Flinders University
Australian Industrial Transformation Institute

Creative solutions -

creativity, innovation and sustainable jobs in South Australia

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Australian Industrial Transformation Institute

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Creative solutions

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Australian Industrial Transformation Institute

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Contents

RESEARCH FINDINGS AT A GLANCE ..... **III**

STRATEGIC IMPLICATIONS AT A GLANCE ..... **IV**

EXECUTIVE SUMMARY ..... **V**

Technological change and employment ..... *v*
The creative economy ..... *vii*
The creative workforce and resistance to automation ..... *viii*
The future of the workforce ..... *ix*

1 INTRODUCTION **1**

2 TECHNOLOGICAL CHANGE AND WORK **1**

3 THE IMPACT OF AUTOMATION ON WORK **3**

4 THE CREATIVE ECONOMY **9**

4.1 RISE OF THE CREATIVE INDUSTRIES 10
4.2 CREATIVE EMPLOYMENT 12

5 THE CREATIVE WORKFORCE AND RESISTANCE TO AUTOMATION **19**

6 THE FUTURE OF THE WORKFORCE **25**

7 STRATEGIC DIRECTIONS **28**

7.1 NURTURING CREATIVE SKILLS AND CAPABILITIES 29
7.2 GROWING A RESILIENT AND CREATIVE WORKFORCE 30
7.3 FOSTERING CREATIVITY AND AN INNOVATION ECOSYSTEM 30

8 FUTURE RESEARCH **31**

8.1 BUSINESS FACTORS INHIBITING AUTOMATION 31
8.2 CURRENT DISTRIBUTION OF CREATIVE OCCUPATIONS (2016) 32
8.3 THE SOUTH AUSTRALIAN 'GIG' ECONOMY 32
8.4 FUTURE PROOFING THE VET SECTOR 32

REFERENCES **33**

APPENDIX A. METHODOLOGY **35**

List of Tables

TABLE 1: MULTIPLIER (FLOW-ON) EFFECTS FOR THE CREATIVE INDUSTRY 10
TABLE 2: ANZSCO CREATIVE OCCUPATIONS (UNIT GROUP) WITH AUTOMATION SCORES 22

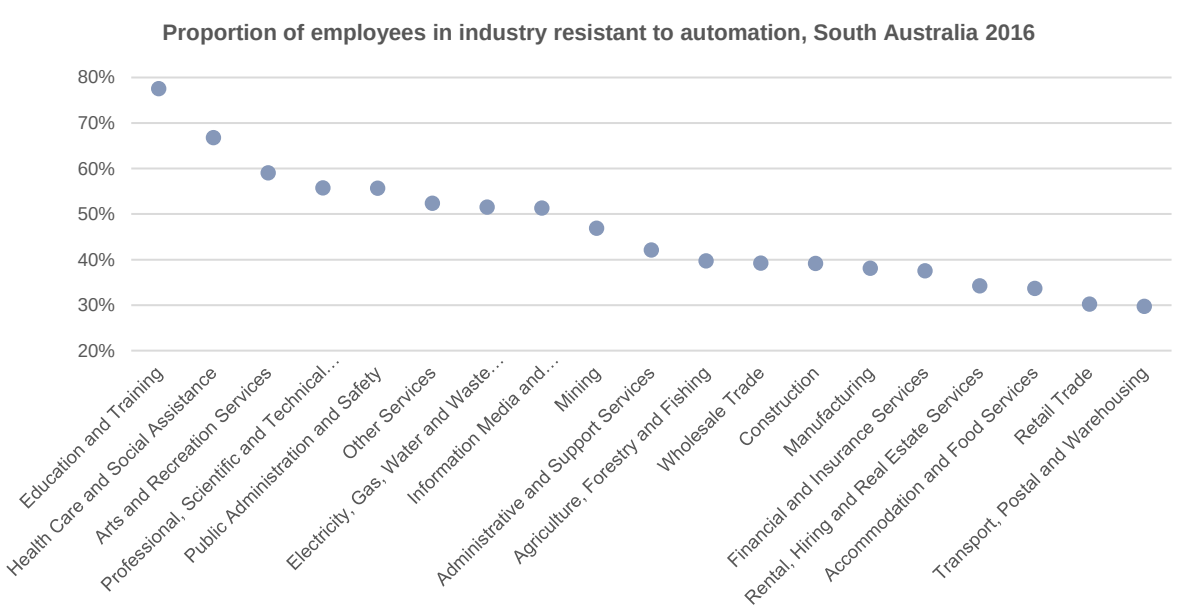
List of Figures

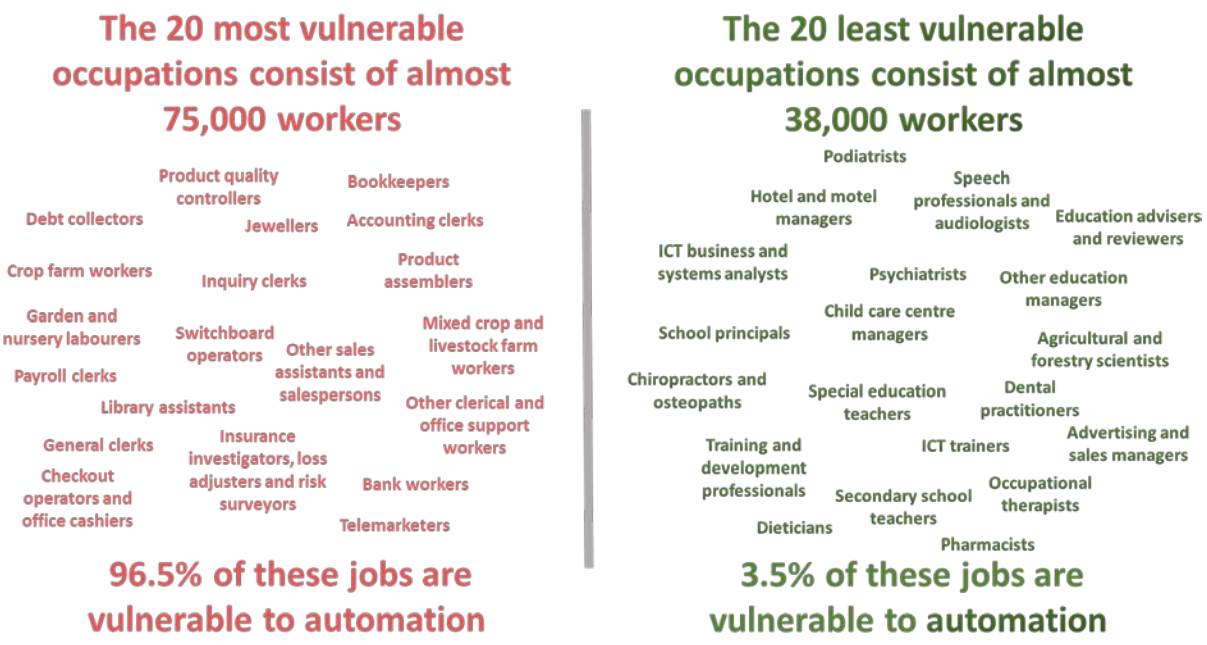
FIGURE 1: FOUR MECHANISMS THROUGH WHICH TECHNOLOGY AFFECTS EMPLOYMENT 2
FIGURE 2: TECHNICAL FEASIBILITY, % OF TIME SPENT ON ACTIVITIES THAT CAN BE AUTOMATED BY ADAPTING CURRENT TECHNOLOGY, UNITED STATES 3
FIGURE 3: COMPUTERISATION MATRIX 4

FIGURE 4: PROBABILITY OF JOB AUTOMATION IN SOUTH AUSTRALIA COMPARED TO AUSTRALIA ..5
FIGURE 5: AUTOMATION SUSCEPTIBILITY BY STATE, 2004-2014.....6
FIGURE 6: TEN YEAR CHANGE IN PERSONS ('000) EMPLOYED BY INDUSTRY, SOUTH AUSTRALIA 2006-2016 7
FIGURE 7: THE CREATIVE TRIDENT, AUSTRALIA 2011 12
FIGURE 8: THE CREATIVE TRIDENT, SOUTH AUSTRALIA 2015-2016.....13
FIGURE 9: NUMBER (%) EMPLOYED IN CREATIVE OCCUPATIONS, SOUTH AUSTRALIA, 2015-2016 14
FIGURE 10: NUMBER AND PROPORTION OF CREATIVE JOBS BY INDUSTRY, SOUTH AUSTRALIA, 2015-2016 15
FIGURE 11: INDUSTRY SHARE OF TOTAL AND CREATIVE OCCUPATIONS EMPLOYMENT, SOUTH AUSTRALIA, 2015-2016 16
FIGURE 12: DISTRIBUTION (N) OF CREATIVE SEGMENTS BY INDUSTRY, SOUTH AUSTRALIA 201617
FIGURE 13: PROPORTIONAL (%) DISTRIBUTION OF CREATIVE SEGMENTS BY INDUSTRY, SOUTH AUSTRALIA 2016 18
FIGURE 14: PROPORTION OF EMPLOYEES IN INDUSTRY RESISTANT TO AUTOMATION, SOUTH AUSTRALIA 2004 AND 2016.....20
FIGURE 15: RESISTANCE TO AUTOMATION OF TOP TEN PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES OCCUPATIONS, SA, 2015-2016 21
FIGURE 16: RESISTANCE TO AUTOMATION OF TOP TEN ARTS AND RECREATION OCCUPATIONS, 2015-2016 21
FIGURE 17: RESISTANCE TO AUTOMATION OF TOP TEN INFORMATION MEDIA AND TELECOMMUNICATIONS OCCUPATIONS, 2015-2016.....22
FIGURE 18: CURRENT WORKFORCE BY POST AUTOMATION WORKFORCE FOR THE CREATIVE OCCUPATIONS (>1000 EMPLOYED), SOUTH AUSTRALIA 2015-16 24
FIGURE 19: CURRENT WORKFORCE BY POST AUTOMATION WORKFORCE FOR THE CREATIVE OCCUPATIONS (<=1000 EMPLOYED), SOUTH AUSTRALIA 2015-16.....25
FIGURE 20: RELATIONSHIP BETWEEN AUTOMATION SCORE AND AVERAGE ANNUAL GROWTH, SOUTH AUSTRALIA.....26

Research findings at a glance

- Existing technologies make a range of occupations and tasks within occupations vulnerable to automation. The likely extent and pace of automation will be mediated by a range of factors including the relative benefits and costs of automation along with organisational capacity to absorb new technologies successfully.
- Around 2 in every 5 (41.3%) South Australian jobs are at high risk of automation. While this is similar to that found for Australia, South Australian jobs were more likely to be at medium risk and less likely to be at low risk, compared with the nation as whole.
- Susceptibility to automation in South Australia declined by 5.6% over the ten years to 2014, noting that heavy employment losses have been experienced in manufacturing industry - around 25,000 over the last ten years representing more than one quarter (25.9%) of the earlier (2006) workforce. Related research focusing on vulnerability of tasks to automation argues that less than 5 percent of occupations could be fully automated using existing technologies. Overall it argues that 50 percent of tasks within jobs could potentially be automated.
- Digital technologies contributed an additional 58% to the Australian economy from 2011 to 2013-14, increasing from $50 to $79 billion.
- In Australia, approximately $90.2 billion is estimated to be contributed to the national economy every year by the creative industries, adding $45.9 billion to the GDP and $3.2 billion of exports.
- In 2011, 5.3% of the Australian creative workforce were employed in South Australia contributing a 4.5% share of the State's employment. Between 2006 and 2011 the average annual growth rate of creative employment in Australia was 2.8%, forty percent higher than the total workforce's annual growth rate of 2%.
- Three substantial creative industries were identified in South Australia - information, media and telecommunications (28.9% of the creative workforce); professional, scientific and technical services (24.6%); and arts and recreation services (20.8%). These three industries comprise a total of 73,700 employees (an 8.9% share of South Australian employment), one quarter (n=18,200) of whom are employed in creative occupations.
- There is considerable variation in the expected impact of automation on occupations. Around 24.0% of the creative occupation workforce are considered vulnerable to automation – whereas 54.0% of those in all other occupations are considered vulnerable.





Strategic implications at a glance

- Significant competitive advantage is derived from being a leader in the design, development, uptake of new technologies and complex services embedded in knowledge intensive, creative and innovative industries.
- Policies need to be directed to nurturing creative skills and capabilities, growing a resilient and creative workforce and fostering creativity and an innovation economy as a foundation for sustainable jobs, industrial diversification and transformation.
- There is a role for government to:
  - Encourage student engagement at the secondary level with STEAMED (science, technology, engineering, arts, maths, entrepreneurship and design) subjects.
  - Promote the delivery of creative skills in the VET sector.
  - Identify skills gaps and workforce shortages in the creative industries and ensure the right programs, apprenticeships, training and educational opportunities are available.
  - Promote the place of women in the creative workforce and encourage industry to provide entry level opportunities for women to participate in this area.
  - Support knowledge intensification strategies that build skills and knowledge in traditional occupations and industries to make them more resilient to automation.
  - Encourage venture capital and other investment to support creative businesses to develop commercial potential.

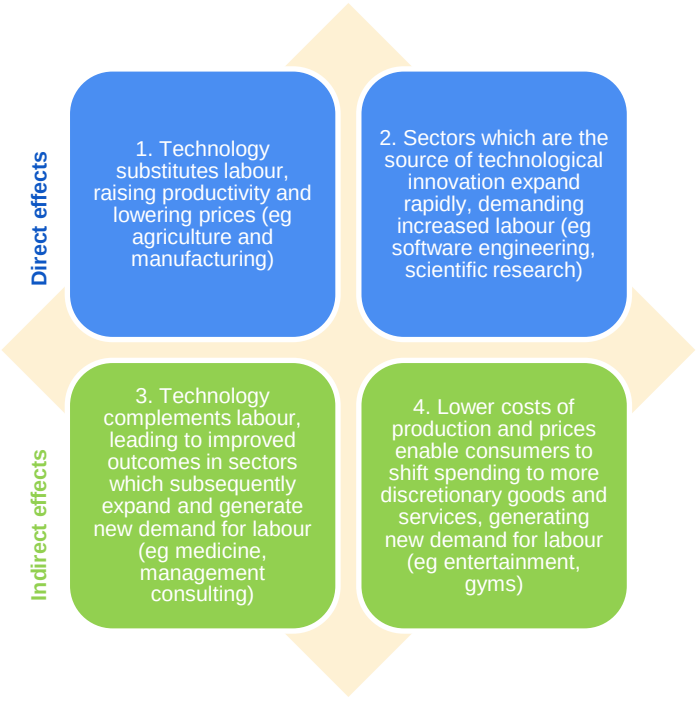
Executive summary

A robust debate is underway internationally on what the likely impact of existing automation capabilities will be upon employment. This has fuelled fears that a large proportion of occupations and tasks are vulnerable to automation. In this report we examine the extent to which occupations and related capabilities are resistant to automation. We focus particularly on a set of occupations described as the creative occupations, those jobs that require the exercise of high level creative capabilities, abstract thinking, emotional intelligence and complex problem solving skills in uncertain environments.

The automation debate is often polarised between hope and fear – hope that new technology will usher in a new period of growth and fear that it might do so at a great cost to employment. Fortunately a new body of research on automation provides a more nuanced assessment of vulnerability to automation. While great occupational disruption is expected, the relationship between technological innovation and employment is a much more complex one than is commonly understood. Routine tasks and capabilities rather than occupations need to be the focus of much greater attention in assessments of the likely employment impacts of automation. Looking at the impact of technology on employment through these different lenses will give rise to better informed policy and practice.

Technological change and employment

Viewed over time, technological advances produce social divides - generating wealth and new opportunities for some, while creating unemployment and disadvantage for others (Frey & Osborne, 2013). While inevitably the introduction of technology has been disruptive, the progress it brings is positive. In addition, the loss of jobs and disruption of occupations through automation and technological change needs to be balanced with an understanding of the role of technology in *complementing* and *augmenting* human labour, and against new jobs that emerge because of that technology.

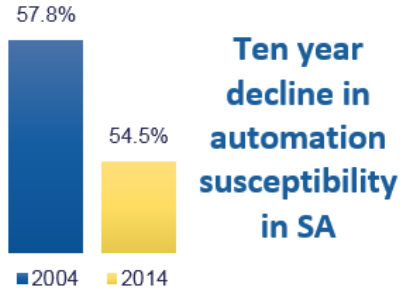


The role of the algorithm has been significant in the process of change with its influence arising from advances in computing power that enable the codification of non-routine tasks, and the automation of tasks that are beyond human capacity (Edmonds & Bradley, 2015b). This is a disruptive and substantial leap in the progress of computerisation which has seen computers evolve from simple calculation tools to thinking, potentially learning devices (Bakhshi, Frey, & Osborne, 2015; Frey & Osborne, 2013). However, these new computer technologies have the potential to displace workers in vulnerable occupations, resulting in an inescapable restructuring of labour markets over coming decades (Bakhshi et al., 2015).

