-line emergency services, and to develop data indicators and dashboards for Victoria's Regional Partnerships to inform local decision making. Extracting value from this data requires a team with a mix of technical and analytical skills, and broader problem solving and critical thinking capabilities. "It's essential for the VCDI to be able to translate our understanding of the data into actual decisions. A mix of skills isrequired to ensure that the tools we develop are fit for purpose for the relevant Victorian departments and agencies," said Batchelor.

The VCDI's role also includes developing a broader data reform strategy to embed data capabilities and build a data culture across the Victorian Government. The strategy seeks to proactively address some of the challenges associated with data-driven policymaking. According to Ryan, some of the issues the strategy navigates include "managing data quality and consistency issues across departments; improving the data literacy of policy officers; and considering how we can invest in technologies and systems in a way that meets our current and future data requirements." Successfully managing these issues will be a key driver of demand for greater use of data analytics to inform policymaking in the future.

Chart 5.1: OECD Open Useful Reusable Government Data Index, 2017



Source: OECD (2018e)

Positive spillovers and collaboration in technology procurement

The size of government expenditure on procuring technology services, infrastructure and solutions is significant; Commonwealth departments alone spend around $6 billion per year on ICT goods and services (Department of Finance, 2016; DTA, 2017). Government investment in technology-related projects can have positive spillovers, for driving innovation, improving technology and knowledge transfer, and developing the digital capabilities of ICT businesses and workers in Australia. This concept is not a new one; an early paper published by the Australian Government noted that "the most direct involvement of government in technology transfer is through its purchasing activity … [which] may be used to encourage the development of innovative and internationally competitive Australian companies" (ASTEC, 1986).

Governments in other countries also have significant technology expenditures, and these digital investments often lead to broader economic and social benefits. For example, the Singapore Government's Smart Nation initiative invests in strategic national projects to increase the adoption of digital technologies – including creating a national digital identity; deploying sensor technology across the city to improve liveability and security; and using data and AI to improve public transport (Smart Nation, 2018). This has required new collaborations between the public and private sectors, as industry assists the government by examining problem statements and discussing possible solutions (GovTech, 2017).

It's becoming recognised around the world that flexibility and collaboration are important drivers of successful outcomes in government IT procurement. For instance, in the US, a number of state governments are adopting a more agile approach to technology procurement.

One such example was the request for a new case management system for California's Child Welfare Services, which gathers data on tens of thousands of vulnerable children across the state. While the initial request for proposal was overly complex and therefore unlikely to result in the development of a good system, the agency worked with Code for America to improve the procurement process. The contract was divided into modules based on particular functions and scopes, which enabled the development of prototypes that could be user tested and continually evaluated. This approach enabled technology to be embedded throughout the project (Miller, 2017).

Governments in Australia also understand that collaborating with businesses can lead to more effective technology procurement, and therefore better outcomes from their investments in digital projects. The box below highlights an example of how the NSW Government worked with the ICT industry to identify the problems and potential solutions in reforming the state's compulsory third-party insurance system.

Previous research has found that there are ways to improve government procurement policies and practices, including by pursuing greater clarity in project objectives, using more appropriate project delivery models and adapting procurement frameworks to encourage innovation (DAE, 2015c). Collaborating with industry in the procurement stage of government technology projects can be one way to achieve these improvements.

To ensure that governments can effectively and efficiently undertake technology procurement in the future, the procurement process itself must adapt to the new approaches made possible by digital advances. For example, shifting all components of the procurement process to a digital platform – from tendering, to contracting, to invoicing – is not just more efficient, it also allows governments to gather valuable data that can be used for more detailed analysis of expenditures over time. This analysis could include categorising spending and identifying overlaps and gaps in procurement. Overall, becoming smarter procurers by using digital technology will enable governments to improve their decision making and better prioritise expenditures in the long run.

Collaborating with industry for technology procurement in the NSW Government

Given the amount that Australian governments spend on technology projects, a well-designed procurement process can be an important enabler of innovation and technological growth more broadly across the economy. However, the size of these projects, the complexity of the problems and their solutions, and the associated governance requirements mean that it can be challenging for governments to design effective and efficient processes for procuring technology services and infrastructure.

ICT industry expert and NSW Government Chief Data Scientist Ian Oppermann believes that "while data is the most important factor of production for truly digital economies, many procurement processes are still stuck in the 20th century". Better use of technology throughout the overall process – such as moving away from paper systems towards digital tendering and invoicing – can enable more efficient procurement practices and detailed analysis of government expenditure.

With respect to procuring technology solutions, technical capabilities in procurement can be a significant challenge, and in some cases the problem the government needs to solve is difficult to pinpoint. According to Oppermann, one way to address this challenge is for governments to collaborate with industry throughout the procurement stages. "By working with industry through a co-design approach, government can better understand and define the problem, and then look to find innovative solutions," he says. For example, the NSW Government's Innovation Directive allows agencies to test new ideas on policy and reform with industry, developing and supporting innovative solutions to policy challenges.

The first successful application of this program saw the State Insurance Regulatory Authority (SIRA) work with the NSW Data Analytics Centre (DAC) to reform compulsory third-party (CTP) insurance in NSW. The reform had a range of objectives for improving the insurance system, including reducing the number of accidents, enhancing the system's usability and better identifying fraudulent activity. "SIRA and the NSW DAC conducted four 'ideation workshops' with the CSIRO and 24 companies, including data analytics firms and consulting firms, in order to collaboratively identify problems and potential solutions," said Oppermann. "Over the series of workshops, a broad set of ideas was refined until finally two ideas were selected by SIRA. These ideas described the alpha phase of potential solutions and were progressed through procurement into development contracts under the Procurement Innovation Directive." The process received strong support from Minister Dominello.

Addressing large and complex problems with potentially large and complex technological solutions will continue to be a significant challenge for governments around Australia. This suggests that in the future, there will be more opportunities to apply a collaborative approach between Australian companies, government agencies and the rest of the procurement system to drive better technology procurement outcomes.

