Digital skills in the Australian and International economies

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Abstract

Digital skills proficiency is important to the economy on multiple levels. It can ensure success for people in the labour market, enable transitions between jobs, and open new opportunities for Australia to lead in the development of digital technologies into the future.

This paper provides an analysis of digital skills in the Australian and International economies using a mix of data sources and analysis techniques. The first part of the analysis addresses key questions about definitions, utilisation, and employer demand for digital skills across the Australian labour market. The second part of the analysis addresses key questions about how digital engagement in Australia compares to Canada, New Zealand, Singapore, and the United States. We examine the digital skills sought by employers and the roles that require them across the five countries.

Our findings suggest the skills needed to respond to the digital world are amongst the fastest growing in the Australian economy. Skills clustered around engaging with the digital economy are expected to increase by up to 28 per cent on current use levels over the next five years. We found digital skills are sought by employers in a diverse range of occupations, with the specialist level of these skills higher for ICT related occupations. Despite considerable international consistency in the demand for digital skills such as IT automation, machine learning, artificial intelligence and the internet of things, the share of job advertisements requiring cutting edge skills in Singapore outstrips those of the US and Australia.

Introduction

Digital skills are increasingly important in today's economy. Growth in new technologies is changing the way businesses are run and the way tasks within jobs are undertaken. Indeed, the recent NSC *State of Australia's Skills report* has shown skills responding to the digital economy are among the fastest growing skills in the economy*.*

This paper begins with a section explaining the National Skills Commission's (NSC) research on the digital economy. We explain how the Australian Skills Classification (ASC) has been curated to provide a comprehensive taxonomy of skills and how this has led to the formation of skills clusters devoted entirely to digitisation. We introduce the concept of trending and emerging skills and provide some examples of where digital skills have emerged in occupations for the first time in the last five years.

We then examine the Australian landscape of digital skills using job advertisement data and compare it to that of New Zealand, the United States, Canada, and Singapore. To understand the spread of digital skills across the labour market differences in demand for digital skills inside and outside the ICT sector are considered. This can help with our understanding of how the digital engagement of Australian industry compares internationally, where Australia's skills gaps might be, where skilled talent may be lost, and where industry growth opportunities and future skills demand may be.

Overall, our analysis found the demand for data and digital skills is spreading quickly across the Australian labour market. Trending and emerging data and digital skills are going beyond the specialisation of existing occupations and creating entirely new ones. While Australian employers are recognising the need for more technical, specialised digital skills in line with international markets further effort is required to build base digital skills proficiency at all skill levels, not just the higher skill levels to be on par with other countries. There are also

significant gains to individuals, and likely also the economy more broadly, from investing in those skills.

Section 1: Curating different data sources to define digital skills

Through the lens of the Australian Skills Classification

We initially set out to define 'digital skills' in the Australian labour market as part of developing the Australian Skills Classification (ASC). The purpose of the ASC is to provide a common language of skills, enabling stakeholders to identify and articulate skills using a comprehensive and universal taxonomy. For the analyst it provides the basis for turning an occupation-based view of the economy into a skills-based view – by mapping the way occupations are made up of skills.

There are three elements of the ASC. *Core competencies* common to all occupations, such as teamwork, writing, problem solving and planning and organising; *specialist tasks*, which are the work activities a person undertakes specific to an occupation; and *technology tools*, which are the hardware and software technologies required to be used in an occupation.

For this section the analysis focuses on how specialist tasks like each other can be grouped together to form skills clusters. There are 279 skills clusters in the ASC which in turn group into 29 skills cluster families. *Digital Technologies and Electronics* is the skill cluster family of focus along with the seven associated skill clusters.

The skills clusters were developed using a mix of machine learning, qualitative analysis and human judgement and drew on different data sources including O*Net's Detailed Work Activities and employer surveys[2]. We used 3 different clustering algorithms: k-means, Affinity Propagation and Spectral Clustering

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[2] O*NET is developed by the National Center for O*NET Development and is sponsored by the U.S. Department of Labor, Employment & Training Administration (https://www.onetonline.org).

algorithms followed by a customised cluster refining process. We used a similar process to further group the skill clusters into families.

To analyse how specialist tasks are utilised in an occupation we calculated working hours allocated to a task each day using O*NETtask ratings as a base. O*Net asks survey respondents how often they perform each task in their role. We used average of implied yearly frequency for a task weighted by respondent share to calculate a task utilisation score for each occupation and task pair and then compared the relative share for each task to the sum of all task utilisation scores for the occupation to get the relative importance of the task for the role. The relative share was then multiplied by 40 to give the typical number of hours in a week spent on a task for the occupation[3].

Therefore, the total number of hours a week spent on a task *a* for the occupation *x* can be described as:

$$Weekly\ hours_{task\ t,occ\ o} = \frac{\sum_{task\ t,occupation\ o} Implied\ yearly\ frequency_{t,o} \times Share\ of\ respondents_{t,o}}{\sum_{all\ tasks,occupation\ o} Implied\ yearly\ frequency_{O} \times Share\ of\ respondents_{o}} \times 40$$

Through the lens of Emsi-Burning Glass Technologies

The second part of our analysis uses proprietary online job advertisement data from Emsi-Burning Glass, who uses machine learning and web scraping to obtain real-time job advertisement data from various sources across the web including third-party resume databases, job boards, and the recruiting industry directly. Job advertisement data includes raw text of job advertisements as well as information on the occupation being hired for (coded to ANZSCO for the Australian data), the skills required for each job, salaries offered, and location of the job, amongst other variables.

