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Future workforce trends in NSW: Emerging technologies and their potential impact

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by Chris Angus

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EXECUTIVE SUMMARY

With the advent of the digital age, the pace of change and the scope and capacity for innovation have increased exponentially. Experts predict that emerging information and communication technologies, such as cloud computing and advanced machine learning techniques, will have a dramatic impact on the labour force, which will see both growing demand for new skills and occupations, and job losses in a number of more vulnerable industries.

Past and ongoing computerisation of the workforce

Since the 1970s Australia has pivoted away from goods producing sectors such as agriculture, mining and manufacturing towards the services industry. As of 2015, the Australian services sector is responsible for almost 80% of Australia's $1.6 trillion economy, and employs over 10 million people (86.7% of the workforce).

Australia's shift towards a services-dominated economy has much to do with the phenomenon known as computerisation; job automation using computer-controlled equipment. The ongoing computerisation of work in Australia has resulted in job polarisation: a decrease in middle skill jobs and increase in the share of high and low skill jobs. **[2.1]**

In NSW, as elsewhere, the emergence of low cost computers over the past few decades that can quickly and reliably perform routine tasks has resulted in substantial growth in non-routine occupations; primarily low and high income jobs in the services sector. In contrast, occupations characterised by routine tasks, such as bookkeepers or manufacturing workers, have seen very limited growth during this period. **[2.2]**

Characteristics of future work

Technology is expected to bring net benefits to a workforce that will largely, but not entirely, adapt to change. A number of skills will become increasingly sought after by employers, including science, technology, engineering and mathematics (STEM) skills, or hybrid skillsets such as project management and nanotechnology. **[3.1]**

Experts have identified five overarching technological developments in the field of information and communications technology (ICT) that are predicted to have the most profound impact on the Australian workforce: **[3.2]**

- Cloud services;
- The "Internet of Things";
- "Big Data";
- Machine learning and robots; and
- Immersive communications.

Importantly, existing ICT and emerging technologies have two features that differentiates them from previous technological developments: **[3.2.2]**

1. ICT functions as a true general purpose technology, comparable to electricity; and
2. Emerging technology has the potential for its cognitive capacity to be greatly expanded in future, allowing machines to perform many tasks more effectively than humans ever could.

Opportunities and risks in the future workforce

There are a number of future opportunities predicted to emerge as a result of technological innovation. These opportunities, such as lower barriers when starting a business, greater workplace flexibility, and significant productivity gains, may offer individuals more creative, independent and meaningful work.

The “winners” of technological changes to the workforce are likely to be “knowledge workers” such as professionals, managers, engineers, and scientists. In part, this is because skilled workers are better at adapting to technological change than their lower skilled counterparts. **[4.1]**

There are a number of emerging risks in the future workforce: namely, increased unemployment, rising income inequality between skilled and unskilled labour, and job insecurity as people increasingly perform contract and part-time work. These trends are likely to continue in future, possibly resulting in macroeconomic instability similar to that faced during the Global Financial Crisis.

While middle skill occupations have traditionally borne the brunt of computerisation, new machine learning techniques and other technological advances mean that a growing number of low skill service workers are expected to become the new “losers” of technological change. Previous rounds of computerisation have disproportionately impacted male blue collar workers; given the substantial size of the services sector, the future may see large numbers of low skill workers missing out on the benefits of emerging technology, or forced out of the workforce entirely. **[4.2]**

Predicted future impacts of computerisation

Computerisation may have a dramatic impact on jobs across the global workforce. An influential 2013 paper by Frey and Osborne serves as the basis for a number of later studies in this area of research.

The authors argue that emerging technologies will rapidly replace labour across a range of non-routine tasks, and will usher in two further waves of computerisation. The first wave will see a large number of transportation, manufacturing and white collar jobs computerised. However, a “technological plateau” caused by several engineering bottlenecks will slow computerisation, with the second wave of computerisation only commencing once these bottlenecks can be overcome.

Frey and Osborne concluded that up to 47% of US jobs have a high risk of being computerised within the next decade or two. Other studies using Frey and Osborne's methodology have made similar findings, with a 2014 study reporting that 35% of jobs in the UK, and 30% of jobs in London, are at high risk of disappearing over the next two decades. **[5.2]**

Using Frey and Osborne's methodology, a 2015 study by CEDA found that nearly 40% of current Australian jobs have a high risk of being computerised within the next 10 to 15 years. Turning to Australian youth, a study by the Foundation of Young Australians estimated that up to 70% of young workers enter occupations that are highly vulnerable to computerisation **[5.3]**

The potential impact of computerisation in NSW

To date, Australian research on the impacts of computerisation has had a national focus. This paper on the other hand uses CEDA data, in turn based on Frey and Osborne's methodology, to estimate the susceptibility of NSW jobs to computerisation.

Replicating CEDA's analysis, approximately two out of five (40.9%) NSW jobs are in the highest risk category for the probability of computerisation over the next 10 to 15 years. Several major employment groups, notably labourers, and machinery operators and drivers, have very high probabilities of computerisation. **[6.1]**

NSW occupations have a risk of being computerised of between 3% and 96.4%. On average, 51.58% of all NSW jobs are at risk of being computerised in the next 10 to 15 years. See Appendix A for methodology.

This paper also maps the estimated probability of job loss due to computerisation by NSW State electorate. According to the analysis, electorates with greater numbers of low and middle skilled workers have greater exposure to job computerisation. Conversely, electorates with higher proportions of managers or professionals have a lower likelihood of job computerisation. **[6.2-6.3]**

Policies to transition to a future work environment

Many commentators argue that policies should be developed that most effectively realise the benefits of emerging technology on one hand, and provide protections for those who will be adversely affected on the other. **[7.1]**

At both the State and Commonwealth level there have been a number of policy initiatives aimed at helping the Australian workforce adapt to changing technology. In NSW, the State Government has developed a series of Economy Industry Action Plans to encourage government and industry collaboration to drive innovation and competitiveness, while also announcing other related education and business policies.

Elsewhere in Australia, both the Victorian and Queensland Governments have established funds designed to support industry sectors with the potential for high economic growth and the capacity to create high skill, high wage jobs. Additionally, the Commonwealth Government has committed funding for STEM and computer coding courses in Australian schools. **[7.2]**

Of the many policy proposals in response to changing workforces, an increased focus on high quality and specialised education is the most widely supported. Increased STEM education has been strongly advocated by experts, as these skills not only benefit individuals but also have flow-on benefits to the community as a whole.

However, the Office of the Chief Scientist has criticised the existing state of STEM in Australia, citing a lack of coordination, misdirected effort, instability and duplication between Australian governments. In response, the Office of the Chief Scientist outlined several strategies to try and mitigate these issues at both the State and Commonwealth level. **[7.3]**

In addition to improving education, a range of other policies are worth noting, these being either currently in use overseas or advocated by policymakers: **[7.4]**

- **"Flexicurity" and Active Labour Market Policies:** An industrial relations policy used in European countries such as Denmark, whereby employers are given the 'flexibility' to hire and fire workers, and employees granted 'security' through generous unemployment benefits and comprehensive training programs helping them gain new job skills;
- **Initiatives for startup companies:** A number of policies that can be implemented at the State level include increased funding avenues, entrepreneurship leave, and steps to reduce a systemic fear of failure that is a major impediment to startup activity in Australia;
- **Inclusive growth:** A series of policies that invest investment in human capital, which can subsequently produce a range of economic benefits. Examples include tax reform to shift tax burdens from labour towards consumption, and ongoing and increased investment in skills and training for workers.

1. INTRODUCTION

In the industrial era the world of work, and the way society functions more generally, has been shaped and reshaped by technological innovation. With the advent of the digital age, the pace of change and the scope and capacity for innovation have increased exponentially. It is now the case that even seemingly minor developments can bring about rapid and significant change in our day-to-day lives. Two recent examples are the impact of the app-based platforms Uber and Airbnb on the traditional taxi and hotel industries respectively.[1]

Experts have long predicted that emerging information and communication technologies (referred to as "emerging technology" in this paper) will have a dramatic impact on global societies. These trends have occurred for a number of decades, with positive and negative consequences for communities across the world.

The focus of this paper is on the *future* implications of emerging technology for the labour force; namely, how new technology, such as cloud computing, "Big Data", and advances in machine learning techniques, may drive the creation of new skills and jobs while simultaneously rendering obsolete other forms of work, even entire industries.

This briefing paper outlines the key emerging technologies expected to affect the Australian (and the world's) workforce, with particular emphasis on advanced machine learning techniques that will allow computers to take over jobs currently performed only by humans. The paper lists the possible characteristics of future workplaces and workers, and the opportunities and risks that are likely to arise in the coming decades. The "computerisation" of the workforce, both now and into the future, is discussed, with a summary of existing research showing the predicted impact of this phenomenon on global workforces.

Focusing on NSW, the briefing paper then applies existing research to State electorates in order to determine which workforces in which areas of NSW are most, and least, likely to be affected by computerisation. The paper concludes with a snapshot of existing and proposed policy ideas which may assist NSW, and Australia more broadly, to transition into the new world of work.

[1] For further information on these platforms and their impact in NSW, see A Haylen, Uber and Airbnb: the legal and policy debate in NSW, NSW Parliamentary Research Service, e-brief 6/2015.

2. PAST AND ONGOING COMPUTERISATION OF THE WORKFORCE

The ability of technology to reshape the workforce is not a new phenomenon. During the 19th century the Industrial Revolution ushered in a radical shift from artisan work to the factory system, increasing productivity, demand for low skill workers, and ultimately benefiting ordinary people as producers. Similarly, the switch to electricity and the displacement of the steam engine in the early 20th century saw a rise in demand for high school-educated workers, leading to what has been described as "the race between technology and education".[2]

This chapter briefly outlines the most recent reshaping of the NSW workforce; namely, the shift towards a predominantly service-based economy, accompanied by a disproportionate reduction in middle skill jobs. It then discusses the computerisation of jobs – an ongoing process that has radically altered how we work.

2.1 Previous changes to the NSW workforce

2.1.1 The rise of the services industry

Since the 1970s the declining cost of computers, along with reduced industry protection and the increasing productivity and sophistication of manufacturing in Asian countries, has seen Australia's industry mix change dramatically. Between 1975 and 2014, manufacturing's share of total employment has more than halved, while employment in the utilities, construction and communication sectors has also declined. [3]

In contrast, services industries, particularly areas such as health, finance, retail and education, have seen substantial rises in their share of the Australian workforce. As of 2015, the Australian services sector is responsible for almost 80% of Australia's $1.6 trillion economy, and employs over 10 million people (86.7% of the nation's workforce).[4]

Figure 1 shows the dominant position of the services industry in the NSW economy compared to non-service sectors; namely agriculture, mining, manufacturing and construction. It also indicates that there is substantially higher employment and gross value added[5] in service industries than non-service industries.

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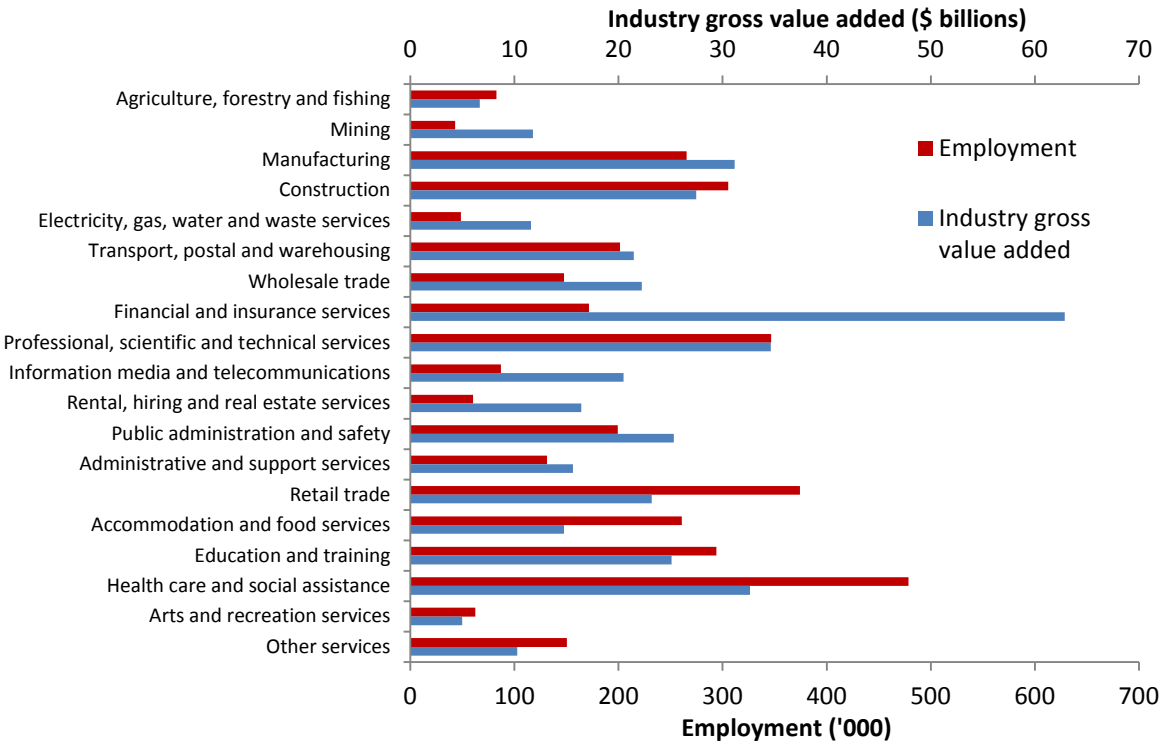
[2] C Frey, M Osborne, Technology at work: The future of innovation and employment, Citigroup, February 2015, pp 16-7.

[3] P Lewis, 'Technological and structural change in Australia's labour market' in Committee for Economic Development of Australia, *Australia's future workforce?* (2015) 109, p 111.

[4] T Bradley, 'Australia's shifting economy' in Committee for Economic Development of Australia, *Australia's future workforce?* (2015) 98, p 100.

[5] The value of output at basic prices minus the value of intermediate consumption at purchasers' prices. Note that State GVA in current prices is not directly compiled so the Australia GVA by industry is allocated to the states using factor income shares. See Australian Bureau of Statistics, Australian National Accounts: State Accounts, 2014-15, Cat No 5220.0, November 2015, Glossary.

Figure 1: Gross value added and employment by NSW industry, 2014-15[6]



Various factors have impacted Australian industry over the past few decades, with some drivers affecting particular industries more than others. For example, as discussed in the Committee for Economic Development of Australia's 2015 report *Australia's future workforce?* (CEDA Report), the partial deregulation and privatisation of the utilities sector in the 1990s and 2000s resulted in substantial restructuring and labour shedding. Similarly, tariff reductions and the ability to outsource work to Asian nations have disproportionately impacted the manufacturing sector.[7]

However, these factors alone have not brought about the changes to Australia's industry mix. As discussed below, many studies have concluded that technological change has played a key role in bringing systematic change to the Australian (and the world's) workforce.

2.1.2 Computerisation and the routinisation hypothesis

Australia's shift towards a services-dominated economy has much to do with the phenomenon known as "computerisation". Computerisation—also referred to as "automation", "computerisation and automation", or "computerisation and technology"—is defined as "job automation by means of computer-controlled equipment."[8]

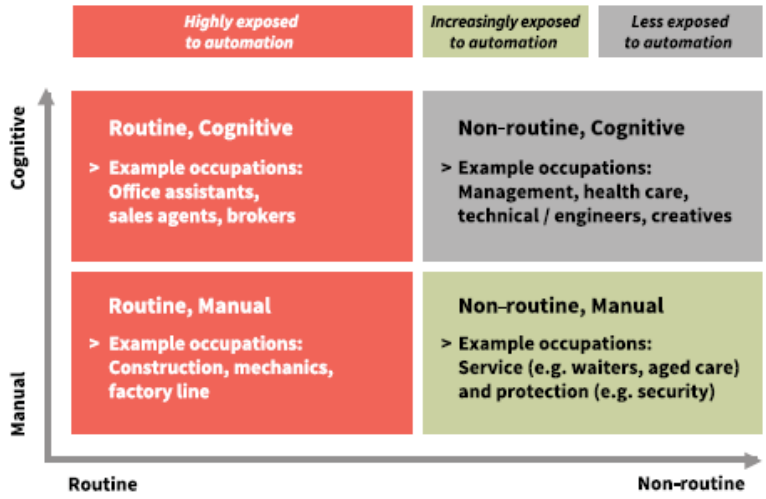
[6] Ibid Table 2.

[7] Lewis, note 3, p 111.

[8] C Frey, M Osborne, The future of employment: how susceptible are jobs to computerisation?,

The theory underpinning this trend, known as the *routinisation hypothesis*,[9] was developed in 2003 by Autor, Levy and Murnane. Their study broadly categorised occupations as comprising manual and/or cognitive tasks, which are carried out in either routine or non-routine ways (see Figure 2):[10]

Figure 2: Exposure of workplace tasks to computerisation[11]



Autor et al explain the shift to services-dominated economies by reference to the way in which computers and robots have been particularly efficient at performing routine tasks, such as repetitive customer service tasks or record keeping. In contrast, non-routine tasks have traditionally proven harder to computerise, as their rules have not been sufficiently well understood to be specified in computer code and executed by machines.[12]

Frey and Osborne have argued that, due to technological advances, Autor et al's model no longer applies. This is because computers can now conduct a range of non-routine tasks previously only performable by humans, thereby increasing the risk that these jobs will be computerised.[13] For further discussion of the emerging technologies instigating this change, and their impact on global workforces, see chapters 3.2 and 5.

While the routinisation hypothesis may not apply in future, it nevertheless explains the changes that have affected global workforces from the 1970s until the present day. This is discussed further in the next section.

Working Paper, 17 September 2013, p 2. Note that the CEDA Report refers to this phenomenon as "computerisation and automation".

[9] J Borland, M Coelli, 'Information technology and the Australian labour market' in Committee for Economic Development of Australia, *Australia's future workforce?* (2015) 131, p 133.

[10] D Autor, F Levy, R Murnane 'The skill content of recent technological change: an empirical exploration' (2003) 118 *The Quarterly Journal of Economics* 1279.

[11] Foundation for Young Australians, The New Work Order: Ensuring young Australians have skills and experience for jobs of the future, not the past, August 2015, p 11.

[12] Autor et al, note 10, p 1283.

[13] Foundation for Young Australians, note 11, p 11; Frey and Osborne, note 8, pp 22-3.

2.1.3 Job polarisation and the "hollowing out" of middle skill jobs

As highlighted in Figure 2, routine work is highly vulnerable to computerisation. According to Frey and Osborne, this vulnerability has been exacerbated by widespread reductions in computing costs, which create major economic incentives for employers to substitute computer capital for human labour.[14]

While occupations of all income or skill levels which involve high levels of routine work run the risk of computerisation, it is middle skill jobs (see breakout box) that have been disproportionately affected over recent decades. This is mainly a consequence of two characteristics of these occupations:

1. Middle skill jobs have generally contained the highest concentration of routine tasks, and as a result are the easiest to replace by computers;[19] and
2. The higher wages of middle skill occupations have meant that businesses are more likely to computerise these jobs first in a bid to reduce costs.[20]

What are middle skill occupations?

Middle skill occupations are jobs that generally fall within the middle third of wage percentiles.[15] Although "middle skill" may not always accurately describe the tasks performed by these workers, in general middle skill workers perform predominantly routine tasks that require intermediate levels of training.[16] A 2007 British study by Goos and Manning found that:

> Of workers in occupations earning between the 33rd and 66th wage percentiles, 63% require above-average routine cognitive [skills] and 58% above-average routine manual skills. These numbers are higher than for any other specified wage range.[17]

Routine cognitive work is often characteristic of sales and office-related professions (e.g. administrative secretaries, bookkeepers), while routine manual tasks are done mainly in the services sector (e.g. healthcare support, cashiers) as well as the manufacturing sector.[18]

Once total growth in the Australian labour force is accounted for, middle skill (and certain low skill) occupations have experienced either very little or negative jobs growth over the past few decades.[21] In particular, blue collar middle skill workers have suffered the most from a combination of technological innovation and other economic forces, such as the reduction of tariffs on imported goods:

> Over the past 25 years, we have lost around 100,000 machinery operator jobs,

[14] Frey and Osborne, note 8, p 14.

[15] M Goos, A Manning, 'Lousy and lovely jobs: The rising polarization of work in Britain' (2007) 89 *The Review of Economics and Statistics* 118, p 120.

[16] A Feng, G Graetz, Rise of the Machines: the Effects of Labor-Saving Innovations on Jobs and Wages, Centre for Economic Performance, CEP Discussion Paper No 1330, February 2015, p 3. Also see Citigroup, note 2, p 19.

[17] Goos and Manning, note 15.

[18] Citigroup, note 2, p 19; Frey and Osborne, note 8, p 3.

[19] Citigroup, note 2, p 19.

[20] Feng and Graetz, note 16, p 3.

[21] Foundation for Young Australians, note 11, p 12.

> nearly 400,000 labourers, and nearly 250,000 jobs from the technicians and trades. … nearly one in ten unskilled men lost their jobs and did not return to the labour force. Today, more than one in four unskilled men don't participate. Big economic shifts are not costless for everyone.[22]

In contrast, both high and low skill occupations have been less affected by computerisation. According to a 2015 report by Citigroup, this is because many jobs within these two groups involve non-routine tasks, requiring either cognitive capacity or manual labour to complete them:

> At the high end, these include jobs in managerial and professional occupations, such as those in law, architecture and design, and finance; at the low end, jobs requiring manual labour are found in the construction sector, in installation and maintenance, and in the transportation and shipping sectors (e.g. truck drivers), to name a few.[23]

Feng and Graetz have argued that low skill occupations are shielded from computerisation not only because many tasks they perform are highly complex in engineering terms (and are therefore difficult to computerise), but also because these workers are cheaper to hire than middle or high skill workers.[24]

While high skill occupations attract higher wages, these workers perform tasks that are both highly complex and that require a large amount of training, rendering them less susceptible to computerisation.[25] In fact, technological advances have predominantly favoured skilled workers; computers can complement skilled workers in completing tasks,[26] while individuals entering newly created, high skill industries receive substantial wage premiums.[27]

The disproportionate computerisation of middle income jobs has led to a phenomenon called job polarisation, where growing employment in high income cognitive jobs and low income manual occupations is accompanied by the loss, or "hollowing out", of middle income routine jobs.[28] Job polarisation has occurred in Australia for some time, with the CEDA Report concluding that, since the 1970s, the proportion of middle skill occupations in the Australian workforce has declined significantly (see Table 1).[29]

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[22] Foundation for Young Australians, note 11, p 5.
[23] Citigroup, note 2, p 19.
[24] Feng and Graetz, note 16.
[25] Ibid.
[26] Autor et al, note 10, p 1280.
[27] T Berger, C Frey, Industrial Renewal in the 21st Century: Evidence from U.S. Cities, 2014, p 7.
[28] Frey and Osborne, note 8, p 3.
[29] Borland and Coelli, note 9, p 136.

Table 1: Change in employment shares by occupational skill level[30]

	Lowest pay occupations	Middle pay occupations	Highest pay occupations
Australia (1966–2011)	+2.2	–19.2	+17.0
Australia (1991–2011)	+1.5	–8.5	+7.0
Europe average (1993–2010)	+2.7	–9.9	+7.2

Job polarisation is also prevalent in other developed countries. In the United States for example, Autor et al commented that, due to computerisation, there has been a decline in routine cognitive and manual work and an increase in non-routine analytic and interactive work over the past few decades. According to the study, other possible reasons for the change, such as increased educational attainment, did not explain the shift away from routine work towards non-routine work.[31]

By reducing middle skill employment's share of the market, job polarisation has exacerbated the wage gap between high and low income jobs. As explained by Citigroup, this is because former middle skill workers find it easier to "skill down" to find a low skill job than to "skill up" into a high skill occupation. This results in an oversupply of low income workers that in turn reduces wage increases in these occupations:

> To skill up requires increased cognitive capacity, which tends to come about from education and job training – both slow moving processes. Indeed, this is why some have dubbed our era as a 'race between technology and education.' The former occurs rapidly and disruptively; the latter very slowly. The end result is that additional labour supply keeps wage growth relatively muted at the bottom, while its absence causes wages to accelerate quickly at the top.[32]

While some observers believe that computerisation will continue to polarise labour markets in the long term,[33] other experts have argued that job polarisation will not continue indefinitely. This is because, although many middle skill *tasks* are susceptible to automation, many remaining middle skill *jobs* require both routine technical tasks and non-routine tasks that are not easily computerised, such as interpersonal interaction, flexibility, adaptability and problem-solving skills.[34]

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[30] Ibid p 136.