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Appendix: Statistical compendium

At a glance – Australia

Table A.1: Summary of key national statistics

Indicator	Statistic	Period
ICT workers in Australia	663,100	2017
Of which: ICT-related industry subdivisions	327,000	2017
Other industries	336,100	2017
Of which: Technical, professional, management and operational occupations	445,700	2017
Other occupations (including trades and sales)	217,400	2017
ICT workers' proportion of total workforce	5.4%	2017
Forecast size of ICT workforce	758,695	2023
Inbound temporary migration of ICT workers (457 visas granted)	13,406	2016–17
Net migration inflow of ICT workers	20,664	2015–16
Female share of ICT workers	28%	2017
Older workers' (aged 55+) share of ICT workers	12%	2017
Businesses' ICT research and development expenditure	$6.6bn	2015–16
Total ICT service exports	$3.18bn	2016–17
Total ICT service imports	$2.89bn	2016–17
ICT university enrolments by domestic students	32,370	2016
ICT university completions by domestic students	5,502	2016
ICT university enrolments by international students	34,016	2016
ICT university completions by international students	8,865	2016

Source: ABS catalogues 5368.0 (2018) and 8104.0 (2017) and customised report (2018); Department of Education U-Cube (2018); Department of Immigration and Border Protection Subclass 457 Visa Statistics (2018)

At a glance – states and territories

Table A.2: Summary of key state statistics

Indicator	NSW	Vic	Qld	SA	WA	Tas	ACT	NT
ICT workers in Australia (2017)	259,300	192,300	94,600	30,400	50,100	6,700	23,376*	4,324*
Of which: ICT-related industry subdivisions	132,900	98,300	43,200	13,900	23,200	3,300	N/A	N/A
Other industries	126,400	94,000	51,400	16,500	26,900	3,400	N/A	N/A
Of which: Technical, professional, management and operational occupations	173,400	132,100	61,400	19,300	33,400	3,700	20,038*	2,362*
Other occupations (including trades and sales)	85,900	60,200	33,200	11,100	16,700	3,000	5,338*	1,962*
ICT workers' proportion of total workforce (2017)	6.7%	6.0%	3.9%	3.7%	3.8%	2.7%	N/A	N/A
ICT university enrolments by domestic students (2016)	11,173	9,220	6,625	1,811	1,631	349	1,312	111
ICT university completions by domestic students (2016)	1,997	1,626	962	244	319	56	251	16

* While the ABS 2017 labour force data contained combined figures for the NT and the ACT for confidentiality reasons, NT employment has been separated from ACT employment at an aggregate and occupational level using the Deloitte Access Economics employment forecast model.

Sources: ABS customised report (2018); Deloitte Access Economics (2018); and Department of Education U-Cube (2018)

ICT employment

Table A.3: CIIER classification of ICT workers at the four-digit Australian and New Zealand Standard Classification of Occupations (ANZSCO) level

ICT management and operations
1351 ICT managers
2232 ICT trainers
2247 management and organisation analysts
2249 other information and organisation professionals
2621 database and systems administrators, and ICT security specialists
2632 ICT support and test engineers
ICT technical and professional
2324 graphic and web designers, and illustrators
2611 ICT business and systems analysts
2612 multimedia specialists and web developers
2613 software and applications programmers
2631 computer network professionals
2633 telecommunications engineering professionals
3132 telecommunications technical specialists
ICT sales
2252 ICT sales professionals
6212 ICT sales assistants
ICT trades
3131 ICT support technicians
3424 telecommunications trades workers
Electronic trades and professional*
3123 electrical engineering draftspersons and technicians*
3124 electronic engineering draftspersons and technicians*
3423 electronics trades workers*
ICT industry admin and logistics support*
All other occupations where the employee works in an ICT-related industry subdivision (telecommunications services; internet service providers, web search portals and data processing services; and computer system design and related services)

* For these occupations, only workers employed in the ICT-related industry subdivisions (telecommunications services; internet service providers, web search portals and data processing services; and computer system design and related services) are counted as ICT workers

Sources: ACS and CIIER

Table A.4: OECD's broad measure of ICT-skilled employment at the four-digit ANZSCO level

1111 chief executives and managing directors	2349 other natural and physical science professionals
1112 general managers	2512 medical imaging professionals
1311 advertising and sales managers	2600 ICT professionals nfd
1320 business administration managers not further defined (nfd)	2610 business and systems analysts, and programmers nfd
1322 finance managers	2611 ICT business and systems analysts
1323 human resource managers	2612 multimedia specialists and web developers
1324 policy and planning managers	2613 software and applications programmers
1332 engineering managers	2621 database and systems administrators, and ICT security specialists
1335 production managers	2630 ICT network and support professionals nfd
1336 supply and distribution managers	2631 computer network professionals
1351 ICT managers	2632 ICT support and test engineers
1419 other accommodation and hospitality managers	2633 telecommunications engineering professionals
1494 transport services managers	2710 legal professionals nfd
2210 accountants, auditors and company secretaries nfd	2711 barristers
2211 accountants	2712 judicial and other legal professionals
2212 auditors, company secretaries and corporate treasurers	2713 solicitors
2220 financial brokers and dealers, and investment advisers nfd	3100 engineering, ICT and science technicians nfd
2221 financial brokers	3123 electrical engineering draftspersons and technicians
2222 financial dealers	3124 electronic engineering draftspersons and technicians
2223 financial investment advisers and managers	3130 ICT and telecommunications technicians nfd
2232 ICT trainers	3131 ICT support technicians
2241 actuaries, mathematicians and statisticians	3132 telecommunications technical specialists
2242 archivists, curators and records managers	3400 electrotechnology and telecommunications trades workers nfd
2243 economists	3420 electronics and telecommunications trades workers nfd
2244 intelligence and policy analysts	3423 electronics trades workers
2246 librarians	5100 office managers and program administrators nfd
2247 management and organisation analysts	5121 office managers
2249 other information and organisation professionals	5122 practice managers
2251 Advertising and marketing professionals	5211 personal assistants
2252 ICT sales professionals	5212 secretaries
2320 architects, designers, planners and surveyors nfd	5321 keyboard operators
2321 architects and landscape architects	5510 accounting clerks and bookkeepers nfd
2322 cartographers and surveyors	5511 accounting clerks
2326 urban and regional planners	5512 bookkeepers
2331 chemical and materials engineers	5513 payroll clerks

2332 civil engineering professionals	5521 bank workers
2333 electrical engineers	5522 credit and loans officers
2334 electronics engineers	5523 insurance, money market and statistical clerks
2335 industrial, mechanical and production engineers	6111 auctioneers, and stock and station agents
2336 mining engineers	6112 insurance agents
2341 agricultural and forestry scientists	6212 ICT sales assistants
2342 chemists, and food and wine scientists	6399 other sales support workers
2343 environmental scientists	7123 engineering production systems workers
2344 Geologists and geophysicists	2349 other natural and physical science professionals
2345 life scientists	