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[3] Further details and worked examples of this methodology are available in the Australian Skills Classification BETA release discussion paper (https://www.nationalskillscommission.gov.au/australian-skills-classification-10).

We explore digital skills and how they are trending and emerging in the Australian context. *Trending skills* are defined as those that have grown over the past five years. They are not necessarily new skills, but skills that are increasing in demand. *Emerging skills* are a subset of *trending* skills, they have recently emerged in some occupations where they were not previously required. They have both grown as well as being new to particular occupations over the past five years.

To derive the list of trending and emerging skills, we analyse over 6 million Australian online job advertisements. For each occupation in the ASC, we compute 'intensity' scores, representing the proportion of job ads that requested a skill in 2020 and in 2015. Where the occupation did not have at least 100 jobs in 2020, we traverse up the ANZSCO hierarchy to the ANZSCO minor code (ANZSCO 3-digit code) to compute the intensity score. We then filter the skills which had grown or emerged from the baseline year, providing us with the basic list of trending and emerging skills.

To capture the frontier skills that are changing the nature of work, we apply a relevance score inspired from the 'term frequency/inverse-document frequency (TF-IDF)'[4] formula to further filter the results.

For each occupation, we compare the 'intensity' of a particular trending skill in an occupation to its intensity across all jobs in the economy. We only consider skills with a higher intensity in that occupation compared to all jobs (relevance score greater than 1). This resultant list provides a curated set of trending skills that were changing the nature of work across the economy.

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[4] The statistic tf-idf is intended to measure how important a word is to a document in a collection (or corpus) of documents (Source: https://www.tidytextmining.com/tfidf.html).

Computing relevance score for a skill, occupation pair

$$Relevance\ score_{Skill\ a,occupation\ x} = \frac{\frac{\sum_{skill\ a,occ\ x} jobs}{\sum_{occ\ x} jobs}}{\frac{\sum_{skill\ a,\ all\ occs} jobs}{\sum_{all\ occs} jobs}}$$

We then explore how digital skills in the Australian context compares to countries with similar economies like Canada, New Zealand, Singapore and the United States. This analysis uses three different types of digital skills that can be compared across countries in the Burning Glass data:

- *Baseline digital skills* – are digital literacy skills requested by employers for most occupations. They include skills in office suite software (word processing, spreadsheet, and presentation software), enterprise resource planning and project management software.
- *Specific digital skills* – are digital skills required for more technical occupations grouped into seven specific digital skill categories developed by Emsi-Burning Glass, including skills in data analysis, digital design and marketing, software and programming, computer and network support, customer relationship management, and machining and manufacturing technology.[5]
- *Cutting edge skills* – are digital skills that have experienced growth of over 150 per cent in Australian online job advertisements requiring them between 2013 and 2020. These skills are growing quickly, but from a low base.

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[5] This categorisation was developed by Burning Glass Technologies in a report for the UK Government Department for Digital, Culture, Media and Sport, *No longer optional: Employer demand for digital skills*, 2019.

The data used in the international study is from years 2013-2020 and focusses on skills and occupations relevant to 'digital engagement' across all countries. The data was analysed via cloud storage, using Burning Glass's international 'Snowflake' beta database by passing the need for local ingestion and data engineering and to speed timeframes for the analysis.

We acknowledge the effects of COVID are not accounted for in this paper, as the data cut-off date for the job advertisement data included in the study is early 2020. Since then, an increase in remote work is likely to have amplified the demand for digital skills and digital know-how globally.

Section 2: Findings from measuring digital skills

The National skills Commission's recent report *The State of Australia's Skills 2021: now and into the future* provides a comprehensive analysis of findings relating to the current, emerging and future skills needs of the Australian economy. This section summarises these findings and draws together next steps to align the various data definitions across taxonomies to improve the measurement of the digital economy in Australia.

Importance of the Digital Technologies and Electronics skills cluster family

By looking through a skills lens and analysing the tasks needed for any occupation, the ASC allows us to provide a different and more granular measurement of the digital economy. We can identify the digital skills in demand, independent of occupation or industry, and use this as the basis for conversations about how industry and the tertiary education system should respond.

The ASC can be used to convert occupation level data into skills data. The NSC produces annual five-year employment projections by occupation. The projections are based on a well-established time series forecasting methodology that has been used within the Australian Government since 2013[6].