In the first instance automation needs to be understood at the level of *tasks within occupations* as tasks of a routine nature are more easily codified and as such are potentially at risk of

automation. Such tasks are generally associated with jobs that require low and mid-range skills. In contrast many jobs requiring highly skilled workers (creative thought, flexibility and problem solving) are complemented by new technologies, which results in increased productivity and higher demand for workers with those skills (Productivity Commission, 2016).

Our results found around 2 in every 5 (41.3%) South Australian jobs were at high risk of automation. While this was similar to that found for Australia, South Australian jobs were more likely to be at medium risk and less likely to be at low risk, compared with Australian jobs. It is important to understand vulnerability to automation at the task level within jobs. Recent research focusing on vulnerability of tasks to automation argues that less than 5 percent of occupations could be fully automated using existing technologies (Manyika et al., 2017). It estimates that 50 percent of tasks within jobs could potentially be automated. While recognising that automation will lead to considerable dislocation and adjustment for many, the outlook is not entirely bleak. Digital disruption also leads to opportunity and it is noted that employment growth in Australia as a whole has been stronger in occupations with lower automation potential. Those with higher vulnerability have grown by only 0.9% per annum over the past decade, while those with limited automation potential have grown by 3.1% per year (Edmonds & Bradley, 2015a). Similarly in South Australia we found the average annual growth rate for occupations with low automation vulnerability was strong at 2.65%, however for occupations with high automation vulnerability jobs growth was in decline at -0.81%.



These findings are evident in a longitudinal analysis of automation susceptibility which shows a reduction in vulnerability to occupational automation across Australian states and territories in the ten years to 2014. In South Australia, the decline over this period was 5.6%, noting that the likely driver of this decline in vulnerability was a sharp decline in manufacturing employment in South Australia. Around 25,000 manufacturing jobs were lost in South Australia over ten years to 2014, representing more than one quarter (25.9%) of the manufacturing workforce.

The creative economy

The concept of a creative economy highlights the economic value of arts and culture and creative thinking, displacing the view that their place in the economy is marginal with an understanding of them as significant and growing sources of work and wealth creation (BOP Consulting, 2010). The United Nations trade and development body (UNCTAD) quantified the impact of creative industries on the world's economy in 2005 as accounting for 3.4% of world trade and $424 billion of exports with an average annual growth rate of 8.7% in the five years from 2000 (United Nations, 2008). In Australia, approximately $90.2 billion is estimated to be contributed to the national economy every year by the creative industries, adding $45.9 billion to the GDP and $3.2 billion of exports (SGS, 2013).

As in previous times of technological advancement, workers with skills which complement today's technology, increase production and become more employable, whereas those performing routine tasks and with limited skills are at risk of being replaced by the new technology (Brynjolfsson & McAfee, 2014; Hajkowicz et al., 2016). The concept of a 'creative industry' links creativity and innovation with commercial outcomes which in turn make their impact in the broader economy. The challenge of quantifying creative work has been approached in different ways by different researchers, with a recurring theme in the literature the debate about which occupations to include and exclude. This is further complicated by the level of intersection of the creative and non-creative workforces. Early work on creative industries employed the classifications developed in 1998 by the United Kingdom Department of Culture, Media and Sport (DCMS). Bakhshi, Freeman, and Higgs (2013) developed an analytical framework based on five essential criteria (novel, mechanisation resistant, non-repetitive, creative contribution to the value chain, and interpretation) defining creative work all of which need to be seen as a whole rather than in isolation. Viewed through this lens, creative occupations were seen to require cognitive skills that contributed to new or enhanced products with a form that was not determined in advance.

The 'Creative Trident' approach to accounting for employment in creative work encapsulates the creative workforce as a whole. It was developed to quantify 'commercially relevant' creative activity and distinguished three groups of the creative workforce – those working in creative *industries* as well as those working in creative *occupations* (SGS, 2013). This important contribution ensured 'embedded' creatives were no longer overlooked and contributed along with 'specialists' and 'support' to the economic measurement of creative activity in the economy.

- **Specialists** - those employed in creative occupations in the core creative industries
- **Embedded** - those working in creative occupations in other industries
- **Support** - those employed in specific creative industries in non-creative management

In 2011, 5.3% of the Australian creative workforce were employed in South Australia contributing a 4.5% share of the State's employment. Between 2006 and 2011 the average annual growth rate of creative employment in Australia was 2.8**%,** forty percent higher than the total workforce's annual growth rate of 2% (SGS, 2013).

Our results include 32 creative occupations at the 4-digit ANZSCO unit level employing 46,221 South Australians. As such creative occupations make up 5.6% of the South Australian workforce which numbered an average of 826,000 people during the period May 2015 to February 2016. In addition, 55,522 workers were engaged in the creative industries providing support to those in creative occupations. The largest four occupations (advertising and sales managers; software and applications programmers; architectural, building and surveying technicians; and advertising and marketing professionals) contributed almost half (48.1%) the employees in South Australian creative occupations.

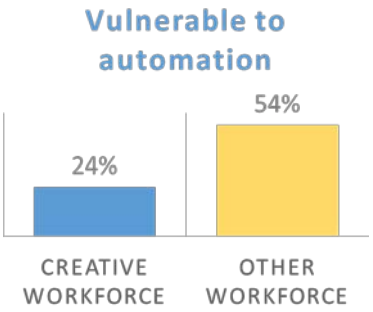
Three creative industries were identified in South Australia - information, media and telecommunications (28.9% of the creative workforce); professional, scientific and technical services (24.6%); and arts and recreation services (20.8%). These three industries comprise a total of 73,700 employees (an 8.9% share of South Australian employment), one quarter (n=18,200) of whom are employed in creative occupations.

The creative workforce and resistance to automation

Much of the debate on the impact of automation and digitalisation has focused on its disruptive and job or task displacing impacts. Less attention has been paid to occupations and tasks that are resistant to automation. A closer examination of this is warranted as it has very important public policy implications, particularly for industry development and education and training provision.

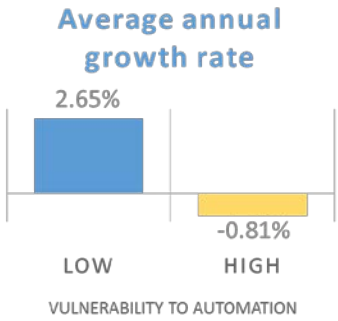
Three impediments to the ability of computers to mimic human tasks have been identified (Edmonds & Bradley, 2015a): perception and manipulation, creative intelligence and social intelligence. Analysing data on UK occupations, Bakhshi et al. (2015) reported that only 15% of jobs in creative industries were at high risk of automation compared with 32% of jobs in non-creative industries. Most jobs (64%) in creative industries had a low probability of automation, compared with only 38% in non-creative industries. Where occupations were found to be highly creative they were often also directly involved with new technologies. The key point being computers and new technologies complement creative occupations – enhancing productivity rather than replacing their labour.

In 2004, around 56.5% of South Australian employees were seen as potentially vulnerable to automation; this declined by 4.3 percentage points to 52.3% of the 2016 workforce. Inversely, 43.5% of South Australian employees were *resistant* to automation in 2004 with resistance to automation increasing to 47.7% in 2016. There is considerable variation in the expected impact of automation on all occupations. However, it is notable that only 24.0% of the creative occupation workforce are considered vulnerable to automation – whereas 54.0% of those in all other occupations are considered vulnerable.



The future of the workforce

Edmonds and Bradley (2015a) explored the relationship between employment annual growth rates and automation in Australia. They found that the average annual growth rate for occupations with low automation vulnerability grew by 3.1% per annum, whereas those with high automation vulnerability grew by only 0.9% per annum. We have replicated this using the South Australian Training and Skills Commission annual growth rates. A similar relationship is evident as that found by Edmonds and Bradley, but with South Australian growth rates lower than that found in the Australian example. In South Australia, the average annual growth rate for occupations with low automation vulnerability was strong at 2.65%, however for occupations with high automation vulnerability jobs growth was in decline at -0.81%.



The introduction of new advanced technologies and automation have led to significant workforce changes over the last few decades. The impact of this is often mediated by government and industry funded adjustment programs or compensation and affected by prevailing economic circumstances, particularly the availability of alternative employment at any point in time. Additionally, experience shows the application of new technologies has the potential to both displace existing occupations and tasks within occupations as well as create new occupations.

There are potential opportunities for replacing job losses in occupations that are susceptible to automation with jobs in the creative industries. However, currently job numbers in the creative industries have much room to grow with appropriate targeted policies. These policies should grow knowledge and skill intensive industries and occupations, while designing strategies to address job losses and skill deficits associated with vulnerable occupations and industries. In the United Kingdom, policies to support the creative economy addressed evidence and analysis, infrastructure, education and skills, technology, competition and intellectual property, access to finance and business and diversity.

A policy framework to support a creative economy in Australia might build on that proposed in the United Kingdom, involving three levels of intervention – individual worker skills, job and workplace design to support a creative economy, and industry level support. A policy framework with these areas of focus will assist SA to prepare for the technology-driven restructuring of our labour market which can be expected over the coming decades.

Nurturing creative skills and capabilities

Currently, Australian education policy encourages individuals to attain the skills and qualifications they need for the employment they seek (Beitz, 2015). However, this is in a context where literacy in maths is falling and science education participation is low (den Holland, 2015). Individual capacity to thrive in a creative economy requires the provision of learning opportunities across the lifecycle fostering skills in innovation, problem solving and creativity. For students (and their parents) in their final years of schooling who are planning for further education and/or their workforce careers, it is important they have knowledge about opportunities for creative occupations.

The Creative Industries Council (2014) suggest this can best be supported through the promotion of STEAM (science, technology, engineering, arts and mathematics) subjects, rather than focusing on STEM which exclude the arts (which encapsulate the humanities and social sciences). Continuing professional development training for those in the workplace need to focus on ensuring the right combination of skills is available as well as building leadership and management skills. The need for an appropriate and expansive skill set is reiterated by Durrant-

Whyte (2015) who asserts there will be far fewer technology specialists in the future, but rather technology generalists who are agile, flexible and creative problem solvers.

It is therefore critical that secondary students and their families understand how STEAM skills can translate into the real world in order to ignite a spark of interest in these subjects. To meet the growing needs of the creative economy it is even suggested that 'entrepreneurship' and 'design' should be included (STEAMED) in the mix. In the current employment environment, ongoing learning is also critical both for those in a job who require continuing professional development and those whose jobs are being displaced and require reskilling to take advantage of new opportunities.

Growing a resilient and creative workforce

Government and industry need to work together to identify skills gaps and workforce shortages in the creative industries and ensure the right programs, apprenticeships, training and educational opportunities are available. Training should focus on unique skills that are less susceptible to automation such as creativity, innovation and problem-solving (Green, Marsh, & Pitelis, 2015). In addition, management and leadership training can help to build a creative economy that is effective, efficient and flexible. Workforce planning and development will be essential to support the creative economy and ideally this should be guided at the organisation level by a State-wide Creative Economy Workforce Development Strategy.

Policy in the United Kingdom is directing more focus to encouraging diversity in the creative workforce that reflects the diversity of society (Creative Industries Council, 2014), recognising creativity is not the sole dominion of white males. In South Australia it has been noted that almost half (45%) of secondary school Prime STEM students are female, with this proportion reduced on entry to university when female enrolment contributes only one quarter (25%) of applicants to Prime STEM subjects. Once enrolled, females are proportionally more likely to graduate Prime STEM subjects than males. However, females comprise fewer than one in eight (12%) in the Prime STEM workforce. This points to an ongoing need for policy development that promotes women's place in the creative workforce and encourages industry to provide entry level opportunities for women to participate in this area.

Fostering creativity and an innovation ecosystem

State government (along with national and local government) have a role to play in fostering creativity as a foundation for the development of sophisticated innovation ecosystems operating in the most liveable of cities. The concept of the 'liveable city' is significant because of its capacity to attract knowledge workers and the businesses employing them, and to provide an innovation-friendly environment. South Australia is well placed to provide such an environment; Adelaide is frequently nominated as one of the most liveable cities in the world, and its strong university presence and promotion of a learning culture provides a firm foundation for development of a creative economy.

In tandem with the development of new opportunities for the creative workforce in new growth industries, government should support knowledge intensification strategies that build skills and knowledge in traditional occupations and industries to make them more resilient to automation. Industries such as manufacturing have traditionally provided a launch pad for new workers to develop and build skills and then move on to work in other industries (Green et al., 2015). Manufacturing also contributes significantly to research and development driving technological change and innovation. From a policy perspective there is a need to recognise and promote creative industries and occupations within South Australia, emphasising their value to the state in economic terms and their role in underpinning the growth of the industries and jobs of the future.

1 Introduction

A robust debate is underway internationally on the likely impact of new technologies on employment. The potential of technology to displace occupations or particular occupational tasks has been the main focus of this debate. More recently, attention has turned to new occupations being created by new technologies and the net impact of these on employment outcomes. This report examines an important related dimension of this debate - the extent to which creative occupations and related capabilities are resistant to automation and the implications of this for industry and workforce development policy.

We examine the proposition that problem solving, emotional intelligence and creativity are fundamentally important to building occupation resilience at time when a range of tasks are vulnerable to automation. Simply speaking, occupations or (more critically) occupational tasks, that can be codified are potentially vulnerable while occupations that are knowledge and skill intensive and involve complex problem solving and high levels of creativity and emotional intelligence are foundational to the digital economy and much more resilient over time as a consequence.

2 Technological change and work

The debate about the impact on work of new technologies seems recent, but the capacity for automation has been occurring for centuries. The industrial revolution commenced in the late 18th Century with the introduction of factories powered by machinery using energy sources that included water, steam and coal power. While the quantum is debated, it is generally agreed that the subsequent period saw advances in living standards for many but also significant disruption in the process (Stewart, De, & Cole, 2015). Through to the late 19th century, industrialisation provided opportunities for unskilled labour in place of skilled artisans (Bakhshi et al., 2015). Skilled labour forces were back in demand when electrification was introduced to factories along with assembly lines.

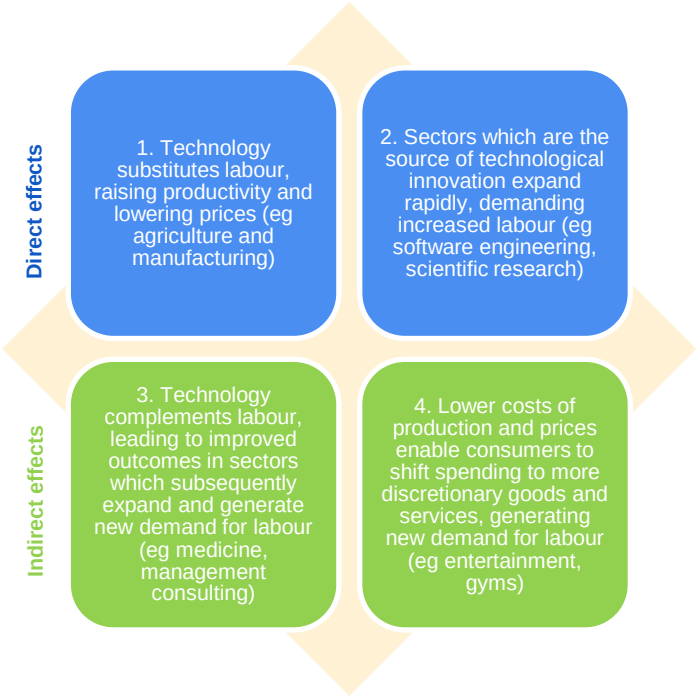
Viewed over time, technological advances historically produce social divides - generating wealth and new opportunities for some, while creating unemployment and disadvantage for others (Frey & Osborne, 2013). The impact of technology has always been 'disruptive' and its impact can be difficult to comprehend without the benefit of reflection. Today, technological disruption occurs so frequently and rapidly that it is considered the norm. It has been described as a "perfect storm" creating unique conditions and involving "greater, faster and different transitions" than previously experienced (Hajkowicz et al., 2016, pp., p.7). Nevertheless, the narrative about technology and the progress it can bring is essentially positive when viewed retrospectively, noting that this narrative traditionally has also been interspersed with negative analyses associated mainly with technology's job-destroying impacts (Deloitte Access Economics, 2015).

> Disruptive technologies… are developments that drive substantial change across the economy for many firms, households or workers, with impacts that impose significant costs of adjustment as they make capital obsolete and leave some workers significantly underutilised for some time (Productivity Commission, 2016, p. 17).