Source: OECD (2012)

Table A.5: ICT workers by industry and CIIER occupation grouping, 2017

	ICT management and operations	ICT technical and professional	ICT sales	ICT trades	Electronic trades and professional	ICT industry admin and logistics support	Total ICT workers
Industry divisions							
Agriculture, forestry and fishing	700	400	0	100	0	0	1,200
Mining	3,300	800	0	600	0	0	4,700
Manufacturing	8,000	12,300	1,200	1,900	0	0	23,400
Electricity, gas, water and waste services	5,600	1,400	100	800	0	0	7,900
Construction	1,800	3,200	300	3,800	0	0	9,100
Wholesale trade	4,700	5,000	2,600	1,300	0	0	13,600
Retail trade	5,200	8,500	5,700	3,300	0	0	22,700
Accommodation and food services	1,000	900	100	200	0	0	2,200
Transport, postal and warehousing	5,400	3,800	100	2,000	0	0	11,300
Rest of information media and telecommunications*	2,500	8,100	200	1,200	0	0	12,000
Financial and insurance services	21,000	18,000	100	3,300	0	0	42,400
Rental, hiring and real estate services	1,000	1,400	0	0	0	0	2,400
Rest of professional, scientific and technical services**	31,800	37,400	800	2,800	0	0	72,800
Administrative and support services	3,300	3,400	200	1,200	0	0	8,100

	ICT management and operations	ICT technical and professional	ICT sales	ICT trades	Electronic trades and professional	ICT industry admin and logistics support	Total ICT workers
Public administration and safety	29,800	16,300	100	4,900	0	0	51,100
Education and training	9,900	7,800	100	5,000	0	0	22,800
Healthcare and social assistance	6,800	2,900	200	4,000	0	0	13,900
Arts and recreation services	2,100	4,600	0	300	0	0	7,000
Other services	2,400	3,000	100	2,000	0	0	7,500
ICT industry subdivisions							
Telecommunications services	11,700	17,300	5,600	13,200	1,100	45,200	94,100
Internet service providers, web search portals and data processing services	800	1,800	100	1,300	0	4,000	8,000
Computer system design and related services	35,600	93,000	10,300	19,700	2,500	63,800	224,900
Total ICT workers	**194,400**	**251,300**	**27,900**	**72,900**	**3,600**	**113,000**	**663,100**

* Excluding telecommunications services, and internet service providers, web search portals and data processing services, which are separately identified as ICT industry subdivisions.

** Excluding computer system design and related services, which is separately identified as an ICT industry subdivision.

Source: ABS customised report (2018)

Table A.6: ICT employment forecasts by occupation grouping, 2017–23

Occupation grouping	2017	2023	Average annual growth (%)
ICT management and operations	194,400	225,683	2.5
ICT technical and professional	251,300	277,521	1.7
ICT sales	27,900	32,386	2.5
ICT trades	72,900	88,510	3.3
Electronic trades and professional*	3,800	3,964	1.6
ICT industry admin and logistics support*	115,962	130,630	2.4
Total ICT workers	**663,100**	**758,695**	**2.3**

* Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.

Source: Deloitte Access Economics (2018)

Table A.7: ICT skills forecasts by occupation grouping, 2017–23

	2017	2023	Average annual growth (%)
ICT management and operations			
Postgraduate	74,205	90,245	3.3
Undergraduate	142,332	171,344	3.1
Diploma or advanced diploma	55,961	64,835	2.5
Certificate III or IV	36,493	43,552	3.0
Certificate I or II	15,667	16,743	1.1
ICT technical and professional			
Postgraduate	77,380	89,630	2.5
Undergraduate	197,467	225,133	2.2
Diploma or advanced diploma	72,386	77,728	1.2
Certificate III or IV	42,301	47,740	2.0
Certificate I or II	18,661	19,010	0.3
ICT sales			
Postgraduate	4,589	5,663	3.6
Undergraduate	10,163	12,660	3.7
Diploma or advanced diploma	4,753	5,774	3.3
Certificate III or IV	4,083	4,963	3.3
Certificate I or II	1,965	2,123	1.3
ICT trades			
Postgraduate	18,784	26,152	5.7
Undergraduate	35,595	49,426	5.6
Diploma or advanced diploma	21,581	26,091	3.2
Certificate III or IV	24,704	30,905	3.8
Certificate I or II	11,788	13,877	2.8
Electronic trades and professional			
Postgraduate	325	431	4.8
Undergraduate	850	1,119	4.7
Diploma or advanced diploma	1,111	1,250	2.0
Certificate III or IV	1,927	2,213	2.3
Certificate I or II	727	796	1.5
ICT industry admin and logistics support			
Postgraduate	20,708	23,870	2.4
Undergraduate	34,113	38,874	2.2
Diploma or advanced diploma	14,959	16,892	2.0
Certificate III or IV	14,189	14,932	0.9
Certificate I or II	5,010	5,317	1.0

ICT migration

Table A.8: Temporary skilled migration (457) visa grants for ICT occupations, FY2014–17

	2013–14	2014–15	2015–16	2016-17
1351 ICT managers	786	939	919	852
2232 ICT trainers	15	10	15	22
2247 management and organisation analysts	1,239	1,445	1,345	1,362
2249 other information and organisation professionals	445	452	399	350
2252 ICT sales professionals	458	527	531	604
2324 graphic and web designers, and illustrators	307	472	411	459
2611 ICT Business and items analysts	1,795	2,098	2,208	2,125
2612 multimedia specialists and web developers	117	162	133	121
2613 software and applications programmers	4,161	5,231	4,984	4,909
2621 database and systems administrators, and ICT security specialists	356	383	385	424
2631 computer network professionals	240	272	260	294
2632 ICT support and test engineers	671	767	854	864
2633 telecommunications engineering professionals	53	127	99	81
3123 electrical engineering draftspersons and technicians	365	351	353	305
3124 electronic engineering draftspersons and technicians	53	127	99	71
3131 ICT support technicians	340	320	291	273
3132 telecommunications technical specialists	61	52	43	79
3423 electronic trades workers	88	115	80	94
3424 telecommunications trades workers	161	102	121	117
Total ICT workers*	**11,805**	**13,937**	**13,521**	**13,406**

* Excludes ICT industry administration and logistics support, for which breakdowns are unavailable; data for electronic trades and professional roles is for all industries.