[31] Autor et al, note 10, p 1281.

[32] Citigroup, note 2, p 21.

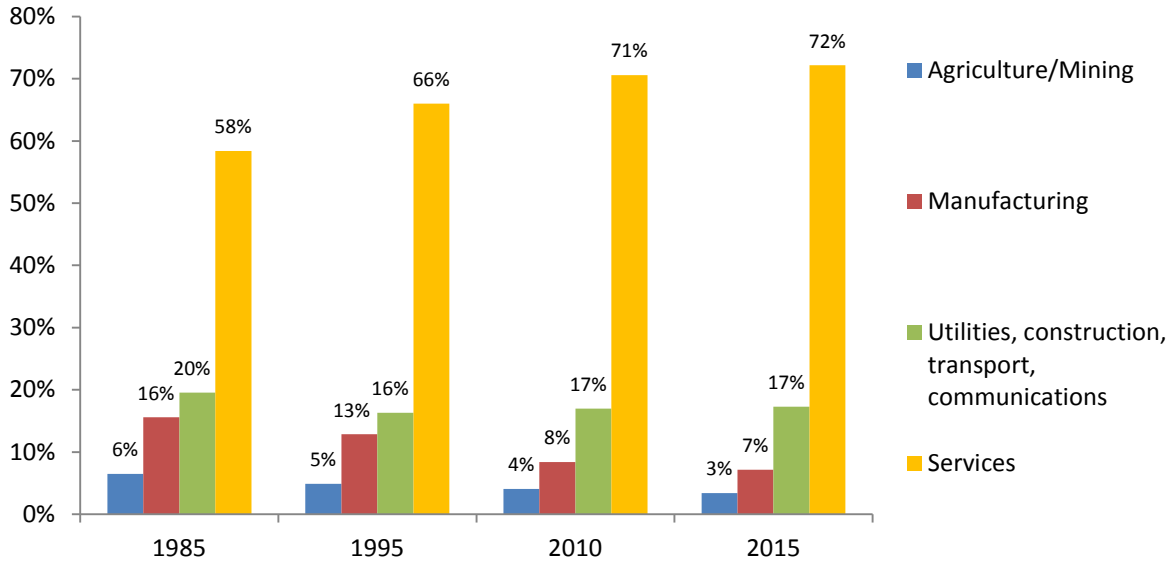
[33] Feng and Graetz, note 16.

[34] D Autor, Polanyi's Paradox and the Shape of Employment Growth, National Bureau of Economic Research, NBER Working Paper No 20485, September 2014, pp 39-40.

2.2 Computerisation and its impact on NSW jobs

The emergence of low cost computers that can quickly and reliably perform routine tasks has had a strong impact on the skills that are in demand in the NSW labour market. With increased demand for non-routine skills such as interpersonal interaction, there has been a significant rise in "soft" services industries as a total proportion of the State's workforce, while the proportion of goods-producing jobs in agriculture, mining and manufacturing has shrunk (Figure 3):

Figure 3: Employment share by industry in NSW, 1985 to 2015[35]



Figures 4 and 5 overleaf show the growth in NSW jobs by occupation over the past 30 years. Non-routine jobs have grown substantially over this time period, particularly low income community and personal service roles. In contrast, occupations characterised by routine tasks have seen very limited growth over the past few decades compared to the overall growth of the NSW workforce:

[35] Australian Bureau of Statistics, Labour Force, Australia, Detailed, Quarterly, Cat No 6291.0.55.003. This figure replicates a similar chart for Australia in Lewis, note 3, p 111. Note that "Services" includes the following industry sectors: wholesale trade; retail trade; accommodation and food services; financial and insurance services; rental, hiring and real estate services; professional, scientific and technical services; administrative and support services; public administration and safety; education and training; health care and social assistance; arts and recreation services; and other services.

Figure 4: Growth in number of NSW jobs by occupation, 1986 to 2015 (%)[36]

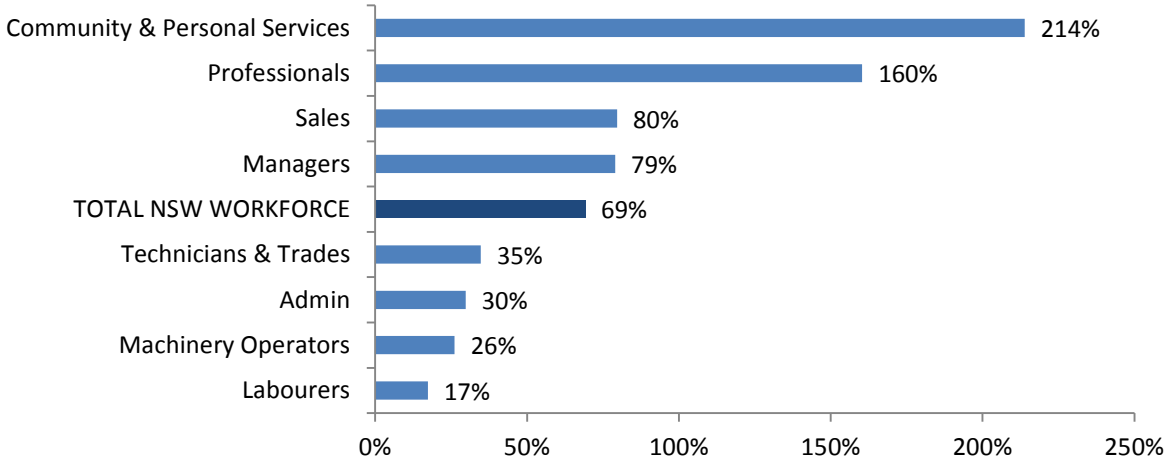
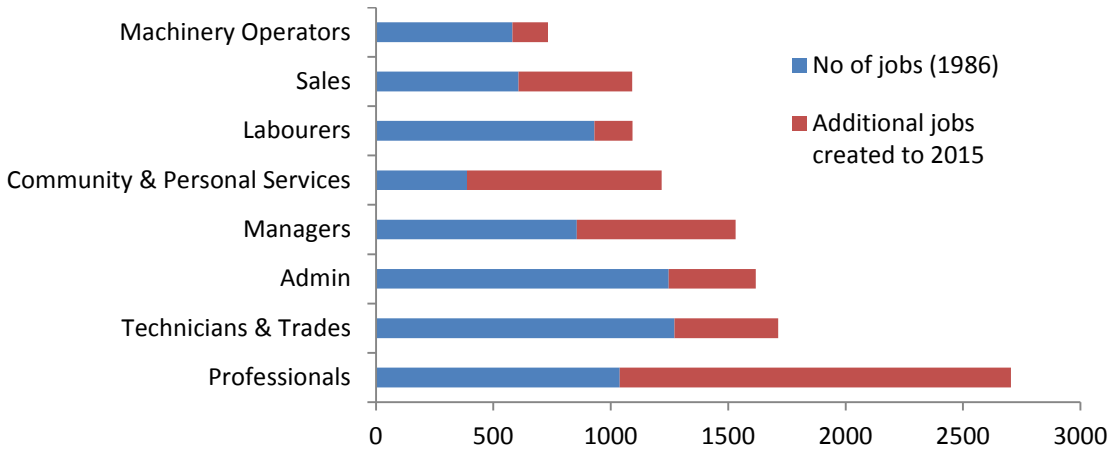


Figure 5: Growth in number of NSW jobs by ANZSCO Major Group, 1986 to 2015 ('000)[37]



[36] Australian Bureau of Statistics, note 5.

[37] Ibid. For further information regarding ANSZCO occupation classifications see Australian Bureau of Statistics, Census Dictionary, 2011, Cat No 2901.0.

3. CHARACTERISTICS OF FUTURE WORK

Although predictions of job computerisation may appear grim, very few (if any) experts expect widespread catastrophe to ensue as a result of technological innovation. Instead, many believe that technology will bring a net benefit to the workforce, which will largely (but not entirely) adapt to change.

This chapter outlines the likely characteristics of the future workforce, including the skills likely to be of value to the labour market, key emerging technologies, and how these new technologies differ from earlier innovations.

3.1 Increasing demand for particular skills

A 2014 paper by the UK Commission for Employment and Skills summarised what it believes will be the key aspects of the UK labour market in 2030:

- Technological growth and expansion: resulting in changing skills needs across all sectors. For example, new construction technologies will require people with specialised building and maintenance skills.
- Interconnectivity and collaboration: work will become increasingly virtual and collaborative, requiring excellent people and project management skills.
- Convergence of innovation: innovative breakthroughs will result from cross-disciplinary working and the exploitation of novel materials and technologies. Businesses will increasingly seek people with hybrid skillsets, such as project management and nanotechnology.
- Increased individual responsibility for skills development. [38]

The Commission for Employment and Skills also identified four key drivers for skill demand in the future workforce, which are summarised below:

Table 2: Drivers of skill demand in the workplace[39]

Technical change	A range of key trends driven by technological innovation are expected to occur by 2030, including on-demand manufacturing (e.g. 3D printing technology), the emergence of regenerative medicines, and the use of new materials. To maximise the economic potential of these breakthroughs, it will be necessary to create an infrastructure to move innovations from initial ideas into the marketplace, such as improved links between industry and research institutions.
Competition and globalisation	As trade barriers continue to lower, firms have increased choice regarding the location of production. Simultaneously, developments in ICT make it possible for products and services to be produced anywhere in the world and exported, taking advantage of relative economic advantages possessed by a particular country.

[38] UK Commission for Employment and Skills, The Labour Market Story: Skills For the Future, Briefing Paper, July 2014, p 21.

[39] Ibid pp 2-6.

Demographic change	An ageing population potentially gives rise to increased demand for health and social care products and services, including advanced medical self-diagnostic kits and telemedicine that allows remote imaging and diagnosis.
Corporate strategic choice	Trade liberalisation brings with it the prospect of greater competition from elsewhere in the world. As such, several countries have placed a premium on the innovation process and on having a strong supply of people qualified in science, technology, engineering and mathematics (STEM) careers, allowing them to dominate the production of high value goods which depend on highly skilled workers.

Given the similarity of Australia's labour market to that of the UK,[40] it is likely that the same demand for and drivers of these skills will apply in this country.

3.2 Emerging technologies

There are many examples of technological developments that experts believe can transform the way we live. Rather than provide an exhaustive list of all possible innovations, this paper outlines key emerging technologies that are likely to have the greatest impact on the Australian workforce and wider society.

3.2.1 Key trends in technological development

In June 2015 the Committee for Economic Development of Australia (CEDA) released the report *Australia's future workforce?* (CEDA Report), which drew together contributions from over 25 authors on past and future Australian labour force trends.

As shown in Table 3, the CEDA Report identified five overarching technological developments that it believes will have the most profound impact on the Australian workforce:

Table 3: Emerging technologies expected to affect the workplace[41]

Technology	Overview
Cloud services	Cloud services deliver on-demand computing resources over the internet, generally on a pay-for-use basis. Such services range from individual software programs to "infrastructure as a service", which can provide organisations with all necessary computing resources including servers, networking, storage, and data centre space.[42]

[40] For example, according to the World Bank both Australia and the UK have similar sized services sectors (70.4% of GDP in Australia; 79.6% in the UK). In a separate study, CEDA argued that both nations have similar levels of occupations susceptible to computerisation. See World Bank, Data: Services, etc., value added (% of GDP), 2011-2015; H Durrant-Whyte, L McCalman, S O'Callaghan, A Reid, D Steinberg, 'The impact of computerisation and automation on future employment' in Committee for Economic Development of Australia, *Australia's future workforce?* (2015) 56, p 60.

[41] H Bradlow, 'The impact of emerging technologies in the workforce of the future' in Committee for Economic Development of Australia, *Australia's future workforce?* (2015) 38, pp 40-3.

[42] IBM, What is cloud computing?, n.d.

	Cloud services allow users to operate using the same data and applications on any device that suits their current context, while also increasing security and lowering operational costs.
The Internet of Things	The "Internet of Things" (IoT) refers to a range of inexpensive, internet-connected sensors that can report measurements of the physical world. The low cost of IoT, combined with its ability to constantly record and share pertinent data, means that this technology can optimise the physical world in ways not previously possible. One example of IoT's potential can be seen in the medical field; small, unobtrusive ECG monitors allow patients to continue their daily routine, with their heart signal relayed by the user's phone to a cloud database that constantly monitors it for anomalies.
Big Data	"Big Data" refers to the ability to take massive amounts of data—often obtained through cloud services and IoT technologies—and store it in a scalable cloud-computing environment. This vast repository of information can then be analysed by machine learning techniques (see below). This enables highly accurate prediction and optimisation of outcomes; for example, by modelling the implications of business decisions, or using data to recognise anomalous heart signals from a monitor.
Machine learning and robots	The abundance of computing power and Big Data has led to significant advances in machine learning techniques, also known as 'artificial intelligence'. These techniques enable computers to perform human tasks such as natural language understanding, speech recognition and pattern recognition. Combining artificial intelligence with sensors, communications and cloud computers can create robots that are able to emulate a wide range of human capabilities. This is discussed in further detail in chapter 3.2.2.
Immersive communications	The adoption and use of broadband access technology is set to continue into the future, with faster and more widespread broadband networks allowing other technologies such as cloud services to function with greater capacity and reliability. When broadband networks are combined with rapidly developing screen technology, workers may be able to work almost anywhere for work-life balance reasons, and may even be able to compete for highly skilled jobs in other geographies.

3.2.2 What makes emerging technology different

In his 2015 book *Rise of the Robots*, Martin Ford identified two defining characteristics of information and communications technology (ICT)—both existing ICT and emerging technologies—that he contends differentiates it from earlier technological developments:[43]

[43] M Ford, Rise of the Robots: Technology and the Threat of a Jobless Future (Basic Books, 2015) pp 72-3.

1. Existing ICT has evolved into a true general purpose technology; and
2. The cognitive capacity of emerging technology is increasing to the point where machines will soon outperform humans at many workplace tasks.

According to Ford, one defining characteristic of ICT is its ability to function as a true general purpose technology, comparable to electricity. This is evident when observing how embedded this technology has become in modern society:

> There are very few aspects of our daily lives, and especially of the operation of businesses and organizations of all sizes, that are not significantly influenced by or even highly dependent on information technology. Computers, networks, and the Internet are now irretrievably integrated into our economic, social, and financial systems. IT is everywhere, and it is difficult to even imagine life without it.[44]

Ford further noted that some observers believe ICT to be a form of public utility, again comparable to electricity in its ability to transform entire societies. However, according to Ford, emerging technology will likely have a more nuanced impact on society and, unlike electricity, may not have as positive an impact on communities.[45]

The second characteristic of emerging technology is the potential for its cognitive capacity to be greatly expanded in future. This will occur as a result of new machine learning techniques, which in essence allow computers to churn through data and write their own programs based on the statistical relationships they discover.[46]

While machine learning techniques have been in continuous development for decades, it has proven difficult to get computers to perform such "human tasks" as deciphering handwriting or interpreting the meaning of text.[47] But the past decade has seen significant advances in this technology, with new computing architectures now expected to allow many tasks to be performed on a larger scale, with lower power and higher speed.[48]

A key factor facilitating the further advancement of machine learning is the availability of large amounts of Big Data. A 2015 report by Citigroup explains why:

> [Big] data serves as a substitute for the implicit knowledge human workers possess. Such data (termed training data in the parlance of machine learning) is usually drawn from recorded human judgment: for example, the data might be human-provided labels of the translation of a piece of text. As such, these data can be seen as a way of encoding human knowledge such that it can be extended to many different iterations of a task. That is, algorithms allow for

[44] Ibid p 72.
[45] Ibid pp 72-3.
[46] Ibid p 89.
[47] Citigroup, note 2, pp 24-5.
[48] Bradlow, note 41, p 41.

> scaling beyond the human: a single dataset of human judgments might be drawn upon to make decisions many times a second for years. As a result, computerisation is no longer confined to tasks that can be written as rule-based procedures a priori, but is spreading to any task where big data becomes available.[49]

The combination of machine learning techniques and Big Data not only enables computers to perform tasks that previously only human beings could perform; it allows computers to perform many tasks more effectively than humans ever could. A prominent example of this is the ability of IBM's supercomputer Watson to perform fast and accurate medical diagnoses:

> IBM's Watson system is being employed by oncologists at Memorial Sloan-Kettering Cancer Center to suggest treatment options for cancer patients. These suggestions are informed by data from 600,000 medical evidence reports, 1.5 million patient records and clinical trials, and two million pages of text from medical journals. With reference to this data, Watson can personalise a treatment plan with reference to a given patient's individual symptoms, genetics, family and medication history.[50]

Frey and Osborne identified several examples of emerging technology that can replace (or is already replacing) human workers, including:[51]

- Sophisticated algorithms that perform legal discovery tasks normally performed by paralegals;
- Inexpensive sensors that capture sounds and video in public spaces, reducing the number of law enforcement workers needed to monitor these locations; and
- Big data analysis in the education field that effectively predicts student performance, or their suitability to undertake post-graduate occupations.

It may be that the greatest benefits of recent development in machine learning are yet to be seen. Citigroup commented in this respect that productivity gains follow investment in emerging technologies with a lag of approximately 5 to 15 years. Accordingly, the technological developments we are currently seeing—such as accurate medical diagnosis by computer and self-driving vehicles—are likely to be only the tip of the technological iceberg.[52]

With this unprecedented ability to perform complex tasks, it comes as no surprise that observers such as PwC predict that machine learning "will be a source of major productivity gains … [and] will have significant implications for traditional workforces."[53]

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[49] Citigroup, note 2, p 24.

[50] Ibid pp 24-5.

[51] Frey and Osborne, note 8, pp 16-22.

[52] Ibid p 79.

[53] PwC, A smart move: Future-proofing Australia's workforce by growing skills in science, technology, engineering and maths (STEM), April 2015, p 9.

4. OPPORTUNITIES AND RISKS IN THE FUTURE WORKFORCE

This chapter discusses the opportunities that are predicted to emerge through technological innovation, and the risks and challenges faced by parts of the workforce as a result of emerging technology.

4.1 Future work opportunities

4.1.1 Positive trends

The Foundation for Young Australians identified three positive trends that it believes will arise in the Australian labour market, offering opportunities for higher productivity jobs, and more creative, independent and meaningful work:

Table 4: Opportunities in the new world of work[54]

Lower barriers to entry	Barriers that once hindered entrepreneurship are falling as a result of more efficient regulatory regimes and start-up procedures. Meanwhile, technology and globalisation are making it easier and cheaper to operate at multiple stages in the lifecycle of a startup company.
Greater flexibility	New technologies and ways of working are providing unprecedented flexibility in how and where people work, which is one of the key drivers of worker happiness. For example, research indicates that adopting digital talent platforms in Australia may add 1.9% to GDP and 271,000 jobs by 2025 as a result of higher participation and hours worked, lower unemployment and higher productivity.
Wider markets and specialisation	Technology has accelerated the division of labour and enabled companies to divide up work into ever-smaller tasks that can be sourced from a global labour pool. Young people in Australia are getting more educated and graduate at higher rates than OECD averages, creating a pipeline of high skilled talent moving into the labour force.

These trends are already beginning to emerge, as increasingly fluid career pathways, combined with technological advances, create demand for more collaborative and flexible working environments.[55] For example, a 2014 report by financial protection insurer Unum found that British employees sought highly collaborative work environments, with hot-desking, the ability to regularly change locations or teams, and opportunities to take part in workshops and other brainstorming activities.[56]

Separately, Citigroup identified several possible benefits of technological innovation in the workforce, including:[57]

[54] Foundation for Young Australians, note 11, p 8.

[55] K Fox, J O'Connor, 'Five ways work will change in the future', The Guardian (online), 29 November 2015.

[56] Unum, The Future Laboratory, The Future Workplace: Key trends that will affect employee wellbeing and how to prepare for them today, 2014, p 17.

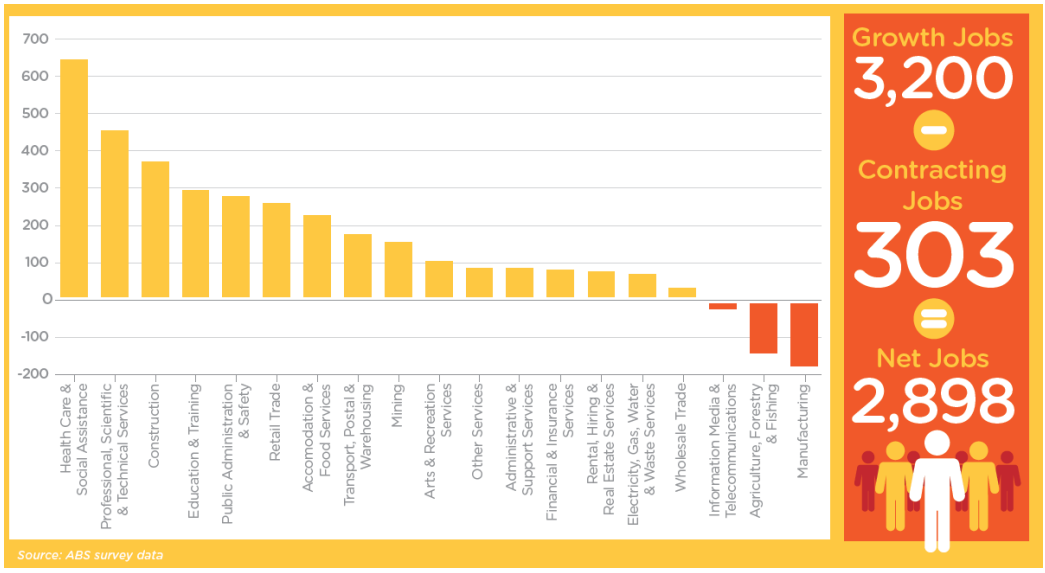
[57] Citigroup, note 2, pp 79-80.

- The potential for significant productivity gains, particularly in traditionally low productivity sectors that experience wage growth without corresponding productivity increases (e.g. healthcare and education); and
- Benefits accruing from the "sharing economy", whereby a range of online services enable people to share goods and services, reducing supply and demand costs. Example services include Uber and Airbnb.[58]

Additionally, new technology can help foster what experts have labelled "innovation jobs": highly skilled employment that makes intensive use of human capital and human ingenuity.[59] Although only constituting a small proportion of the labour force,[60] innovation jobs may serve as a catalyst for economic growth, with each innovation job indirectly creating up to five additional jobs outside the innovation sector.[61]

These positive predictions are credible: on balance, Australia has benefited from previous disruption to its workforce. In a 2015 report for NBN Co, demographer Bernard Salt commented on the relationship between job loss and job growth in Australia over the past 15 years. While job losses did occur during this period, job growth outnumbered these losses by a ratio of 10-to-one (Figure 6).[62]

Figure 6: Change in employment levels by workforce sector, 2000-2015 (by '000s employees)[63]



[58] For further information on these companies in NSW, see Haylen, note 1.

[59] E Moretti, The New Geography of Jobs (Mariner Books, 2013), p 48.

[60] 10% of all jobs in the United States according to Moretti, but as low as 0.5% of American jobs according to Berger and Frey. See Moretti, note 59, p 13; Berger and Frey, note 27, p 18.

[61] Moretti, note 59, p 13.

[62] B Salt, Super connected jobs: understanding Australia's future workforce, NBN Co, September 2015, p 6.

[63] Ibid p 7.