Historically, automation of many workplace tasks has not produced an upward trend in overall unemployment rates (Productivity Commission, 2016). Therefore, the loss of jobs and disruption

of workforce structures through automation and technological change needs to be balanced with an understanding of the role of technology in *complementing* and *augmenting* human labour, and against new jobs that emerge because of that technology. Stewart et al. (2015) analysed employment data over 150 years and found four mechanisms whereby technology has led to the creation rather than the destruction of jobs (see Figure 1).

Figure 1: Four mechanisms through which technology affects employment



Reproduced from Stewart et al. (2015, p. 1)

Recent advances in technology have given rise to what is commonly described as the digital economy – an economy based on digital computing technologies. In Australia, like most of the developed world, the digital economy has been growing at an exponential rate with profound implications for the local economy (Productivity Commission, 2016). Digital technologies contributed an additional 58% to the Australian economy from 2011 to 2013-14, increasing from $50 to $79 billion (Deloitte Access Economics, 2015). It is forecast that information and communication technology (ICT) employment in Australia will grow by 2.5% per annum over the six years from 2014 to 2020, increasing the ICT employment base from 600,000 to 700,000 workers and outperforming the Australian jobs growth forecast. However, for those working in ICT management and operations the annual growth rate during the same period is expected to be 3.1%.

Critically, in assessing the disruptive potential of technology on work, it is important to factor in limitations associated with computer technology – particularly current challenges in automating creative and social intelligence. While significant advances in our understanding of the human brain and how to replicate its functions are being made in the field of artificial intelligence, these are unlikely to result in technologies that will challenge skilled and creative employment over the short term. Over the medium term we can expect artificial intelligence to advance to a point where it has disruptive impacts on a range of creative tasks (Productivity Commission, 2016).

The role of the algorithm has been significant in the process of change, and brings the advantage of being free from human biases (Frey & Osborne, 2013). However, its influence arises from advances in computing power that enable the codification of non-routine tasks, and the automation of tasks that are beyond human capacity (Edmonds & Bradley, 2015b). This is a disruptive and substantial leap in the progress of computerisation which has seen computers evolve from simple calculation tools to thinking, potentially learning devices (Bakhshi et al., 2015; Frey & Osborne, 2013).

algorithm
ˈalgərɪð(ə)m/
Noun: **algorithm**; plural noun: **algorithms**
1. a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.

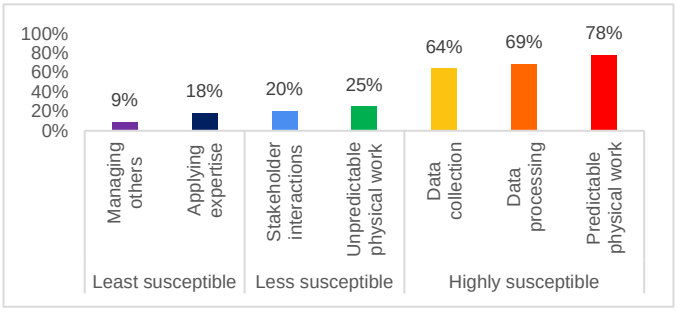
http://www.oxforddictionaries.com/

Some estimates indicate that sophisticated algorithms could substitute around 140 million full time workers world-wide (Frey & Osborne, 2013). These new computer technologies have the potential to displace workers in vulnerable occupations, resulting in an inescapable restructuring of labour markets over coming decades (Bakhshi et al., 2015).

3 The impact of automation on work

Automation and associated technological change not only influence how and where people work, but have created an 'automation divide' that separates occupations into those that are rendered vulnerable, sometimes obsolete, by automation and those that are strengthened, sometimes created, by computerisation. Chui et al. (2016) suggest that rather than occupations being eliminated en masse, technological changes are more likely to impact a small or large portion of all jobs depending on the job requirements and skill mixes. Accordingly, potential automation should be understood at the level of *tasks within occupations* as tasks or activities of a routine nature are more easily codified and as such are potentially at risk of automation (see Figure 2). Such tasks are generally associated with jobs that require low and mid-range skills. In contrast many jobs requiring highly skilled workers are complemented by new technologies, which results in increased productivity and higher demand for workers with those skills (Productivity Commission, 2016).

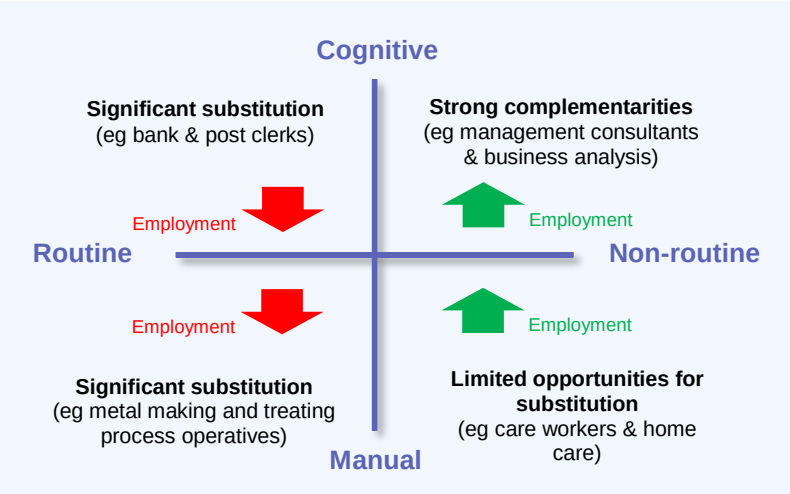
Figure 2: Technical feasibility, % of time spent on activities that can be automated by adapting current technology, United States



Reproduced from Chui, Manyika, and Miremadi (2016, p. 3)

Early work by Autor, Levy, and Murnane (2003) categorised work tasks on a two by two matrix (see Figure 3), where one axis was used to present manual through to cognitive tasks, with the other axis providing for the continuum from routine to non-routine tasks. In this paradigm, routine tasks are those most susceptible to computerisation through the application of program rules and computer code, whereas non-routine tasks are not easily coded and require creative thought, flexibility and problem solving. Stewart et al. (2015) analysed employment data, reporting that routine jobs have suffered the biggest losses over the last 20 years.

Figure 3: Computerisation matrix



Modified from Stewart et al. (2015).

Understanding of occupation-based vulnerability to automation increased significantly with the research findings of Frey and Osborne (2013). They used data from the 2010 version of O*NET, an online database that provides information on 903 occupations which drew heavily from the United States Labor Department's Standard Occupational Classification:

> *O*NET defines the key features of an occupation as a standardised and measurable set of variables and provides open-ended descriptions of tasks specific to each occupation (Frey & Osborne, 2013, p. 28)*

The mix of knowledge, skills and abilities in tasks were used by researchers to facilitate objective ranking of occupations with the mix of tasks in each occupation also included in the development of the categorisation. Occupations were then classified as being at high (over 70% probability), medium (probability of more than 30% but less than 70% risk) or low (probability of less than 30%) risk of computerisation (Frey & Osborne, 2013).

Frey and Osbourne (2013) classified occupations based on their probability of automation:

High > 70% probability

Medium ≥ 30% < 70% probability

Low < 30% probability

Their analysis identified that 47% of jobs in the United States were at *high* risk of computerisation over the next twenty years (Frey & Osborne, 2013). The most vulnerable occupations involving transport, logistics, manufacturing and production, construction, office administration, services (e.g. household services) and several sales-related occupations (e.g. cashiers, telemarketers).

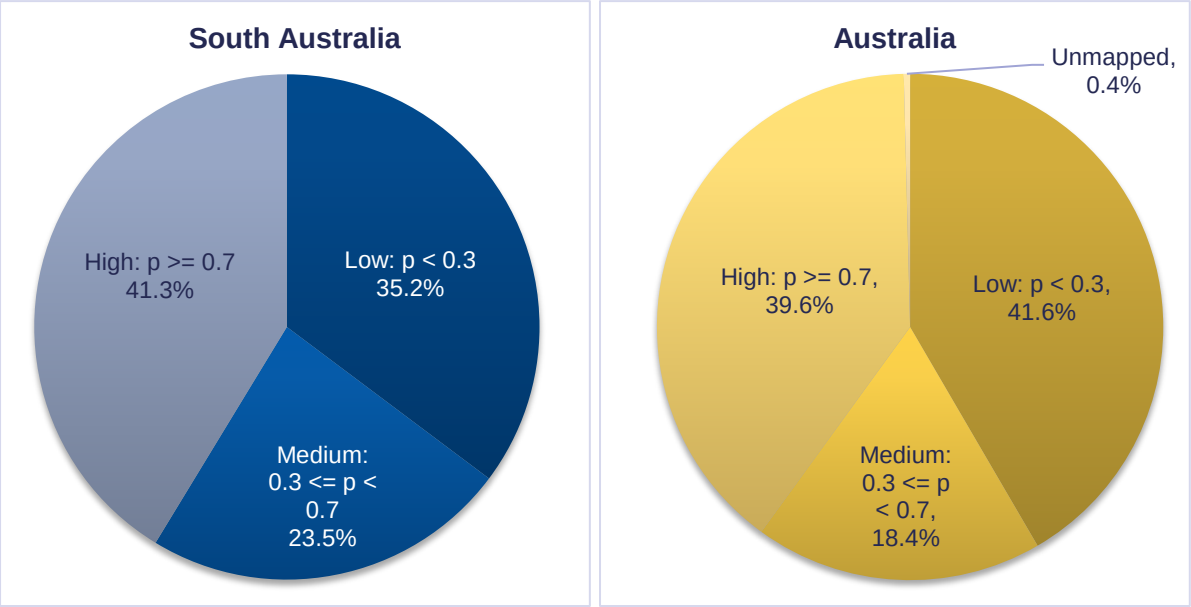
Frey and Osborne subsequently worked with Deloitte Access Economics (2014) to apply the high, medium, low risk automation approach (Frey & Osborne, 2013) to the United Kingdom labour force. They found that 35% of jobs in the United Kingdom (30% in London) were at *high* risk of obsolescence over the next two decades because of computerisation, while 40% of all jobs and 51% of London jobs were at low or non-existent risk. Low risk jobs included those in skilled management, financial services, computers engineering and science, education, legal services, community services, the arts and media, and health care (Deloitte Access Economics, 2014).

Australian researchers have used the same method to calculate occupational vulnerability to automation in Australia (CEDA, 2015; Edmonds & Bradley, 2015b). CEDA (2015) reported 40% of current jobs had a high probability of automation in the next 10-15 years (see Figure 4), results comparable to those reported for the United

Kingdom workforce. Edmonds and Bradley (2015b) took a different approach for calculating automation scores and produced a similar result as Frey and Osborne's study of United States occupations with 43.9% found to be at high risk of automation.

Our results in South Australia with regard to jobs at high risk of automation were broadly similar to those reported in Australia (CEDA, 2015; Edmonds & Bradley, 2015b) with around 2 in every 5 jobs (41.3%) in this category (see Figure 4). However, almost one quarter (23.5%) of South Australian jobs fell into the medium risk categories compared with fewer than one in five (18.4%) Australian jobs, with a correspondingly smaller proportion of jobs at low risk in South Australia compared to Australia (35.2% and 41.6%, respectively). In South Australia, this currently equates to 341,000 jobs at high risk of automation, 194,000 at medium risk and 291,000 at low risk.

Figure 4: Probability of job automation in South Australia compared to Australia



Source: South Australia (ABS, 2016a); Australia (CEDA, 2015)

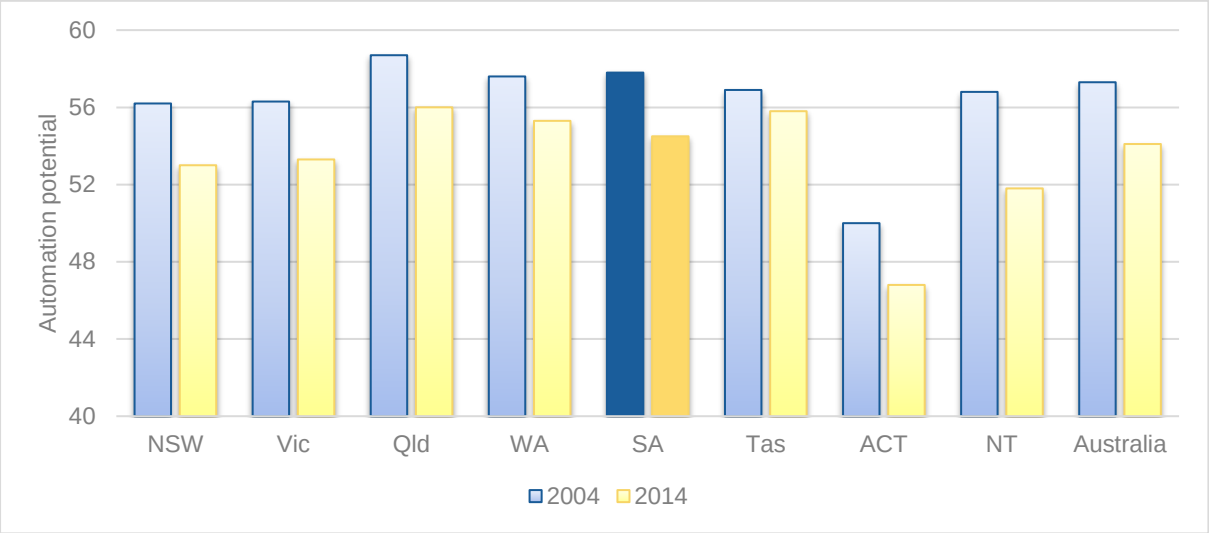
Recent research focusing on vulnerability of tasks to automation suggests that less than 5 percent of occupations could be fully automated using existing technologies (Manyika et al., 2017). On the other hand it argues that 50 percent of tasks within jobs could potentially be automated.While recognising the anticipated job automation will lead to considerable adjustment for many, the outlook is not entirely bleak. Digital disruption also leads to opportunity and it is noted that employment growth in Australia as a whole has been stronger in occupations with lower automation potential. Those with higher vulnerability have grown by only 0.9% over the past decade, while those with limited automation potential have grown by 3.1% per year (Edmonds & Bradley, 2015a).

> *… the automation score can be seen as a proxy for time – those jobs with a higher score will be automated in the near future, while those with a low automation score will take some time for technology to evolve sufficiently to automate their tasks. (Edmonds & Bradley, 2015a, p. 11)*

These findings are evident in a longitudinal analysis of automation susceptibility which shows a reduction in vulnerability to occupational automation across Australian states and territories between 2004 and 2014 (see Figure 5). Occupational vulnerability in South Australia, New South Wales and Australia all declined by a similar amount (5.6% to 5.7%) over the ten years, whereas Tasmanian vulnerability only declined by 1.9% during the same period. At the other end of the spectrum Northern Territory's vulnerability to automation reduced by 8.8%, with the Australian

Capital Territory starting from the lowest base in Australia in 2004 (50.0) declining by 6.4% to 46.8.

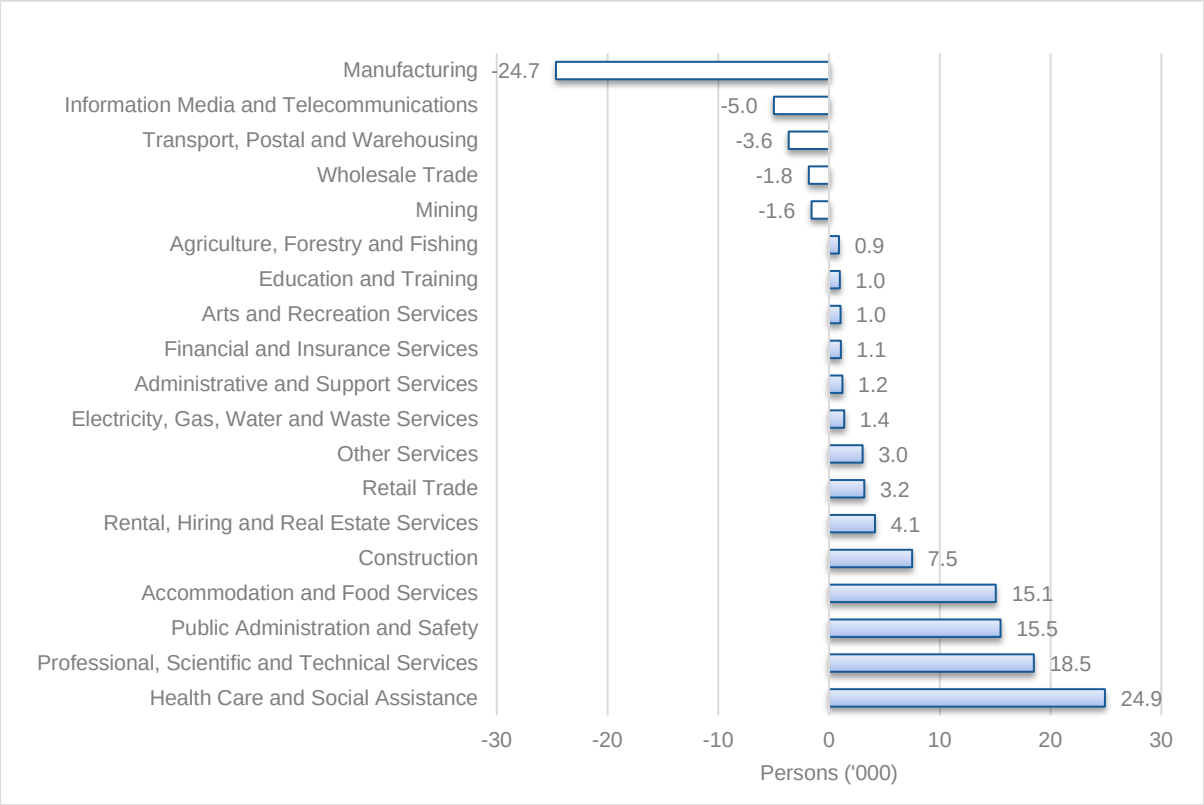
Figure 5: Automation susceptibility by state, 2004-2014



Source: Edmonds and Bradley (2015a)

It is likely that the driver of this decline in vulnerability is a shake-out of susceptible jobs over this period – particularly in the manufacturing industry. This is evident in Figure 6, where almost 25,000 jobs have been lost in South Australian manufacturing over the last ten years representing more than one quarter (25.9%) of the earlier (2006) workforce. As vulnerable jobs are lost, they are either not replaced or are replaced by roles that are less vulnerable.