Source: Department of Immigration and Border Protection Subclass 457 Visa Statistics (2018)

Table A.9: Net migration of ICT workers, FY2013–16*

	2012–13	2013–14	2014–15	2015–16
1351 ICT managers	1,561	1,212	1,350	1,480
2232 ICT trainers	37	45	89	61
2247 management and organisation analysts	3,127	2,409	1,991	1,092
2249 other information and organisation professionals	1,281	1,223	1,150	1,066
2252 ICT sales professionals	1,112	1,260	1,347	1,593
2324 graphic and web designers, and illustrators	728	631	823	812
2611 ICT Business and items analysts	2,609	2,503	3,018	3,146
2612 multimedia specialists and web developers	120	179	162	190
2613 software and applications programmers	5,212	5,152	5,324	6,876
2621 database and systems administrators, and ICT security specialists	672	610	579	625
2631 computer network professionals	427	342	281	363
2632 ICT support and test engineers	710	969	984	1,072
2633 telecommunications engineering professionals	246	118	188	26
3123 electrical engineering draftspersons and technicians	800	733	864	852
3124 electronic engineering draftspersons and technicians	464	314	240	256
3131 ICT support technicians	708	670	602	512
3132 telecommunications technical specialists	248	274	237	134
3423 electronic trades workers	285	167	192	238
3424 telecommunications trades workers	173	298	221	270
Total ICT workers**	**20,520**	**19,109**	**19,642**	**20,664**

* Due to changes in the methodology for collecting overseas arrivals and departures data, a detailed occupational breakdown of this data is no longer published. As such, updated figures for the net migration of ICT workers are unavailable for this year's *Australia's Digital Pulse* report.

** Excludes ICT industry admin and logistics support, for which breakdowns are unavailable; data for electronic trades and professional roles is for all industries.

Source: Department of Immigration and Border Protection Overseas Arrivals and Departure Statistics (2017)

ICT higher and vocational education

Table A.10: Domestic enrolments and completions in IT degrees, 2001–16

	Course enrolments		Course completions	
	Undergraduate	Postgraduate	Undergraduate	Postgraduate
2001	35,661	10,161	5,451	2,850
2002	36,647	10,280	6,219	3,294
2003	35,172	9,118	6,580	2,588
2004	31,232	8,139	6,283	2,272
2005	26,527	6,923	5,696	1,976
2006	22,762	6,101	4,672	1,642
2007	20,709	5,488	4,185	1,474
2008	18,905	5,077	3,577	1,349
2009	18,545	5,143	3,159	1,315
2010	18,966	5,213	3,050	1,275
2011	19,902	5,386	3,266	1,353
2012	21,047	5,562	3,339	1,326
2013	22,055	5,447	3,463	1,423
2014	23,829	5,560	3,638	1,468
2015	25,700	5,482	3,949	1,491
2016	26,596	5,774	3,985	1,517

Source: Department of Education U-Cube (2018)

Table A.11: International enrolments and completions in IT degrees, 2001–16

	Course enrolments		Course completions	
	Undergraduate	**Postgraduate**	**Undergraduate**	**Postgraduate**
2001	17,009	10,225	2,993	3,558
2002	20,843	11,238	4,157	4,821
2003	21,701	11,087	5,659	4,337
2004	20,683	12,638	6,010	3,586
2005	17,480	13,512	5,213	5,428
2006	15,475	11,580	5,021	5,635
2007	14,415	10,265	4,433	4,258
2008	14,236	10,964	3,715	4,369
2009	15,113	12,104	3,851	4,009
2010	15,018	11,435	4,120	5,037
2011	15,108	9,452	3,996	4,528
2012	14,495	8,992	3,749	3,385
2013	13,978	10,908	3,673	3,223
2014	14,152	13,742	3,617	3,573
2015	14,217	15,406	3,516	4,537
2016	16,063	17,953	3,602	5,263

Source: Department of Education U-Cube (2018)

Table A.12: Government-funded vocational education and training students in the IT field of education, 2012–16

	2012	2013	2014	2015	2016
Diploma or higher	5,026	5,056	5,480	3,916	4,074
Certificate IV	7,609	7,239	6,954	5,836	5,394
Certificate III	9,703	10,588	10,763	9,025	7,425
Certificate I/II	7,301	8,710	7,532	6,269	4,465
Non-Australian Qualifications Framework	286	125	94	259	265

Source: National Centre for Vocational Education Research (2018)

Table A.13: Female ICT workers by industry, 2017

	Female ICT workers	Percentage of female ICT workers (%)	Percentage of female workers in all occupations (%)
Industry divisions			
Agriculture, forestry and fishing	300	25	30
Mining	1,100	23	15
Manufacturing	6,200	26	27
Electricity, gas, water and waste services	2,800	35	23
Construction	1,500	16	11
Wholesale trade	3,800	28	33
Retail trade	6,400	28	55
Accommodation and food services	600	27	55
Transport, postal and warehousing	2,200	19	22
Rest of IMT*	2,600	22	41
Financial and insurance services	11,700	28	49
Rental, hiring and real estate services	900	38	51
Rest of professional, scientific and technical services**	29,800	41	43
Administrative and support services	3,200	40	52
Public administration and safety	19,000	37	49
Education and training	7,500	33	71
Healthcare and social assistance	3,900	28	78
Arts and recreation services	2,900	41	49
Other services	1,200	16	44
ICT industry subdivisions			
Telecommunications services	26,200	28	28
Internet service providers, web search portal and data processing services	2,400	30	30
Computer system design and related services	51,400	23	23
Total ICT workers	**187,600**	**28**	**47**

* Excluding telecommunications services, and internet service providers, web search portals and data processing services, which are separately identified as ICT industry subdivisions.