4.1.2 The "winners" of the future workforce

Salt has argued that, as the Australian economy continues to shift away from manufacturing and agriculture to services, there will be increased demand for "knowledge workers" such as professionals, managers, engineers, computer programmers, law graduates, and scientists.[64] This view is shared by PwC, which commented that technology and innovation are key to solving both workforce and growth challenges:

> Modelling shows that the jobs most likely to endure over the next couple of decades are ones that require high levels of social intelligence, technical ability and creative intelligence. This includes doctors and nurses, teachers, engineers, and information communication and technology (ICT) professionals, and managers.[65]

Ultimately though, technological development has historically benefited, and will continue to benefit, skilled workers. As noted by Berger and Frey, this is because skilled workers are better at adapting to technological change than their lower skilled counterparts:

> [Skilled workers] are better at implementing new ideas, adopt new technologies faster, and are more likely to reallocate to the firms with the most promising innovations. Furthermore, consistent with the evidence presented above, showing that educated workers are more likely to shift into new industries, skilled workers are also more frequently observed in new types of occupations.[66] [references omitted]

4.2 Emerging risks in the future workforce

4.2.1 Risks and challenges of future work

Even if the benefits of technology outweigh its drawbacks, negative consequences can still affect individuals and communities. One illustrative example arises from the increasing use of mobile devices for work purposes. As explained by the University of South Australia's Centre for Work + Life, while increased use of mobile email devices has benefited professional workers by allowing them to work "anywhere, anytime":

> … it also created undesirable consequences by contributing to shared expectations (a collective norm) of being constantly available and responsive, with participants feeling a compulsion to remain continually connected to incoming emails on their device.[67]

According to The Future Workplace report, being "always on" for work purposes significantly increases stress levels and the likelihood that they will leave their

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[64] Ibid p 6.

[65] PwC, note 53, p 12.

[66] Berger and Frey, note 27, p 10.

[67] B Pocock, N Skinner, Morning, noon and night: The infiltration of work email into personal and family life, Centre for Work+ Life, University of South Australia, May 2013, p 3.

job, which could cost British businesses up to £101 billion.[68]

The Foundation for Young Australians identified three major risks that policymakers will need to address in the new world of work:

Table 5: Risks in the new world of work[69]	
Unemployment	Nearly one in three young people in Australia are currently unemployed or underemployed, with occupations that help young people get their foothold in the workforce disappearing. Ongoing changes to the workforce risk growing unemployment, and creating additional difficulties for unskilled workers attempting to find work.
Inequality	As skilled labour becomes more valuable, and unskilled labour becomes a global commodity, incomes are likely to continue to diverge. Pay for the skilled will rise, while unskilled workers will be forced to compete with low cost computerisation at home and foreign workers abroad.
Insecurity	The future of work contains a risk of increased employment insecurity, an ongoing trend that has occurred since the 1990s. Although the collaborative economy presents enormous opportunities, important questions remain unanswered: how will the collaborative economy maintain social protections? How can perpetually flexible workers access entitlements like minimum wages, insurance, sick leave and parental leave?

A major concern amongst experts is the continued rise of inequality within labour markets, with low skilled workers missing out on the advantages brought about by emerging technology.

As noted in chapter 2.1.3, experts believe that job polarisation will not continue in the future. However, inequality may yet increase further: rather than hollowing out middle skill jobs, computers are expected to replace low income, low skill workers in the coming decades.[70] Summarising current research, Citigroup warned that further inequality caused by computerisation could lead to macroeconomic instability similar to that faced during the Global Financial Crisis, reduced spending in the economy, and permanently lower aggregate demand.[71]

Even the potential benefits of future work, such as flexible working environments and the ability to divide work tasks across a global labour pool, may act as a double-edged sword for workers. Writing in The Guardian, Fox and O'Connor argued that, while these trends benefit employers, they may erode workplace benefits and security for employees:

> The benefits for companies using these [freelancing] sites are obvious: instant access to a pool of cheap, willing talent, without having to go through lengthy recruitment processes. And no need to pay overheads and holiday or sick pay.

[68] Unum and The Future Laboratory, note 56, p 5.
[69] Foundation for Young Australians, note 11, p 8.
[70] Citigroup, note 2, p 59. Also see Autor et al, note 10.
[71] Ibid p 72.

> … By inviting people to bid for work, sites such as Upwork inevitably trigger a "race to the bottom", with workers in Mumbai or Manila able to undercut their peers in Geneva or London thanks to their lower living costs.[72]

4.2.2 The "losers" in the new world of work

As discussed in chapter 2.1.3, middle skill occupations characterised by routine tasks have borne the brunt of computerisation over the past 30 to 40 years. Male blue collar workers in industries such as manufacturing and utilities have faced the greatest difficulty remaining in, or returning to, work. The CEDA Report explained some of the challenges that these workers face when attempting to re-enter the labour force:

> To become employed again, many of the people need to become skilled in other jobs. Until these people are retrained they are unemployed. Others have been unable to find alternative work, particularly older men, since the skills in new jobs that have been created, mainly in the service sector, do not match theirs. Economists consider these people *structurally unemployed*. There is a persistent mismatch between the job skills or attributes of workers and the requirements of jobs. Structural unemployment can last for long periods because workers need time to learn new skills and some may never acquire these. Some workers lack even basic skills, such as literacy or people skills, making it difficult for them to adequately perform the duties of almost any job available.[73]

In future, a growing number of workers in non-routine occupations may also face similar issues due to new machine learning techniques and other technological advances. Assessing the US labour market, Citigroup reported that the majority of service occupations, where most US job growth has occurred over the past decades, are now at risk of computerisation. In particular, "[as] machines get better at performing tasks involving mobility and dexterity, the pace of displacement in service occupations is likely to increase even further."[74]

Should these predictions come to fruition, the challenges faced by blue collar workers in manufacturing and the utilities sector may soon be faced by workers in services industries such as accommodation and food services or retail trade.[75] Given the significant number of people employed in the services industry, the number of workers that may miss out on the benefits of emerging technology, or even struggle to remain in the workforce, could be enormous.

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[72] Fox and O'Connor, note 55.

[73] Lewis, note 3, p 123.

[74] Citigroup, note 2, p 59.

[75] Ibid p 60.

5. PREDICTED FUTURE IMPACTS OF COMPUTERISATION

5.1 The limitations to prediction

Danish physicist and Nobel laureate Niels Bohr was once attributed as saying "prediction is very difficult, especially if it's about the future".

If accurate predictions are hard to make, there remains a clear need for policymakers to consider possible and potential futures based on a range of factors, from demographic trends to changes in lifestyles and technologies. This is as true of the potential developments in the world of work as of other areas of life, where it is necessary for policymakers to craft long term plans to assist the community to transition to new work and social environments. There are sure to be missteps and wrong turns, but that does not obviate the value of thinking creatively about possible future scenarios based on known trends and foreseeable observations.

One example of this mode of thinking is found in Hajkowicz's 2015 book *Global Megatrends*. There, the author shares his vision of the retail sector in 2040:

> So what might a shop look like in 2040? If we sign up to the bricks and clicks models of retail – which seems to be the most successful – physical shops will still exist. But they will be very different. The customer has no need to visit a shop so they're not going to be there unless that shop delivers on the all-important experience factor. The shop will become a place primarily to interact with trained and knowledgeable people who can help a customer navigate their way through the many options and buy a product that meets their budget and needs. Shops will become places where people can experience the product they're contemplating buying and what it means for their lifestyle. When a customer does make a purchase, a background supply chain will be triggered and the lawnmower, tweed jacket or binoculars will be waiting on their doorstep before they get home. Probably the main reason to visit a shop is to interact with a human being to learn and experience the product before making a purchase.[76]

We can view Hajkowicz's prediction as a possible scenario based on current trends such as the widespread use of self-checkouts[77] and the creation of concept stores in the US that use robots and other new technology.[78]

5.2 Computerisation's predicted impact on global workforces

As discussed in chapter 3.2, the computerisation of jobs has until recently been limited to routine tasks. This is no longer the case, as ongoing advances in machine learning and the accumulation of more and more pertinent data mean

[76] S Hajkowicz, Global megatrends: Seven patterns of change shaping our future (CSIRO Publishing, 2015), pp 112-13.

[77] E Wynne, Self-service checkouts risking consumer loyalty: marketing expert, ABC News (online), 22 July 2015.

[78] P Wahba, Target wants to turn Minneapolis into a mini Silicon Valley, Fortune (online), 20 September 2015.

that many non-routine tasks increasingly face the possibility of computerisation.[79]

5.2.1 The Frey and Osborne study

An influential 2013 paper by Oxford University academics Frey and Osborne estimated the probability of computerisation of occupations in the United States. Their paper serves as the basis for a number of later studies in this area of research, including those in Australia. Chapter 6 of this paper applies their work to NSW and its electorates.

Autor et al explain the shift to services-dominated economies by reference to the computerisation of routine tasks (see chapter 2.1). Frey and Osborne argue that this model does not apply to the potential impacts of computerisation on 21st century employment because new machine learning techniques enable computers to rapidly substitute for labour across a wide range of non-routine tasks, both cognitive and manual.[80] Instead of the job polarisation that has characterised previous shifts in the composition of employment, the authors predict that the following will occur:

> Rather than reducing the demand for middle-income occupations, which has been the pattern over the past decades, our model predicts that computerisation will mainly substitute for low-skill and low-wage jobs in the near future. By contrast, high-skill and high-wage occupations are the least susceptible to computer capital.[81]

Frey and Osborne argued that two waves of computerisation will usher in these changes. The first wave will see the computerisation of transportation and logistics occupations, large numbers of office and administrative support workers, and further computerisation of the manufacturing industry. However, a "technological plateau" caused by three engineering bottlenecks (see Table 6) will slow computerisation, with a second wave only commencing once further technological innovation overcomes these bottlenecks.[82]

Table 6: Engineering bottlenecks to computerisation[83]

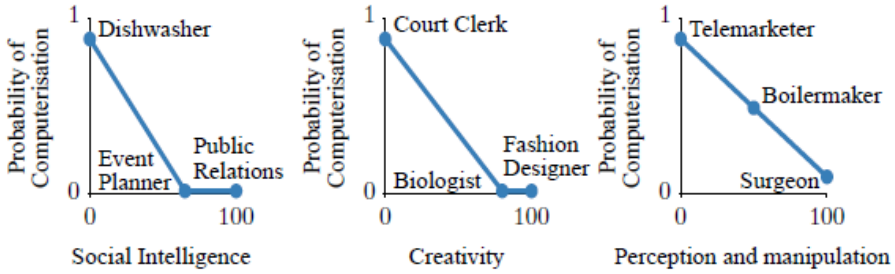
Perception and manipulation tasks	Robots are still unable to match the depth and breadth of human perception. While basic geometric identification is reasonably mature, enabled by the rapid development of sophisticated sensors and lasers, significant challenges remain for more complex perception tasks, such as identifying objects and their properties in a cluttered field of view.
Creative intelligence tasks	The psychological processes underlying human creativity are difficult to specify and replicate. For example, if a computer were to make a subtle joke, it would require a database with a richness of knowledge comparable to that of humans, and

[79] Frey and Osborne, note 8, p 14.
[80] Ibid p 23.
[81] Ibid p 42. Also see Citigroup, note 2, p 59.
[82] Ibid pp 38-40.
[83] Frey and Osborne, note 8, pp 24-6.

	methods of benchmarking the algorithm's subtlety.
Social intelligence tasks	Human social intelligence is important in a wide range of work tasks, such as those involving negotiation, persuasion and care. While algorithms and robots can now reproduce some aspects of human social interaction, the real-time recognition of natural human emotion remains a challenging problem, and the ability to respond intelligently to such inputs is even more difficult.

These bottlenecks are present in different occupations at varying levels. Generally, the more an occupation makes use of one or more of these skills, the lower the probability it will be computerised. For example, as shown in Figure 7, the low degree of social intelligence required to be a dishwasher means that this job is more susceptible to computerisation than a public relations specialist, which requires high levels of social intelligence:

Figure 7: How the probability of computerisation might vary as a function of bottleneck variables[84]



The methodology adopted by Frey and Osborne has been summarised as follows:

> For their US study they took detailed survey data from the 2010 version of the O*NET database, an online service developed by the US Department of Labor. They systematically identified features corresponding to the degree of each of the skills required to perform 702 occupations. (The O*NET defines the key skills required to perform an occupation as a standardised and measurable set of variables on a scale of 0 to 100.)
>
> In order to measure the risk to each occupation from automation, 70 occupations were hand-labelled, assigning a value 1 if 'automatable' and 0 if not. For these subjective assignments, Osborne and Fey drew on a workshop held at the Oxford University Engineering Sciences Department, examining the 'automatability' of a wide range of job tasks. They used a Gaussian process classifier [a statistical distribution technique] to predict the probability of automation for each occupation. This approach enabled them to identify irregularities in their hand-labelling process so that they could correct for potential subjective errors.[85]

The study has a number of limitations, notably that the actual extent and pace

[84] Ibid p 28.

[85] C Frey, M Osborne, Agiletown: the relentless march of technology and London's response, Deloitte, November 2014, p 29. Also see Frey and Osborne, note 8, pp 28-36.

of computerisation will depend on several additional factors that were not taken into account in the study. These include:[86]

- Future wage levels, capital prices or labour shortages;
- The impact of regulatory concerns and political activism; and
- Uncertainty over how long it will take to overcome existing engineering bottlenecks.

5.2.2 Research findings into the impact of computerisation

According to Frey and Osborne's research, up to 47% of US jobs have a high risk of being computerised (greater than 70% probability), possibly within the next decade or two.[87] The methodology underpinning Frey and Osborne's paper was subsequently used by Citigroup in its 2015 follow-up study into the susceptibility of various US industries to computerisation. The results of that study are set out in Table 7 below:

Table 7: Employment share at risk by US industry[88]

	Low Risk (%)	Medium Risk (%)	High Risk (%)
Accommodation & Food Services	2.8%	10.5%	86.7%
Administrative & Support Services	1.6%	36.2%	62.2%
Agriculture, Forestry, Fishing & Hunting	75.6%	12.0%	12.3%
Arts, Entertainment & Recreation	47.9%	12.5%	39.6%
Construction	21.6%	19.8%	58.6%
Educational Services	63.1%	19.7%	17.2%
Finance & Insurance	28.9%	17.3%	53.7%
Government	46.2%	30.6%	23.2%
Health Care & Social Assistance	39.4%	25.0%	35.6%
Information	51.6%	38.3%	10.1%
Management of Companies & Enterprises	82.8%	6.2%	11.0%
Manufacturing	19.9%	18.4%	61.7%
Mining, Quarrying and Oil & Gas Extraction	7.8%	46.3%	45.9%
Other Services (ex Public Admin)	44.9%	24.7%	30.4%
Professional, Scientific & Technical Services	54.0%	10.9%	35.1%
Real Estate and Rental & Leasing	0.7%	32.0%	67.2%
Retail Trade	14.5%	18.9%	66.6%
Self-Employed	60.4%	8.9%	30.7%
Transportation & Warehousing	5.5%	19.4%	75.0%
Utilities	40.3%	27.8%	31.9%
Wholesale Trade	15.9%	18.4%	65.7%

A 2014 Deloitte report that also used Frey and Osborne's methodology found that 35% of jobs in the UK, and 30% of jobs in London, are at high risk of disappearing over the next two decades as a result of computerisation. As in the US, jobs involving routine tasks have the highest risk of becoming obsolete, while jobs that are reliant on creative and social intelligence skills are least at risk.[89]

[86] Ibid pp 42-3.
[87] Ibid p 38.
[88] Citigroup, note 2, p 60.
[89] Deloitte, note 85, p 5.

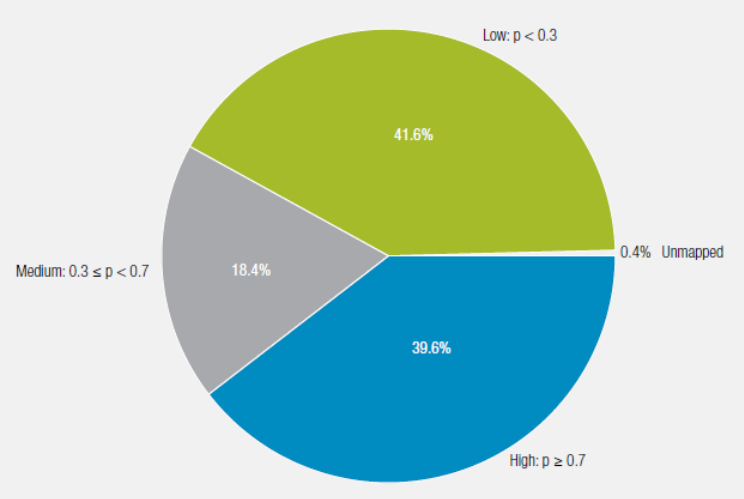
Other studies highlight the fact that computerisation is a worldwide phenomenon. A 2010 discussion paper by the Centre for Economic Performance reported that OECD countries with a high uptake of information and communication technologies (ICT) experienced the fastest growth in demand for the most educated workers. In contrast, the paper also found that the fastest falls in demand were for workers with intermediate levels of education that performed largely routine tasks, such as bank clerks and paralegals.[90]

5.3 Computerisation's predicted impact on the Australian workforce

Using Frey and Osborne's methodology as a base for further research, several Australian studies arrived at findings, consistent to those from overseas, as to the predicted impact of computerisation on the number and types of jobs at risk.

A study in the 2015 CEDA Report, *Australia's future workforce?*, migrated Frey and Osborne's estimates for the susceptibility of job types to computerisation from US to Australian jobs, concluding that nearly 40% of current Australian jobs have a greater than 70% probability of being computerised within the next 10 to 15 years.[91]

Figure 8: Probability of computerisation in Australia[92]



As shown in Figure 9, certain occupations are more susceptible to computerisation than others. According to the CEDA study, this is because work in these occupations involves high levels of routine tasks. In contrast, professional and managerial roles are unlikely to be computerised, being

[90] G Michaels, A Natraj, J Van Reenen, Has ICT Polarized Skill Demand? Evidence from Eleven Countries over 25 Years, Centre for Economic Performance, Discussion Paper No 987, June 2010, p 20.

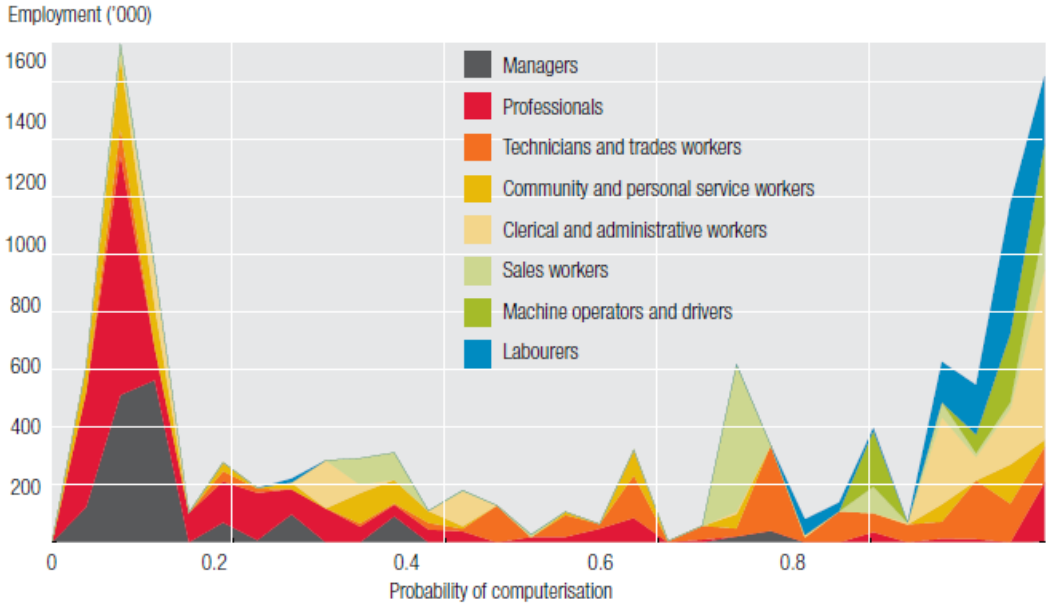
[91] H Durrant-Whyte, L McCalman, S O'Callaghan, A Reid, D Steinberg, 'The impact of computerisation and automation on future employment' in Committee for Economic Development of Australia, *Australia's future workforce?* (2015) 56, p 60.

[92] Ibid.

characterised by non-routine thinking and high levels of creativity and originality.[93]

But note that the findings further indicate that a significant number of middle income, non-routine occupations in Australia are also at risk of computerisation.

Figure 9: Distribution of job categories against probability of computerisation in Australia[94]



Other studies have reached similar conclusions to that of the CEDA report. In an April 2015 paper, PwC found that up to 44% of Australian jobs (an estimated 5.1 million jobs) are at high risk of being affected by computerisation over the next 20 years.[95]

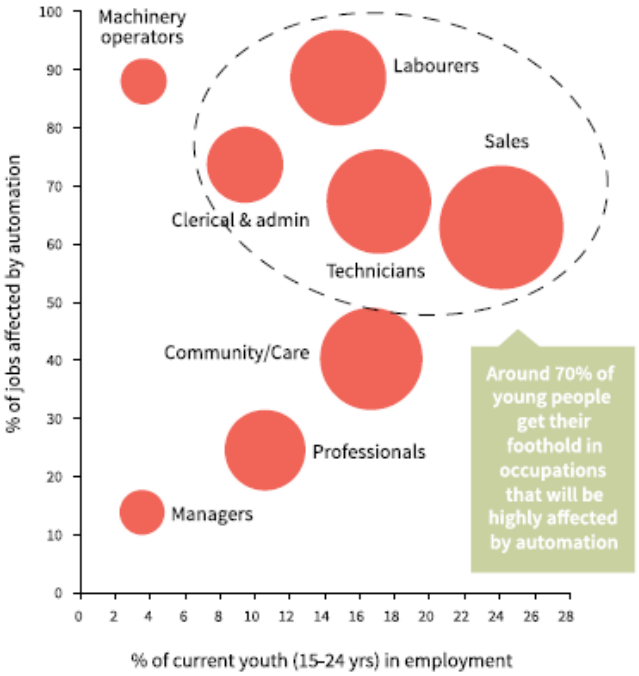
Young Australians may be especially vulnerable to computerisation. Using CEDA's data, the Foundation of Young Australians estimated that up to 70% of young workers enter occupations that have high likelihoods of computerisation (see Figure 10 overleaf):

> Young people tend to get their first jobs in fields like retail, admin, and laboring. These fields are highly exposed to the impact of technology. Economists have forecast that jobs like checkout operators, receptionists, personal assistants and fast food workers will either be lost or radically changed by technology. By contrast, young people tend not to get their foothold in the workforce in occupations that are less exposed to automation, such as managers and professionals.[96]

[93] Ibid p 61.
[94] Ibid p 60.
[95] PwC, note 53, p 10.
[96] Foundation for Young Australians, note 11, p 25.

Figure 10: Jobs held by young Australians and risk of computerisation[97]

Bubble size = % of employed youth (15-24 yrs) in that occupation



6. THE POTENTIAL IMPACT OF COMPUTERISATION IN NSW

To date, Australian research on the impacts of computerisation has had a national focus. In this paper, the focus is moved to the sub-national level. Using the standard methodology employed in this area of research, this chapter identifies NSW occupations by their risk of computerisation, and maps the overall probability of job loss by State electorate.

In brief, the analysis takes the CEDA Report's estimates of job susceptibility to computerisation,[98] and applies them to NSW occupation data from the 2011 Census to obtain a NSW-wide estimate of the potential impact of computerisation. 2013 NSW State electorate boundaries are then used to map the estimated probability of job loss within each electorate's workforce. A more detailed explanation of the methodology used is set out at Appendix A.

It should be emphasised that this analysis is an estimate only, and does not take into account the creation of new jobs or other positive developments that may occur as a result of digital disruption (these are discussed in chapter 4 of this paper).

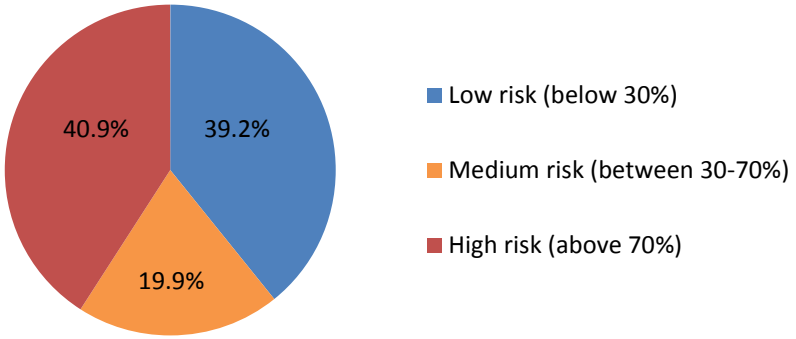
[97] Ibid p 24.