Figure 6: Ten year change in persons ('000) employed by industry, South Australia 2006-2016



Source: ABS (2016b)

> *While automation can affect jobs across the full skill spectrum, the evidence suggests that it has less often affected occupations that involve non-routine tasks, complex cognition … and the need for personal and social skills (Productivity Commission, 2016, p. 70).*

Technological advances continue to gain pace and sophistication. While, to date, automation has had a profound impact on essentially routine tasks, new digital technologies in machine learning and mobile robotics associated with the growing role of big data, provide enhanced scope for computers to substitute for labour in relation to *non-routine* tasks – both manual and cognitive (Bakhshi et al., 2015; Productivity Commission, 2016). Significant increases in storage, processing and communication capacity along with machine-learning techniques are enabling machines to display 'artificial intelligence' and undertake complex tasks involving thought and judgement at reduced cost (CEDA, 2015; Deloitte Access Economics, 2015). Frey and Osborne (2013) cite the example of automated cars. Ten years ago the challenges associated with driverless cars were almost insurmountable. However, today driverless cars have been trialled on South Australian roads, and laws to allow them are expected within a decade.

Improvements in robotics are rapid and involve an increasing range of non-routine manual tasks and more recently, some cognitive and social tasks. Their growing workplace role is apparent as an increasing number of work environments are reconfigured for them, for example, by removing physical obstacles or by caging robots for the safety of human workers (Productivity Commission, 2016).

Improvements in sensor technology, combined with the use of specific algorithms, are making many tasks computerisable, for example, replacing closed circuit TV operators, workers detecting equipment faults, personnel reading meters, and clinical staff monitoring patients in care. Sensors placed on trucks and pallets now improve supply chain and logistics management.

As the costs of digital sensing decline these approaches are being applied more often and with greater impact (Frey & Osborne, 2013).

Digital technologies can trigger changes in occupations and skill requirements not only through automation or computerisation, but also through *skill shifts*. The most apparent example of this has involved the replacement by personal computers of typists as the only workers undertaking typing and the shifting of this to skilled employees. The task of typing continues but has been diffused rather than concentrated in typing pools. Substitution has also occurred as textile technologies that developed wrinkle-free garments have reduced the need for ironing by humans or machines (Productivity Commission, 2016).

4 The Creative Economy

The concept of a creative economy highlights the economic value of arts and culture and creative thinking, displacing the view that their place in the economy is marginal with an understanding of them as significant and growing sources of work and wealth creation (BOP Consulting, 2010). Internationally, the mapping of creative work (see *Section 3*) has contributed to the evidence base for the concept of a *creative economy*.

The emergence of the creative economy is inextricably linked to the growing influence of technological change, and the symbiotic relationship between creativity and technology as reflected in the Australian Government's policy statement:

> *Creativity is the key to innovation, and innovation drives growth, sustainability and prosperity. Creative innovation comes from many sources – the arts, science, business, research and development, and communities – and enriches Australia's cultural capital (Government of Australia, 2011, p. 5).*

The digital revolution, which brought with it an increased broad-based demand for digital and design services, had a large impact on the growth in the creative industries in Australia (CCI, 2013). However, British researchers draw a stronger link resulting from technological change, depicting a 'merging' of the digital and creative industries (BOP Consulting, 2010). In the United Kingdom, Bakhshi et al. (2013) reported most creative workers were employed *outside* the creative industries thereby being counted in and contributing to the wider economy - with these latter occupations showing substantial growth. Notably, they identified strong symbiosis and co-location between creative and ICT occupations within single industries - a relatively recent economic phenomenon.

> *Every dollar in turnover generated by creative industries (i.e. initial revenue stimulus) results in 3.76 times total revenue for all other industries in the Australian economy. Similarly, each dollar in gross regional product generated by the creative sector results in an uplift in total value-added by all industries by a factor of 3. Finally, on average each job in creative industries (not necessarily creative workers) supports total employment in Australia, which is 2.92 times higher than employment in creative industries. (SGS, 2013, p. 13)*

The United Nations' trade and development body (UNCTAD) quantified the impact of creative industries on the world's economy in 2005 as accounting for 3.4% of world trade and $424 billion of exports with an average annual growth rate of 8.7% in the five years from 2000 (United Nations, 2008).

In Australia, approximately $90.2 billion is estimated to be contributed to the national economy every year by the creative industries, adding $45.9 billion to the GDP and $3.2 billion of exports (SGS, 2013).

As evident in Table 1 the flow-on effects of the creative industries exceed that of all other industries[1]. The total output and value-added multipliers are highest for advertising and marketing and architecture, while the employment multiplier is most marked for film, television and radio.

[1] Noting the multipliers are averages of the multipliers of the 1-digit ANZSIC industries.

Table 1: Multiplier (flow-on) effects for the creative industry

Creative industry segments	Total output multiplier	Value-added multiplier	Employment multiplier
Advertising and marketing	4.02	3.56	2.91
Architecture	4.02	3.56	2.91
Design and visual arts	3.95	3.53	2.88
Film, television and radio	3.52	3.21	3.57
Music and performing arts	3.57	3.10	1.84
Software development and interactive content	4.02	2.83	3.13
Writing, publishing and print media	3.14	2.30	3.24
Creative Industries	**3.76**	**3.00**	**2.92**
All other industries	3.59	2.80	2.47

Source: SGS (2013).

In South Australia, the picture is less clear although in 2010-11 the local creative industries revenue achieved $1.34 billion (South Australian Arts, 2013). Employment growth in the creative industries (7.5%) exceeds the South Australian average (5.3%) with much of this growth in creative services being delivered to the broader economy.

4.1 Rise of the Creative Industries

As in previous times of technological advancement, workers with skills which complement today's technology, increase production and become more employable, whereas those performing routine tasks and with limited skills are at risk of being replaced by the new technology (Brynjolfsson & McAfee, 2014; Hajkowicz et al., 2016). Additionally, in recent years it has become apparent that many occupations that are *creative* in nature can be complemented by new computer-related technologies. For example, it is not unusual to see musicians use computers to play and test new music ideas, while architects and designers develop simulated two and three dimensional models using computer technology to visualise their work (Bakhshi et al., 2015). As such, technology can *augment* the value of human labour (Davenport & Kirby, 2015) and is likely to be a key driver of the increase in skilled employment in Australia over the past two decades.

Through technology, people now have access to tools and information that can facilitate complex problem-solving, leaving workers to spend more time on challenging, rather than routine, tasks (Hajkowicz et al., 2016). There are many opportunities for people to become more productive by working with new technology. For example, the numbers of bank tellers has declined sharply due to automation (by 50,000 in Australia between 1995 and 2005), as the introduction of automated teller machines meant the same services could be delivered cheaper and more conveniently. During this period, there was a corresponding increase in the number of finance professionals who had skills that were not so easily replaced - and who were more highly paid (Autor et al., 2003; Davenport & Kirby, 2015; Hajkowicz et al., 2016).

> At a most basic definition, creative industries can be distinguished from other industries in that creativity is used to create value for their consumers. While all industries will include an element of creativity … creative industries are different because they use creativity to create value for their clients and the products or services created are intellectual property (SGS, 2013, p. 7).

The concept of a 'creative industry' links creativity and innovation with commercial outcomes which in turn make their impact in the broader economy,

and was first used in the 1990s[2]. Creative industries "have their origin in individual creativity, skill and talent and which have potential for wealth and job creation through the generation and exploitation of intellectual property" (Bakhshi et al., 2013, p. 6, citing DCMS, 1998).

The challenge of quantifying creative work has been approached in different ways by different researchers, with a recurring theme in the literature the debate about which occupations to include and exclude. This is further complicated by the level of intersection of the creative and non-creative workforces -

> *While all industries will include an element of creativity within them to a greater or lesser extent, creative industries are different because they use creativity to create value for their clients and the products or services created are intellectual property. (SGS, 2013, p. 7).*

Early work on creative industries employed the classifications developed in 1998 by the United Kingdom Department of Culture, Media and Sport (DCMS). While this was an important starting point, it has been acknowledged the DCMS definition was limited due to its focus on the Department's service boundaries which included some industries that were not considered a good fit, resulting in an overquantification of employment associated with creative work (Bakhshi et al., 2013).

Bakhshi et al. (2013) developed an analytical framework based on five essential criteria defining creative work, all of which need to be seen as a whole rather than in isolation. Viewed through this lens, creative occupations were seen to require cognitive skills that contributed to new or enhanced products with a form that was not determined in advance. From the perspective of the relationship between vulnerability to automation and creative work, the second criterion is of particular importance.

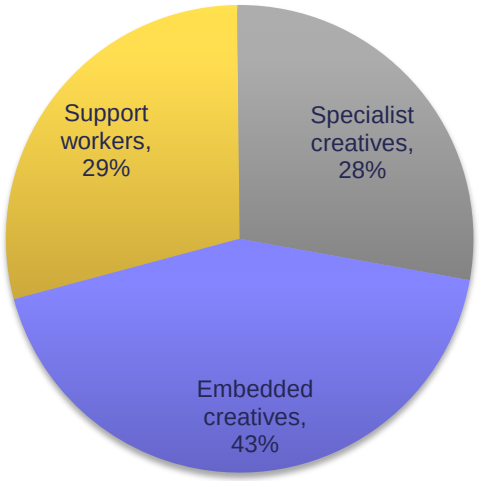
1. **Novel process** – problems are solved in novel ways
2. **Mechanisation resistant** - a mechanical labour substitute is not possible
3. **Non-repetitiveness or non-uniform function** - labour requirement need random and constantly evolving solutions
4. **Creative contribution to the value chain** - the occupational outcome is novel and creative and unrelated to its context (ie a singer is creative regardless of the industry they are working in)
5. **Interpretation, not mere transformation** - skill and creativity are inherent in the specific occupation, rather than being reproduced by them (Bakhshi et al., 2013).

[2] In 1994 by Cutler & Co in the *Commerce in Content* report prepared for the Department of Industry Science and Technology and more explicitly as a term in 1998 in the *Creative Industries Mapping Study* of the UK DCMS (Higgs, Cunningham, & Pagan, 2007).

4.2 Creative employment

The 'Creative Trident' approach (see Figure 7) to accounting for employment in creative work encapsulates the creative workforce as a whole. It was developed to quantify 'commercially relevant' creative activity and distinguished three groups of the creative workforce – those working in creative *industries* as well as those working in creative *occupations* (SGS, 2013). This important contribution ensured 'embedded' creatives were no longer overlooked and contributed along with 'specialists' and 'support' to the economic measurement of creative activity in the economy.

Figure 7: The Creative Trident, Australia 2011



- **Specialists** - those employed in creative occupations in the core creative industries
- **Embedded** - those working in creative occupations in other industries
- **Support** - those employed in specific creative industries in non-creative management

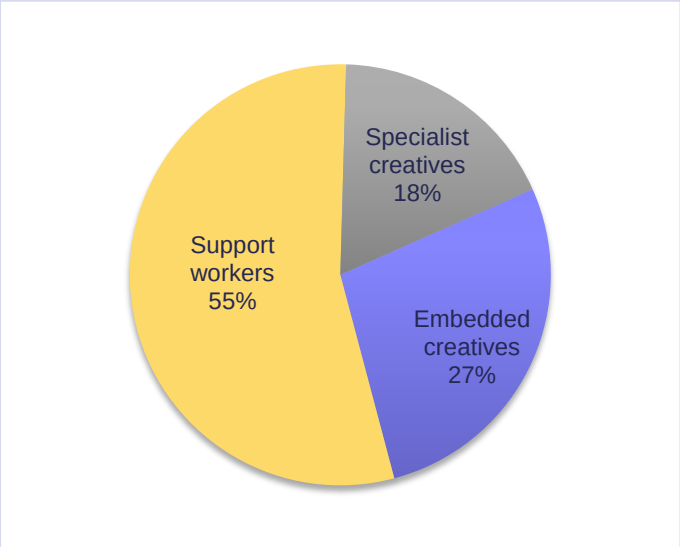
	Creative industries	Non-creative industries	Total
Creative occupations	**Specialist creatives** 169,402 (1.7%)	**Embedded creatives** 263,563 (2.7%)	432,965 (4.4%)
Non-creative occupations	**Support workers** 178,342 (1.8%)		178,342 (1.8%)
Total occupations	**347,744 (3.5%)**	**263,563 (2.7%)**	**611,307 (6.2%)**

Source: SGS (2013, p. 39)

In 2011, the creative workforce contributed 6.2% of the total Australian workforce comprised of 611,307 workers most of whom resided in the eastern seaboard states (SGS, 2013). In South Australia at this time 32,159 people (representing 5.3% of this workforce) were employed in the creative industries contributing a 4.5% share of the State's employment. Between 2006 and 2011 the average annual growth rate of creative employment in Australia was 2.8**%,** forty percent higher than the total workforce's annual growth rate of 2% (SGS, 2013).

For this report (and as described in Appendix A) we have identified creative occupations in South Australia at the 4-digit unit ANZSCO level (ABS, 2013a) drawing on the work of SGS (2013) which used the methodology developed by Bakhshi et al. (2013). We note that using the 4-digit unit level ANZSCO codes is a gross measure of creative industries, which is evident when we reproduce the Creative Trident (see Figure 8). Our analysis provides somewhat diluted findings as around double the proportion of the workforce is captured – most notably we have included a higher proportion of 'support workers'. However, while the results don't provide the level of specificity of the SGS model, it is the best picture of the creative industries in South Australia currently available.