** Excluding computer system design and related services, which is separately identified as an ICT industry subdivision,

Source: ABS customised report (2018)

Older ICT workers

Table A.14: Older ICT workers by CIIER occupation grouping, 2017

	Number of ICT workers aged 55+	Percentage of total ICT workforce
ICT management and operations	29,700	15
ICT technical and professional	2,800	10
ICT sales	23,200	9
ICT trades	8,600	12
Electronic trades and professional	7,000	18
Total ICT workers*	**71,300**	**12**

* Excludes ICT industry admin and logistics support, for which breakdowns are unavailable; data for electronic trades and professional roles is for all industries.
Source: ABS customised report (2018)

ICT research and development

Table A.15: Business expenditure on R&D, FY201–16

	2010–11	2011–12	2013–14	2015-16
Information and computing science	$5,001,174	$5,496,165	$6,073,221	$6,634,394
Engineering	$9,283,280	$8,686,256	$7,474,231	$5,538,180
Technology	$917,109	$1,235,487	$1,689,446	$1,409,803
Medical and health sciences	$928,398	$941,159	$1,123,956	$1,253,415
Chemical sciences	$275,030	$425,941	$565,758	$632,619
Agricultural and veterinary sciences	$492,921	$455,372	$533,754	$404,003
Earth sciences	$200,390	$122,476	$286,511	$166,626
Environmental sciences	$192,797	$281,155	$270,044	$158,043
Built environment and design	$209,244	$231,743	$238,591	$152,082
Commerce, management, tourism and services	$152,605	$144,273	$227,088	$110,793
Other fields of research	$253,939	$301,295	$346,838	$199,338

Source: ABS catalogue 8104.0 (2017)

Table A.16: Government expenditure on ICT R&D, 2008–09 to 2014–15

	2008–09	2011–12	2012–13	2014–15
Commonwealth ICT R&D expenditure ($)	$260,948,000	$314,437,000	$240,828,000	$247,462,000
Commonwealth ICT share of R&D expenditure (%)	12%	13%	10%	11%
State and territory ICT R&D expenditure ($)	$29,570,000	$8,596,000	$12,778,000	$20,882,000
State and territory ICT share of R&D expenditure (%)	3%	1%	1%	2%

Source: ABS catalogue 8109.0 (2017)

Trade in ICT services

Table A.17: Exports and imports of ICT services, 2012–13 to 2016–17 ($bn)

	2012–13	2013-14	2014-15	2015–16	2016-17
Exports	1.68	1.96	2.48	2.80	3.18
Imports	1.84	2.50	2.59	2.91	2.89

Source: ABS catalogue 5368.0 (2018)

Detailed state figures

Table A.18: State and territory breakdown of ICT workers by industry, 2017

	NSW	Vic	Qld	SA	WA	Tas	ACT*	NT*
Industry divisions								
Agriculture, forestry and fishing	100	200	200	300	100	100	N/A	N/A
Mining	100	600	700	300	3,000	0	N/A	N/A
Manufacturing	10,200	7,200	3,700	1,400	600	0	N/A	N/A
Electricity, gas, water and waste services	1,000	3,500	1,500	500	800	500	N/A	N/A
Construction	3,400	2,600	900	900	1,000	200	N/A	N/A
Wholesale trade	6,300	3,800	1,700	700	800	0	N/A	N/A
Retail trade	8,500	7,300	3,600	1,000	1,500	200	N/A	N/A
Accommodation and food services	1,200	600	200	0	100	0	N/A	N/A
Transport, postal and warehousing	3,800	4,400	2,500	100	500	0	N/A	N/A
Rest of IMT**	6,200	2,600	1,500	200	900	400	N/A	N/A
Financial and insurance services	24,600	11,300	3,700	500	1,800	100	N/A	N/A
Rental, hiring and real estate services	1,200	300	500	200	100	0	N/A	N/A
Rest of professional, scientific and technical services***	30,500	21,000	9,000	3,000	6,200	700	N/A	N/A
Administrative and support services	1,600	3,300	1,200	700	800	0	N/A	N/A
Public administration and safety	12,600	9,200	10,700	3,000	4,300	800	N/A	N/A
Education and training	8,100	6,900	2,900	1,300	2,000	300	N/A	N/A
Healthcare and social assistance	3,900	4,300	2,900	1,600	1,300	0	N/A	N/A
Arts and recreation services	1,200	2,300	2,100	400	600	100	N/A	N/A
Other services	1,900	2,600	1,900	400	500	0	N/A	N/A
ICT industry subdivisions								
Telecommunications services	35,000	30,600	15,500	4,700	5,100	1,700	N/A	N/A
Internet service providers, web search portals and data processing services	3,200	2,400	900	700	600	100	N/A	N/A
Computer design and related services	94,700	65,300	26,800	8,500	17,500	1,500	N/A	N/A
Total ICT workers	**259,300**	**192,300**	**94,600**	**30,400**	**50,100**	**6,700**	**25,367**	**4,324**

* While the 2017 labour force data from the ABS contained combined figures for the NT and the ACT for confidentiality reasons, NT employment has been separated from ACT employment at an aggregate level using the Deloitte Access Economics employment forecast model.

** Excluding telecommunications services, and internet service providers, web search portals and data processing services, which are separately identified as ICT industry subdivisions.

*** Excluding computer system design and related services, which is separately identified as an ICT industry subdivision.

Sources: ABS customised report (2018), Deloitte Access Economics (2018)

Table A.19: NSW ICT employment forecasts by CIIER occupation grouping, 2017–23

	2017	2023	Average annual growth rate (%)
ICT management and operations	72,400	87,426	3.2
ICT technical and professional	101,000	109,259	1.3
ICT sales	11,400	13,246	2.5
ICT trades	25,700	34,288	4.9
Electronic trades and professional*	2,200	2,453	1.8
ICT industry admin and logistics support*	46,600	53,470	2.3
Total ICT workers	**259,300**	**300,141**	**2.5**

* Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.
Source: Deloitte Access Economics (2018)

Table A.20: Victoria's ICT employment forecasts by CIIER occupation grouping, 2017–23

	2017	2023	Average annual growth rate (%)
ICT management and operations	56,700	64,728	2.2
ICT technical and professional	75,400	88,728	2.7
ICT sales	7,100	8,180	2.4
ICT trades	19,100	21,538	2.0
Electronic trades and professional*	300	335	1.8
ICT industry admin and logistics support*	33,700	39,464	2.7
Total ICT workers	**192,300**	**222,972**	**2.5**

* Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.
Source: Deloitte Access Economics (2018)

Table A.21: Queensland's ICT employment forecasts by CIIER occupation grouping, 2017–23

	2017	2023	Average annual growth rate (%)
ICT management and operations	26,600	31,724	3.0
ICT technical and professional	34,800	35,858	0.5
ICT sales	4,100	4,616	2.0
ICT trades	12,300	13,301	1.3
Electronic trades and professional*	700	746	1.1
ICT industry admin and logistics support*	16,100	18,513	2.4
Total ICT workers	**94,600**	**104,758**	**1.7**

* Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.
Source: Deloitte Access Economics (2018)

Table A.22: South Australia's ICT employment forecasts by CIIER occupation grouping, 2017–23