[98] Durrant-Whyte et al, note 91, pp 63-4.

6.1 Computerisation of jobs in NSW

Replicating the analysis of job computerisation previously undertaken by CEDA (see Figure 8), Figure 11 segments the NSW labour force into three groups by probability of computerisation: high risk (70% or above probability), medium risk (between 30-70%) and low risk (below 30%).

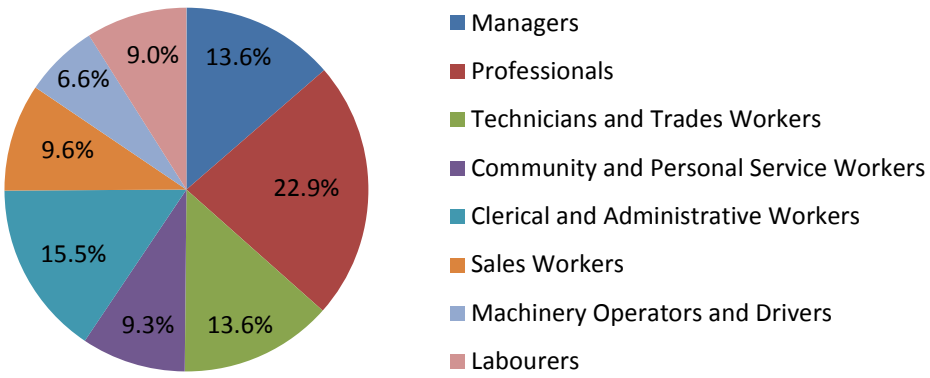
Figure 11: Proportion of NSW jobs at risk of computerisation, by risk category



As shown above, approximately two out of five NSW jobs have a high risk (above 70%) of being computerised over the next decade or two. This is similar to CEDA's estimate of the Australian average (41.6%), which is higher than the UK average (35%) but lower than the US (47%). According to CEDA, these differences are due to differing proportions of service workers in each country.[99]

The 2011 Census classifies Australian occupations into eight Major Groups. Each Major Group and its respective proportion of the NSW labour force is shown in Figure 12 overleaf:

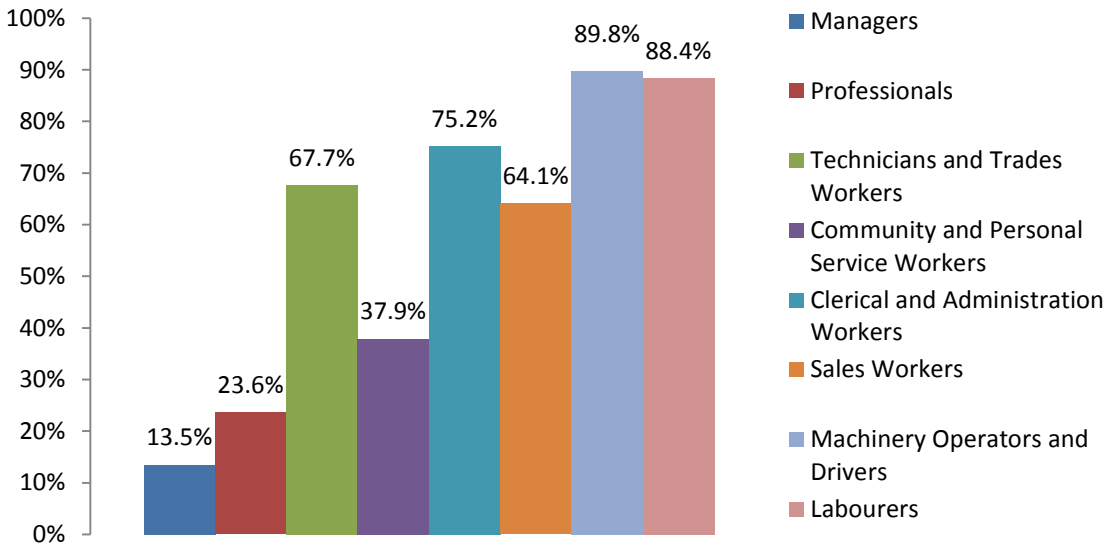
Figure 12: Percentage of NSW labour force by ANZSCO Major Group



[99] Ibid p 60.

The probability of computerisation for each Major Group is shown in Figure 13:

Figure 13: Probability of computerisation by Major Group in NSW



The likelihood of a particular occupation becoming computerised varies between occupations within a Major Group, as well as between Major Groups. For example, although the Professionals Major Group has a low overall risk of computerisation (23.6%), this is the average likelihood of computerisation across all professional occupations. Different occupations within this broad category have varying risks of computerisation. For instance, secondary school teachers have a 3.3% chance of being computerised, while surveyors and spatial scientists have an 83.7% probability of being made obsolete by new technologies.[100]

Tables 8 and 9 show, respectively, the 20 occupations most likely to be computerised, and the 20 occupations least likely to be computerised:

[100] Figures for probabilities of computerisation provided by Professor Hugh Durrant-Whyte.

Table 8: NSW occupations most likely to be computerised			
ANSZCO occupation	**Probability of computerisation**	**Size of NSW workforce**	**No of jobs at risk of computerisation**
Butchers and Smallgoods Makers	96.4%	5539	5339
Meat Boners and Slicers, and Slaughterers	96.4%	1813	1747
Labourers nfd*	96.1%	7092	6818
Service Station Attendants	95.9%	2431	2331
Filing and Registry Clerks	95.7%	4666	4467
Bank Workers	95.7%	21,224	20,313
Machine operators nfd*	95.7%	6662	6376
Numerical Clerks nfd*	95.6%	381	364
Machinery operators and drivers nfd*	95.6%	3389	3240
Purchasing and Supply Logistics Clerks	95.6%	21,289	20,345
Other Mobile Plant Operators	95.6%	2607	2491
Couriers and Postal Deliverers	95.6%	11,907	11,379
Checkout Operators and Office Cashiers	95.5%	31,772	30,356
Garden and Nursery Labourers	95.5%	7192	6870
Machine and Stationary Plant Operators nfd*	95.5%	600	573
Insurance, Money Market and Statistical Clerks	95.4%	11,025	10,522
Mobile plant operators nfd*	95.4%	1609	1535
Plastics and Rubber Production Machine Operators	95.4%	2268	2163
Structural Steel and Welding Trades Workers	95.3%	15,575	14,850

*nfd = not further defined

Table 9: NSW occupations least likely to be computerised			
ANSZCO occupation	**Probability of computerisation**	**Size of NSW workforce**	**No of jobs at risk of computerisation**
Chiropractors and Osteopaths	3.0%	1405	42
Occupational Therapists	3.0%	2776	83
Podiatrists	3.0%	760	23
Pharmacists	3.1%	6018	185
Secondary School Teachers	3.3%	43,253	1427
Hotel and Motel Managers	4.0%	6208	250
Hotel Service Managers	4.0%	1880	76
Medical Practitioners nfd*	4.2%	541	23
Generalist Medical Practitioners	4.3%	13,892	593
Anaesthetists	4.3%	1128	48
Specialist Physicians	4.3%	1806	77
Psychiatrists	4.3%	766	33
Surgeons	4.3%	1548	66
Private Tutors and Teachers	4.5%	10,271	461
Other Health Diagnostic and Promotion Professionals	4.6%	1576	72
Fitness Instructors	4.6%	6988	323
Outdoor Adventure Guides	4.6%	506	23
Physiotherapists	4.8%	4855	235
General Managers	5.0%	14,193	710
Agricultural and Forestry Scientists	5.4%	1430	77

*nfd = not further defined

Figure 14 graphs all NSW occupations, showing a distribution of occupations against their probability of computerisation:

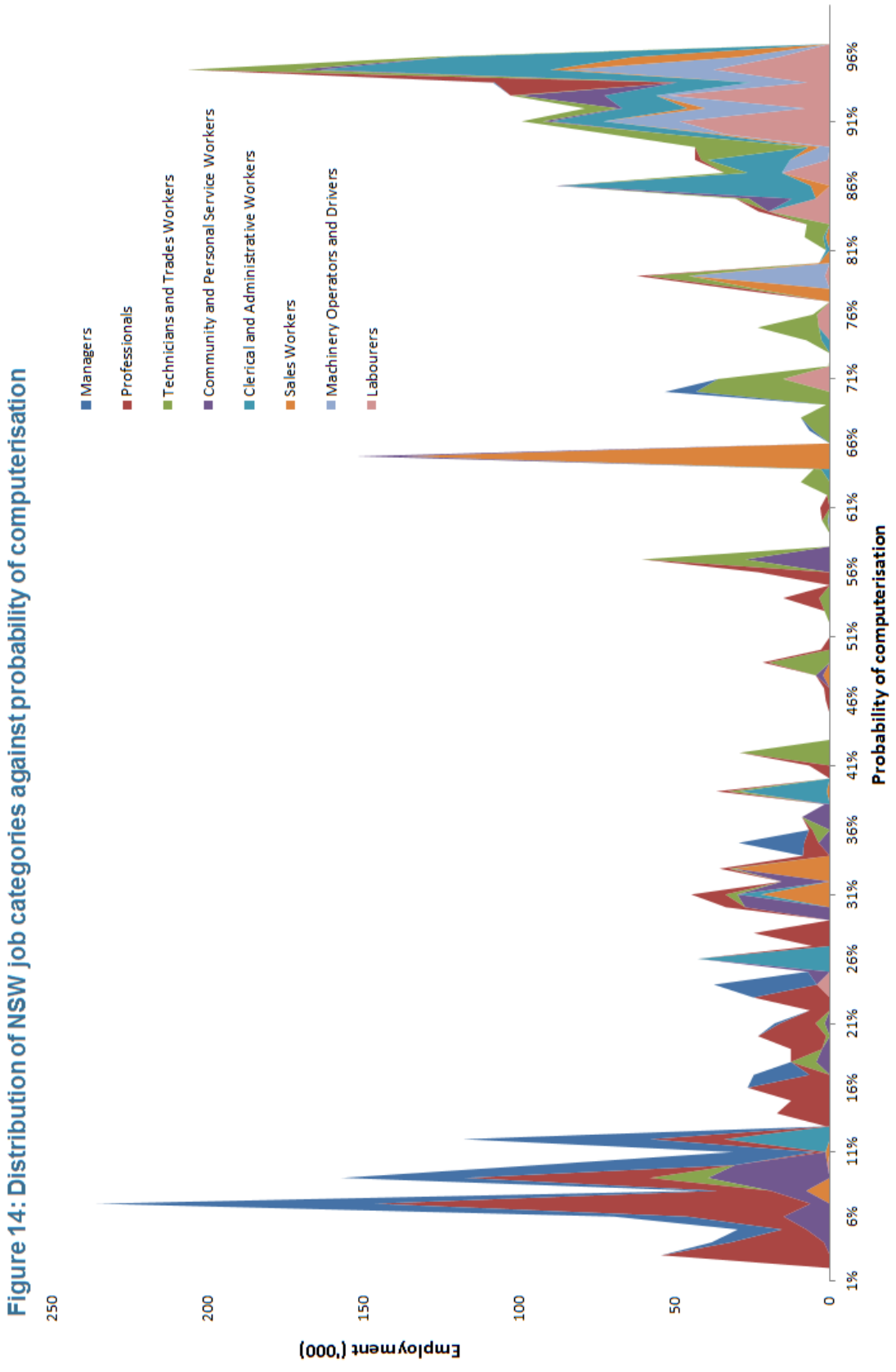


Figure 14: Distribution of NSW job categories against probability of computerisation

Figures 13 and 14 suggest that several major employment groups, notably labourers, and machinery operators and drivers, have very high probabilities of computerisation. An explanation for this at the national level was given in the CEDA Report:

> First, potential job losses are polarised: Jobs in administration and sales (and many service areas) will disappear, while jobs in the technical professions and personal services will remain. Second, many of those jobs remaining are characterised by non-routine thinking and especially high levels of originality and creativity.[101]

6.2 Computerisation by NSW electorate

51.58% (1.57 million) of all NSW jobs are at risk of being computerised in the next 10 to 15 years.[102] However, this figure does not apply evenly throughout NSW. This is because some State regions have particularly high numbers of managers or professionals, while other parts have greater numbers of lower skilled workers.

Figures 15 to 18 map the estimated probability of job loss through computerisation for the employed residents of each NSW State electorate. As acknowledged in the CEDA Report, these findings are preliminary and do not factor in information such as population levels. Accordingly, the following figures should not be over-analysed.[103]

Note that, as explained further in Appendix A, for technical reasons the electoral boundaries in the following maps do not correspond in all cases to the exact boundaries as drawn by the NSW Electoral Commission. Some maps are generated using an approximation of the electoral boundaries using SA1s, not the exact electoral boundaries as made by the Commission. The data used to create these maps is available in Appendix B of this paper.

[101] Ibid p 61.

[102] If anything, this may be an underestimate due to (i) the undercount in Census data, and (ii) the exclusion of a small number of occupations from the analysis. See further Appendix A.

[103] Durrant-Whyte et al, note 91, p 61.