The employment projections primarily use time series data taken from the ABS Labour force survey, which provides high quality estimates of employment from a large sample survey which has been run quarterly for almost 40 years. The projections are then derived from time series models applied to the Labour force survey data by combining forecasts from autoregressive integrated moving

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[6] A detailed methodology and downloadable data sets for the 2020 Employment Projections - for the five years to November 2025 are available at:
https://lmip.gov.au/default.aspx?LMIP/EmploymentProjections

average (ARIMA) and exponential smoothing with damped trend (ESWDT) models, adjusted to take account of NSC research findings and expected industry and occupation developments. They are based on forecast and projected total employment growth rates published in the 2020–21 Mid-year economic and fiscal outlook (MYEFO) and labour force employment data to November 2020[7].
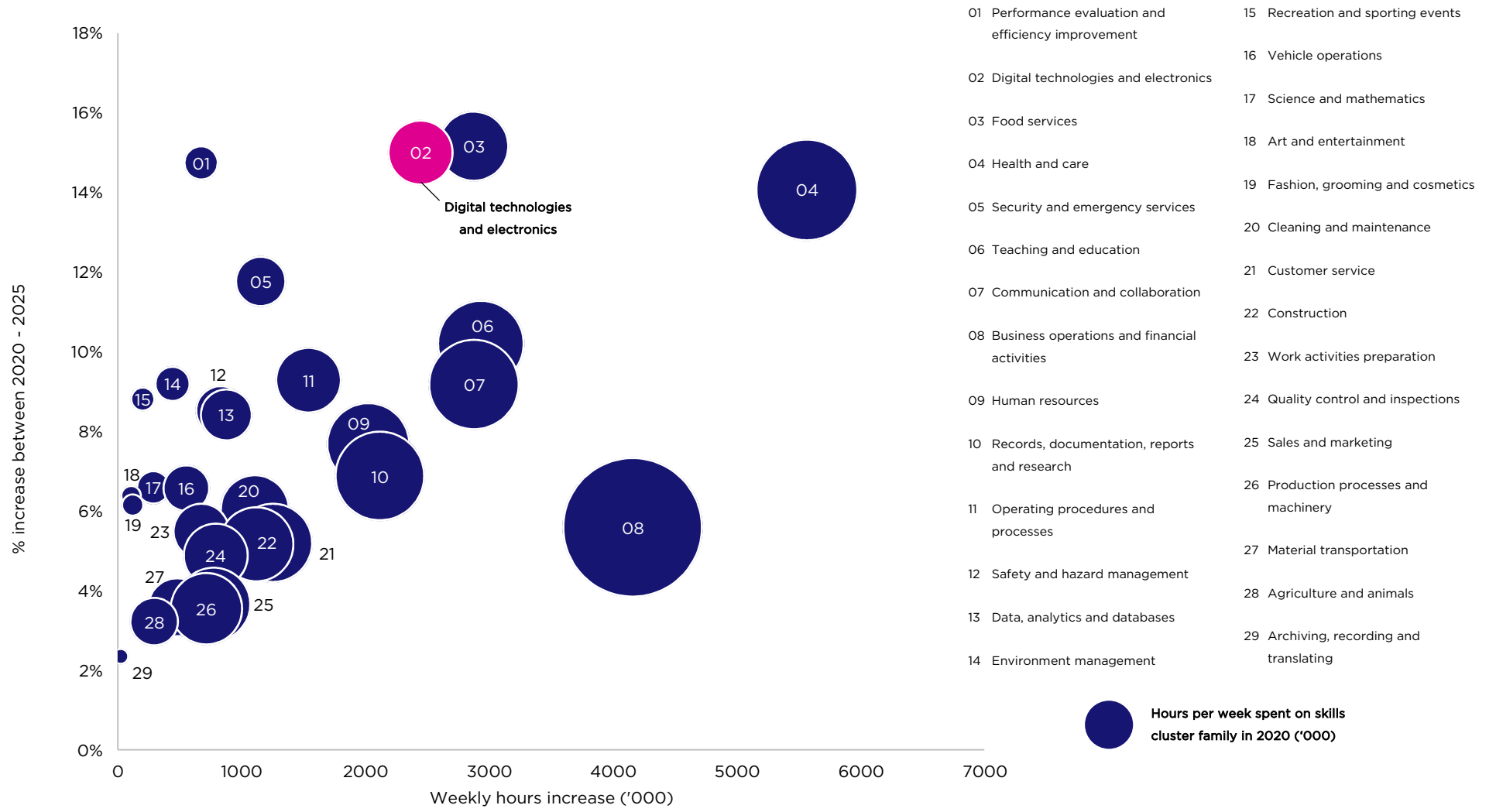
The five-year occupation projections are mapped to their component skills in the ASC. We then aggregate by skill to project skills growth across the economy. Figure 1 identifies the 29 skill cluster families in the ASC. The size of the bubbles represents the number of hours Australians currently spend on the skills cluster families across the workforce. The y axis measures the projected growth in demand in percentage terms while the x axis measures the number of additional hours per week expected to be spent on each of the skills clusters. The *Digital Technologies and Electronics* skill cluster family is highlighted in pink. As shown in the figure, it is the second fastest growing family, with demand for skills within that cluster expected to increase by 15 per cent. It comes in mid-range in respect to the number of hours per week spent on the skill cluster across the whole economy.