	2017	2023	Average annual growth rate (%)
ICT management and operations	8,400	7,956	-0.9
ICT technical and professional	10,900	12,392	2.2
ICT sales	1,300	1,525	2.7
ICT trades	4,600	5,593	3.3
Electronic trades and professional*	100	105	0.8
ICT industry admin and logistics support*	5,100	5,636	1.7
Total ICT workers	**30,400**	**33,207**	**1.5**

* Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.
Source: Deloitte Access Economics (2018)

Table A.23: Western Australia's ICT employment forecasts by CIIER occupation grouping, 2017–27

	2017	2023	Average annual growth rate (%)
ICT management and operations	15,700	18,972	3.2
ICT technical and professional	17,700	17,939	0.2
ICT sales	2,700	3,257	3.2
ICT trades	7,300	8,248	2.1
Electronic trades and professional*	N/A	N/A	N/A
ICT industry admin and logistics support*	6,700	8,203	3.4
Total ICT workers	**50,100**	**56,619**	**2.1**

* Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.
Source: Deloitte Access Economics (2018)

Table A.24: Tasmania's ICT employment forecasts by CIIER occupation grouping, 2017–23

	2017	2023	Average annual growth rate (%)
ICT management and operations	2,100	2,439	2.5
ICT technical and professional	1,600	1,570	-0.3
ICT sales	300	340	2.1
ICT trades	1,400	1,856	4.8
Electronic trades and professional*	100	110	1.7
ICT industry admin and logistics support*	1,200	1,395	2.5
Total ICT workers	**6,700**	**7,711**	**2.4**

* Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.
Source: Deloitte Access Economics (2018)

Table A.25: Northern Territory's ICT employment forecasts by CIIER occupation grouping, 2017–23*

	2017	2023	Average annual growth rate (%)
ICT management and operations	1,369	1,526	1.8
ICT technical and professional	994	1,183	3.0
ICT sales	216	256	2.9
ICT trades	854	949	1.8
Electronic trades and professional**	30	31	0.7
ICT industry admin and logistics support**	863	782	-1.6
Total ICT workers	**4,324**	**4,726**	**1.5**

* While the 2017 labour force data from the ABS contained combined figures for the NT and the ACT for confidentiality reasons, NT employment forecasts have been produced separately from ACT employment forecasts using the Deloitte Access Economics employment forecast model.

** Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.

Source: Deloitte Access Economics (2018)

Table A.26: Australian Capital Territory's ICT employment forecasts by CIIER occupation grouping, 2017–23*

	2017	2023	Average annual growth rate (%)
ICT management and operations	11,131	10,913	-0.3
ICT technical and professional	8,906	10,591	2.9
ICT sales	784	967	3.6
ICT trades	1,646	2,737	8.8
Electronic trades and professional**	170	185	1.4
ICT industry admin and logistics support**	2,737	3,168	2.5
Total ICT workers	**25,376**	**28,561**	**2.0**

* While the 2017 labour force data from the ABS contained combined figures for the NT and the ACT for confidentiality reasons, NT employment forecasts have been produced separately from ACT employment forecasts using the Deloitte Access Economics employment forecast model.

** Employment in these occupations has only been counted for the ICT-related industry subdivisions, consistent with the definitions in Table A.3.

Source: Deloitte Access Economics (2018)

Table A.27: State breakdown of net overseas migration of ICT workers, 2015–16*

	NSW	Vic	Qld	WA
1351 ICT managers	888	463	116	173
2232 ICT trainers	21	20	5	0
2247 Management and organisation analysts	1,646	817	189	204
2249 Other information and organisation professionals	668	155	129	73
2252 ICT sales professionals	1,154	304	76	41
2324 Graphic and web designers, and illustrators	498	290	93	26
2611 ICT business and items analysts	1,805	1,090	188	154
2612 Multimedia specialists and web developers	107	50	28	8
2613 Software and applications programmers	4,299	2,405	431	353
2621 Database and systems administrators, and ICT security specialists	350	168	36	62
2631 Computer network professionals	210	98	53	39
2632 ICT support and test engineers	596	325	54	21
2633 Telecommunications engineering professionals	51	39	6	25
3123 Electrical engineering draftspersons and technicians	131	57	206	422
3124 Electronic engineering draftspersons and technicians	58	26	40	117
3131 ICT support technicians	313	97	65	38
3132 Telecommunications technical specialists	38	35	35	8
3423 Electronic trades workers	47	43	12	123
3424 Telecommunications trades workers	69	28	32	59
Total ICT workers**	**12,730**	**6,510**	**1,794**	**1,946**

* Due to changes in the methodology for collecting overseas arrivals and departures data, a detailed occupational breakdown of this data is no longer published. As such, updated figures for the net migration of ICT workers are unavailable for this year's *Australia's Digital Pulse* report. Data represents net overseas migration only and does not include interstate migration within Australia. Other states and territories are not shown for confidentiality reasons (fewer than five workers reported).

** Excludes ICT industry admin and logistics support, for which breakdowns are unavailable; data for electronic trades and professional roles is for all industries.

Source: Department of Immigration and Border Protection Overseas Arrivals and Departure Statistics (2017)

Table A.28: State breakdown of domestic enrolments and completions in IT degrees, 2016

	Course enrolments		Course completions	
	Undergraduate	Postgraduate	Undergraduate	Postgraduate
NSW	9,034	2,139	1,440	557
Vic	7,378	1,836	1,216	410
Qld	5,787	838	763	199
SA	1,551	260	76	168
WA	1,182	449	153	166
Tas	313	36	48	8
NT	97	14	19	16
ACT	1,118	194	168	83
Multistate	136	8	10	2

Source: Department of Education U-Cube (2018)

Table A.29: State breakdown of international enrolments and completions in IT degrees, 2016

	Course enrolments		Course completions	
	Undergraduate	Postgraduate	Undergraduate	Postgraduate
NSW	5,291	4,655	1,300	970
Vic	6,975	6,155	2,261	1,273
Qld	570	1,292	1,163	524
SA	752	577	150	351
WA	570	1,292	159	124
Tas	201	677	55	188
NT	62	48	16	15
ACT	377	634	144	138
Multistate	42	117	15	19

Source: Department of Education U-Cube (2018)

International comparisons

Table A.30: Internet access, 2017

Rank	Country	Percentage of population with internet access (%)	Rank	Country	Percentage of population with internet access (%)
1	Korea	99.5	9	Spain	83.4
2	Denmark	97.0	10	Italy	81.0
3	Norway	96.7	11	Turkey	80.7
4	United Kingdom	94.0	12	New Zealand*	80.0
5	Germany	92.9	13	Israel*	75.4
6	France	86.4	14	United States*	73.4
7	**Australia**	**86.1**	15	Japan*	67.1
8	Canada*	83.9	N/A	Singapore	N/A