Figure 8: The Creative Trident, South Australia 2015-2016

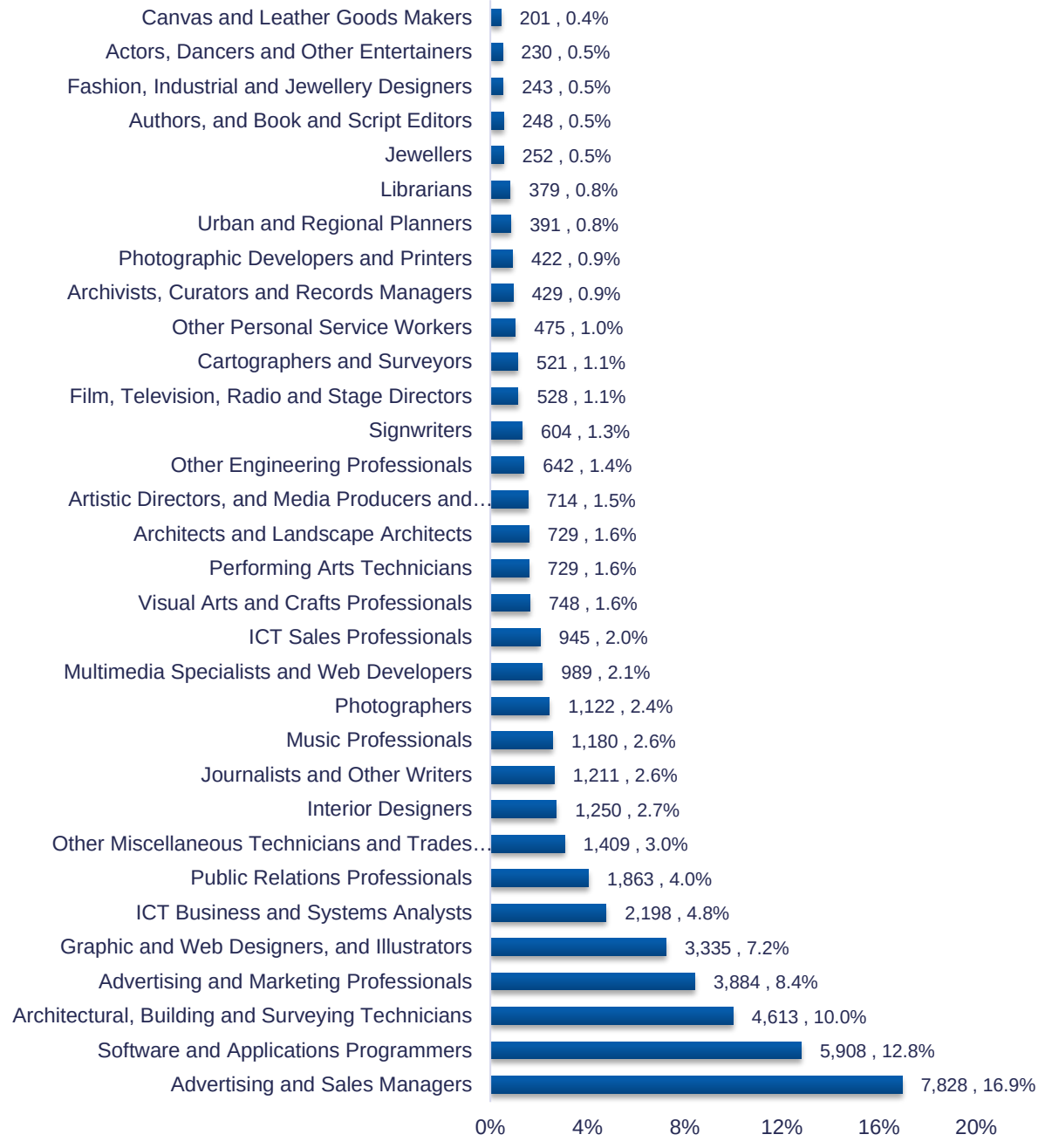


	Creative industries	Non-creative industries	Total
Creative occupations	**Specialist creatives** 18,203 (2.2%)	**Embedded creatives** 28,018 (3.4%)	46,221 (5.6%)
Non-creative occupations	**Support workers** 55,522 (6.7%)		55,522 (6.7%)
Total occupations	**73,725 (8.9%)**	**28,018 (3.4%)**	**101,743 (12.3%)**

Our results include 32 creative occupations[3] at the 4-digit ANZSCO unit level employing 46,221 South Australians (see Figure 8). As such creative occupations make up 5.6% of the South Australian workforce which numbered an average of 826,000 people during the period May 2015 to February 2016. In addition, 55,522 workers were engaged in the creative industries providing support to those in creative occupations. The largest four occupations contributed almost half (48.1%) the employees in South Australian creative occupations (see Figure 9). Advertising and sales managers was the largest occupation comprised of 7,828 employees – one in six (16.9%) of those employed in these occupations. Software and applications programmers followed with 5,908 employees – one in eight (12.8%) creative employees. The third largest creative occupation was architectural, building and surveying technicians with 4,613 employees (10.0%) of this workforce, followed by advertising and marketing professionals with 3,884 employees (8.4%).

[3] For more information about the identification of creative industries see Appendix A.

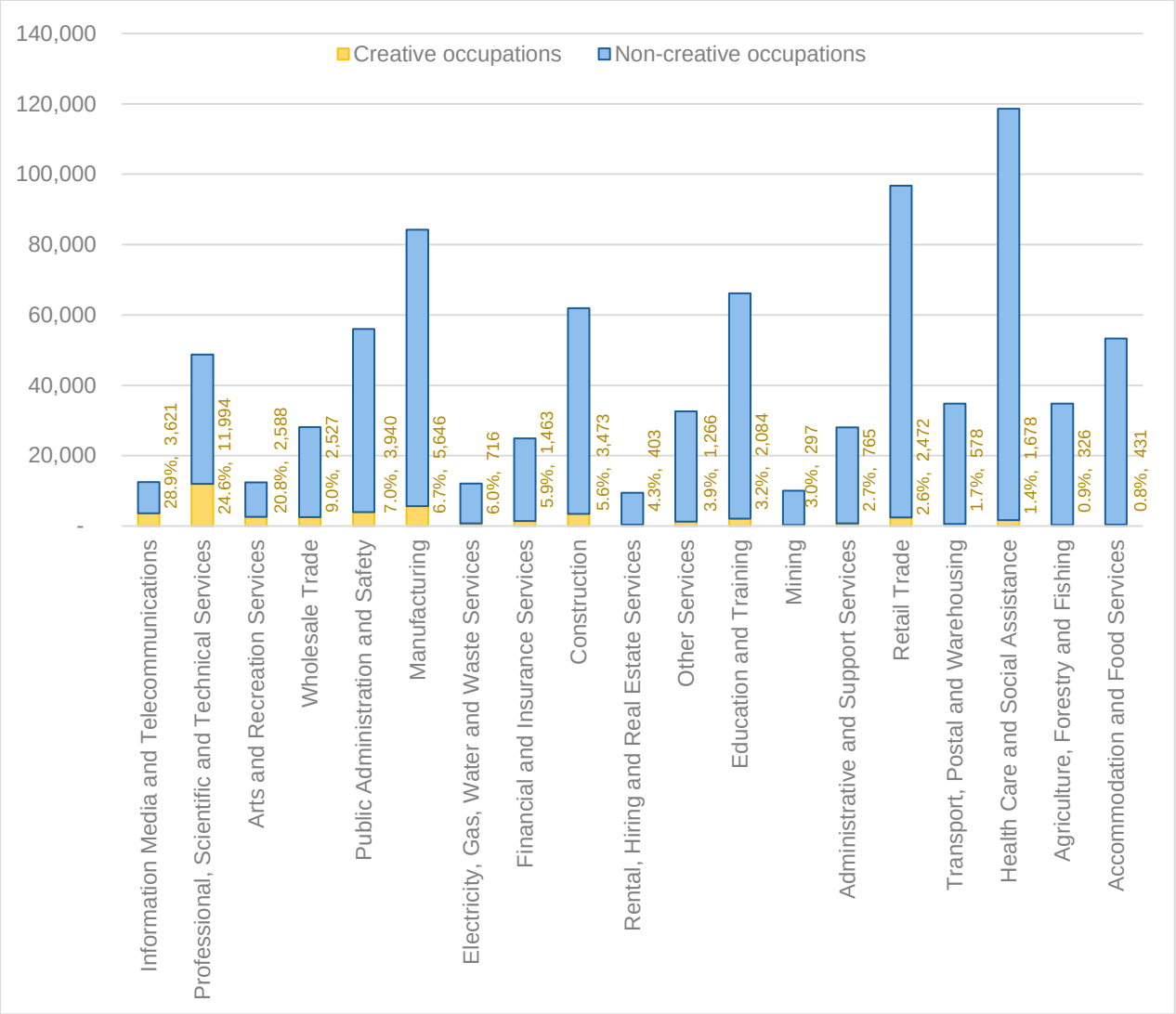
Figure 9: Number (%) employed in creative occupations, South Australia, 2015-2016



Source: ABS (2016a).

SGS (2013) used a benchmark of 30% to identify creative industries at the ANZSIC 4-digit 'Class' level. However, this report uses a 20% benchmark given the dilution effect of using industry data at 2-digit 'Division' level.[4] Applying this criterion, three creative industries were identified in South Australia - information, media and telecommunications (28.9%); professional, scientific and technical services (24.6%); and arts and recreation services (20.8%, see Figure 10). These three industries comprise a total of 73,700 employees (an 8.9% share of South Australian employment), one quarter (n=18,200) of whom are employed in creative occupations.

Figure 10: Number and proportion of creative jobs by industry, South Australia, 2015-2016



Source: ABS (2016a). Note only numbers and proportions for creative occupations by industry are shown.

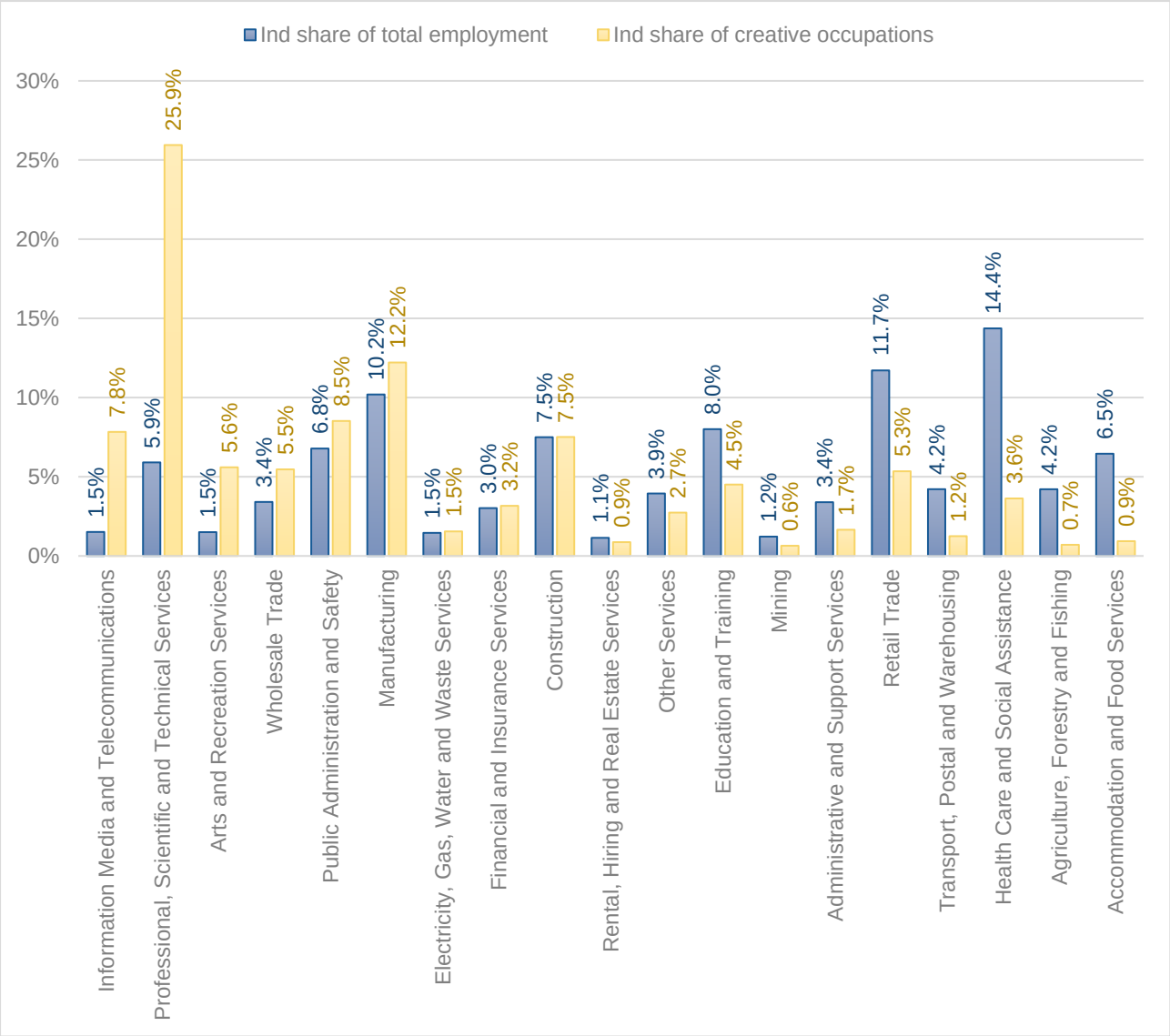
Figure 11 presents industry share of the South Australian total workforce and industry share of the creative occupations workforce. The industry with the largest share of South Australian employees was health care and social assistance comprised of 14.4% (n=118,500) of the workforce. This was followed by retail trade with 11.7% (n=96,700) and manufacturing with 10.2% (n=84,200) of employees. At the other end of the spectrum with shares of less than 1.5% of South Australian employees were information media and telecommunications (n=12,500); arts

[4] For more information about ANZSIC classifications see ABS (2013b).

and recreation services (n=12,400); electricity, gas, water and waste services (n=12,000); mining (n=10,100); and rental, hiring and real estate services (n=9,400).

When considering creative industries, we can see that professional, scientific and technical services comprised only one in 16 (5.9%) South Australian workers in 2016, but one in four (25.9%) of the creative occupations workforce. Not surprisingly, information, media and telecommunications and arts and recreation services industries also had a high share of creative occupations - at approximately five and four times, respectively, the size of their share of the total workforce.

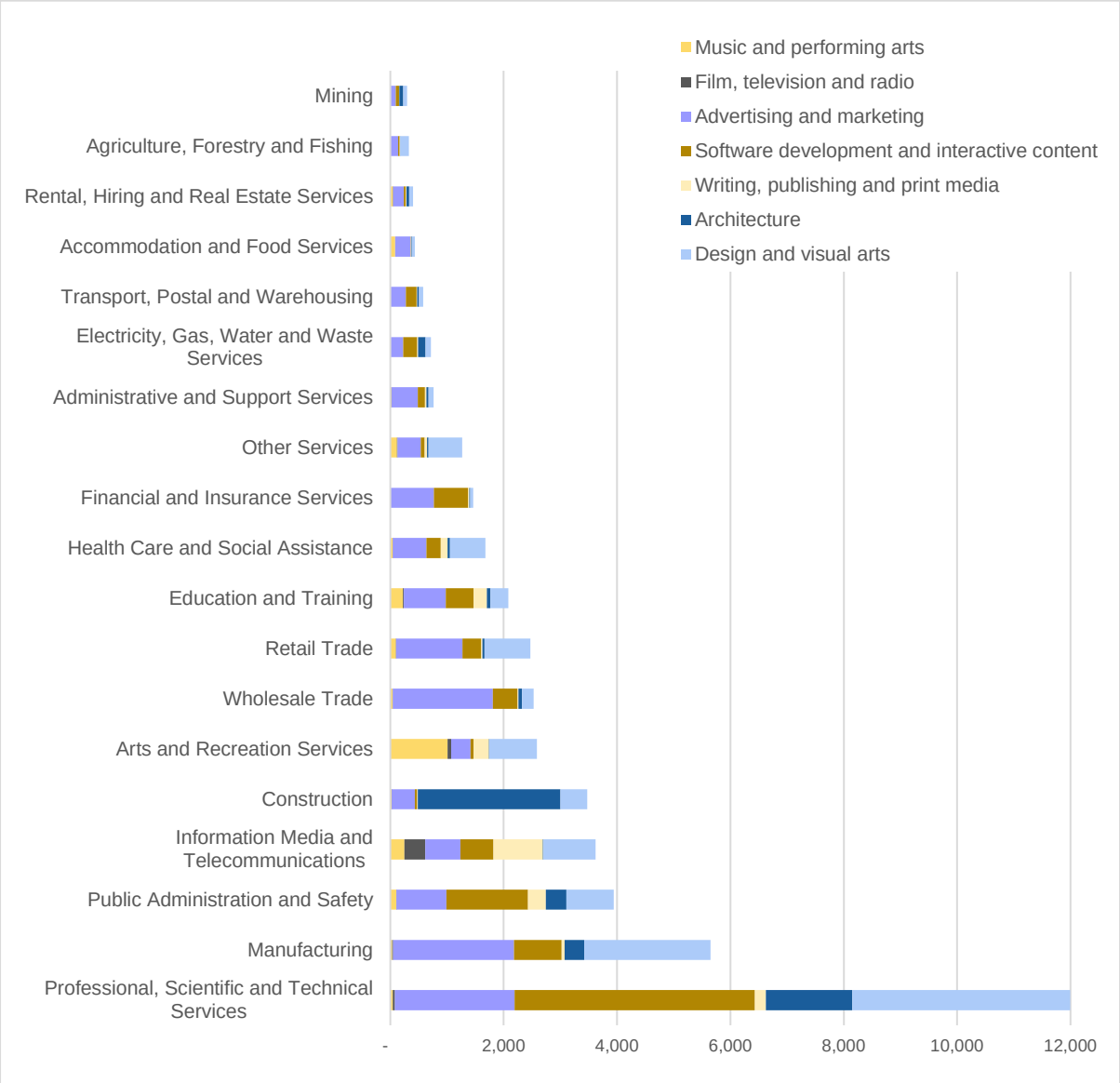
Figure 11: Industry share of total and creative occupations employment, South Australia, 2015-2016



Source: ABS (2016a).