If we drill down further into within the *Digital Technologies and Electronics* cluster family, we see varying growth rates. The NSC has published projected weekly hours growth rates for all of the ASC's skills clusters[8]. Three out of the top six skills clusters are from the *Digital Technology and Electronics* cluster family. Growth is stronger for skills clusters involving *software development, design and performance* (28 per cent), *computer application and systems issues* (25 per cent), *develop websites or software* (21 per cent), *ICT support, design and management* (21 per cent).

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[7] Applying to these data the forecast and projected employment growth rates from the 2021-22 Budget, published on 11 May 2021 results in no material difference to the future outlook for employment over a five-year period.

[8] https://www.nationalskillscommission.gov.au/SOAS/five-year-skills-cluster-outlook

Figure 1: Digital Technologies and Electronics skill cluster family

01	Performance evaluation and efficiency improvement	15	Recreation and sporting events
02	Digital technologies and electronics	16	Vehicle operations
03	Food services	17	Science and mathematics
04	Health and care	18	Art and entertainment
05	Security and emergency services	19	Fashion, grooming and cosmetics
06	Teaching and education	20	Cleaning and maintenance
07	Communication and collaboration	21	Customer service
08	Business operations and financial activities	22	Construction
09	Human resources	23	Work activities preparation
10	Records, documentation, reports and research	24	Quality control and inspections
11	Operating procedures and processes	25	Sales and marketing
12	Safety and hazard management	26	Production processes and machinery
13	Data, analytics and databases	27	Material transportation
14	Environment management	28	Agriculture and animals
		29	Archiving, recording and translating

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# Section 3: Findings on emerging and trending skills

Emerging and trending skills analysis can give us close to real-time insights into how Australian jobs are evolving and changing. We found that data and digital skills dominate the fastest growing emerging skills and these are trending quickly across the labour market.

Digital skills are dominating emerging skills in Australia

The fastest growing emerging skills in the economy, in terms of percentage of all job listings which request them, are data and digital skills. Figure 2 shows the cumulative growth of these skills since 2015. For example, demand for *software orchestration/automation* skills has grown almost 30 times, with growth in this skill exceeding all other skills from 2016 to 2020. Other skills, like data analysis and on-line marketing skills, that were growing significantly in 2018 and 2019, experienced lower growth in 2020. In future, we expect these emerging and trending skills to become less apparent in the list of emerging or trending skills data as they are embedded into the labour market with new job titles that explicitly recognise the important skills needed for the role.[9] New emerging and trending skills, not currently visible in Australian job advertisement data, will also arise.

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[9] Software orchestration/automation refers to the automated configuration, management and coordination of computer systems, applications, and services, helping IT to more easily manage complex tasks and workflows. Over time, as this skill is integrated into the labour market, it is likely become part of the standard skill set expected for roles DevOps Manager (a role that involves managing software development and software operation to ensure service delivery, reliability and scalability).
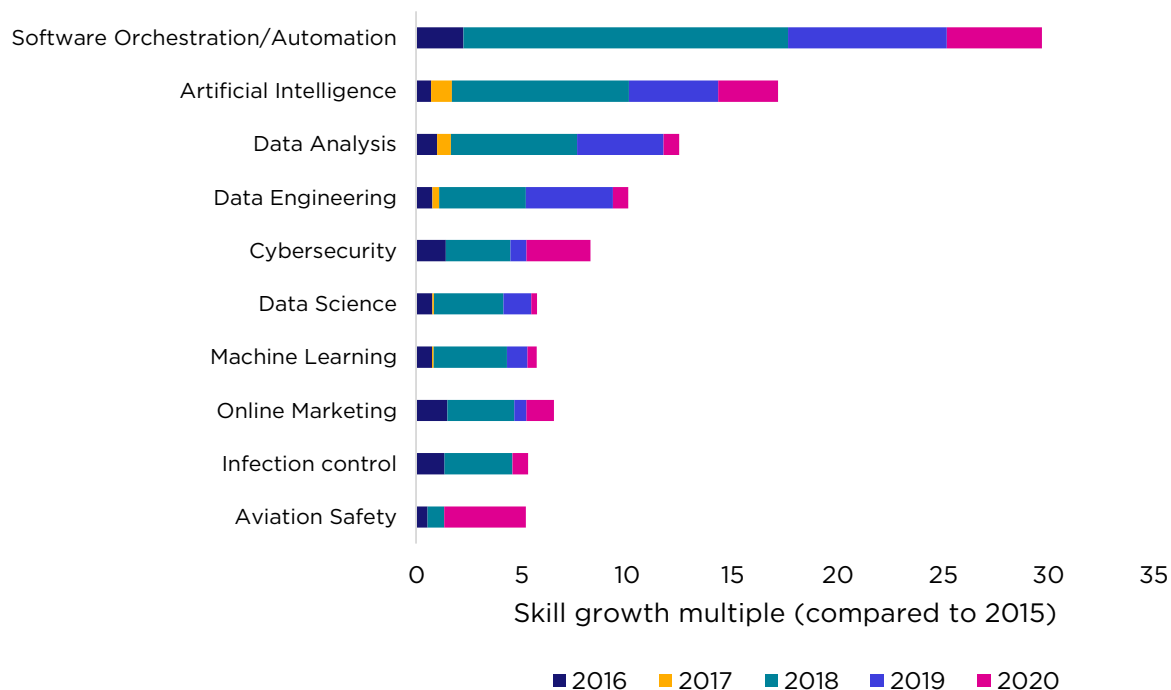
Sources: Burning Glass Technologies data, 2015-20, NSC analysis

The demand for emerging digital skills is creating new occupations

The need to collect, manage and safely store data and information on-line is leading to demand for skills in data management, architecture and analysis, cloud solutions and scripting languages. This increase in demand for new skills is creating new occupations like d*ata scientist* and *data engineer* that do not exist in the current Australian occupational classification system.