* Data for selected countries was unavailable for 2017. Data was only available for Israel in 2016; the US in 2015; Canada in 2013; New Zealand in 2012; and Japan in 2009.
Sources: OECD (2018a) and ABS (2018)

Table A.31: Internet access, 2012

Rank	Country	Percentage of population with internet access (%)	Rank	Country	Percentage of population with internet access (%)
1	Korea	97.3	9	New Zealand	80.0
2	Norway	92.7	10	United States	74.8
3	Denmark	92.0	11	Israel	70.7
4	United Kingdom	87.0	12	Japan*	67.1
5	Germany	86.0	13	Spain	66.6
6	Canada	83.9*	14	Italy	62.9
7	**Australia**	**83.0**	15	Turkey	47.2
8	France	80.0	N/A	Singapore	N/A

* Data for selected countries was unavailable for 2012. Data was only available for Canada in 2013 and Japan in 2009.
Source: OECD (2018a)

Table A.32: Mobile broadband, 2017

Rank	Country	Mobile subscriptions per 100 inhabitants	Rank	Country	Mobile subscriptions per 100 inhabitants
1	Japan	157.4	9	United Kingdom	89.0
2	**Australia**	**132.5**	10	Italy	85.7
3	Denmark	129.0	11	France	81.2
4	United States	128.6	12	Germany	78.6
5	Korea	111.1	13	Israel	70.7
6	New Zealand	101.3	14	Canada	70.7
7	Norway	96.4	15	Turkey	70.7
8	Spain	92.7	N/A	Singapore	N/A

Source: OECD (2018b)

Table A.33: Mobile broadband, 2012

Rank	Country	Mobile subscriptions per 100 inhabitants	Rank	Country	Mobile subscriptions per 100 inhabitants
1	Korea	102.9	9	United Kingdom	58.8
2	**Australia**	**98.7**	10	Spain	47.6
3	Denmark	91.7	11	France	46.3
4	Japan	84.0	12	Italy	45.4
5	United States	82.7	13	Canada	41.0
6	Israel	72.1	14	Germany	39.4
7	New Zealand	66.7	15	Turkey	24.0
8	Norway	65.7	N/A	Singapore	N/A

Source: OECD (2018b)

Table A.34: Consumer trust in technology, 2017

Rank	Country	Digital Evolution Index	Rank	Country	Digital Evolution Index
1	Norway	3.79	9	New Zealand	3.54
2	Denmark	3.72	10	Japan	3.52
3	Singapore	3.69	11	Germany	3.36
4	Korea	3.68	12	France	3.25
5	United Kingdom	3.67	13	Israel	3.14
6	United States	3.61	14	Spain	2.95
7	**Australia**	**3.55**	15	Italy	2.58
8	Canada	3.55	16	Turkey	2.49

Source: Tufts University (2017)

Table A.35: Investment in ICT R&D, 2015

Rank	Country	ICT R&D as a percentage of GDP (%)	Rank	Country	ICT R&D as a percentage of GDP (%)
1	Korea	1.74	9	Canada	0.22
2	Israel	1.61	10	Denmark	0.20
3	United States	0.68	11	United Kingdom	0.17
4	Japan	0.53	**12**	**Australia**	**0.14**
5	Singapore	0.45	13	Turkey	0.14
6	Germany	0.35	14	New Zealand	0.13
7	Norway	0.31	15	Italy	0.12
8	France	0.27	16	Spain	0.08

Source: OECD (2017a)

Table A.36: E-commerce, 2015

Rank	Country	Rank	Country
1	United States	9	Singapore
2	United Kingdom	10	Denmark
3	Japan	11	Spain
4	Germany	12	Norway
5	France	13	Italy
6	Korea	14	New Zealand
7	**Australia**	N/A	Turkey
8	Canada	N/A	Israel

Source: A.T. Kearney (2015)

Table A.37: E-commerce, 2013

Rank	Country	Rank	Country
1	Japan	9	Singapore
2	United States	10	New Zealand
3	United Kingdom	11	Turkey
4	Korea	12	Norway
5	Germany	13	Denmark
6	France	N/A	Spain
7	**Australia**	N/A	Turkey
8	Canada	N/A	Israel

Source: A.T. Kearney (2013)

Table A.38: Businesses' broadband connectivity, 2016

Rank	Country	Percentage of businesses with broadband (%)	Rank	Country	Percentage of businesses with broadband (%)
1	Korea	99.3	9	Japan	94.5
2	Canada	98.1	10	United Kingdom	94.3
3	Spain	97.4	11	Italy	94.2
4	**Australia**	**97.0**	12	Norway	93.4
5	France	95.5	13	Turkey	92.6
6	New Zealand	95.4	N/A	USA	N/A
7	Denmark	94.8	N/A	Israel	N/A
8	Germany	94.7	N/A	Singapore	N/A

Source: OECD (2017a)

Table A.39: Businesses' broadband connectivity, 2010

Rank	Country	Percentage of businesses with broadband (%)	Rank	Country	Percentage of businesses with broadband (%)
1	Korea	98.4	9	United Kingdom	88.0
2	Spain	95.4	10	Norway	86.8
3	**Australia**	**94.4**	11	Denmark	86.6
4	Canada	94.3	12	Italy	84.0
5	New Zealand	93.5	13	Japan	79.7
6	France	93.3	N/A	USA	N/A
7	Germany	89.3	N/A	Israel	N/A
8	Turkey	88.8	N/A	Singapore	N/A

Source: OECD (2017a)

Table A.40: Use of cloud technology, 2016

Rank	Country	Percentage of businesses using cloud services (%)	Rank	Country	Percentage of businesses using cloud services (%)
1	Japan*	44.6	9	France	17.1
2	Denmark	41.6	10	Germany	16.3
3	Norway	39.7	11	Korea*	12.9
4	United Kingdom	34.7	12	Turkey	10.3
5	**Australia**	**30.7**	N/A	New Zealand	N/A
6	Canada	30.5*	N/A	United States	N/A
7	Italy	21.5	N/A	Singapore	N/A
8	Spain	18.3	N/A	Israel	N/A

* Data for selected countries was unavailable for 2016. Data was only available for Japan and Korea in 2015; and Canada in 2012.