Figure 15: Probability of computerisation – Sydney

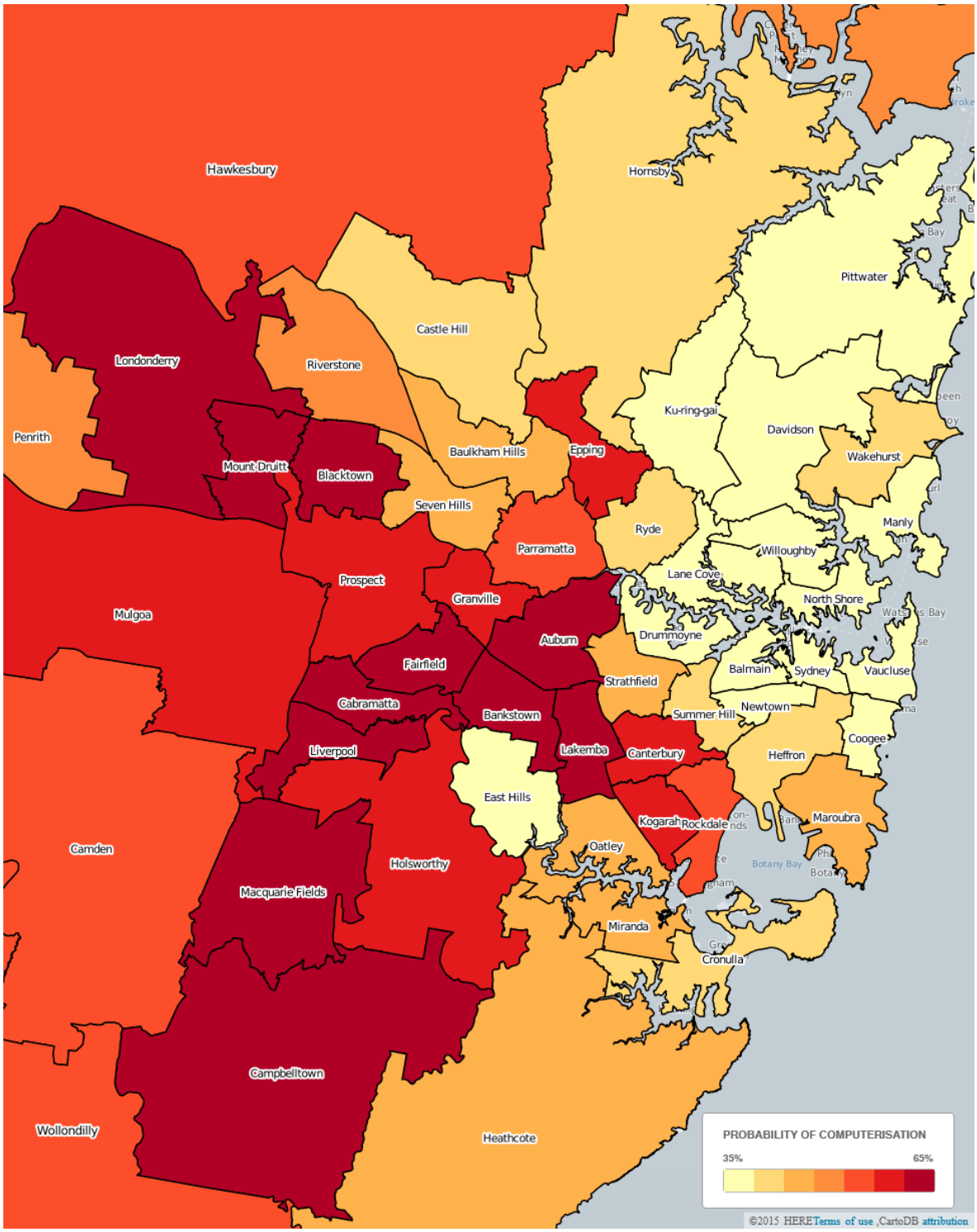


Figure 16: Probability of computerisation – Hunter and Central Coast

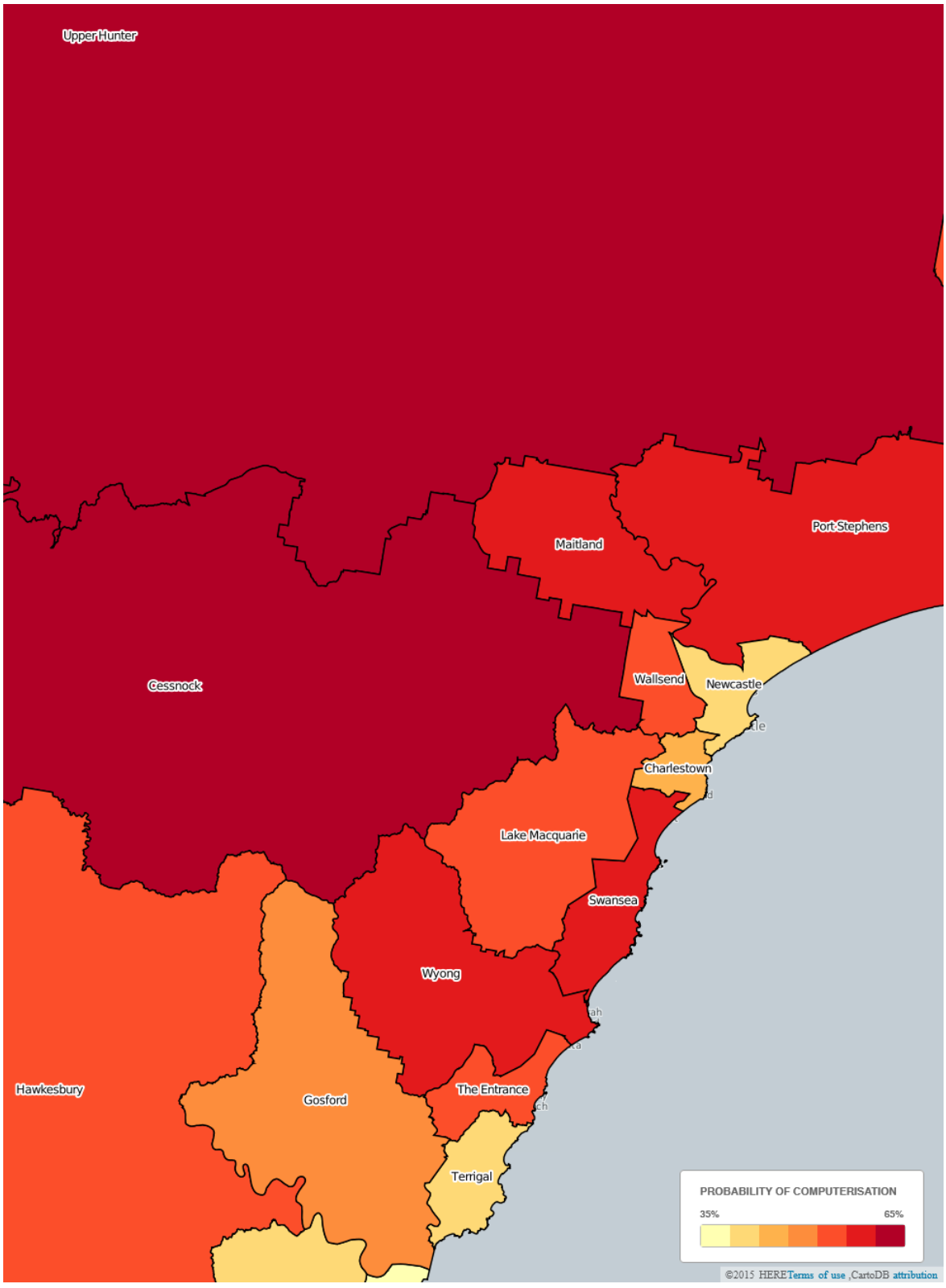


Figure 17: Probability of computerisation – Illawarra

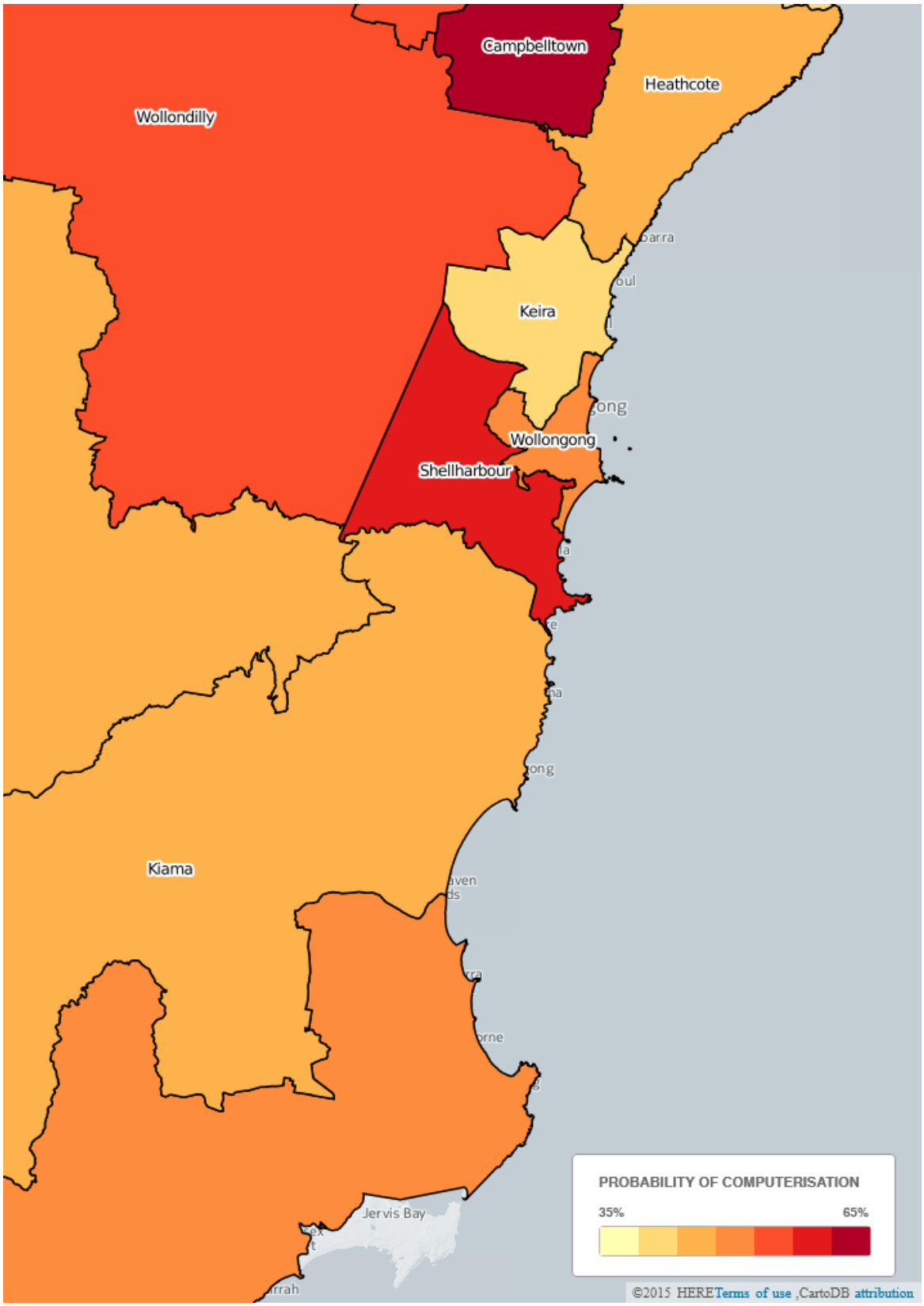
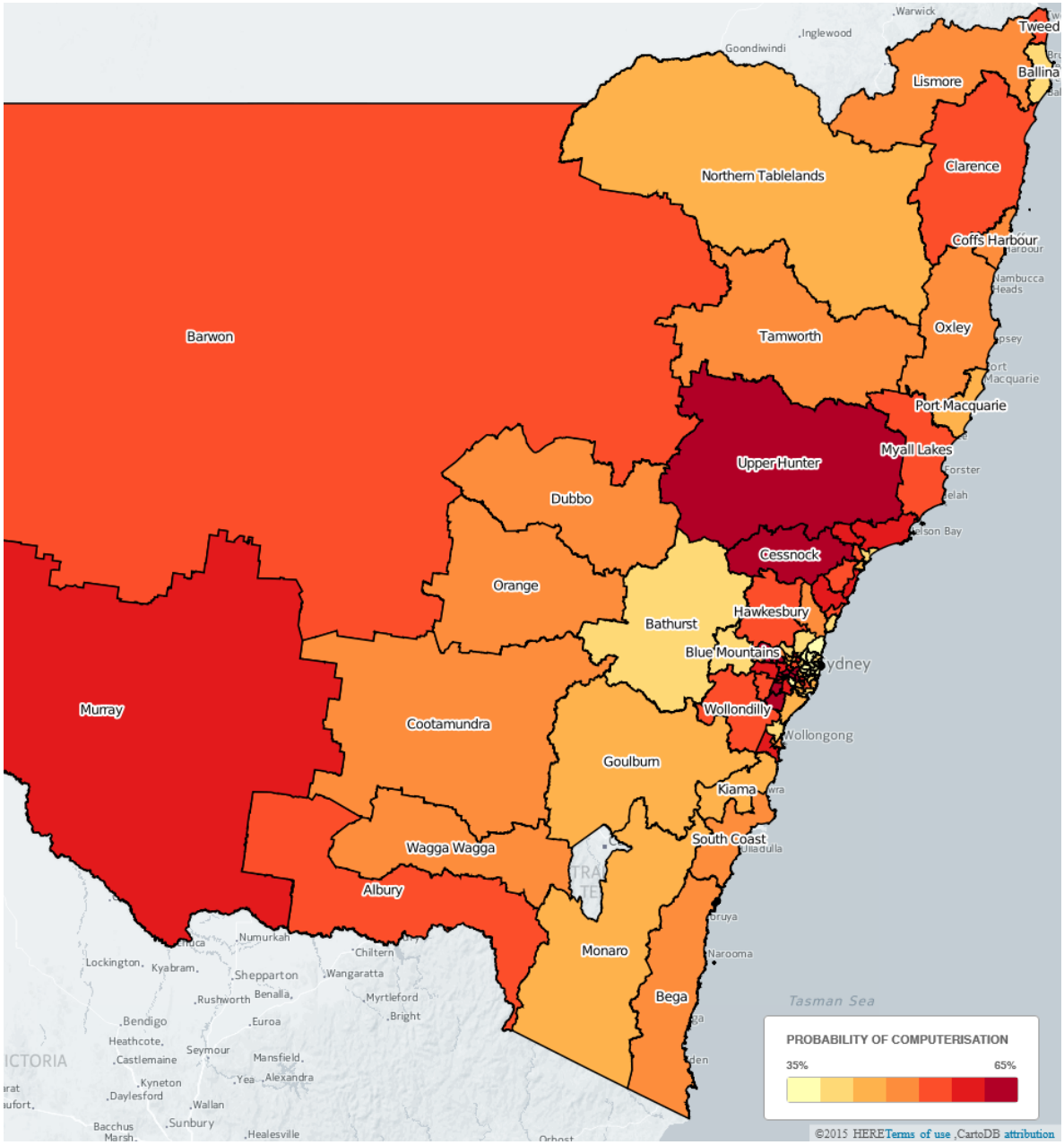


Figure 18: Probability of computerisation – Regional NSW



6.3 Characteristics of different NSW electorates

The maps above suggest that certain NSW electorates and regions are likely to be more susceptible to computerisation than others.

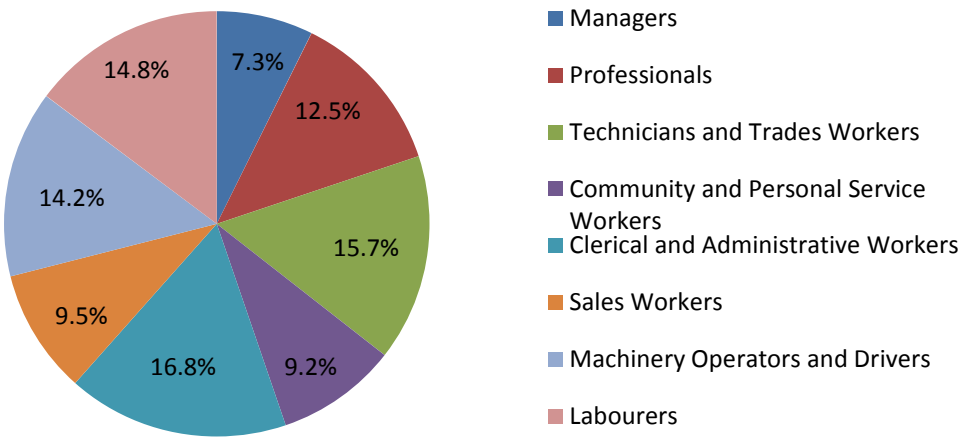
To illustrate the reasons for these differences, this section analyses the distribution of jobs within the five NSW electorates that have the highest chance of computerisation, and the distribution of jobs within the five electorates with the lowest probabilities.

6.3.1 Electorates with the highest risk of computerisation

The five electorates with the highest risk of computerisation[104] are characterised by a predominantly low or middle skilled workforce – less than a fifth of the labour force in these electorates are managers a professionals.

By way of comparison, the largest employment group, clerical and administrative workers (16.8% of the workforce), is almost as large as the combined number of managers and professionals in these electorates:

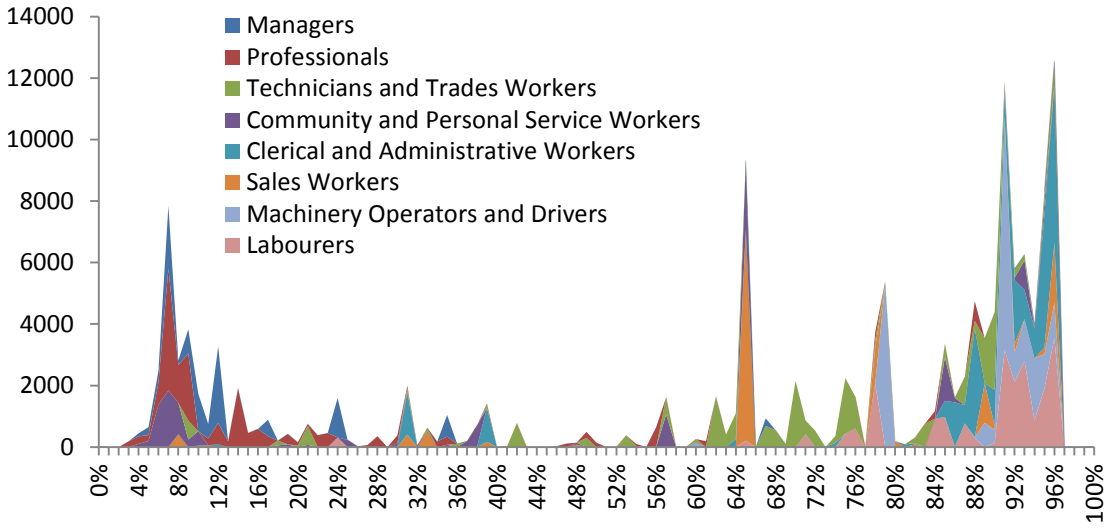
Figure 19: Percentage of labour force by Major Group – Electorates with highest probability of computerisation



Because these electorates have greater numbers of low and middle skilled workers, a greater proportion of workers run the risk of having their jobs computerised, as shown by the distribution graph overleaf:

[104] Fairfield; Cabramatta; Mount Druitt; Londonderry; and Liverpool.

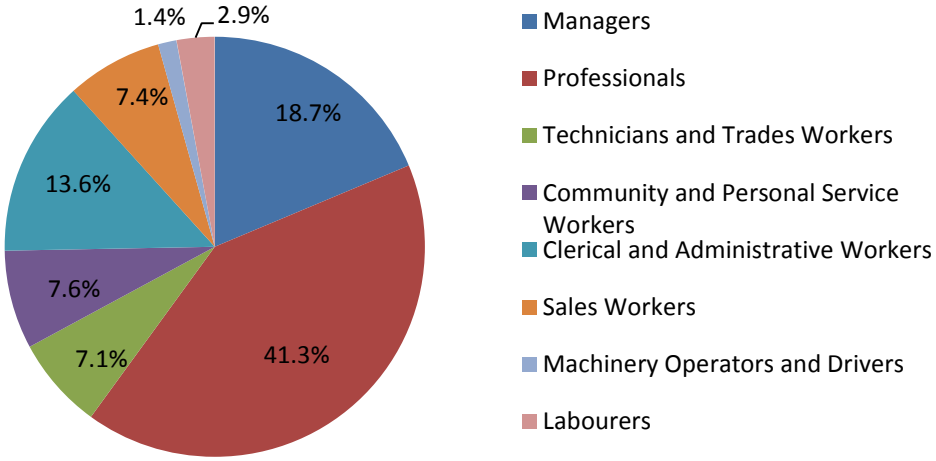
Figure 20: Distribution of job categories – Electorates with the highest probability of computerisation



6.3.2 Electorates with the lowest risk of computerisation

In contrast to the electorates with the highest probabilities of computerisation, the workforces in electorates with the lowest risk[105] are comprised overwhelmingly of managers and professionals:

Figure 21: Percentage of labour force by Major Group – Electorates with lowest probability of computerisation



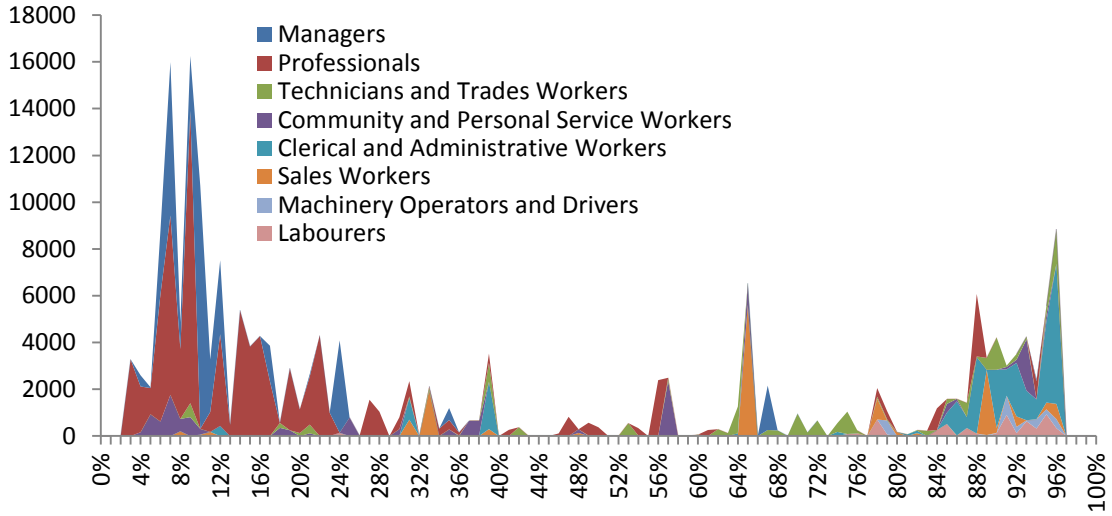
Approximately 60% of workers in these five electorates are managers or professionals: both types of employment that are relatively safe from computerisation.

[105] Vaucluse; Balmain; North Shore; Coogee; and Newtown.

Occupations with a high risk of computerisation comprise a very low proportion of the labour force in these electorates: the two highest risk occupations—machinery operators and drivers and labourers—constitute less than 5% of the total workforce in these five electorates.

Accordingly, the distribution of jobs is skewed towards the lower end of the spectrum in terms of probability of computerisation, as shown in the graph below:

Figure 22: Distribution of job categories – Electorates with the lowest probability of computerisation



7. POLICIES TO TRANSITION TO A FUTURE WORK ENVIRONMENT

7.1 Embracing and managing change

Although change may not be welcomed by all, stemming the tide of technological advancement is not considered to be an option. The International Labour Organisation (ILO) has argued that attempting to halt change would limit productivity growth and improvements in output. Instead, the ILO recommended that policymakers determine "how policies can most effectively realize the benefits while ensuring protections for those adversely affected and inclusiveness in the economy and labour market."[106]

The ILO's view is shared by many in Australia. While welcoming the potential benefits of emerging technology, CEDA nevertheless cautioned that strategic, long-term planning is needed to allow all of society to benefit from computerisation and other technological developments.[107] In a speech to the

[106] International Labour Organisation, World Employment and Social Outlook: Trends 2015, January 2015, p 24.

[107] Bradlow, note 41, p 46.

2015 Economic and Social Outlook Conference, Reserve Bank of Australia Governor Glenn Stevens outlined a number of issues that policymakers should address as Australia begins to enter a new world of work:

> The questions then are whether Australian businesses and their workforces have, or can acquire, the necessary capabilities to offer [new] services and perform [new] jobs; whether the incentives they face to do so are adequate; whether the public policy framework appropriately encourages risk-taking and entrepreneurship; and so on.[108]

The following sections discuss existing and proposed policies designed to maximise the benefits, and minimise the pain, of technological change. Some of these policies are already in place in Australia at the State or Commonwealth level, while others are used in other developed nations or are advocated by public policy experts.

In Australia, a number of the policies discussed would only be implemented at the national level. These are discussed in this paper in part because of their intrinsic interest and also in recognition of the need for all Australian governments to work together to harmonise their respective laws and policies.

7.2 Examples of current policies

This section lists a selection of recent policy initiatives at both the State and Commonwealth level. While not an exhaustive list, it is intended to illustrate various responses aimed at helping the Australian workforce adapt to changing technology.

7.2.1 Current NSW policies

Since 2011 the NSW Government has introduced or proposed a number of policies aimed at encouraging development of a strong future workforce.

A series of Economy Industry Action Plans have been developed that, among other goals, aim to encourage government and industry collaboration to drive innovation and competitiveness.[109] As part of this series, in 2012 the NSW Government released its NSW Digital Economy Industry Action Plan.

The Action Plan's goal is to ensure that the State's ICT and creative industries sectors are well placed to drive productivity improvements across all sectors of the economy.[110] In accordance with this goal, the Action Plan developed seven major recommendations for consideration by the NSW Government:

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[108] G Stevens, 'The Path to Prosperity' (Speech delivered at the 2015 Economic and Social Outlook Conference, Melbourne, 5 November 2015).

[109] Department of Industry, A framework for future growth, NSW Government, n.d.

[110] NSW Digital Economy Industry Taskforce, Industry Action Plan: NSW Digital Economy, NSW Government, 25 September 2012, p 5.

Table 10: NSW Digital Economy Industry Action Plan recommendations[111]	
Achieving Digital Leadership	Position NSW as a global leader in the Digital Economy in which ICT is central to productivity, innovation and competitiveness across all sectors.
Building Digital Skills	Improve the digital skills and technology knowledge of NSW citizens through actions such as a new technology curriculum and exploitation of e-Learning and digital technology.
Connecting Regional Communities	Stimulate the Digital Economy in regional NSW by improving technology access and literacy, and by encouraging regional stakeholders to develop local digital strategies.
Implementing Open Data Innovation	Increase open data access through initiatives such as implementing an open access licensing framework across NSW government, and investing in the necessary IT infrastructure to support efficient access to data.
Growing Sydney's Digital Precinct	Develop an 'innovation ecosystem' for NSW, with additional investment to support the growth and development of the Digital Precinct focusing on infrastructure, work spaces, global identity and connectivity.
Improving Finance and Investment Channels	Increase funding opportunities for NSW-based high growth companies, both by diversifying the sources of capital available to these companies and by attracting international investors.
Driving Infrastructure Productivity	The NSW Government to ensure that all state infrastructure projects should integrate ICT to deliver smart infrastructure.

More recently, the 2015-16 NSW Budget established a $25 million *Jobs of Tomorrow Scholarship Fund*, which aims to provide 25,000 scholarships for students undertaking qualifications for technology and growth jobs.[112]

Then in October 2015 the Government released the *Bays Precinct Transformation Plan* which, along with other initiatives, aims to convert the White Bay Power Station into a hub for knowledge-intensive industries:

> A potential new technological and innovation campus at the nearby Glebe Island in emerging industries such as:
>
> - medical and biomedical research;
> - international education;
> - digital disruptors;
> - infrastructure and engineering; and
> - maritime technology,
>
> may complement the knowledge-intensive industries of White Bay Power Station with the potential to spur export-focussed entrepreneurship and support the growth of Sydney's future generations and the New South Wales economy.[113]

[111] Ibid pp 2-3.

[112] NSW Government, Budget Statement 2015-16, Budget Paper No 1, p 2-12.

[113] UrbanGrowth NSW, The Bays Precinct Sydney Transformation Plan, NSW Government,

Further, the 2014 *Plan for Growing Sydney* proposed the expansion of the "Global Economic Corridor"; a section of Sydney stretching from Macquarie Park through the Sydney CBD to Port Botany and Sydney Airport that generates over 41% of Gross State Product:

> This economic cluster is unique in Australia due to the extent, diversity and concentration of globally competitive industries.
>
> Sydney's knowledge jobs are heavily concentrated within the Global Economic Corridor, including sectors such as education, financial and other business services, communications, high-tech manufacturing and emerging industries such as biotechnology. These sectors are at the forefront of innovation in Sydney's economy.[114]

7.2.2 Other recent Australian policies

Other Australian jurisdictions have released or announced their own policies designed to increase technological education and support innovative businesses.

In the education field, the Commonwealth Government has committed $12 million to increase student uptake of science, technology, engineering and mathematics (STEM) courses in primary and secondary schools, along with other initiatives such as $3.5 million in funding for computer coding programs in Australian schools.[115] In Victoria, the Andrews Government recently provided $27 million in extra funding for primary mathematics and science specialists in disadvantaged primary schools from 2016.[116]

As part of its 2015-16 Budget, the Victorian Government established the $200 million Future Industries Fund, which will support six priority sectors with the potential for high economic growth and the capacity to create high skill, high wage jobs within the State. These priority sectors include medical technologies and pharmaceuticals; new energy technologies; and transport, defence and construction technologies.[117]

Similarly, in 2015 the Queensland Government established a $40 million Business Development Fund. The Fund will invest between $125,000 and $2.5 million in Queensland businesses that are commercialising research, or innovative ideas, products or services, with the aim of promoting angel and venture capital investment in Queensland.[118] Furthermore, Queensland's 2015-

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October 2015, p 27.

[114] NSW Planning & Environment, A Plan for Growing Sydney, NSW Government, 2014, p 44.

[115] Department of Education and Training, Restoring the focus on STEM in schools initiative, Australian Government, 21 October 2015.

[116] J Merlino, Education State: $27 Million Maths And Science Boost For Kids Who Need It Most (Media Release, 15 September 2015).

[117] Business Victoria, Future Industries: Building a Stronger Victoria, Victorian Government, 2 November 2015.

[118] Advance Queensland, Business Development Fund, Queensland Government, 4 November 2015.

16 Budget, which featured a suite of policies for start-up businesses and STEM education, was widely praised by industry groups as encouraging a "thriving start-up culture" in the State.[119]

In March 2015, the Abbott Government acknowledged that government bureaucracies must adapt to technological innovation, discussing the aims of the Digital Transformation Office (DTO) in the 2015 Intergenerational Report:

> The DTO will focus on end-user needs in developing digital services, so that government services can be delivered digitally from start to finish and better serve the needs of citizens and businesses. … Government policy development is heavily reliant on available data. There is huge potential to modernise and better manage Australia's national data infrastructure, with appropriate data sharing and access arrangements that take advantage of new technologies, and make the best use of existing data and scarce resources. Improved data quality and the ability to respond more quickly to emerging trends and issues will better inform policies for the benefit of all Australians.[120]

On 7 December 2015, Prime Minister Malcolm Turnbull released the Commonwealth Government's National Innovation and Science Agenda.[121] The Agenda contains 24 measures, with key measures including:[122]

- Tax incentives for early-stage investors, including a 20% non-refundable tax offset and a capital gains tax exemption. These incentives are closely modelled on the United Kingdom's Seed Enterprise Investment Scheme (SEIS);[123]
- A $200 million innovation fund to co-invest in businesses that develop technology from the CSIRO and Australian universities; and
- $48m for a STEM literacy program, $14m to encourage women and girls into the STEM sector, and $51m to promote digital literacy.

However, the Federal Labor Opposition has criticised earlier Commonwealth spending cuts to research, technology and innovation,[124] and announced its own Future Smart policy suite, designed to:[125]

- Create HECS-style loans of up to $10,440 per annum for fledgling

[119] D Swan, Tech-friendly Queensland budget lauded, The Australian (online), 15 July 2015.

[120] Australian Treasury, 2015 Intergenerational Report: Australia in 2055, Australian Government, March 2015, p 91.

[121] Australian Government, National Innovation and Science Agenda, 2015.

[122] D Hurst, Malcolm Turnbull's innovation package offers tax breaks and school focus, The Guardian (online), 7 December 2015; E Borrello, F Keany, Innovation statement: PM Malcolm Turnbull calls for 'ideas boom' as he unveils $1b vision for Australia's future, ABC News (online), 7 December 2015.

[123] For an overview of the UK scheme see: HM Revenue and Customs, Business tax – guidance: Seed Enterprise Investment Scheme, UK Government, 22 October 2013.

[124] For example, see K Carr, Time for Turnbull to reverse cuts to all science agencies (Media Release, 12 November 2015).

[125] Australian Labor Party, Future Smart: Educating for the jobs of tomorrow, 2015; Labor Herald, Entrepreneurs, higher learning and a plan for more start-up businesses, 25 September 2015.

business ideas from university graduates, as well as access to mentoring and professional development;
- Create a STEM teacher training fund to support 25,000 primary and secondary school teachers to undertake professional development in STEM disciplines over five years;
- Establish a $500 million Smart Investment Fund to co-invest in early stage companies, with a Commonwealth investment of up to 50% of the start-up capital to commercialise innovations.

7.3 Improving education in Australia

Of the many policy proposals in response to changing workforces, an increased focus on high quality and specialised education is the most prominent and widely supported. The CEDA Report identified three key educational goals needed to manage the challenges of a complex and ambiguous future:[126]

1. There must be greater numbers of Australians with a grounding in STEM skills;
2. Universities must forge deeper relationships with industry and employers in order to improve the employability of graduates; and
3. Rather than merely accumulate facts, individuals must gain the ability to deal nimbly with complex and often ambiguous knowledge.

The focus of this section is on the role of governments at all levels in enhancing STEM education. However, future workforces will require education beyond these fields, as well as beyond primary and secondary studies, with CEDA emphasising the importance of lifelong learning in order to adjust to a world changing in unknown ways.[127] In relation to low skilled workers, Berger and Frey have argued that educational efforts should aim to provide workers with integrated skill-sets of technical, creative and social skills, these being areas where human workers are likely to retain a comparative advantage despite ongoing technological advances.[128]

It is also recognised that individuals themselves must share responsibility for their ongoing education and development.[129]

7.3.1 Increasing STEM knowledge and skills

The benefits of STEM education have been advocated by many observers,[130]

[126] J den Hollander, 'A brave new world of higher education' in Committee for Economic Development of Australia, *Australia's future workforce?* (2015) 225, p 231.