In August 2020, the NSC published a report which defined emerging occupations[10] as frequently advertised jobs which are substantially different to other occupations already defined in the Australian and New Zealand Classification of Occupations (ANZSCO). One of these occupations was a data engineer and the top skills most frequently mentioned in Australian job advertisements are *big data, python, SQL, apache hadoop, java, scala, extraction transformation and loading (ETL),* and *data pipelines*.

The NSC is working with the ABS to consider including the data and digital related occupations in the formal structure of ANZSCO. The impact these occupations are having on the broader economy will then be able to be measured in a meaningful way.

Digital skills impact on a range of occupations not just IT occupations

One of the interesting aspects of our work on digital skills is discovering how they affect the way work is undertaken across many occupations. The digital skills spreading most quickly across the labour market are *'data analysis'*, trending in 61 occupations currently represented in the ASC and emerging in 11 others, *'social media'* trending in 47 occupations and emerging in 18, and '*graphic and visual design software'* trending in 32 occupations and emerging in 14.

Looking into the data surrounding social media skills provides a good example of how digital skills are infiltrating the skills composition of occupations. The demand for this skill in child-care managers grew from less than 1 per cent of job advertisements in 2015 to just under 15 per cent of job advertisements in 2020. The use of social media has grown significantly, albeit from a very low base in

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[10] National Skills Commission (2020) Emerging Occupations (https://www.nationalskillscommission.gov.au/emerging-occupations-0)

2015, for occupations as diverse as *fitness instructors*, *hotel managers*, *film and video editor* and *library assistant*.

Improvements to measure the digital economy

Measuring the digital economy in Australia has its challenges given the pace of technological change and the creation of data sets to suit different purposes. A key next step for the NSC is to better align the two data sets discussed in this paper. This will be achieved by mapping emerging and trending skills from Emsi-Burning Glass in the ASC and flagging them to create a skills taxonomy that is more dynamic and can be updated in a sustainable way.

# Section 4: Findings from International comparison of digital skills

Comparing the trends in data and digital skills between Australia and other countries allows for greater understanding of how Australian industry's digital engagement fares internationally, where Australia's skills gaps might be, where skilled talent may be lost, and where industry growth opportunities and future skills demand may be.

Using big data techniques, our analysis tracks digital skills sought by employers from job advertisements and the roles that require them to create a picture of the international digital skills market. All these countries have been compared because they have similar economies but are at different stages of developing their ICT sectors.

Australia's demand for baseline digital skills lags Singapore, Canada and the US

As shown in Figure 3, the proportion of Australian job advertisements requesting digital skills remained relatively stable – between 26 per cent and 33 per cent over the period of the study. Australia had the second lowest overall observed demand for digital skills, with the downward trend from 2018 to 2020 in contrast to most other countries. Of the five countries, Singapore showed the strongest growth in demand, with a constant increase from 41 per cent to 55 per cent, and a noticeable upward trend from 2019.