Source: OECD (2017b)

Table A.41: ICT sector's contribution to economic activity, 2015

Rank	Country	ICT's percentage of total industry value added (%)	Rank	Country	ICT's percentage of total industry value added (%)
1	Korea	10.3	9	Canada	4.0
2	United States	6.0	10	Spain	3.8
3	Japan	6.0	11	Italy	3.6
4	United Kingdom	5.4	12	Norway	3.5
5	Germany	5.0	13	Turkey	2.7
6	France	4.6	N/A	Israel	N/A
7	**Australia**	**4.4**	N/A	New Zealand	N/A
8	Denmark	4.2	N/A	Singapore	N/A

Source: OECD (2017a); ABS (2017b); and IBISWorld (2018)

Table A.42: ICT services exports, 2016

Rank	Country	ICT services' share of total exports (%)	Rank	Country	ICT services' share of total exports (%)
1	Israel	12.02	9	Italy	1.63
2	United Kingdom	3.23	10	Canada	1.42
3	Spain	2.81	11	Singapore	1.32
4	Denmark	2.57	12	New Zealand	1.28
5	France	2.29	**13**	**Australia**	**1.03**
6	Germany	2.04	14	Korea	0.61
7	United States	1.71	15	Japan	0.47
8	Norway	1.70	16	Turkey	0.09

Source: WTO (2018)

Table A.43: ICT services exports, 2011

Rank	Country	ICT services' share of total exports (%)	Rank	Country	ICT services' share of total exports (%)
1	United Kingdom	2.61	9	Norway	1.23
2	United States	1.93	10	New Zealand	1.15
3	Canada	1.87	11	Singapore	0.74
4	France	1.82	**12**	**Australia**	**0.54**
5	Denmark	1.44	13	Japan	0.39
6	Israel	1.39	14	Turkey	0.27
7	Germany	1.38	15	Korea	0.20
8	Italy	1.35	16	Spain	N/A

Source: WTO (2018)

Table A.44: ICT workforce, 2016

Rank	Country	ICT specialists' percentage of total employment (%)	Rank	Country	ICT specialists' percentage of total employment (%)
1	United Kingdom	4.95	9	Spain	3.01
2	Canada	4.72	10	Italy	2.76
3	Denmark	4.41	11	Turkey	1.06
4	United States	4.06	N/A	Israel	N/A
5	**Australia**	**3.77**	N/A	Japan	N/A
6	Germany	3.58	N/A	Korea	N/A
7	Norway	3.43	N/A	New Zealand	N/A
8	Canada	3.09	N/A	Singapore	N/A

Source: OECD (2017a)

Table A.45: Cyber capabilities and framework, 2017

Rank	Country	Global Cybersecurity Index	Rank	Country	Global Cybersecurity Index
1	Singapore	0.925	9	Korea	0.782
2	United States	0.919	10	New Zealand	0.718
3	**Australia**	**0.824**	11	Israel	0.691
4	France	0.819	12	Germany	0.679
5	Canada	0.818	13	Italy	0.626
6	Japan	0.786	14	Denmark	0.617
7	Norway	0.786	15	Turkey	0.581
8	United Kingdom	0.783	16	Spain	0.519

Source: ITU (2017)

Table A.46: Adult digital literacy, 2012

Rank	Country	PIACC score	Rank	Country	PIACC score
1	Japan	294	9	Canada	282
2	**Australia**	**289**	10	United Kingdom	279
3	New Zealand	287	11	United States	277
4	Singapore	287	12	Israel	274
5	Norway	286	13	Turkey	253
6	Denmark	283	N/A	France	N/A
7	Korea	283	N/A	Italy	N/A
8	Germany	283	N/A	Spain	N/A

Source: OECD (2012a)

Table A.47: ICT graduates' share of total graduates, 2015

Rank	Country	Share of total graduates (%)	Rank	Country	Share of total graduates (%)
1	New Zealand	6.54	9	Norway	3.13
2	Germany	4.54	10	Italy	3.11
3	Denmark	4.36	11	France	3.06
4	Spain	3.95	12	Canada	2.70
5	Israel	3.84	13	South Korea	2.14
6	**Australia**	**3.77**	14	Turkey	1.89
7	United Stated	3.64	15	Japan	N/A
8	United Kingdom	3.61	16	Singapore	N/A

Source: OECD (2018c)

Table A.48: Year 9 student achievement in mathematics, 2015

Rank	Country	PISA score for Year 9 students	Rank	Country	PISA score for Year 9 students
1	Singapore	564	**9**	**Australia**	**494**
2	Japan	532	10	France	493
3	Korea	524	11	United Kingdom	492
4	Canada	516	12	Italy	490
5	Denmark	511	13	Spain	486
6	Germany	506	14	Israel	470
7	Norway	502	15	United States	470
8	New Zealand	495	16	Turkey	420

Source: OECD (2018d)

Table A.49: Year 9 student achievement in mathematics, 2012

Rank	Country	PISA score for Year 9 students	Rank	Country	PISA score for Year 9 students
1	Singapore	573	9	France	495
2	Korea	554	10	United Kingdom	494
3	Japan	536	11	Norway	489
4	Canada	518	12	Italy	485
5	Germany	514	13	Spain	484
6	**Australia**	**504**	14	United States	481
7	Denmark	500	15	Israel	466
8	New Zealand	500	16	Turkey	448

Source: OECD (2018d)

Table A.50: Year 9 student achievement in science, 2015

Rank	Country	PISA score for Year 9 students	Rank	Country	PISA score for Y ear 9 students
1	Singapore	556	9	Denmark	502
2	Japan	538	10	Norway	498
3	Canada	528	11	United States	496
4	Korea	516	12	France	495
5	New Zealand	513	13	Spain	493
6	**Australia**	**510**	14	Italy	481
7	Germany	509	15	Israel	467
8	United Kingdom	509	16	Turkey	425

Source: OECD (2018d)

Table A.51: Year 9 Student achievement in science, 2012

Rank	Country	PISA score for Year 9 students	Rank	Country	PISA score for Year 9 students
1	Singapore	551	9	France	499
2	Japan	547	10	Denmark	498
3	Korea	538	11	United States	497
4	Canada	525	12	Spain	496
5	Germany	524	13	Norway	495
6	**Australia**	**521**	14	Italy	494
7	New Zealand	516	15	Israel	470
8	United Kingdom	514	16	Turkey	463

Source: OECD (2018d)

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