Australian research by SGS (2013) categorised the creative occupations into seven 'creative segments': music and performing arts; film, television and radio; advertising and marketing; software and interactive content; writing publishing and print media, architecture; and design and visual arts. This has been replicated by us for the South Australian creative economy. Figure 12 presents the distribution of the segments within each industry by workforce number, whereas Figure 13 presents the proportional distribution of the segments within the creative workforce.

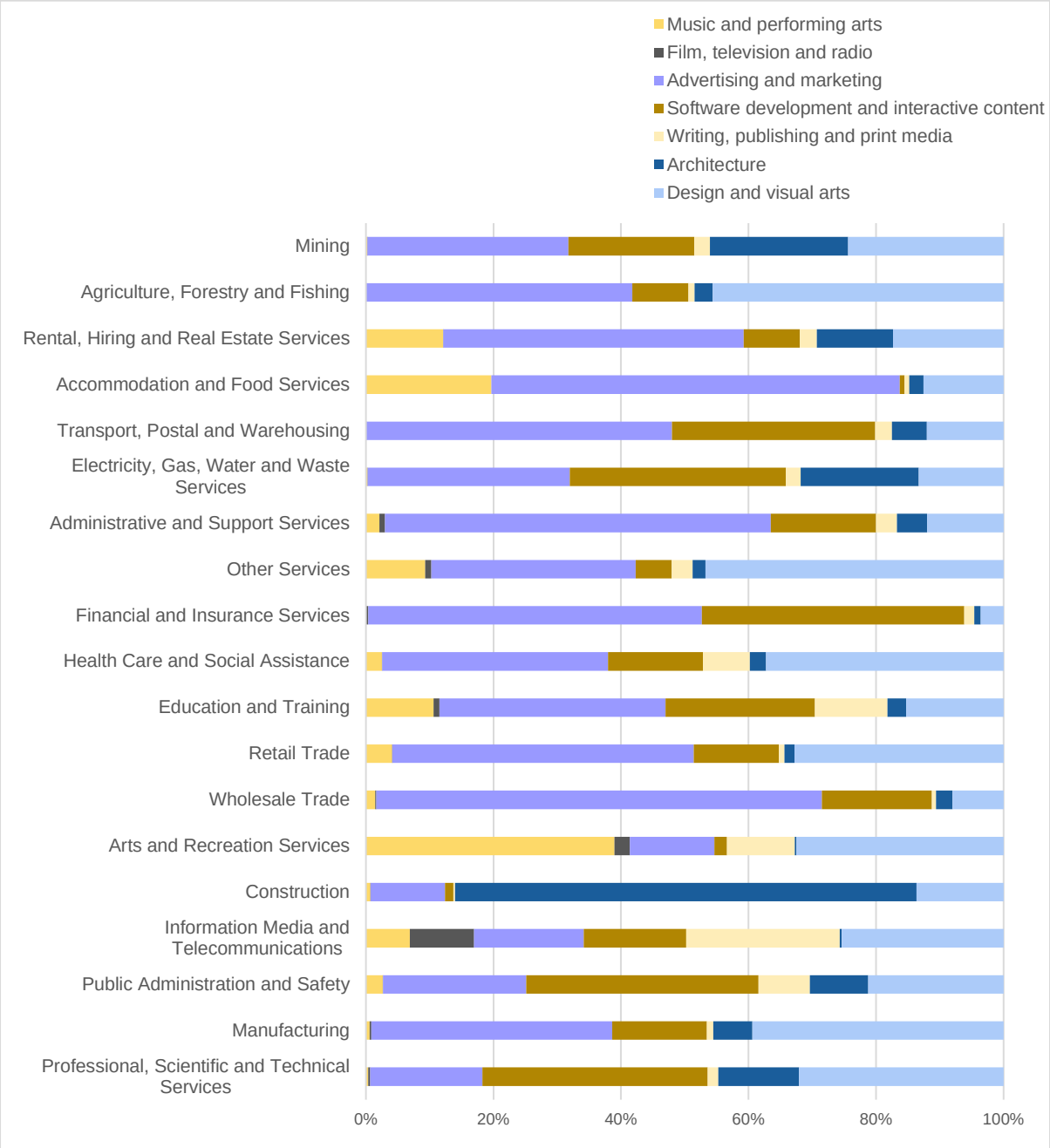
Figure 12: Distribution (n) of creative segments by industry, South Australia 2016



Source: ABS (2016a).

In terms of proportional distribution, almost half (47.2%, 1,009 workers) of the South Australian music and performing arts segment worked in the arts and recreational services industry. More than two thirds (69.1%) of the film, television and radio segment were employed in information media and telecommunications - however, this equated to only 365 of the 528 total workforce. Workers from the advertising and marketing segment were distributed in the manufacturing (15.7%, n=2,134), professional, scientific and technical services (15.5%, n=2,110) and wholesale trade (13.0%, 1,766) industries. More than two in five (42.2%, n=4,238) software development and interactive content segment were also in the professional, scientific and technical services industry, as were 31.2% (n=3,846) of the design and visual arts segment. Almost half (47.1%, n=2,514) of the architecture segment worked in the construction industry. Just under two in five (38.5%, n=873) of the writing, publishing and print media segment were employed in information media and telecommunications.

Figure 13: Proportional (%) distribution of creative segments by industry, South Australia 2016



Source: ABS (2016a).

5 The creative workforce and resistance to automation

Much of the debate on the impact of automation and digitalisation has focused on its disruptive and job or task displacing impacts. Less attention has been paid to occupations and tasks that are resistant to automation. A closer examination of this is warranted as it has very important public policy implications, particularly for industry development and education and training provision.

Three impediments to the ability of computers to mimic human tasks have been identified (Edmonds & Bradley, 2015a):

- **Perception and manipulation** – involving work and tasks in 'unstructured environments' such as surgery.
- **Creative intelligence** – involving the development of original products and solutions such as interior design.
- **Social intelligence** – involving the ability to interact effectively with people, particularly when this involves complex skills such as negotiation or debating.

The Productivity Commission conclude that there are significant limitations to automation.

> *Difficulty in codifying these tasks places limits on the extent of automation. Not all tasks can be reduced to a series of patterns, and not all patterns are easy for machines to work with (Productivity Commission, 2016, p. 72).*

Analysing data on UK occupations, Bakhshi et al. (2015) reported that only 15% of jobs in creative industries were at high risk of automation compared with 32% of jobs in non-creative industries. Most jobs (64%) in creative industries had a low probability of automation, compared with only 38% in non-creative industries. They further identified computer programming (85%), public relations and communication (84%), computer consulting (83%) and cultural education (82%) as some of the jobs with the lowest probability of automation.

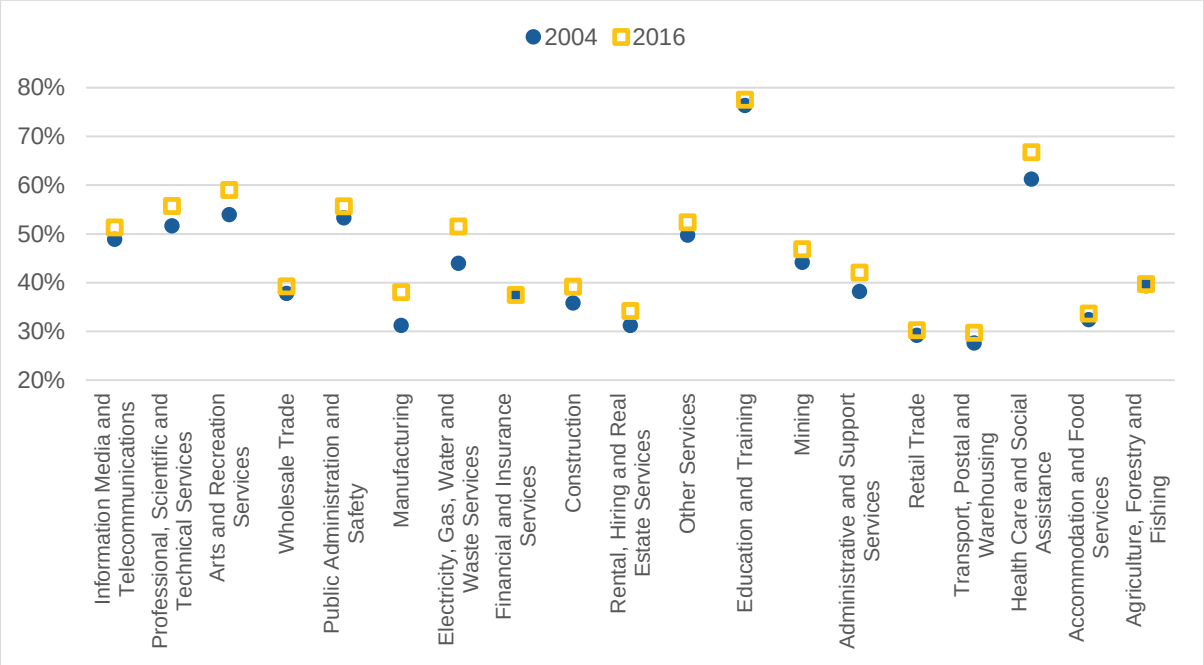
On the basis of their analyses of occupations in the United States and the United Kingdom Bakhshi et al. (2015, p. 6) concluded that 86-87% of workers in highly creative industries in these countries were in occupations they deemed "future proof to computerisation" as they were at low or no risk of automation. They also reported that where occupations were found to be highly creative they were often also directly involved with new technologies. The key point being computers and new technologies complement creative occupations – enhancing productivity rather than replacing their labour.

In 2004, around 56.5% of South Australian employees were seen as potentially vulnerable to automation; this declined by 4.3 percentage points to 52.3% of the 2016 workforce. Inversely, 43.5% of South Australian employees were *resistant* to automation in 2004 with resistance to automation increasing to 47.7% in 2016. The education and training industry was most resistant to automation with more than three quarters (77.5%) of their workforce not considered at risk of automation in 2016, a 1.1 percentage point increase from 2004 (see Figure 14). Two-thirds (66.8%) of workers in the health care and social assistance industry were resistant to the impact of automation – a relatively large 5.5 percentage point increase since 2004.

In terms of magnitude, the greatest growth in resistance to automation was seen in electricity, gas, water and waste services, and in manufacturing increasing by 7.5 and 6.8 percentage points, respectively (see Figure 14). No industry increased in vulnerability during this period, although financial and insurance services, and agriculture, forestry and fishing showed only marginal, if any, decline. For the creative industries, arts and recreation (59.0%), and professional, scientific and technical services (55.8%) were among the most resistant industries

in 2016, having improved by 5.0% and 4.1% percentage points, respectively. Just over half (51.3%) of the information, media and telecommunications workforce were considered resistant in 2016, increasing from 48.9% in 2004.

Figure 14: Proportion of employees in industry resistant to automation, South Australia 2004 and 2016

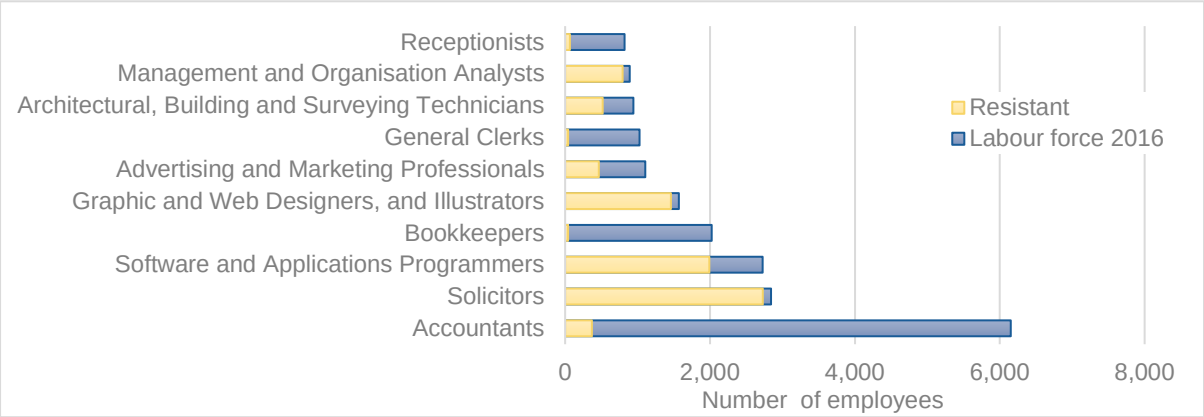


Source: ABS (2016a).

Resistance to automation of the largest occupations within the three creative industries is presented in the next series of charts. Almost 49,000 people were employed in professional, scientific and technical services in 2015-2016 with 41.2% of these employed in the top ten occupations. The resistance of these occupations to automation is shown in Figure 15.

It is notable that while the accountant workforce contributed the highest number of employees (6,152) to this industry, only 6% of these were resistant to automation, while bookkeepers, general clerks and receptionists were also highly vulnerable to automation. This can be contrasted with solicitors, graphic and web designers and management and organisation analysts who were largely immune to the impact of automation.

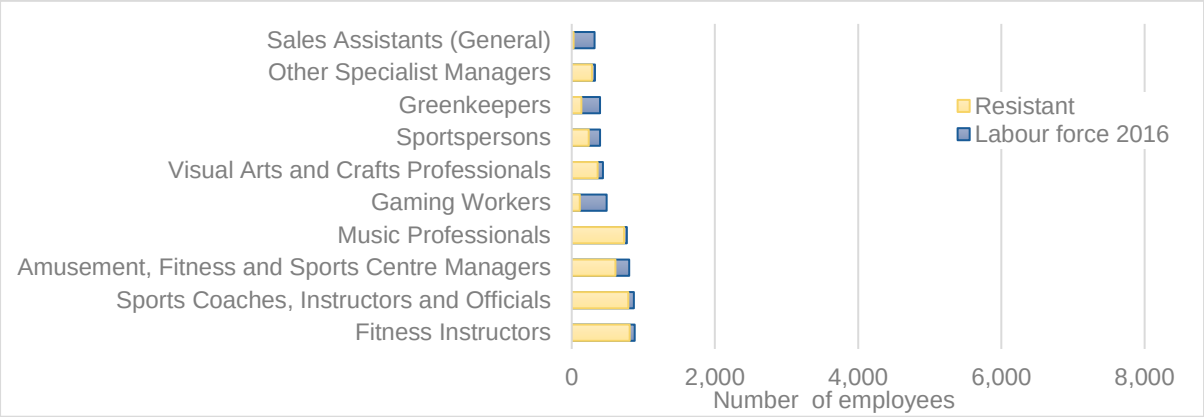
Figure 15: Resistance to automation of top ten professional, scientific and technical services occupations, SA, 2015-2016



Source: ABS (2016a)

The arts and recreation industry was around one quarter the size of professional, scientific and technical services with only 12,422 employees. The ten largest occupations in this industry comprised 45.7% of all workers (see Figure 16). The largest occupations were fitness instructors and sports coaches, instructors and officials with more than 90% of this workforce resistant to automation. While relatively few people were employed as sales assistants and gaming workers in this industry, these occupations were most at risk of automation.

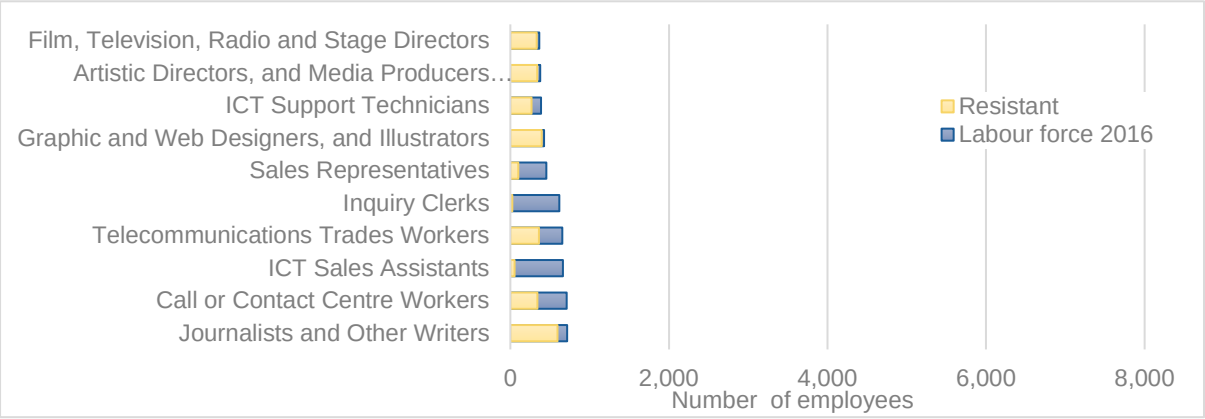
Figure 16: Resistance to automation of top ten arts and recreation occupations, 2015-2016



Source: ABS (2016a)

With 12,521 employees, information media and telecommunications was the same size as the arts and recreation industry. The top ten occupations included 42.9% of the industry workforce (see Figure 17). Workers in this industry who were engaged in sales or general administration were again the most susceptible to automation, whereas those working as directors, producers, design or illustration were most resistant to automation.