Figure 3: Demand for digital skills, 2013 to 2020
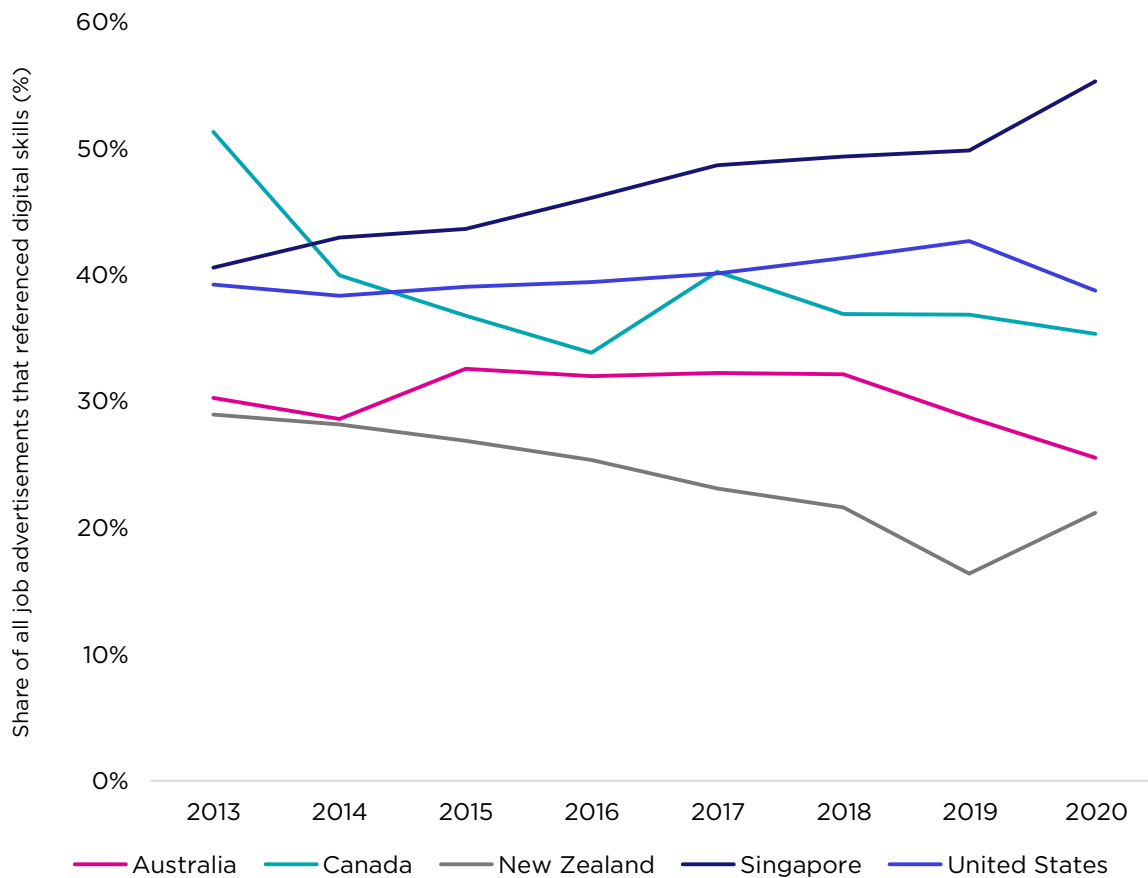
Sources: Burning Glass Technologies data, 2013 to 2020, NSC analysis

Note: The figure shows the share of all job advertisements that referenced digital skills

Further breaking down the demand for digital skills in Australia, we found that the demand for baseline skills flattens out and then decreases over time, while the demand for specific digital skills slowly increases over time, intensifying in 2020. The demand for specific digital skills is consistently high and comparable to other countries for each of the digital skill categories. This suggests that when Australian employers recruit for digital skills, they tend to be looking for technical skills.

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Growth in demand for digital skills spans the ICT and the non-ICT sector

Outside of the ICT sector the top digital skills demanded were less technical in nature. Here, Office suite, enterprise resource planning and social media skills top the list of digital skills in demand. There are digital skills that are commonly requested across sectors, including Office suite, system design and implementation, and even, in some countries, software development principles.

We found the top three specific digital skills advertised in ICT occupations were *software development principles, SQL databases* and *programming and system design and implementation*. These are the top three skills in all countries, although not necessarily in that order.

We also considered what occupations were driving demand for digital skills. The findings for all countries indicated a mix of ICT and non-ICT sector occupations among the top occupations requesting digital skills. In Australia, the highest proportion of job postings requesting specific digital skills is for the ICT occupations of *software and application programmers* and *computer network professionals*, comprising over 16 per cent of all job ads. In other countries, ICT sector occupations topping the list were *software engineers and designers*, *software developers* and *web and multimedia developers*. The top non-ICT sector occupations that requested digital skills were *sales*, *administrative*, *accounting*, *marketing* and *consulting* roles.

Across all five countries, the composition of employer demand for digital skills based on skill level indicated that most jobs requiring digital skills are highly skilled jobs.[11] Figure 4 shows that Australia has the highest share of this category

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[11] Although Australia uses skill levels in the ANZSCO classification system, this was not available for all countries in the Burning Glass Technologies data set. Instead, we used the 'job zone' field from the US classification system, O*NET, as a proxy to allow us to compare across countries. O*NET defines 5 job zones, where 5 requires the highest qualification or experience and 1 requires almost no qualification or experience required. These were then categorised into high (4,5), medium (3) and low (1,2) categories of skilled occupations.

among the five countries at 69 per cent. This reflects the relatively low representation of baseline digital skills in Australian job ads.