[127] S Beitz, 'Developing the capacity to adapt to industry transformation' in Committee for Economic Development of Australia, *Australia's future workforce?* (2015) 156, pp 163-4.

[128] T Berger, C Frey, 'Bridging the skills gap' in T Dolphin (ed), *Technology, Globalisation and the Future of Work in Europe* (March 2015) 75, p 77.

[129] P Glover, H Hope, 'Preparing for tomorrow's world of work' in T Dolphin (ed), *Technology, Globalisation and the Future of Work in Europe* (March 2015) 42, pp 45-6.

[130] For example, see Glover and Hope, note 129; Office of the Chief Scientist, Science, technology, engineering and mathematics: Australia's future, Australian Government,

and have been the subject of significant attention by policymakers. According to Deloitte, STEM graduates have a range of vital workplace skills, including the ability to generate, understand and analyse empirical data; perform systematic and critical assessments of complex problems; and effectively communicate scientific issues.[131]

Crucially, STEM skills have flow-on benefits to the community as a whole. In its 2015 STEM Report, PwC commented that countries that lead in STEM education also rank high in innovation. Turning to Australia, PwC modelling found that developing a STEM workforce in line with other leading countries could generate an additional $57.4 billion in GDP over the next 20 years.[132]

Several Australian governments have recognised the need for better STEM education and have implemented policies in pursuit of this goal. However, Australia faces major shortfalls in STEM knowledge and education.

In late 2014 the Commonwealth Office of the Chief Scientist sharply criticised the existing state of affairs, noting that STEM investment and policies at all levels of Australian Government suffer from a lack of coordination, misdirected effort, instability and duplication.[133] Citing international research, which concluded that 75% of the fastest growing occupations require STEM skills and knowledge, the Chief Scientist argued that greater investment in these fields were needed to enhance competitiveness and grow the Australian economy.[134]

This view is shared by the Foundation for Young Australians, who recently reported that 42% of Australian 15 year olds are not proficient in mathematics, 35% are not proficient in science; and 35% are not proficient in technology.[135]

In response, the Office of the Chief Scientist outlined several strategies, with recommendations ranging from accelerating the integration of STEM experts into industry, business and public sectors; increasing recognition of STEM education and careers as a public good; and promoting inquiry-based STEM teaching in vocational education in consultation with States and Territories.[136]

7.3.2 The limits of education

Despite broad support for increased education, particularly STEM knowledge, experts have cautioned against treating education as a panacea for labour market challenges. The propensity of higher education to produce ever-

September 2014; PwC, note 53.

[131] Deloitte, note 85, p 19.

[132] PwC, note 53, pp 15, 19.

[133] Office of the Chief Scientist, Science, technology, engineering and mathematics: Australia's future, Australian Government, September 2014, pp 10-11.

[134] Ibid pp 6-7.

[135] Foundation for Young Australians, Report Card 2015: How are young people faring in the transition from school to work?, November 2015, p 1.

[136] Ibid pp 18, 23-4.

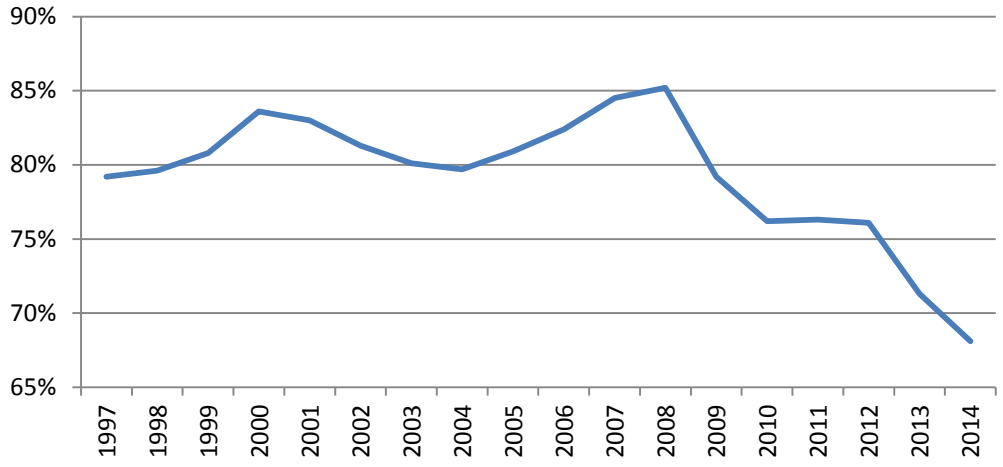
diminishing returns was emphasised by Ford in *Rise of the Robots*:

> The reality is that awarding more college degrees does not increase the fraction of the workforce engaged in the professional, technical, and managerial jobs that most graduates would like to land. Instead, the result very often is credential inflation … We are running up against a fundamental limit both in terms of the capabilities of the people being herded into colleges and the number of high-skill jobs that will be available for them if they manage to graduate. The problem is that the skills ladder is not really a ladder at all: it is a pyramid, and there is only so much room at the top.[137]

While Ford was commenting on circumstances in the United States, similar concerns are emerging in Australia. The Foundation for Young Australians commented on the difficulties young Australians currently face in finding full-time work. According to its most recent annual report, it takes young people an average of 4.7 years to enter full-time work after leaving full-time education, compared to one year in 1986.[138]

Graduate Careers Australia (GCA) statistics further emphasise this issue. Between 2000 and 2014, the percentage of bachelor degree graduates finding full-time employment four months after graduation has decreased from 83.6% in 2000 to 68.1% in 2014 (Figure 23). According to GCA's strategy and policy advisor Bruce Guthrie, "these are the toughest labour market conditions since the early 1990s, that's for sure. The demand for graduates has dropped away."[139]

Figure 23: Percentage of bachelor degree graduates in full-time employment four months after graduation[140]



These figures do not mean that improving educational outcomes or increasing STEM knowledge is a fruitless endeavour: a smarter workforce with strong skills

[137] Ford, note 43, p 252.

[138] Foundation for Young Australians, note 135, p 2.

[139] I Ting, Gen Y: Australia's most educated generation faces worst job prospects in decades, Sydney Morning Herald (online), 8 November 2015.

[140] Compiled from Graduate Careers Australia's GradStats data from 1999-2014.

in these fields will undoubtedly benefit both individuals and the wider Australian economy. Nevertheless, there are limits to what education alone can do to address the coming challenges in the Australian workforce, limits which policymakers will need to take into account.

7.4 Other policy proposals

In addition to improving education, a range of other policies, either currently in use overseas or advocated by policymakers, have been recommended. A selection of these policy ideas are outlined below.

7.4.1 "Flexicurity" and Active Labour Market Policies

A number of European countries, notably Denmark, have implemented an industrial relations system known as the "flexicurity model". The Danish Government provides a summary of this three-pronged model:

> Flexicurity is a compound of flexibility and security. The Danish model has a third element - active labour market policy - and together these elements comprise the golden triangle of flexicurity.
>
> One side of the triangle is flexible rules for hiring and firing, which make it easy for the employers to dismiss employees during downturns and hire new staff when things improve. About 25% of Danish private sector workers change jobs each year.
>
> The second side of the triangle is unemployment security in the form of a guarantee for a legally specified unemployment benefit at a relatively high level - up to 90% for the lowest paid workers.
>
> The third side of the triangle is the active labour market policy. An effective system is in place to offer guidance, a job or education to all unemployed. Denmark spends approx. 1.5% of its GDP on active labour market policy.[141]

Essentially, the flexicurity model provides employers with 'flexibility' by making it easier for them to hire and fire workers, and employees with 'security' by providing generous unemployment benefits and comprehensive Active Labour Market Programs (ALMPs) to help unemployed people gain new skills for jobs.[142] This three-pronged approach has had significant success in Denmark and other European nations. According to the 2014 book *Northern Lights*:

> The unemployment rate in Denmark, with its high investment in ALMPs, was lower in all but one of the 14 years of economic upswing from the early 1990s, until the effects of the GFC were felt in 2009, than the unemployment rate in Australia, with its non-investment in ALMPS. The Danish policy approach was clearly superior at channelling economic growth into jobs growth.[143]

Other studies have found that the flexicurity model does more than reduce the

[141] Danish Government, Flexicurity, 2015.

[142] A Scott, Northern Lights: The positive policy example of Sweden, Finland, Denmark and Norway (Monash University Publishing, 2014) p 135.

[143] Ibid p 140.

headline unemployment rate. According to Belchamber, flexicurity policies in Scandinavian countries have helped keep macroeconomic indicators[144] strong, job satisfaction high, and have helped produce a 5% reduction in structural unemployment levels since the early 1990s.[145]

To what extent the European flexicurity model can or should be implemented in Australia is unclear, given the many legal and cultural differences between these jurisdictions.[146] Nevertheless, experts believe that Australia can learn from this model, particularly in relation to skills enhancement through ALMPs.

For example, ALMPs may be of particular benefit to older Australians, who currently face barriers to participation such as health conditions and discrimination. According to a 2015 paper by Perrier:

> [ALMPs] that integrate skill-retraining and job-placement with healthcare needs should be considered a priority and must be designed in a way that takes into account their mixed record of success internationally.[147]

Because of the mixed success of international ALMPs, Perrier recommended that a comprehensive review should first be undertaken into the development of ALMP programs.[148]

7.4.2 Initiatives for startup companies

As discussed in chapter 4.1.1, innovation jobs have the potential to greatly benefit economic growth despite constituting a small proportion of the workforce. However, StartupAUS has criticised Australian governments for relying disproportionately on resource sector exports to maintain economic prosperity:

> One of Australia's challenges is to shift away from being a derivative economy and to create high labour productivity jobs that are not susceptible to being usurped by lower cost-of-labour locations, as has been seen in the case of car manufacturing, and at the same time to avoid the fate of resource-rich Argentina which has suffered massive economic downturn as a consequence of government failure to alter the composition of its economy.[149]

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[144] Including GDP growth, employment growth, employment and unemployment rates, inflation, external balance and business investment.

[145] G Belchamber, 'Flexicurity: What is it? Can it work Down Under?' (2010) 36 *Australian Bulletin of Labour* 278, p 286.

[146] For example, the relationship between employers and unions in many European countries are far more collaborative than in Australia, while union membership is substantially higher in these nations than in Australia. See M Dimick, 'Labor law, new governance, and the Ghent system' (2012) 90 *North Carolina Law Review* 319; J Lind, 'A Nordic Saga? The Ghent System and Trade Unions' (2007) 15 *International Journal of Employment Studies* 49.

[147] E Perrier, Positive Disruption: Healthcare, Ageing & Participation in the Age of Technology, McKell Institute, September 2015 p 17.

[148] Ibid p 45.

[149] StartupAUS, Crossroads 2015: An action plan to develop a vibrant tech startup ecosystem in Australia, April 2015, p 20.

While the Commonwealth Government is responsible for the majority of policies aimed at creating an effective startup ecosystem (e.g. change the tax treatment of Employee Share Schemes, implement a national program of entrepreneurship education),[150] there are a number of proposals that could be implemented at the State level. Note in this respect that NSW is home to nearly two-thirds of Australia's startup community.[151]

Increased funding for startup companies is one such initiative. While some Australian States have funding initiatives for startups, the United Kingdom has several funding initiatives for UK start-ups in addition to the SEIS, including:

- The Angel CoFund: A £100m investment fund that makes initial investments of between £100,000 and £1 million alongside syndicates of business angels;[152] and
- The StartUp Loans Scheme: A government funded scheme that allows individuals to borrow up to £25,000 set at a 6% p.a. fixed rate of interest, as well as providing access to mentors who can offer free support and advice.[153] According to a House of Commons Library briefing paper, as of September 2014 20,400 loans were made and £102.8 million loaned under the scheme.[154]

Support for entrepreneurs can extend beyond funding. For example, PwC commented on entrepreneurship leave in France in a 2013 report:

> In France, an innovative law fosters entrepreneurship by allowing employees to take up to two years of leave from their company to start their own business or work in another job part-time. At the end of the 'entrepreneurship leave', the employee can choose to return to their previous job or if all goes well, continue with their own business.[155]

From an Australian State perspective, implementation of such a scheme would only apply to the public sector.

PwC also commented on the need to create a strong cultural environment that would allow entrepreneurs to thrive. While the NSW Government is taking steps to create such an environment, PwC nevertheless noted that systemic fear of failure is a major impediment to startup activity in Australia, despite the nation having one of the best regulatory environments for entrepreneurship, along with an engaged and strengthening culture of inclusion and openness.[156]

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[150] Ibid pp 30-1.
[151] PwC, The Startup Economy, April 2013, p 5.
[152] AngelCoFund, n.d.
[153] Startup Loans, FAQs, 2013.
[154] House of Commons Library, Business support schemes – statistics, 4 September 2014, p 2.
[155] PwC, note 151, p 19.
[156] Ibid p 13.

7.4.3 Inclusive growth

Concern over the polarisation of global workforces has led to calls for inclusive growth, a concept that "emphasises the importance of the interdependence of social inclusion and economic growth".[157]

According to Smyth, inclusive growth considers expenditure on key social services to be an investment in human capital, which subsequently produces a range of economic benefits, such as increased productivity and participation.[158]

There are many policy proposals that can be included within an inclusive growth framework.[159] Citigroup has summarised a selection of key policy proposals intended to facilitate inclusive growth in developed countries:[160]

- Undertaking tax reform to shift tax burdens from labour towards consumption. Proposed reforms include reductions in income and payroll taxes to make it cheaper to hire workers, or the implementation of a luxury tax on positional goods[161];
- Encouraging entrepreneurial risk-taking by reducing red tape and promoting self-employment, but also building welfare systems that cap the downside to entrepreneurial failure;
- Ongoing and increased investment in skills and training for workers; and
- Public investment in promising technologies for the future, which could help facilitate new job creation in a range of industries.

Many of these policies are being considered by both State and Commonwealth Governments,[162] and some have already been announced (for example, the Bays Precinct redevelopment in NSW).

For an inclusive growth framework to be successful, all stakeholders must play a role in its implementation. In its 2015 report on inclusive growth, the OECD summarises the challenges that lie ahead:

> For Inclusive Growth to work well, appropriate institutions are needed, and citizens must feel that they can trust them. New technologies can play an important role in strengthening inclusiveness in policy making and implementation, by enabling new forms of collaborative and participatory

[157] P Smyth, J Buchanan, Inclusive growth in Australia: Social policy as economic investment (Allen & Unwin, 2013) p xiv.

[158] P Smyth, 'Social investment, inclusive growth and the Australian way' in P Smyth, J Buchanan, Inclusive growth in Australia: Social policy as economic investment (Allen & Unwin, 2013) 19.

[159] For a full list of inclusive growth policy proposals for Australia, see Smyth and Buchanan, note 157.

[160] Citigroup, note 2, pp 88-9.

[161] Goods that function as status symbols, signalling their owners' high relative standing within society. See Investopedia, Positional Goods, n.d.

[162] For example, see K Murphy, 'Turnbull pledges 'no disadvantage' for most vulnerable in tax overhaul', The Guardian Australia (online), 2 November 2015.

governance. Inclusive policy making and service delivery requires an effective decentralisation of policies which allows for better targeted, place-based approaches.

An inclusive policy process should be inclusive across the policy cycle, requiring effective and representative citizen participation and mechanisms to curb the undue influence of money and power.[163]

[163] OECD, All on Board: Making Inclusive Growth Happen, May 2015, p 13.

8. CONCLUSION

Such technological trends as cloud computing, Big Data and advanced machine learning techniques have the potential to transform not only entire occupations, but whole industries. In particular, the combination of machine learning innovations with massive amounts of relevant data from almost any possible source could provide computers with the capacity to replace human workers in occupations that were hitherto considered beyond the scope of machines.

Research suggests that the potential impact of emerging technology is substantial, with two out of every five workers in both NSW and Australia employed in a job with a high risk of being computerised. Low skilled workers are most vulnerable to these radical changes, but many middle skill workers who perform predominantly routine tasks may also be caught up in the technological disruption.

This paper's analysis of computerisation by NSW electorate highlights the regions of the State most vulnerable to computerisation: namely, areas with large numbers of workers that perform either routine or certain types of non-routine tasks as part of their jobs. In contrast, workers in areas least vulnerable to computerisation work predominantly in jobs where perception and manipulation, creative intelligence and/or social intelligence tasks are key elements of their work.

Despite these seemingly grim findings, it is unlikely that two-fifths of the NSW workforce will become unemployed within a decade or two. As has happened in the past, new technologies bring many positive developments to society, including economic prosperity, new types of work, and an increasingly educated (and potentially happier) workforce. On balance, the net gain from technology is likely to outweigh the negative consequences of change.

Australian governments, businesses and other stakeholders recognise the need to implement policies that help smooth the transition into the new world of work. Although a number of policies are already being implemented in Australia at both the State and Commonwealth levels, there have also been calls for more far-reaching reforms to manage this transition. Increased education, particularly in the STEM fields, has been strongly advocated by many experts; other policies addressing unemployment, taxation for startup companies, and inclusive growth have also been proposed.

It is unclear exactly what will occur in NSW, Australia and the wider world as new technologies transform workplaces and workforces. Nevertheless, current trends signal dramatic changes on the horizon. If the benefits are to be maximised and the potential pain minimised, policymakers will need to address these challenges, thinking creatively, drawing on present trends and future possibilities.

APPENDIX A: METHODOLOGY FOR ASSESSING COMPUTERISATION IMPACT ON NSW

This section outlines the methodology used to assess the predicted impact of computerisation on NSW. The author wishes to acknowledge Professor Hugh Durrant-Whyte and CEDA for providing the NSW Parliamentary Research Service with some of the data.

The analysis uses CEDA estimates for the susceptibility of Australian occupations to computerisation. CEDA determined the probability of susceptibility for 391 ANZSCO occupation codes, the lowest aggregation level for occupations.[164] In turn, CEDA's estimates were based on the methodology and initial data used in the 2013 paper by Frey and Osborne.[165]

1) Determining the probability of computerisation of NSW jobs by ANSZCO occupation code

To create a distribution graph showing each NSW occupation by probability of computerisation, CEDA's probability of computerisation per ANZSCO occupation code was multiplied by the total number of NSW workers in the corresponding occupation. Employment data was derived from the 2011 Census, counting persons by place of usual residence.

Note that total workforce figures used in this analysis differ from the total NSW workforce figures in the 2011 Census. This is because CEDA was unable to map a number of US job codes to Australian ANSZCO occupation codes; these jobs have not been included in either the CEDA study or this analysis. Additionally, the Census occupation categories "Inadequately described" and "Not stated" were not included in this paper's analysis.

This gave an approximate number of jobs within each occupation that may face computerisation. This data was then charted in Figure 14, and used as a base for the subsequent analysis of computerisation by Major Group (step 2a). A similar process was used to determine the probability of computerisation for NSW State Electorates (step 2b).

2a) Determining the probability of computerisation of NSW jobs by ANSZCO Major Group

Following step 1, the number of jobs facing computerisation within each occupation was aggregated into their relevant ANZSCO Major Group. The total for each Major Group was then divided by the total number of jobs within that Major Group in NSW, creating a weighted probability of computerisation. These probabilities were then used to chart Figures 12 and 13.

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[164] ANZSCO uses codes classified into the following aggregation levels: Major; Sub-major; Minor; Unit and Occupation. For further information see Australian Bureau of Statistics, Census Dictionary, 2011, Cat No 2901.0.

[165] See chapter 5.2 of this paper.

To determine a weighted probability for the whole of NSW (see chapter 6.2), the number of jobs facing computerisation within each occupation was aggregated together to create a total for the whole State workforce. This total was then divided by the total number of jobs in NSW, creating a weighted probability of computerisation for the State.

2b) Determining the probability of computerisation of jobs by NSW State Electoral Division and ANSZCO Major Group

For each NSW State Electoral Division (SED), CEDA's probability of computerisation per ANZSCO occupation code was multiplied by the number of people employed in the corresponding occupation. This total was then divided by the total number of jobs in the SED, creating a weighted probability of computerisation for the SED. The data for all 93 SEDs (the probability dataset) was used to create the maps depicted in Figures 15-18 (see chapter 6.2). The process of mapping the probability dataset is explained in step 3.

3) Mapping the probability of computerisation jobs by NSW State Electoral Division

The predicted impact of computerisation for each SED was represented on a map of NSW using the CartoDB web mapping platform, as follows:

1. The CartoDB platform allows custom datasets to be overlaid on pre-existing maps. The following datasets were uploaded in order to map job computerisation by SED:
    a. The weighted probabilities of computerisation by SED (probability dataset);
    b. Two electoral boundary datasets:
        i. The official NSW Electoral Commission SED boundaries (SED dataset) using the 2013 redistribution. The SED dataset incorporates waterways, making it difficult to identify individual electorates in relation to geographic features. This is particularly noticeable in Greater Sydney, with a number of electorates bordering each other across Port Jackson or Botany Bay;
        ii. An approximation of the NSW SED boundaries based on ABS Statistical Areas Level 1 (SA1 dataset). The SA1 dataset bears a close, but not exact, correspondence to the official boundaries. It does not include waterways, making it easier to identify electorates relative to geographic features like Port Jackson.
2. Each boundary dataset was combined with the probability dataset, and each combined dataset was used to create maps showing an approximate representation of job computerisation in each SED.
    a. The SA1 dataset was used to create the Greater Sydney electorate map (Figure 15);
    b. The SED dataset was used to create maps for the Hunter & Central Coast, Illawarra, and Regional NSW (Figure 16-18).