Figure 17: Resistance to automation of top ten information media and telecommunications occupations, 2015-2016



Source: ABS (2016a)

There is considerable variation in the expected impact of automation on all occupations. However, it is notable that only 24.0% of the creative occupation workforce are considered vulnerable to automation – whereas 54.0% of those in all other occupations are considered vulnerable. Creative occupations at 4-digit ANZSCO level (ABS, 2013a) are presented in Table 2 with their corresponding automation scores.

Table 2: ANZSCO creative occupations (unit group) with automation scores

Unit group	Occupation	Automation score
1311	Advertising and Sales Managers	0.01
2111	Actors, Dancers and Other Entertainers	0.21
2112	Music Professionals	0.05
2113	Photographers	0.02
2114	Visual Arts and Crafts Professionals	0.17
2121	Artistic Directors, and Media Producers and Presenters	0.10
2122	Authors, and Book and Script Editors	0.39
2123	Film, Television, Radio and Stage Directors	0.09
2124	Journalists and Other Writers	0.17
2242	Archivists, Curators and Records Managers	0.56
2246	Librarians	0.60
2251	Advertising and Marketing Professionals	0.58
2252	ICT Sales Professionals	0.15
2253	Public Relations Professionals	0.18
2321	Architects and Landscape Architects	0.02
2322	Cartographers and Surveyors	0.49
2323	Fashion, Industrial and Jewellery Designers	0.03

Unit group	Occupation	Automation score
2324	Graphic and Web Designers, and Illustrators	0.07
2325	Interior Designers	0.15
2326	Urban and Regional Planners	0.13
2339	Other Engineering Professionals	0.02
2611	ICT Business and Systems Analysts	0.01
2612	Multimedia Specialists and Web Developers	0.18
2613	Software and Applications Programmers	0.27
3121	Architectural, Building and Surveying Technicians	0.45
3931	Canvas and Leather Goods Makers	0.70
3994	Jewellers	0.95
3995	Performing Arts Technicians	0.50
3996	Signwriters	0.93
3999	Other Miscellaneous Technicians and Trades Workers	0.47
4518	Other Personal Service Workers	0.52
7114	Photographic Developers and Printers	0.67

Source: Creative industries allocated according to Bakhshi et al. (2013). Automation scores provided by DSD.

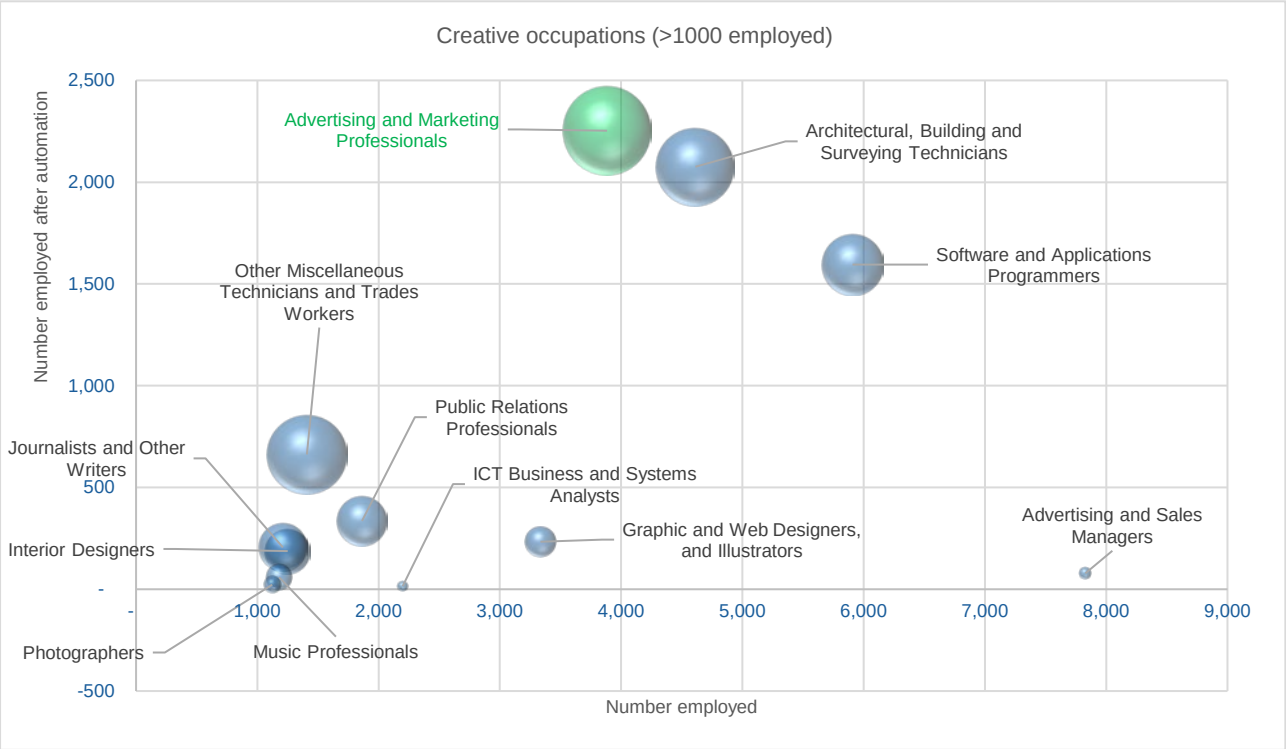
The impact of automation is presented in Figure 18 for creative occupations with over 1000 in the current South Australian workforce, and in Figure 19 for those with 1000 or fewer in the workforce. By way of an explanation:

- the horizontal axis presents the current (2016) workforce for each creative occupation;
- the vertical axis presents the expected workforce (based on 2016 numbers) in each creative occupation who would be employed if automation was to occur in the predicted manner; and
- the bubbles present the automation score[5] with larger bubbles representing more resilient occupations with fewer job losses and smaller bubbles representing greater workforce reductions.

For those creative occupations with more than 1000 South Australians in the workforce, the potential impact on advertising and sales managers is most marked with employees predicted to decline by 99% from 7,828 employees to 78 (see Figure 18). Although starting from a lower base, a similar proportional drop is expected for ICT business and systems analysts which are expected to reduce from 2,198 to fewer than 20 in the workforce. The photographer and music professional workforces are also expecting to decline significantly with automation. Advertising and marketing professionals was the only creative occupation with more than 1000 employees whose employees are not expected to decline by more than 50% (i.e. it has an automation score of 0.58).

[5] Specific automation for each occupation are shown in Table 1.

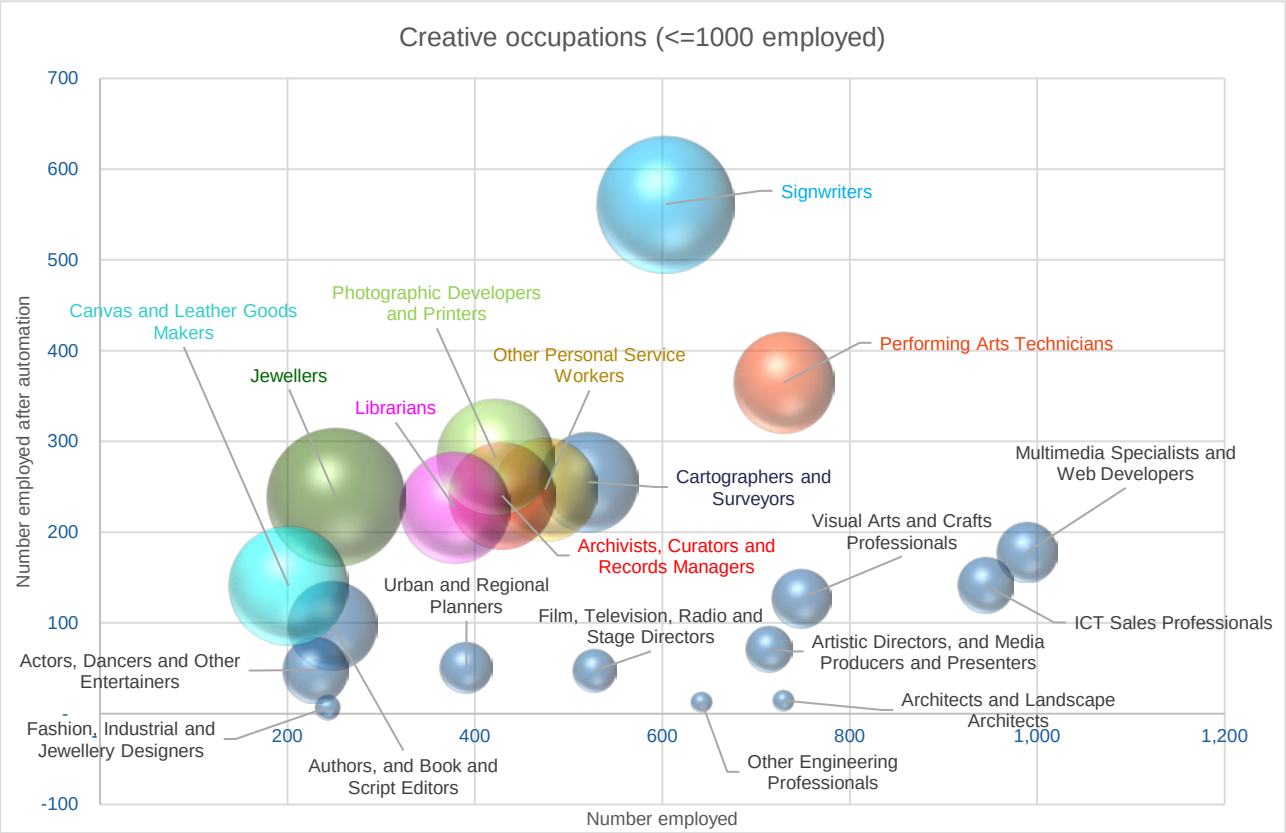
Figure 18: Current workforce by post automation workforce for the creative occupations (>1000 employed), South Australia 2015-16



Source: ABS (2016a). Automation scores provided by DSD.Note, bubble size is determined by automation score. Also note creative occupations with 1000 or fewer in the workforce pre-automation are presented in Figure 19.

The impact of automation on other engineers, and architects and landscape architects is expected to be around 98%, the largest for creative occupations with fewer than 1000 in the workforce (see Figure 19). The impact on these smaller 'specialist' creative occupations was substantially less than the impact on the larger occupations – eleven out of twelve large occupations were expecting their workforce to decline by more than 50%, while only three in five of the small occupations were expecting a decline of this magnitude. For the small occupations, jewellers (5% workforce decline) and signwriters (7%) are expected to be the least impacted by automation.

Figure 19: Current workforce by post automation workforce for the creative occupations (<=1000 employed), South Australia 2015-16

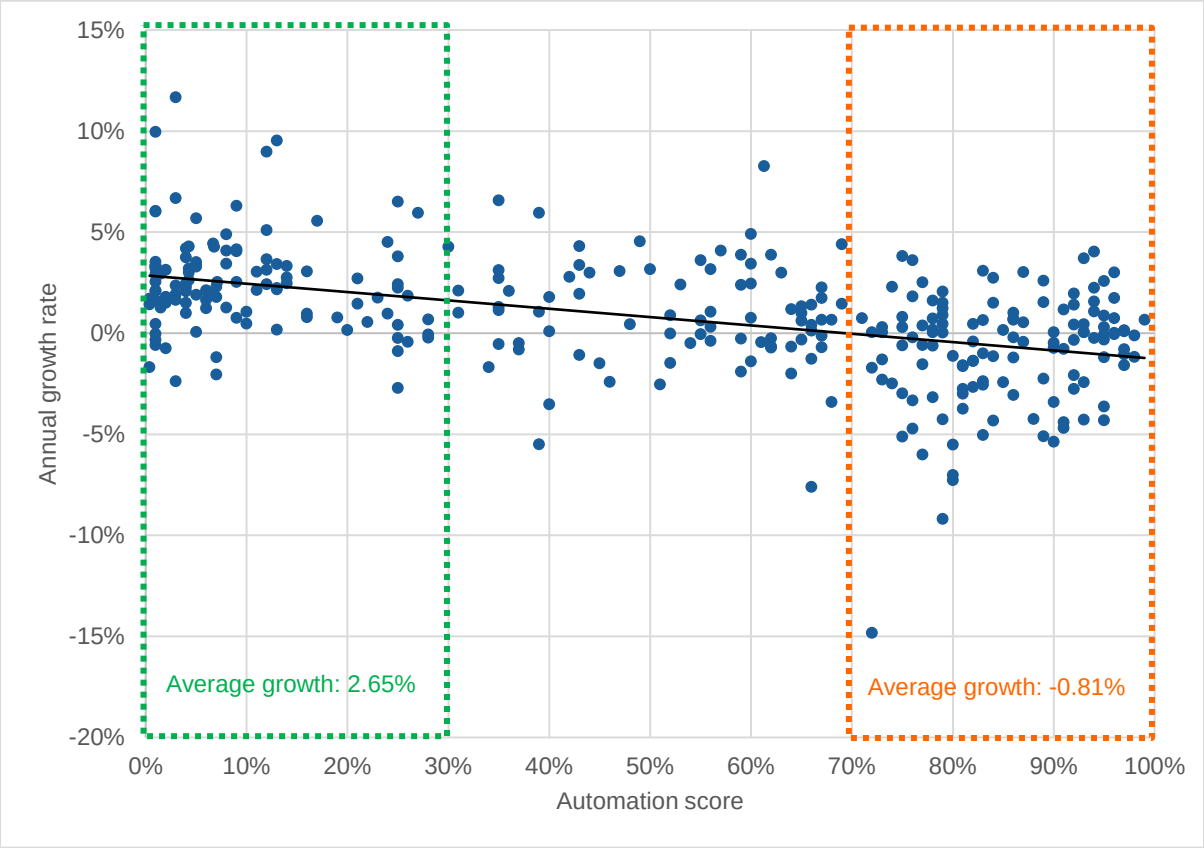


Source: ABS (2016a). Automation scores provided by DSD.
Note, bubble size is determined by automation score. Also note creative occupations with greater than 1000 in the workforce pre-automation are presented in Figure 18.

6 The future of the workforce

Edmonds and Bradley (2015a) have explored the relationship between annual employment growth rates and automation in Australia. They found that the average annual growth rate for occupations with low automation vulnerability grew by 3.1% per annum, whereas those with high automation vulnerability grew by only 0.9% per annum. We have replicated this using the South Australian Training and Skills Commission annual growth rates (see Figure 20). A similar relationship is evident as that found by Edmonds and Bradley, but with South Australian growth rates lower than that found in the Australian example. In South Australia, the average annual growth rate for occupations with low automation vulnerability was strong at 2.65%, however for occupations with high automation vulnerability jobs growth was in decline at -0.81%.

Figure 20: Relationship between automation score and average annual growth, South Australia



Source: Automation and employment growth rate scores provided by DSD.

Viewed over time, the relationship between people, work and technology has always been complex – never fixed and constantly evolving with creativity as its essence. From the time of the Industrial Revolution, technology can be seen to have shaped demand for particular skills and reduced demand for others, and in the process changed workplaces and work roles. The impact of ongoing technological change on individual workers varies depending on their skillset and its relevance to workplace requirements. Most simply, the introduction of new technologies have always separated people into those who gain or who lose because of their skills and capacity for change. Similarly jobs have been separated into those that are displaced and those that are generated by new technologies.

The introduction of new advanced technologies and automation have led to significant workforce changes over the last few decades.[6] The impact of workforce changes are often mediated by government and industry funded adjustment programs or compensation and affected by prevailing economic circumstances, particularly the availability of alternative employment at any

[6] It is noteworthy that the 'gig' workforce has risen in tandem with the escalation of automation. The gig workforce, also referred to as the 'contingent' or 'just-in time' workforce are those employed in short-term, often casualised arrangements such as independent contractors, freelancers, workers employed by contract companies, on-call workers, temporary help agency workers and workers employed through an online broker or intermediary (Katz & Krueger, 2016; Uzialko, 2016). Many creative occupations, including IT workers and those involved in the arts are increasingly engaged in the gig economy.

point in time. Additionally, experience shows the application of new technologies has the potential to both displace existing occupations and tasks within occupations as well as create new occupations.