Figure 4: Composition of jobs requiring digital skills, by job skill level
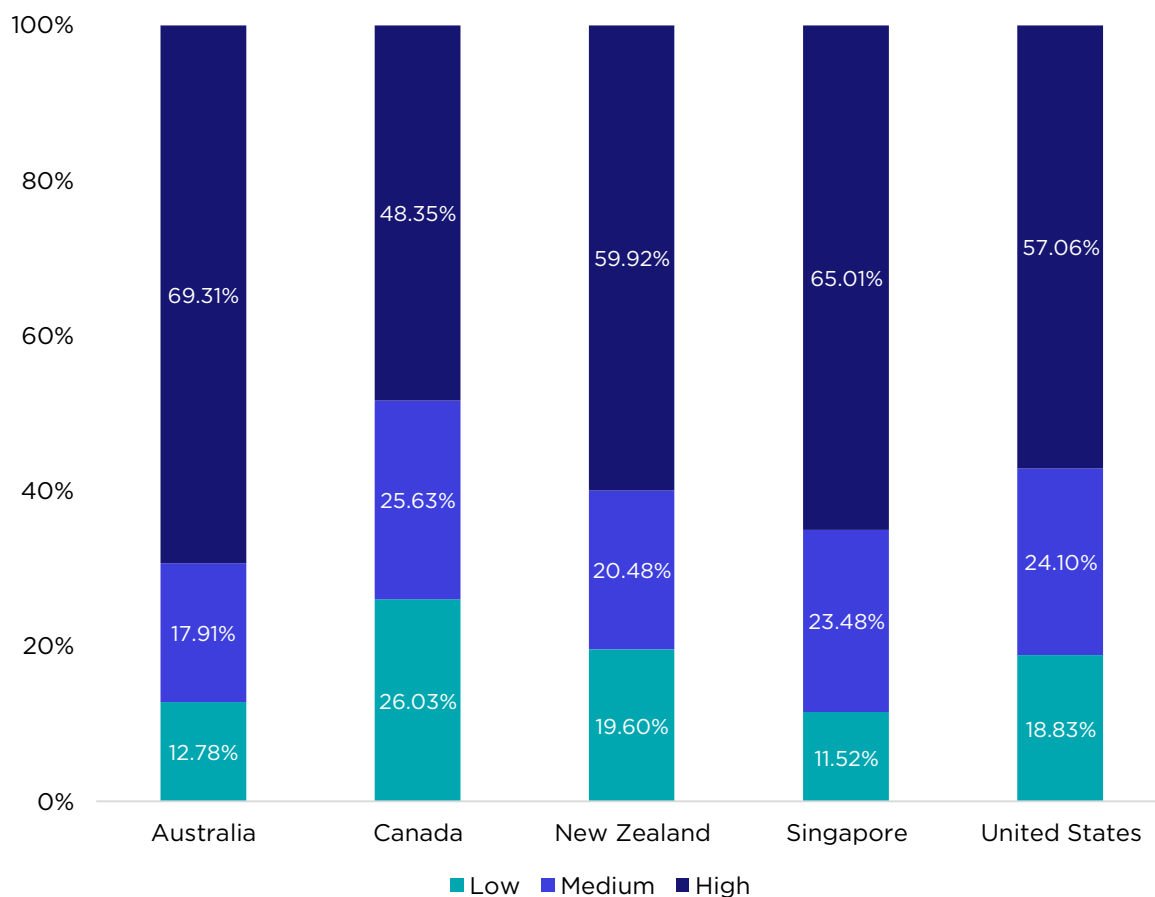
Sources: Burning Glass Technologies data, 2019, NSC analysis.

Demand for cutting edge digital skills vary between countries

The demand for specific digital skills increases and decreases faster than other skills in the labour market. This is driven by the pace of innovation in the ICT sector and the increasing requirement for all businesses to adopt new technologies, update systems, and digitise.

To focus on this phenomenon, the NSC identified a group of cutting-edge skills which have grown by over 150 per cent between 2013 and 2020. These skills are growing quickly, but from a low base. Table 1 compares the 10 fastest growing cutting-edge digital skills in Australia and the US. The results are quite similar in each country.

Despite considerable international consistency, time series analysis reveals some differences in the rate of uptake of cutting-edge skills across countries. Figures 6 shows a similar pattern of demand across Australia and the US for skills in data visualisation, IT automation, machine learning, artificial intelligence and the Internet of Things; but US job advertisements mention cyber security at twice the rate of those in Australia. The growth rate for cutting edge skills in Singapore outstrips those of the US and Australia, particularly for cyber security.

International differences also become apparent when looking at the interaction between cutting edge skills and specific occupations. For example, employers in Australia and New Zealand are more than three times more likely to seek data visualisation skills when recruiting actuaries (15 per cent and 20 per cent respectively) than those in Singapore, the US or Canada.

Table 1: Demand for cutting edge skills in Australia and the US

Australia		United States	
Skill Name	Growth over 2013 – 20 [%]	Skill Name	Growth over 2013 – 20 [%]
Artificial Intelligence (AI)	4,412	IT Automation	3,597
IT Automation	3,817	Data Wrangling	2,250
Internet of Things (IoT)	3,645	Internet of Things (IoT)	1,350
Application Programming Interface (API)	780	Artificial Intelligence (AI)	999
Machine Learning (ML)	724	Augmented Reality / Virtual Reality (AR/VR)	643
Natural Language Processing (NLP)	537	Device Management	459
Distributed Computing	516	Machine Learning (ML)	405
Data Visualisation	482	Data Visualisation	363
Software Development Methodologies	450	Tax Software	317
Big Data	384	Software Development Technologies	288