APPENDIX B: JOBS AT RISK OF COMPUTERISATION BY NSW STATE ELECTORATE

List of electorates in alphabetical order

Electorate	Size of workforce	No of jobs at risk of computerisation	% jobs at risk of computerisation
Albury	33326	18046	54.15%
Auburn	31375	18588	59.24%
Ballina	28405	13914	48.99%
Balmain	40333	14757	36.59%
Bankstown	26361	16217	61.52%
Barwon	31192	17227	55.23%
Bathurst	36153	16662	46.09%
Baulkham Hills	31689	16483	52.01%
Bega	24918	13263	53.23%
Blacktown	34235	20893	61.03%
Blue Mountains	31402	14397	45.85%
Cabramatta	27333	17788	65.08%
Camden	32045	17398	54.29%
Campbelltown	31728	18858	59.44%
Canterbury	33580	18916	56.33%
Castle Hill	36391	16861	46.33%
Cessnock	28418	17655	62.13%
Charlestown	31802	16413	51.61%
Clarence	25228	14110	55.93%
Coffs Harbour	27285	14466	53.02%
Coogee	40593	15624	38.49%
Cootamundra	27609	14612	52.92%
Cronulla	35732	16877	47.23%
Davidson	32766	13153	40.14%
Drummoyne	34259	14855	43.36%
Dubbo	31381	16654	53.07%
East Hills	34784	15456	44.43%
Epping	30891	17307	56.03%
Fairfield	25961	16909	65.13%
Gosford	28932	15495	53.56%
Goulburn	31457	16150	51.34%
Granville	31659	18729	59.16%
Hawkesbury	34802	19149	55.02%
Heathcote	38156	19178	50.26%
Heffron	40502	18788	46.39%
Holsworthy	34051	19127	56.17%
Hornsby	37943	17491	46.10%
Keira	31971	15541	48.61%
Kiama	29068	15049	51.77%
Kogarah	36673	20750	56.58%
Ku-ring-gai	33306	13380	40.17%
Lake Macquarie	28321	15800	55.79%
Lakemba	27297	16705	61.20%
Lane Cove	36790	15000	40.77%
Lismore	29034	15257	52.55%
Liverpool	29569	18628	63.00%
Londonderry	30778	19580	63.62%
Macquarie Fields	33864	20393	60.22%
Maitland	30481	17600	57.74%
Manly	39203	16036	40.90%
Maroubra	32852	16236	49.42%
Miranda	35023	17356	49.55%
Monaro	36259	18643	51.42%
Mount Druitt	32834	21264	64.76%
Mulgoa	36396	20988	57.67%
Murray	34588	19559	56.55%
Myall Lakes	22728	12338	54.29%
Newcastle	32875	15596	47.44%

Newtown	40673	15830	38.92%
North Shore	39394	14431	36.63%
Northern Tablelands	31611	16108	50.96%
Oatley	33480	17083	51.02%
Orange	32319	17263	53.41%
Oxley	23948	12781	53.37%
Parramatta	34641	19176	55.36%
Penrith	39919	21221	53.16%
Pittwater	33047	14637	44.29%
Port Macquarie	24451	12495	51.10%
Port Stephens	26519	15140	57.09%
Prospect	32680	19282	59.00%
Riverstone	36307	19242	53.00%
Rockdale	33986	18486	54.39%
Ryde	38123	18774	49.25%
Seven Hills	36664	19253	52.51%
Shellharbour	30609	17883	58.42%
South Coast	21222	11403	53.73%
Strathfield	38067	19396	50.95%
Summer Hill	37110	17277	46.56%
Swansea	27118	15372	56.68%
Sydney	47851	19254	40.24%
Tamworth	31418	16991	54.08%
Terrigal	30731	14717	47.89%
The Entrance	29834	16191	54.27%
Tweed	26590	14418	54.22%
Upper Hunter	33562	20114	59.93%
Vaucluse	38112	13674	35.88%
Wagga Wagga	34291	18156	52.95%
Wakehurst	36479	17508	48.00%
Wallsend	33091	18116	54.75%
Willoughby	38567	15352	39.81%
Wollondilly	30400	16559	54.47%
Wollongong	30972	16705	53.93%
Wyong	26938	15474	57.44%
NSW	**3037959**	**1567110**	**51.58%**

List of electorates by probability of computerisation (highest to lowest)

Electorate	% jobs at risk of computerisation	Size of workforce	No of jobs at risk
Fairfield	65.13%	27285	16909
Cabramatta	65.08%	36307	17788
Mount Druitt	64.76%	34291	21264
Londonderry	63.62%	27609	19580
Liverpool	63.00%	29034	18628
Cessnock	62.13%	36664	17655
Bankstown	61.52%	31689	16217
Lakemba	61.20%	29068	16705
Blacktown	61.03%	31802	20893
Macquarie Fields	60.22%	36259	20393
Upper Hunter	59.93%	31457	20114
Campbelltown	59.44%	24451	18858
Auburn	59.24%	33480	18588
Granville	59.16%	31611	18729
Prospect	59.00%	38067	19282
Shellharbour	58.42%	38156	17883
Maitland	57.74%	35023	17600
Mulgoa	57.67%	32852	20988
Wyong	57.44%	38123	15474
Port Stephens	57.09%	28405	15140
Swansea	56.68%	31971	15372
Kogarah	56.58%	36479	20750
Murray	56.55%	30731	19559
Canterbury	56.33%	32875	18916
Holsworthy	56.17%	35732	19127
Epping	56.03%	37110	17307
Clarence	55.93%	40502	14110
Lake Macquarie	55.79%	36391	15800
Parramatta	55.36%	37943	19176
Barwon	55.23%	36153	17227
Hawkesbury	55.02%	31402	19149
Wallsend	54.75%	34784	18116
Wollondilly	54.47%	33047	16559
Rockdale	54.39%	34259	18486
Camden	54.29%	39203	17398
Myall Lakes	54.29%	36790	12338
The Entrance	54.27%	47851	16191
Tweed	54.22%	33306	14418
Albury	54.15%	32766	18046
Tamworth	54.08%	38567	16991
Wollongong	53.93%	40673	16705
South Coast	53.73%	40593	11403
Gosford	53.56%	39394	15495
Orange	53.41%	40333	17263
Oxley	53.37%	38112	12781
Bega	53.23%	27285	13263
Penrith	53.16%	36307	21221
Dubbo	53.07%	34291	16654
Coffs Harbour	53.02%	27609	14466
Riverstone	53.00%	29034	19242
Wagga Wagga	52.95%	36664	18156
Cootamundra	52.92%	31689	14612
Lismore	52.55%	29068	15257
Seven Hills	52.51%	31802	19253
Baulkham Hills	52.01%	36259	16483
Kiama	51.77%	31457	15049
Charlestown	51.61%	24451	16413
NSW	**51.58%**	**3037959**	**1567110**
Monaro	51.42%	33480	18643
Goulburn	51.34%	31611	16150
Port Macquarie	51.10%	38067	12495
Oatley	51.02%	38156	17083

Northern Tablelands	50.96%	35023	16108
Strathfield	50.95%	32852	19396
Heathcote	50.26%	38123	19178
Miranda	49.55%	28405	17356
Maroubra	49.42%	31971	16236
Ryde	49.25%	36479	18774
Ballina	48.99%	30731	13914
Keira	48.61%	32875	15541
Wakehurst	48.00%	35732	17508
Terrigal	47.89%	37110	14717
Newcastle	47.44%	40502	15596
Cronulla	47.23%	36391	16877
Summer Hill	46.56%	37943	17277
Heffron	46.39%	36153	18788
Castle Hill	46.33%	31402	16861
Hornsby	46.10%	34784	17491
Bathurst	46.09%	33047	16662
Blue Mountains	45.85%	34259	14397
East Hills	44.43%	39203	15456
Pittwater	44.29%	36790	14637
Drummoyne	43.36%	47851	14855
Manly	40.90%	33306	16036
Lane Cove	40.77%	32766	15000
Sydney	40.24%	38567	19254
Ku-ring-gai	40.17%	40673	13380
Davidson	40.14%	40593	13153
Willoughby	39.81%	39394	15352
Newtown	38.92%	40333	15830
Coogee	38.49%	38112	15624
North Shore	36.63%	27285	14431
Balmain	36.59%	36307	14757
Vaucluse	35.88%	34291	13674

APPENDIX C: OCCUPATIONS AT RISK OF COMPUTERISATION IN NSW

List of occupations in alphabetical order

ANSZCO occupation	Probability of computerisation	Size of NSW workforce	No of jobs at risk
Accommodation and Hospitality Managers nfd	12.1%	185	22
Accountants	93.6%	52245	48921
Accountants, Auditors and Company Secretaries nfd	93.6%	173	162
Accounting Clerks	94.8%	35964	34079
Actors, Dancers and Other Entertainers	14.3%	1918	275
Actuaries, Mathematicians and Statisticians	47.4%	1866	884
Advertising and Marketing Professionals	23.5%	19515	4578
Advertising, Public Relations and Sales Managers	6.5%	37648	2466
Aged and Disabled Carers	10.4%	28394	2949
Agricultural and Forestry Scientists	5.4%	1430	77
Agricultural Technicians	56.8%	488	277
Agricultural, Forestry and Horticultural Plant Operators	91.2%	2220	2025
Air Transport Professionals	38.8%	3533	1372
Airconditioning and Refrigeration Mechanics	35.8%	5560	1988
Aircraft Maintenance Engineers	67.9%	5696	3869
Ambulance Officers and Paramedics	34.5%	3603	1244
Amusement, Fitness and Sports Centre Managers	10.7%	2168	232
Anaesthetists	4.3%	1128	48
Animal Attendants and Trainers	91.7%	3653	3351
Aquaculture Farmers	93.8%	508	477
Aquaculture Workers	64.9%	53	34
Architects and Landscape Architects	8.9%	6078	541
Architects, Designers, Planners and Surveyors nfd	8.3%	1684	139
Architectural, Building and Surveying Technicians	79.1%	13360	10567
Archivists, Curators and Records Managers	16.5%	1594	263
Artistic Directors, and Media Producers and Presenters	9.1%	4925	446
Arts Professionals nfd	14.9%	670	100
Auctioneers, and Stock and Station Agents	39.1%	954	373
Auditors, Company Secretaries and Corporate Treasurers	93.6%	6236	5839
Authors, and Book and Script Editors	87.9%	1921	1689
Automobile Drivers	91.2%	11402	10400
Automotive and Engineering Trades Workers nfd	91.8%	144	132
Automotive Electricians	75.5%	1715	1294
Bakers and Pastrycooks	90.1%	7569	6818
Bank Workers	95.7%	21224	20313
Bar Attendants and Baristas	57.4%	27144	15582
Barristers	9.4%	2284	215
Beauty Therapists	65.1%	6725	4376
Betting Clerks	86.5%	912	789
Boat Builders and Shipwrights	92.4%	888	820
Bookkeepers	94.8%	22871	21673
Bricklayers and Stonemasons	90.8%	6633	6021
Bricklayers, and Carpenters and Joiners nfd	72.0%	336	242
Building and Engineering Technicians nfd	68.5%	1947	1333
Building and Plumbing Labourers	93.1%	12600	11731
Bus and Coach Drivers	92.2%	12037	11094
Butchers and Smallgoods Makers	96.4%	5539	5339
Cabinetmakers	84.6%	4172	3531
Cafe and Restaurant Managers	7.3%	14616	1065
Cafe Workers	94.6%	7987	7555
Call or Contact Centre and Customer Service Managers	24.1%	11161	2688
Call or Contact Centre Workers	31.5%	7553	2379
Canvas and Leather Goods Makers	78.0%	763	595
Car Detailers	24.0%	4165	1000
Caravan Park and Camping Ground Managers	24.1%	1022	246
Carers and aides nfd	21.0%	1618	340

Caretakers	76.2%	2409	1836
Carpenters and Joiners	41.6%	29030	12088
Checkout Operators and Office Cashiers	95.5%	31772	30356
Chefs	9.4%	18712	1758
Chemical and Materials Engineers	11.6%	596	69
Chemical, Gas, Petroleum and Power Generation Plant Operators	90.3%	1970	1778
Chemists, and Food and Wine Scientists	30.9%	2052	635
Chief Executives and Managing Directors	8.6%	16001	1373
Child Care Centre Managers	9.4%	2852	268
Child Carers	9.4%	35051	3294
Chiropractors and Osteopaths	3.0%	1405	42
Civil Engineering Draftspersons and Technicians	63.8%	2442	1558
Civil Engineering Professionals	20.1%	9732	1956
Clay, Concrete, Glass and Stone Processing Machine Operators	93.6%	880	823
Cleaners and Laundry Workers nfd	92.8%	9939	9219
Clerical and administrative workers nfd	93.7%	2761	2586
Clothing Trades Workers	89.2%	2417	2155
Commercial Cleaners	89.6%	33613	30103
Commissioned Officers (Management)	24.1%	2539	612
Complementary Health Therapists	6.6%	2003	133
Computer Network Professionals	30.1%	6141	1847
Concreters	91.5%	6878	6293
Conference and Event Organisers	8.4%	5991	503
Construction Managers	10.0%	22873	2277
Construction Trades Workers nfd	88.8%	576	511
Contract, Program and Project Administrators	39.1%	27999	10953
Conveyancers and Legal Executives	90.8%	3673	3336
Cooks	95.1%	15378	14631
Corporate Services Managers	10.2%	1352	138
Counsellors	6.4%	5004	318
Couriers and Postal Deliverers	95.6%	11907	11379
Court and Legal Clerks	91.3%	3380	3086
Crane, Hoist and Lift Operators	94.3%	2723	2568
Credit and Loans Officers (Aus) / Finance Clerks (NZ)	85.2%	7657	6525
Crop Farm Workers	95.3%	3611	3441
Crop Farmers	69.6%	9963	6932
Database and Systems Administrators, and ICT Security Specialists	27.6%	7640	2108
Debt Collectors	64.2%	2800	1798
Deck and Fishing Hands	78.6%	1568	1233
Defence Force Members - Other Ranks	18.4%	4337	797
Delivery Drivers	91.2%	10781	9834
Dental Assistants	65.1%	6003	3907
Dental Hygienists, Technicians and Therapists	38.4%	1660	638
Dental Practitioners	9.2%	3715	341
Diversional Therapists	6.6%	1527	102
Domestic Cleaners	84.8%	4483	3801
Drillers, Miners and Shot Firers	88.4%	12183	10768
Driving Instructors	10.2%	1302	132
Early Childhood (Pre-primary School) Teachers	7.9%	7621	600
Earthmoving Plant Operators	95.2%	9871	9401
Economists	23.1%	1024	236
Education Advisers and Reviewers	5.8%	2737	159
Education Aides	32.2%	15464	4982
Education Professionals nfd	5.7%	1245	70
Electrical Distribution Trades Workers	21.2%	2950	624
Electrical Engineering Draftspersons and Technicians	31.4%	2292	721
Electrical Engineers	33.9%	4883	1656
Electricians	57.4%	32833	18858
Electronic Engineering Draftspersons and Technicians	31.4%	1520	478
Electronics Engineers	23.1%	946	219
Electronics Trades Workers	63.4%	9370	5942
Electrotechnology and Telecommunications Trades Workers nfd	60.2%	931	560

Engineering Managers	7.2%	4633	334
Engineering Production Workers	93.9%	6023	5658
Engineering Professionals nfd	20.8%	6574	1364
Engineering, ICT and Science Technicians nfd	68.4%	1665	1139
Enrolled and Mothercraft Nurses	6.6%	4651	307
Environmental Scientists	20.0%	4437	886
Factory Process Workers nfd	93.2%	4307	4012
Farm, forestry and garden workers nfd	95.1%	756	719
Farmers and Farm Managers nfd	67.0%	1308	876
Fashion, Industrial and Jewellery Designers	7.4%	2570	189
Fast Food Cooks	94.8%	10208	9679
Fencers	91.5%	2420	2214
Filing and Registry Clerks	95.7%	4666	4467
Film, Television, Radio and Stage Directors	9.3%	3798	354
Finance Managers	23.6%	15747	3716
Financial Brokers	41.0%	6619	2712
Financial Dealers	7.8%	7686	603
Financial Investment Advisers and Managers	54.1%	11611	6280
Fire and Emergency Workers	8.2%	3985	328
Fitness Instructors	4.6%	6988	323
Floor Finishers	78.2%	2407	1883
Florists	52.8%	1700	898
Food and Drink Factory Workers	90.7%	7390	6705
Food preparation assistants nfd	93.7%	214	200
Food Trades Assistants	91.5%	1025	937
Forestry and Logging Workers	88.4%	599	529
Forklift Drivers	92.0%	13604	12522
Freight and Furniture Handlers	75.2%	3495	2627
Funeral Workers	18.7%	1087	204
Gallery, Library and Museum Technicians	18.5%	1422	263
Gallery, Museum and Tour Guides	18.7%	1428	267
Gaming Workers	86.5%	1391	1203
Garden and Nursery Labourers	95.5%	7192	6870
Gardeners	69.6%	14328	9968
General Clerks	85.8%	73504	63031
General Managers	5.0%	14193	710
Generalist Medical Practitioners	4.3%	13892	593
Geologists and Geophysicists	45.9%	1254	575
Glaziers	91.9%	2119	1948
Graphic and Web Designers, and Illustrators	14.0%	13238	1857
Graphic Pre-press Trades Workers	20.4%	1163	237
Greenkeepers	69.6%	3064	2132
Hairdressers	70.5%	16631	11727
Handypersons	86.6%	9327	8074
Health and Welfare Services Managers	7.5%	5914	442
Hospitality Workers nfd	91.0%	2768	2519
Hotel and Motel Managers	4.0%	6208	250
Hotel Service Managers	4.0%	1880	76
Housekeepers	93.6%	7006	6560
Human Resource Clerks	73.7%	2657	1959
Human Resource Managers	11.4%	12058	1373
Human Resource Professionals	12.2%	16649	2029
ICT Business and Systems Analysts	6.3%	7829	493
ICT Managers	9.0%	17534	1579
ICT Professionals nfd	31.5%	8954	2819
ICT Sales Assistants	77.7%	5033	3912
ICT Sales Professionals	6.4%	5373	343
ICT Support and Test Engineers	61.3%	3067	1880
ICT Support Technicians	49.3%	15531	7657
ICT Trainers	15.9%	855	136
Importers, Exporters and Wholesalers	34.9%	7951	2771
Industrial Spraypainters	89.8%	1423	1278
Industrial, Mechanical and Production Engineers	20.6%	4842	998
Inquiry Clerks	91.8%	18493	16972
Inspectors and Regulatory Officers	86.9%	10993	9552
Insulation and Home Improvement Installers	83.6%	4356	3640

Insurance Agents	88.6%	3618	3204
Insurance Investigators, Loss Adjusters and Risk Surveyors	90.8%	1591	1444
Insurance, Money Market and Statistical Clerks	95.4%	11025	10522
Interior Designers	11.3%	2455	277
Jewellers	33.2%	1358	450
Journalists and Other Writers	18.7%	8312	1552
Judicial and Other Legal Professionals	9.5%	2451	232
Keyboard Operators	94.3%	15476	14601
Kitchenhands	91.5%	26225	23984
Labourers nfd	96.1%	7092	6818
Land Economists and Valuers	78.9%	3354	2647
Laundry Workers	86.8%	4647	4034
Librarians	23.3%	3095	722
Library Assistants	92.1%	2451	2257
Licensed Club Managers	24.1%	2639	636
Life Scientists	12.5%	1146	144
Livestock Farm Workers	95.3%	7359	7013
Livestock Farmers	10.5%	23159	2421
Machine and Stationary Plant Operators nfd	95.5%	600	573
Machine operators nfd	95.7%	6662	6376
Machinery operators and drivers nfd	95.6%	3389	3240
Mail Sorters	94.8%	4093	3881
Management and Organisation Analysts	28.2%	16822	4736
Managers nfd	10.8%	12170	1313
Manufacturers	6.8%	6394	436
Marine Transport Professionals	48.8%	1845	901
Massage Therapists	7.6%	3244	248
Meat Boners and Slicers, and Slaughterers	96.4%	1813	1747
Meat, Poultry and Seafood Process Workers	90.7%	4520	4101
Mechanical Engineering Draftspersons and Technicians	68.7%	1221	839
Media Professionals nfd	10.9%	924	101
Medical Imaging Professionals	15.3%	4414	677
Medical Laboratory Scientists	77.9%	4549	3545
Medical Practitioners nfd	4.2%	541	23
Medical Technicians	18.5%	6731	1242
Metal Casting, Forging and Finishing Trades Workers	95.1%	702	668
Metal Engineering Process Workers	92.8%	3072	2852
Metal Fitters and Machinists	89.0%	22654	20153
Middle School Teachers (Aus) / Intermediate School Teachers (NZ)	7.0%	114	8
Mining Engineers	35.8%	1151	412
Ministers of Religion	9.4%	5498	516
Mixed Crop and Livestock Farm Workers	95.3%	1081	1030
Mixed Crop and Livestock Farmers	10.5%	11098	1160
Mobile plant operators nfd	95.4%	1609	1535
Models and Sales Demonstrators	80.2%	3423	2746
Motor Mechanics	69.8%	24601	17168
Motor Vehicle and Vehicle Parts Salespersons	77.7%	8500	6606
Motor Vehicle Parts and Accessories Fitters	84.2%	2949	2482
Music Professionals	17.3%	3061	530
Natural and Physical Science Professionals nfd	15.1%	1671	253
Numerical Clerks nfd	95.6%	381	364
Nurse Managers	7.1%	3892	276
Nurserypersons	69.6%	1038	722
Nursing Support and Personal Care Workers	29.7%	24235	7209
Occupational and Environmental Health Professionals	35.3%	4660	1645
Occupational Therapists	3.0%	2776	83
Office Managers	12.1%	34098	4116
Optometrists and Orthoptists	12.0%	1589	191
Other Accommodation and Hospitality Managers	21.4%	1724	368
Other Building and Engineering Technicians	49.3%	4210	2075
Other Cleaners	93.1%	2983	2778
Other Clerical and Office Support Workers	94.1%	5570	5244
Other Construction and Mining Labourers	76.1%	1660	1264

Other Education Managers	6.3%	3358	211
Other Engineering Professionals	16.8%	1883	317
Other Factory Process Workers	93.0%	3192	2969
Other Farm, Forestry and Garden Workers	92.8%	3130	2905
Other Health Diagnostic and Promotion Professionals	4.6%	1576	72
Other Hospitality Workers	92.2%	1350	1245
Other Hospitality, Retail and Service Managers	17.0%	17902	3051
Other Information and Organisation Professionals	26.9%	5724	1537
Other Machine Operators	89.2%	3278	2925
Other Medical Practitioners	6.8%	2819	192
Other Miscellaneous Clerical and Administrative Workers	85.8%	6108	5239
Other Miscellaneous Labourers	94.7%	14509	13740
Other Miscellaneous Technicians and Trades Workers	74.0%	4794	3549
Other Mobile Plant Operators	95.6%	2607	2491
Other Natural and Physical Science Professionals	11.8%	1711	202
Other Personal Service Workers	30.0%	2948	884
Other Sales Assistants and Salespersons	95.1%	4893	4652
Other Sales Support Workers	94.5%	682	645
Other Specialist Managers	5.6%	14101	786
Other Stationary Plant Operators	91.9%	5428	4988
Outdoor Adventure Guides	4.6%	506	23
Packers	71.2%	15027	10704
Packers and Product Assemblers nfd	78.2%	110	86
Painting Trades Workers	89.4%	10817	9676
Panelbeaters	82.2%	4019	3304
Panelbeaters, and Vehicle Body Builders, Trimmers and Painters nfd	87.5%	418	366
Paper and Wood Processing Machine Operators	94.2%	1880	1771
Paving and Surfacing Labourers	92.2%	2245	2070
Payroll Clerks	91.0%	8180	7441
Performing Arts Technicians	38.8%	4018	1559
Personal Assistants	93.3%	16587	15473
Personal Care Consultants	65.1%	1199	780
Pharmacists	3.1%	6018	185
Pharmacy Sales Assistants	77.7%	10239	7957
Photographers	11.6%	3209	373
Photographic Developers and Printers	59.7%	678	405
Physiotherapists	4.8%	4855	235
Plasterers	83.0%	5969	4953
Plastics and Rubber Factory Workers	92.8%	653	606
Plastics and Rubber Production Machine Operators	95.4%	2268	2163
Plumbers	75.0%	17987	13487
Podiatrists	3.0%	760	23
Policy and Planning Managers	10.2%	4526	462
Practice Managers	90.4%	4887	4420
Precision Metal Trades Workers	88.2%	2168	1911
Primary Products Inspectors	87.4%	1066	931
Primary School Teachers	7.0%	41799	2913
Print Finishers and Screen Printers	92.5%	1078	997
Printers	70.6%	4258	3008
Printing Assistants and Table Workers	92.8%	1539	1429
Printing Trades Workers nfd	84.7%	132	112
Prison Officers	7.8%	4172	324
Private Tutors and Teachers	4.5%	10271	461
Product Assemblers	92.6%	6191	5735
Product Quality Controllers	93.0%	2841	2642
Production Managers	6.8%	13659	932
Professionals nfd	9.2%	10072	930
Psychiatrists	4.3%	766	33
Psychologists	6.9%	6453	446
Public Relations Professionals	15.0%	5645	849
Purchasing and Supply Logistics Clerks	95.6%	21289	20345
Railway Track Workers	92.2%	1397	1288
Real Estate Sales Agents	31.2%	20521	6399
Receptionists	25.9%	42494	10990