Occupational disruption can be particularly difficult for some workers – unskilled young people, those less able to develop skills and workers made redundant through manufacturing closures, often older males, are most likely to be impacted. Policy interventions and structural adjustment or compensation are necessary to provide avenues for reengagement of these workers, with timely adjustments critical for economic progress, growth and prosperity (CEDA, 2015; Office of the Chief Economist, 2014).

Structural reforms introduced in Australia over the last couple of decades include decentralised wage bargaining (with negotiations at the enterprise rather than industry level), increasing the participation rate (through the provision of childcare support and parental leave), alterations to education policy, and subsidies for the automotive sector to increase international competitiveness - which have recently been wound down (Office of the Chief Economist, 2014). These measures have been successful in maintaining overall employment levels while increasing investment.

With production value in advanced economies now focused in the beginning (research and development) and end (marketing and customer service) of the cycle, successful businesses are no longer exclusively focusing on 'tangible' assets (e.g. labour and property) but looking to 'intangible' assets which meet the changing requirements (Arts Industry Council of South Australia, 2015).

It is clear that opportunities exist for replacing job losses in occupations that are susceptible to automation with jobs in the creative industries. We have noted that average employment growth in South Australia is strong in the occupations with a low automation potential at 2.65% per annum, with highly vulnerability occupations in decline at -0.81% per annum. However, job numbers in the creative industries have significant room for growth with appropriate targeted policies. These policies should grow knowledge and skill intensive industries and occupations, while designing strategies to address job losses and skill deficits associated with vulnerable occupations and industries.

In Britain, the *Creative Economy Programme* was a national policy initiative designed in consultation with the creative industries to explore seven cross-sectoral issues in order to support the creative industries to drive success (Department for Culture, 2007). Issues addressed included evidence and analysis, infrastructure, education and skills, technology, competition and intellectual property, access to finance and business and diversity. The results of this work were used to inform the *Creative Britain Strategy* wherein a range of policies were implemented to put the "creative industries at the heart of the economy" (Department for Culture, 2008, p. 9).

Key support was provided for the establishment of the Technology Strategy Board – now *Innovate UK* - providing funding to support collaboration between businesses to develop new ideas, services, products or processes. In nearly ten years since its establishment in 2007, Innovate UK has provided £1.8 billion (plus matched funds from business or partners). Impact on the economy has been six-fold at an estimated £11.5 billion, with projects in 7,600 organisations and the creation of 55,000 jobs[7]. In 2016, the Board are focusing on developing and driving productivity growth by supporting innovation in emerging and enabling technologies, health and life sciences, infrastructure systems, and manufacturing and materials (Innovate UK, 2016).

[7] https://www.gov.uk/government/organisations/innovate-uk/about

Recognising the role diversity plays in contributing to commercial success and performance, Innovate UK is developing a strategy and action plan for diversity and inclusion to be published in 2017.

The Knowledge Transfer Network (KTN) was proposed to bring creative businesses together with research organisations, suppliers and technical experts with the aim of accelerating and growing innovation, problem solving and marketing new ideas.[8] This was initially developed as fifteen sector specific KTNs, but restructured into one network from April 2014 to better improve opportunities and manage challenges in interdisciplinary innovation. In its first year as an amalgamated organisation KTN membership grew to over 75,000 members and facilitated 236 new collaborations (The Knowledge Transfer Network, 2015). KTN works to promote European and international opportunities for United Kingdom businesses

The Creative Industries Council (2014) reported on the opportunities and challenges for the creative industries along with strategies to realise their vision for 2020. Their five priorities over the current period included access to finance, education and skills, infrastructure, intellectual property and international. Data, innovation and cultural environment were identified as critical to achieving future success. Recommendations for financing involve the collaboration of the creative industries, financial institutions and government with the suggestion that policy change would be best placed in supporting the growth of private finance opportunities for 'scale-up' businesses. This could include tax exemptions and the focusing of venture capital investments to support creative industries.

In Australia, government support for innovation is demonstrated through investment in research and development, digital infrastructure and education (Department of the Prime Minister and Cabinet, 2015). Four key areas have been identified to progress this innovation agenda: culture and capital, collaboration, talent and skills and government as an exemplar. Similar to the United Kingdom, Australian government is urging the uptake of new ideas by encouraging private sector financing and government co-investment. In addition, the Federal Government is promoting coding and computing in schools to encourage students to be active in the digital age and develop problem solving and critical reasoning skills.

South Australian Government priorities align well with development of a creative economy and workforce. Priority 4 looks to the creation of the "Knowledge State" through the development of the right industrial and education infrastructure to attract students from around the world – and retain the local knowledge pool (Government of South Australia, 2014). Priority 6 supports growth through innovation, adopting new ways to work, taking calculated risks and reaping rewards. Priority 7 seeks to ensure the state is the best place to do business while Priority 10 supports access to capital and global markets for small enterprises to accelerate business and employment growth.

7 Strategic directions

Creative occupations as a whole are comparatively resistant to the potential impact of automation. In essence creative occupations involve novel processes, are not subject to mechanical substitution, and involve creative interpretations and non-repetitive tasks (Bakhshi et

[8] http://www.ktn-uk.co.uk/about/

al., 2013). But while creative occupations cannot be easily replaced by technology they are consummate consumers of technology, making use of labour and energy efficient resources to achieve their ends.

Currently South Australia is a follower rather than leader in developing and taking up new technology - buying technology from where it is created. The opportunity, therefore, presents to be at the cutting edge and contribute to the design and production of new technologies and equipment.

A policy framework to support a creative economy in South Australia might build on the British example with three levels of intervention – individual worker skills, job and workplace design to support a creative economy, and industry level support. A focus in these areas will assist SA to harness technology and the potential for automation in human centred ways to foster the growth of knowledge intensive jobs in sustainable industries.

7.1 Nurturing creative skills and capabilities

Currently, Australian education policy encourages individuals to attain the skills and qualifications they need for the employment they seek (Beitz, 2015). However, this is in a context where literacy in maths is falling and science participation is low (den Holland, 2015). Individual capacity to thrive in a creative economy requires the provision of learning opportunities across the lifecycle. This includes ensuring that school, post secondary and tertiary curricula that support the fostering of skills in innovation, problem solving and creativity not only to encourage future specialists in these areas but also to ensure that these become generically developed capabilities across a population who see the importance and value of those skills. For students (and their parents) in their final years of schooling who are planning for further education and/or their workforce careers, it is important they have knowledge about opportunities for creative occupations.

The growth of the creativity requires the ongoing nurturing and valuing of creative skills. The Creative Industries Council (2014) suggest this can best be supported through the promotion of STEAM (science, technology, engineering, arts and mathematics) subjects, rather than focusing on STEM which exclude arts. Government has a role in promoting creative career pathways, and ensuring the ‘A’ is not left out of ‘STEAM’. Continuing professional development training for those in the workplace need to focus on ensuring the right combination of skills is available as well as building leadership and management skills. The need for an appropriate and expansive skill set is reiterated by Durrant-Whyte (2015) who asserts there will be far fewer technology specialists in the future, but rather technology generalists who are agile, flexible and creative problem solvers.

It is therefore critical that secondary students and their families understand how STEM (and STEAM) skills can translate into the real world in order to ignite a spark of interest in these subjects. To meet the growing needs of the creative economy it is even suggested that ‘entrepreneurship’ and ‘design’ should be included (STEAMED) in the mix. In the current employment environment, ongoing learning is also critical both for those in a job who require continuing professional development and those whose jobs are being displaced and require reskilling to take advantage of new opportunities.

It is noted that currently training for the creative workplace is predominantly delivered by universities (South Australian Arts, 2013). From this perspective there is a large scope for the vocational education and training (VET) sector to grow the range of courses and qualifications they deliver in South Australia.

7.2 Growing a resilient and creative workforce

Government and industry need to work together to identify skills gaps and workforce shortages in the creative industries and ensure the right programs, apprenticeships, training and educational opportunities are available. Training should focus on capabilities that are less susceptible to automation (Green et al., 2015) such as creativity, innovation and problem-solving which in addition to low vulnerability to computerisation are unlikely to be moved offshore (Durrant-Whyte, 2015). In addition, management, finance and leadership training are important elements that can help to build an effective, efficient and flexible creative economy. Critically, it is important to recognise the sophisticated skill base of the existing workforce and to ensure opportunities for training are targeted at the right level (South Australian Arts, 2013). Workforce planning and development will be essential to support the creative economy and ideally this should be guided at the organisation level by a State-wide Creative Economy Workforce Development Strategy.

The core skills that characterise workforces in the creative economy are unlikely to be supported by most job definition and design. Modelling will be useful to illustrate new work roles configured to maximise the potential associated with new technologies and the development of the creative economy. Firms which are able to achieve this outcome will be those with competitive edge in a technology-driven world (Green et al., 2015).

Policy in Britain is directing more focus to encouraging diversity in the creative workforce that reflects the diversity of society (Creative Industries Council, 2014), recognising creativity is not the sole dominion of white males. In recent years there has been a drive in South Australia to encourage women (and girls) to engage with STEM subjects in both secondary and tertiary education. A recent report (Office for Women, 2012) provided details on gender differences in STEM subjects differentiating between Prime[9], Allied Economics and Allied Health STEM pathways. With regard to Prime STEM, it is noted that almost half (45%) of secondary school Prime STEM students are female, with this proportion reduced on entry to university when female enrolment contributes only one quarter (25%) of applicants to Prime STEM subjects. Once enrolled, females are proportionally more likely to graduate Prime STEM subjects than males. However, females comprise fewer than one in eight (12%) in the Prime STEM workforce. This points to an ongoing need for policy development that promotes women's place in the creative workforce and encourages industry to provide entry level opportunities for women to participate in this area.

7.3 Fostering creativity and an innovation ecosystem

State government (along with national and local government) have a role to play in fostering creativity as a foundation for the development of sophisticated innovation ecosystems operating in the most liveable of cities. The concept of the 'liveable city' is significant because of its capacity to attract knowledge workers and the businesses employing them, and to provide an innovation-friendly environment. Sometimes referred to as 'brain hubs', these are strong predictors of GDP, providing a fertile environment for the creation of new ventures and wage growth (Callander, 2015). South Australia is well placed to provide such an environment; Adelaide is frequently nominated as one of the most liveable cities in the world, and its strong

[9] Prime STEM courses provide a fundamental knowledge in all or one of the traditional STEM subjects.

university presence and promotion of a learning culture provides a firm foundation for development of a creative economy.

> *There are many aspects to the 'liveability' of a city, including: population density; infrastructure and facilities (including transport, health and education facilities); cultural venues and events; community sense of connectedness and security; and environmental aspects (such as green space, air quality and natural landscape). Many of these aspects of liveable cities overlap with those evident in thriving entrepreneurial communities — in particular, proximity to large research or academic institutions, low cost capital, or proximity to infrastructure or highly skilled labour … These features should provide focus to attempts to improve city liveability. (Productivity Commission, 2016, p. 111)*

In tandem with the development of new opportunities for the creative workforce in new growth industries, government should support knowledge intensification strategies that build skills and knowledge in traditional occupations and industries to make them more resilient to automation. For example, although traditional manufacturing is in decline, it has been a lynchpin for the development of engineering skills – employing one in five Australian engineers, contributing indirectly to the employment of many more and providing formative skills for those who move on to work in other industries (Green et al., 2015). Manufacturing also contributes significantly to research and development driving technological change and innovation. From a policy perspective there is a need to recognise and promote creative industries and occupations within South Australia emphasising their value to the state in economic terms and their role in future employment.

Policy in Britain has assisted business growth by encouraging venture capital and other investment to support creative businesses develop commercial potential. In Australia, although business creation is high (ranked between first and fifth in the world), venture capital investment is low – 16th in the OECD relative to GDP (Beitz, 2015). Promotion of the economic benefits and value add of creative industries though policy initiatives could encourage higher investment in creative business development in South Australia.

8 Future research

This report provides an overview of the likely effect of technologies on employment with a focus on the impact in South Australia. We have discussed the importance of the creative occupations as both resilient in the face of automation, but also as more advanced consumers of technology. The following sections identify further areas of potential research that can provide an enhanced understanding of the facilitators and inhibitors for the uptake of technologies and the pace with which this may occur in South Australia.

8.1 Business factors inhibiting automation

Earlier sections have discussed the expected impact of automation on occupations and industries. However, the speed of automation within businesses will be variable and is likely to be dependent on their own absorptive capacity[10] and the uptake of new technologies within their industry and local environment. Accordingly, there is a need to ground this report's findings in the South Australian experience and to better understand the factors impacting a business's decision to engage in new technologies, including their:

[10] Absorptive capacity is a measure of a business's ability to take up new technologies and information.

- **Awareness** – knowledge about the technology and recognition of the business potential.
- **Attitude** – choice and confidence in the changes that may follow.
- **Aptitude** – the requirement for different skills and expertise.
- **Application** – the challenges of the new ways of working that may follow, safety concerns and the cost of implementing the new technology

8.2 Current distribution of creative occupations (2016)

The South Australian data presented in this report drew on the 2011 Census for allocation of employees to industry and occupations. The completion of the most recent Census in August 2016 presents the opportunity to examine current data and apply a longitudinal lens. This analysis would provide additional current information on the distribution and growth of creative occupations within South Australia. In addition, it provides the opportunity to drill down in the ANZSIC and ANZSCO codes to better understand the net impact of technological development on employment in South Australia with a particular focus on the relative vulnerability of different occupations to significant disruption or displacement by new technologies. Drilling down in the ANZSIC and ANZSCO codes will also allow for a more detailed understanding of the 'Creative Trident' in South Australia and the placement of specialist, embedded and support occupations within industries.

8.3 The South Australian 'gig' economy

There is international evidence that the gig economy is growing and that some creative occupations are at greater risk of engaging in the gig economy (Katz & Krueger, 2016). Further exploration is required to better understand the implications of an increasingly casualised self-employed creative industries workforce in South Australia. This could provide an understanding of the hours worked, employment type, gender and age for those in creative occupations and include an examination of creatives designated as specialist, embedded and support workers. The 2017 release of data from the 2016 Census makes this a particularly timely exercise.

8.4 Future proofing the VET sector

The VET sector provides vocational training, education, skill development and qualifications for individuals and businesses across a broad selection of occupations and industries. Currently, training of the creative workforce is predominantly delivered by universities (South Australian Arts, 2013). Accordingly, there is considerable scope for the South Australian VET sector to increase the range of courses and qualifications they deliver. However, it is critical skills are developed to support a sustainable workforce in occupations and industries that are in-demand.

We therefore propose an industry focused audit of the South Australian VET sector, examining the future application for skills taught. This would use an automation and creative occupations lens to examine the relevance of skills, the potential displacement of routine tasks and the potential for new skills and tasks to be taught.

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Appendix A. Methodology

The report builds on initial work undertaken by the Department of State Development (DSD) to critically explore and extend the methodology adopted by Frey and Osborne (2013). A two part methodology has been applied, involving a focused literature review and analysis of Australian occupation-based labour force data relating to the creative industries. Both components of the methodology explore the occupational impact of technological change, particularly automation, and the divide between those vulnerable to, and those benefitting from, new technologies. The growing relevance of creative occupations is given specific attention.

The South Australian data presented here have been derived from multiple sources and supplied by the Department of State Development (DSD).

Labour force by occupation data are presented at various time periods, the latest being an average calculated for the year to February 2016 (ABS, 2016a). Occupation data are presented at the 4-digit ANZSCO level (ABS, 2013a). Data have been adjusted to include not further defined (NFD) occupation data by proportionally distributing data at the 2-digit and 3-digit level into the related 4-digit codes.

Industry data are presented at ANZSIC Division level (ABS, 2013b). Labour force by occupation data have been allocated to industries based on the proportional distribution of industries by occupations at the 2011 Census. Data have been adjusted to include not stated and inadequately described by proportionally distributing that data into industries and occupations.

An automation score for an occupation was calculated and provided by DSD.

A binary score for occupational creativity at the 4-digit unit level occupation was based on that presented at the 6-digit code level by SGS (2013) using the methodology developed by Bakhshi et al. (2013). This method identifies creative occupations through achievement of at least four of five criteria, namely:

- Novel process - are problems solved in novel ways
- Mechanisation resistant - a mechanical labour substitute is not possible
- Non-repetitiveness or non-uniform function - the labour requirement needs random and constantly evolving solutions
- Creative contribution to the value chain - the occupational outcome is novel and creative and unrelated to its context (ie a singer is creative regardless of the industry they are working in)
- Interpretation, not mere transformation - skill and creativity are inherent in the specific occupation, rather than being reproduced by them.

Occupations have been analysed to understand the net impact of technological development on employment in South Australia with a particular focus on the relative vulnerability of different occupations to significant disruption or displacement by new technologies. Specific attention is given to the mediating impact of creativity and knowledge-intensity employment on occupational disruption and displacement.

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