Recycling and Rubbish Collectors	10.0%	784	79
Registered Nurses	6.7%	63819	4249
Research and Development Managers	8.9%	3212	286
Retail and Wool Buyers	31.2%	1665	519
Retail Managers	12.1%	60019	7274
Retail Supervisors	8.2%	7586	624
Road and Rail Drivers nfd	92.6%	3763	3486
Roof Tilers	86.7%	2114	1833
Safety Inspectors	62.0%	872	541
Sales Assistants (General)	65.1%	138388	90050
Sales assistants and salespersons nfd	86.2%	6161	5313
Sales Representatives	33.3%	31133	10374
Sales workers nfd	81.7%	1353	1105
School Principals	6.3%	6226	391
School Teachers nfd	6.1%	6692	405
Science Technicians	53.9%	3379	1822
Secondary School Teachers	3.3%	43253	1427
Secretaries	87.7%	26461	23196
Security Officers and Guards	85.0%	13872	11788
Service Station Attendants	95.9%	2431	2331
Sewing Machinists	93.8%	3067	2878
Shearers	95.3%	1287	1226
Sheetmetal Trades Workers	82.2%	1914	1574
Shelf Fillers	83.9%	12372	10377
Signwriters	95.0%	1650	1567
Social Professionals	50.0%	2811	1406
Social Workers	7.0%	4331	304
Software and Applications Programmers	56.2%	22890	12861
Solicitors	9.4%	18515	1740
Special Care Workers	8.7%	644	56
Special Education Teachers	7.0%	5866	410
Specialist Managers nfd	6.8%	6540	444
Specialist Physicians	4.3%	1806	77
Speech Professionals and Audiologists	5.9%	2052	122
Sports Coaches, Instructors and Officials	36.7%	8955	3284
Sportspersons	48.3%	2357	1138
Storepersons	95.0%	32598	30956
Street Vendors and Related Salespersons	47.9%	2171	1040
Structural Steel and Welding Trades Workers	95.3%	15575	14850
Structural Steel Construction Workers	91.8%	4277	3927
Supply and Distribution Managers	34.9%	8942	3117
Surgeons	4.3%	1548	66
Survey Interviewers	82.4%	788	649
Surveyors and Spatial Scientists	83.7%	3262	2731
Switchboard Operators	80.5%	1220	982
Teachers of English to Speakers of Other Languages	13.7%	1871	257
Technical Sales Representatives	20.4%	7755	1581
Technicians and Trades Workers nfd	90.0%	6590	5931
Telecommunications Engineering Professionals	33.9%	3770	1279
Telecommunications Technical Specialists	75.6%	1393	1052
Telecommunications Trades Workers	66.6%	5257	3500
Telemarketers	90.4%	2612	2362
Tertiary Education Teachers nfd	15.9%	238	38
Textile and Footwear Production Machine Operators	91.5%	973	890
Ticket Salespersons	91.7%	5818	5337
Timber and Wood Process Workers	92.8%	1675	1555
Toolmakers and Engineering Patternmakers	91.6%	1577	1445
Tourism and Travel Advisers	24.9%	7081	1767
Train and Tram Drivers	93.7%	3503	3282
Training and Development Professionals	21.6%	6391	1383
Transport and Despatch Clerks	90.2%	9182	8279
Transport Services Managers	34.9%	4207	1466
Travel Attendants	9.4%	3498	329
Truck Drivers	78.8%	43830	34534
University Lecturers and Tutors	15.9%	13419	2137
Upholsterers	60.0%	847	508

Urban and Regional Planners	33.0%	3003	990
Vehicle Body Builders and Trimmers	82.9%	1434	1189
Vehicle Painters	89.8%	2926	2628
Vending Machine Attendants	87.2%	1427	1244
Veterinarians	9.1%	2155	196
Veterinary Nurses	91.7%	2230	2046
Visual Arts and Crafts Professionals	19.0%	1640	311
Visual Merchandisers	11.3%	1365	154
Vocational Education Teachers (Aus) / Polytechnic Teachers (NZ)	15.9%	11908	1896
Waiters	93.0%	27673	25747
Wall and Floor Tilers	86.7%	4001	3467
Welfare Support Workers	6.0%	14846	894
Welfare, Recreation and Community Arts Workers	7.0%	6485	455
Wood Machinists and Other Wood Trades Workers	92.7%	1456	1350

List of occupations by probability of computerisation (highest to lowest)

ANSZCO occupation	Probability of computerisation	Size of NSW workforce	No of jobs at risk
Butchers and Smallgoods Makers	96.4%	5539	5339
Meat Boners and Slicers, and Slaughterers	96.4%	1813	1747
Labourers nfd	96.1%	7092	6818
Service Station Attendants	95.9%	2431	2331
Filing and Registry Clerks	95.7%	4666	4467
Bank Workers	95.7%	21224	20313
Machine operators nfd	95.7%	6662	6376
Numerical Clerks nfd	95.6%	381	364
Machinery operators and drivers nfd	95.6%	3389	3240
Purchasing and Supply Logistics Clerks	95.6%	21289	20345
Other Mobile Plant Operators	95.6%	2607	2491
Couriers and Postal Deliverers	95.6%	11907	11379
Checkout Operators and Office Cashiers	95.5%	31772	30356
Garden and Nursery Labourers	95.5%	7192	6870
Machine and Stationary Plant Operators nfd	95.5%	600	573
Insurance, Money Market and Statistical Clerks	95.4%	11025	10522
Mobile plant operators nfd	95.4%	1609	1535
Plastics and Rubber Production Machine Operators	95.4%	2268	2163
Structural Steel and Welding Trades Workers	95.3%	15575	14850
Shearers	95.3%	1287	1226
Crop Farm Workers	95.3%	3611	3441
Livestock Farm Workers	95.3%	7359	7013
Mixed Crop and Livestock Farm Workers	95.3%	1081	1030
Earthmoving Plant Operators	95.2%	9871	9401
Metal Casting, Forging and Finishing Trades Workers	95.1%	702	668
Cooks	95.1%	15378	14631
Farm, forestry and garden workers nfd	95.1%	756	719
Other Sales Assistants and Salespersons	95.1%	4893	4652
Signwriters	95.0%	1650	1567
Storepersons	95.0%	32598	30956
Mail Sorters	94.8%	4093	3881
Fast Food Cooks	94.8%	10208	9679
Accounting Clerks	94.8%	35964	34079
Bookkeepers	94.8%	22871	21673
Other Miscellaneous Labourers	94.7%	14509	13740
Cafe Workers	94.6%	7987	7555
Other Sales Support Workers	94.5%	682	645
Keyboard Operators	94.3%	15476	14601
Crane, Hoist and Lift Operators	94.3%	2723	2568
Paper and Wood Processing Machine Operators	94.2%	1880	1771
Other Clerical and Office Support Workers	94.1%	5570	5244
Engineering Production Workers	93.9%	6023	5658
Sewing Machinists	93.8%	3067	2878
Aquaculture Farmers	93.8%	508	477
Train and Tram Drivers	93.7%	3503	3282

Food preparation assistants nfd	93.7%	214	200
Clerical and administrative workers nfd	93.7%	2761	2586
Accountants, Auditors and Company Secretaries nfd	93.6%	173	162
Accountants	93.6%	52245	48921
Auditors, Company Secretaries and Corporate Treasurers	93.6%	6236	5839
Housekeepers	93.6%	7006	6560
Clay, Concrete, Glass and Stone Processing Machine Operators	93.6%	880	823
Personal Assistants	93.3%	16587	15473
Factory Process Workers nfd	93.2%	4307	4012
Other Cleaners	93.1%	2983	2778
Building and Plumbing Labourers	93.1%	12600	11731
Waiters	93.0%	27673	25747
Other Factory Process Workers	93.0%	3192	2969
Product Quality Controllers	93.0%	2841	2642
Metal Engineering Process Workers	92.8%	3072	2852
Plastics and Rubber Factory Workers	92.8%	653	606
Timber and Wood Process Workers	92.8%	1675	1555
Printing Assistants and Table Workers	92.8%	1539	1429
Other Farm, Forestry and Garden Workers	92.8%	3130	2905
Cleaners and Laundry Workers nfd	92.8%	9939	9219
Wood Machinists and Other Wood Trades Workers	92.7%	1456	1350
Road and Rail Drivers nfd	92.6%	3763	3486
Product Assemblers	92.6%	6191	5735
Print Finishers and Screen Printers	92.5%	1078	997
Boat Builders and Shipwrights	92.4%	888	820
Other Hospitality Workers	92.2%	1350	1245
Paving and Surfacing Labourers	92.2%	2245	2070
Railway Track Workers	92.2%	1397	1288
Bus and Coach Drivers	92.2%	12037	11094
Library Assistants	92.1%	2451	2257
Forklift Drivers	92.0%	13604	12522
Glaziers	91.9%	2119	1948
Other Stationary Plant Operators	91.9%	5428	4988
Structural Steel Construction Workers	91.8%	4277	3927
Automotive and Engineering Trades Workers nfd	91.8%	144	132
Inquiry Clerks	91.8%	18493	16972
Ticket Salespersons	91.7%	5818	5337
Animal Attendants and Trainers	91.7%	3653	3351
Veterinary Nurses	91.7%	2230	2046
Toolmakers and Engineering Patternmakers	91.6%	1577	1445
Textile and Footwear Production Machine Operators	91.5%	973	890
Concreters	91.5%	6878	6293
Fencers	91.5%	2420	2214
Food Trades Assistants	91.5%	1025	937
Kitchenhands	91.5%	26225	23984
Court and Legal Clerks	91.3%	3380	3086
Agricultural, Forestry and Horticultural Plant Operators	91.2%	2220	2025
Automobile Drivers	91.2%	11402	10400
Delivery Drivers	91.2%	10781	9834
Hospitality Workers nfd	91.0%	2768	2519
Payroll Clerks	91.0%	8180	7441
Conveyancers and Legal Executives	90.8%	3673	3336
Insurance Investigators, Loss Adjusters and Risk Surveyors	90.8%	1591	1444
Bricklayers and Stonemasons	90.8%	6633	6021
Food and Drink Factory Workers	90.7%	7390	6705
Meat, Poultry and Seafood Process Workers	90.7%	4520	4101
Practice Managers	90.4%	4887	4420
Telemarketers	90.4%	2612	2362
Chemical, Gas, Petroleum and Power Generation Plant Operators	90.3%	1970	1778
Transport and Despatch Clerks	90.2%	9182	8279
Bakers and Pastrycooks	90.1%	7569	6818
Technicians and Trades Workers nfd	90.0%	6590	5931

Vehicle Painters	89.8%	2926	2628
Industrial Spraypainters	89.8%	1423	1278
Commercial Cleaners	89.6%	33613	30103
Painting Trades Workers	89.4%	10817	9676
Other Machine Operators	89.2%	3278	2925
Clothing Trades Workers	89.2%	2417	2155
Metal Fitters and Machinists	89.0%	22654	20153
Construction Trades Workers nfd	88.8%	576	511
Insurance Agents	88.6%	3618	3204
Drillers, Miners and Shot Firers	88.4%	12183	10768
Forestry and Logging Workers	88.4%	599	529
Precision Metal Trades Workers	88.2%	2168	1911
Authors, and Book and Script Editors	87.9%	1921	1689
Secretaries	87.7%	26461	23196
Panelbeaters, and Vehicle Body Builders, Trimmers and Painters nfd	87.5%	418	366
Primary Products Inspectors	87.4%	1066	931
Vending Machine Attendants	87.2%	1427	1244
Inspectors and Regulatory Officers	86.9%	10993	9552
Laundry Workers	86.8%	4647	4034
Roof Tilers	86.7%	2114	1833
Wall and Floor Tilers	86.7%	4001	3467
Handypersons	86.6%	9327	8074
Gaming Workers	86.5%	1391	1203
Betting Clerks	86.5%	912	789
Sales assistants and salespersons nfd	86.2%	6161	5313
Other Miscellaneous Clerical and Administrative Workers	85.8%	6108	5239
General Clerks	85.8%	73504	63031
Credit and Loans Officers (Aus) / Finance Clerks (NZ)	85.2%	7657	6525
Security Officers and Guards	85.0%	13872	11788
Domestic Cleaners	84.8%	4483	3801
Printing Trades Workers nfd	84.7%	132	112
Cabinetmakers	84.6%	4172	3531
Motor Vehicle Parts and Accessories Fitters	84.2%	2949	2482
Shelf Fillers	83.9%	12372	10377
Surveyors and Spatial Scientists	83.7%	3262	2731
Insulation and Home Improvement Installers	83.6%	4356	3640
Plasterers	83.0%	5969	4953
Vehicle Body Builders and Trimmers	82.9%	1434	1189
Survey Interviewers	82.4%	788	649
Sheetmetal Trades Workers	82.2%	1914	1574
Panelbeaters	82.2%	4019	3304
Sales workers nfd	81.7%	1353	1105
Switchboard Operators	80.5%	1220	982
Models and Sales Demonstrators	80.2%	3423	2746
Architectural, Building and Surveying Technicians	79.1%	13360	10567
Land Economists and Valuers	78.9%	3354	2647
Truck Drivers	78.8%	43830	34534
Deck and Fishing Hands	78.6%	1568	1233
Floor Finishers	78.2%	2407	1883
Packers and Product Assemblers nfd	78.2%	110	86
Canvas and Leather Goods Makers	78.0%	763	595
Medical Laboratory Scientists	77.9%	4549	3545
ICT Sales Assistants	77.7%	5033	3912
Motor Vehicle and Vehicle Parts Salespersons	77.7%	8500	6606
Pharmacy Sales Assistants	77.7%	10239	7957
Caretakers	76.2%	2409	1836
Other Construction and Mining Labourers	76.1%	1660	1264
Telecommunications Technical Specialists	75.6%	1393	1052
Automotive Electricians	75.5%	1715	1294
Freight and Furniture Handlers	75.2%	3495	2627
Plumbers	75.0%	17987	13487
Other Miscellaneous Technicians and Trades Workers	74.0%	4794	3549
Human Resource Clerks	73.7%	2657	1959
Bricklayers, and Carpenters and Joiners nfd	72.0%	336	242

Packers	71.2%	15027	10704
Printers	70.6%	4258	3008
Hairdressers	70.5%	16631	11727
Motor Mechanics	69.8%	24601	17168
Crop Farmers	69.6%	9963	6932
Gardeners	69.6%	14328	9968
Greenkeepers	69.6%	3064	2132
Nurserypersons	69.6%	1038	722
Mechanical Engineering Draftspersons and Technicians	68.7%	1221	839
Building and Engineering Technicians nfd	68.5%	1947	1333
Engineering, ICT and Science Technicians nfd	68.4%	1665	1139
Aircraft Maintenance Engineers	67.9%	5696	3869
Farmers and Farm Managers nfd	67.0%	1308	876
Telecommunications Trades Workers	66.6%	5257	3500
Dental Assistants	65.1%	6003	3907
Beauty Therapists	65.1%	6725	4376
Personal Care Consultants	65.1%	1199	780
Sales Assistants (General)	65.1%	138388	90050
Aquaculture Workers	64.9%	53	34
Debt Collectors	64.2%	2800	1798
Civil Engineering Draftspersons and Technicians	63.8%	2442	1558
Electronics Trades Workers	63.4%	9370	5942
Safety Inspectors	62.0%	872	541
ICT Support and Test Engineers	61.3%	3067	1880
Electrotechnology and Telecommunications Trades Workers nfd	60.2%	931	560
Upholsterers	60.0%	847	508
Photographic Developers and Printers	59.7%	678	405
Electricians	57.4%	32833	18858
Bar Attendants and Baristas	57.4%	27144	15582
Agricultural Technicians	56.8%	488	277
Software and Applications Programmers	56.2%	22890	12861
Financial Investment Advisers and Managers	54.1%	11611	6280
Science Technicians	53.9%	3379	1822
Florists	52.8%	1700	898
Social Professionals	50.0%	2811	1406
ICT Support Technicians	49.3%	15531	7657
Other Building and Engineering Technicians	49.3%	4210	2075
Marine Transport Professionals	48.8%	1845	901
Sportspersons	48.3%	2357	1138
Street Vendors and Related Salespersons	47.9%	2171	1040
Actuaries, Mathematicians and Statisticians	47.4%	1866	884
Geologists and Geophysicists	45.9%	1254	575
Carpenters and Joiners	41.6%	29030	12088
Financial Brokers	41.0%	6619	2712
Contract, Program and Project Administrators	39.1%	27999	10953
Auctioneers, and Stock and Station Agents	39.1%	954	373
Air Transport Professionals	38.8%	3533	1372
Performing Arts Technicians	38.8%	4018	1559
Dental Hygienists, Technicians and Therapists	38.4%	1660	638
Sports Coaches, Instructors and Officials	36.7%	8955	3284
Airconditioning and Refrigeration Mechanics	35.8%	5560	1988
Mining Engineers	35.8%	1151	412
Occupational and Environmental Health Professionals	35.3%	4660	1645
Importers, Exporters and Wholesalers	34.9%	7951	2771
Supply and Distribution Managers	34.9%	8942	3117
Transport Services Managers	34.9%	4207	1466
Ambulance Officers and Paramedics	34.5%	3603	1244
Electrical Engineers	33.9%	4883	1656
Telecommunications Engineering Professionals	33.9%	3770	1279
Sales Representatives	33.3%	31133	10374
Jewellers	33.2%	1358	450
Urban and Regional Planners	33.0%	3003	990
Education Aides	32.2%	15464	4982
Call or Contact Centre Workers	31.5%	7553	2379

ICT Professionals nfd	31.5%	8954	2819
Electrical Engineering Draftspersons and Technicians	31.4%	2292	721
Electronic Engineering Draftspersons and Technicians	31.4%	1520	478
Real Estate Sales Agents	31.2%	20521	6399
Retail and Wool Buyers	31.2%	1665	519
Chemists, and Food and Wine Scientists	30.9%	2052	635
Computer Network Professionals	30.1%	6141	1847
Other Personal Service Workers	30.0%	2948	884
Nursing Support and Personal Care Workers	29.7%	24235	7209
Management and Organisation Analysts	28.2%	16822	4736
Database and Systems Administrators, and ICT Security Specialists	27.6%	7640	2108
Other Information and Organisation Professionals	26.9%	5724	1537
Receptionists	25.9%	42494	10990
Tourism and Travel Advisers	24.9%	7081	1767
Commissioned Officers (Management)	24.1%	2539	612
Caravan Park and Camping Ground Managers	24.1%	1022	246
Licensed Club Managers	24.1%	2639	636
Call or Contact Centre and Customer Service Managers	24.1%	11161	2688
Car Detailers	24.0%	4165	1000
Finance Managers	23.6%	15747	3716
Advertising and Marketing Professionals	23.5%	19515	4578
Librarians	23.3%	3095	722
Electronics Engineers	23.1%	946	219
Economists	23.1%	1024	236
Training and Development Professionals	21.6%	6391	1383
Other Accommodation and Hospitality Managers	21.4%	1724	368
Electrical Distribution Trades Workers	21.2%	2950	624
Carers and aides nfd	21.0%	1618	340
Engineering Professionals nfd	20.8%	6574	1364
Industrial, Mechanical and Production Engineers	20.6%	4842	998
Technical Sales Representatives	20.4%	7755	1581
Graphic Pre-press Trades Workers	20.4%	1163	237
Civil Engineering Professionals	20.1%	9732	1956
Environmental Scientists	20.0%	4437	886
Visual Arts and Crafts Professionals	19.0%	1640	311
Funeral Workers	18.7%	1087	204
Gallery, Museum and Tour Guides	18.7%	1428	267
Journalists and Other Writers	18.7%	8312	1552
Gallery, Library and Museum Technicians	18.5%	1422	263
Medical Technicians	18.5%	6731	1242
Defence Force Members - Other Ranks	18.4%	4337	797
Music Professionals	17.3%	3061	530
Other Hospitality, Retail and Service Managers	17.0%	17902	3051
Other Engineering Professionals	16.8%	1883	317
Archivists, Curators and Records Managers	16.5%	1594	263
Tertiary Education Teachers nfd	15.9%	238	38
ICT Trainers	15.9%	855	136
University Lecturers and Tutors	15.9%	13419	2137
Vocational Education Teachers (Aus) / Polytechnic Teachers (NZ)	15.9%	11908	1896
Medical Imaging Professionals	15.3%	4414	677
Natural and Physical Science Professionals nfd	15.1%	1671	253
Public Relations Professionals	15.0%	5645	849
Arts Professionals nfd	14.9%	670	100
Actors, Dancers and Other Entertainers	14.3%	1918	275
Graphic and Web Designers, and Illustrators	14.0%	13238	1857
Teachers of English to Speakers of Other Languages	13.7%	1871	257
Life Scientists	12.5%	1146	144
Human Resource Professionals	12.2%	16649	2029
Retail Managers	12.1%	60019	7274
Accommodation and Hospitality Managers nfd	12.1%	185	22
Office Managers	12.1%	34098	4116
Optometrists and Orthoptists	12.0%	1589	191
Other Natural and Physical Science Professionals	11.8%	1711	202

Chemical and Materials Engineers	11.6%	596	69
Photographers	11.6%	3209	373
Human Resource Managers	11.4%	12058	1373
Interior Designers	11.3%	2455	277
Visual Merchandisers	11.3%	1365	154
Media Professionals nfd	10.9%	924	101
Managers nfd	10.8%	12170	1313
Amusement, Fitness and Sports Centre Managers	10.7%	2168	232
Livestock Farmers	10.5%	23159	2421
Mixed Crop and Livestock Farmers	10.5%	11098	1160
Aged and Disabled Carers	10.4%	28394	2949
Corporate Services Managers	10.2%	1352	138
Policy and Planning Managers	10.2%	4526	462
Driving Instructors	10.2%	1302	132
Recycling and Rubbish Collectors	10.0%	784	79
Construction Managers	10.0%	22873	2277
Judicial and Other Legal Professionals	9.5%	2451	232
Child Care Centre Managers	9.4%	2852	268
Travel Attendants	9.4%	3498	329
Child Carers	9.4%	35051	3294
Chefs	9.4%	18712	1758
Barristers	9.4%	2284	215
Solicitors	9.4%	18515	1740
Ministers of Religion	9.4%	5498	516
Film, Television, Radio and Stage Directors	9.3%	3798	354
Professionals nfd	9.2%	10072	930
Dental Practitioners	9.2%	3715	341
Veterinarians	9.1%	2155	196
Artistic Directors, and Media Producers and Presenters	9.1%	4925	446
ICT Managers	9.0%	17534	1579
Research and Development Managers	8.9%	3212	286
Architects and Landscape Architects	8.9%	6078	541
Special Care Workers	8.7%	644	56
Chief Executives and Managing Directors	8.6%	16001	1373
Conference and Event Organisers	8.4%	5991	503
Architects, Designers, Planners and Surveyors nfd	8.3%	1684	139
Fire and Emergency Workers	8.2%	3985	328
Retail Supervisors	8.2%	7586	624
Early Childhood (Pre-primary School) Teachers	7.9%	7621	600
Financial Dealers	7.8%	7686	603
Prison Officers	7.8%	4172	324
Massage Therapists	7.6%	3244	248
Health and Welfare Services Managers	7.5%	5914	442
Fashion, Industrial and Jewellery Designers	7.4%	2570	189
Cafe and Restaurant Managers	7.3%	14616	1065
Engineering Managers	7.2%	4633	334
Nurse Managers	7.1%	3892	276
Social Workers	7.0%	4331	304
Welfare, Recreation and Community Arts Workers	7.0%	6485	455
Special Education Teachers	7.0%	5866	410
Primary School Teachers	7.0%	41799	2913
Middle School Teachers (Aus) / Intermediate School Teachers (NZ)	7.0%	114	8
Psychologists	6.9%	6453	446
Manufacturers	6.8%	6394	436
Production Managers	6.8%	13659	932
Other Medical Practitioners	6.8%	2819	192
Specialist Managers nfd	6.8%	6540	444
Registered Nurses	6.7%	63819	4249
Complementary Health Therapists	6.6%	2003	133
Diversional Therapists	6.6%	1527	102
Enrolled and Mothercraft Nurses	6.6%	4651	307
Advertising, Public Relations and Sales Managers	6.5%	37648	2466
ICT Sales Professionals	6.4%	5373	343
Counsellors	6.4%	5004	318

ICT Business and Systems Analysts	6.3%	7829	493
School Principals	6.3%	6226	391
Other Education Managers	6.3%	3358	211
School Teachers nfd	6.1%	6692	405
Welfare Support Workers	6.0%	14846	894
Speech Professionals and Audiologists	5.9%	2052	122
Education Advisers and Reviewers	5.8%	2737	159
Education Professionals nfd	5.7%	1245	70
Other Specialist Managers	5.6%	14101	786
Agricultural and Forestry Scientists	5.4%	1430	77
General Managers	5.0%	14193	710
Physiotherapists	4.8%	4855	235
Fitness Instructors	4.6%	6988	323
Outdoor Adventure Guides	4.6%	506	23
Other Health Diagnostic and Promotion Professionals	4.6%	1576	72
Private Tutors and Teachers	4.5%	10271	461
Generalist Medical Practitioners	4.3%	13892	593
Anaesthetists	4.3%	1128	48
Specialist Physicians	4.3%	1806	77
Psychiatrists	4.3%	766	33
Surgeons	4.3%	1548	66
Medical Practitioners nfd	4.2%	541	23
Hotel and Motel Managers	4.0%	6208	250
Hotel Service Managers	4.0%	1880	76
Secondary School Teachers	3.3%	43253	1427
Pharmacists	3.1%	6018	185
Chiropractors and Osteopaths	3.0%	1405	42
Occupational Therapists	3.0%	2776	83
Podiatrists	3.0%	760	23