Sources: Burning Glass Technologies data, 2013 to 2020, NSC analysis

Figure 5: Demand for cutting edge skills in Australia, US and Singapore - share of job advertisements that referenced digital skills
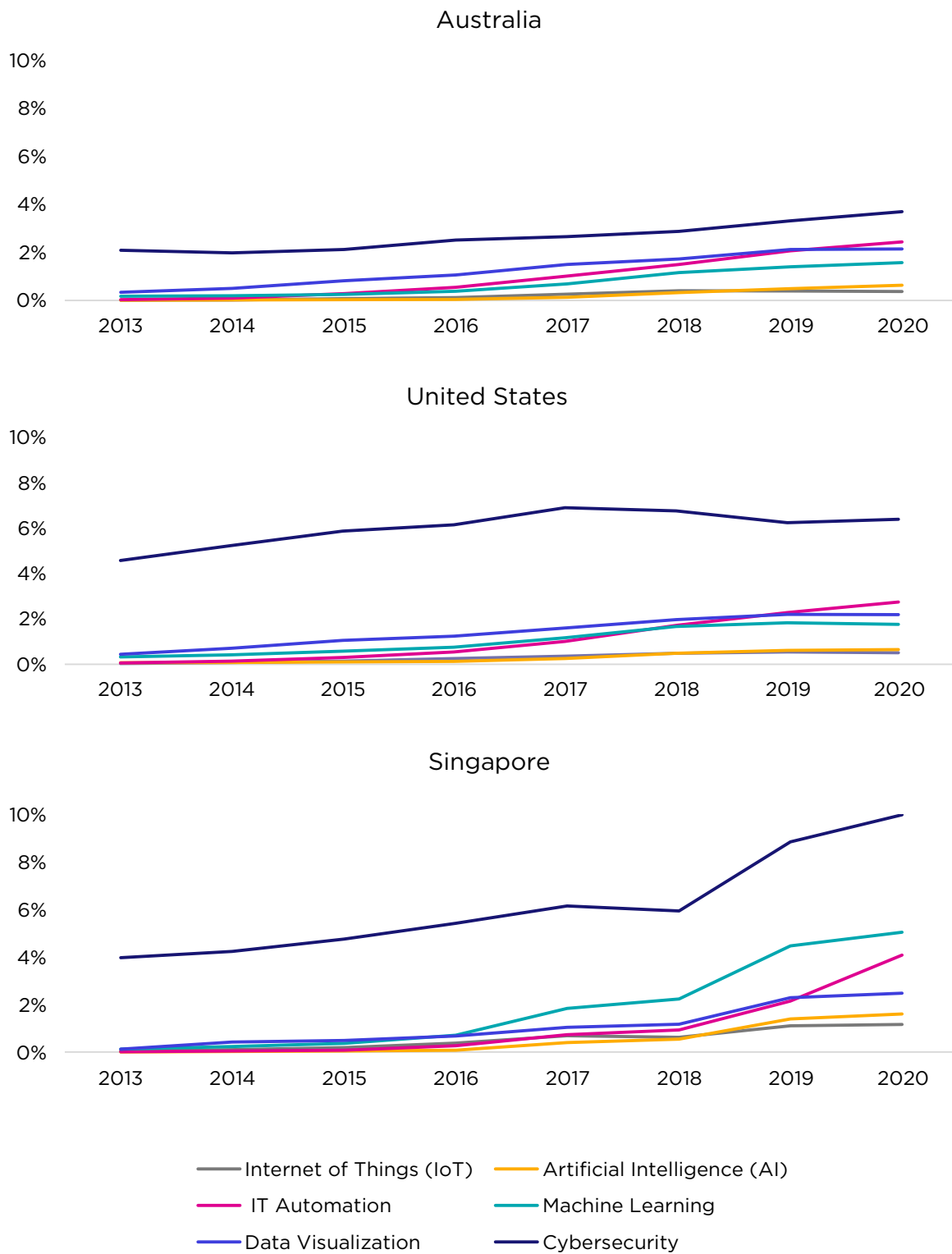
Conclusion

Overall, this paper finds digital skills are and will continue to be increasingly important to the Australian economy. Our findings suggest the skills associated with engaging in the digital economy will continue to grow and be used 15 per cent more of the time within an average person's job in the next five years. Certain digital skills will be more in demand than others, for example 'test computer and software performance' is predicted to increase by 28 per cent on current use levels over the next five years. As the usage of digital skills increases employers will demand a higher level of technical skills, or specific digital skills, for both ICT and non-ICT occupations.

Overall, Australian trends in the digital economy are comparable to those in New Zealand, Canada, the United States, and Singapore. Australia's share of demand for highly skilled jobs needing digital skills is the highest across all countries and our demand for specific digital skills has increased sharply from 2019 in line with the trend of other countries. Although some elements of Australia's digital skills demand seem to be moving at a slower pace than the other countries', there are many possible reasons for this. Demand for baseline digital skills could be lower in Australia because employers have not yet recognised the need for specifying these skills in non-technical occupations.

When looking at emerging trends and a series of 'cutting-edge' skills across the five countries, Australia seems to lag behind somewhat. Although Australia and the United States have a similar set of cutting-edge digital skills, demand for many of these skills is growing much faster in the United States, and in fact, Singapore's growth rates for cutting-edge skills are the highest.

Looking forward, Australian policymakers may wish to look to Singapore as an example. With its demand for digital skills and for cutting-edge skills being the highest out of the five countries, it may demonstrate how to create labour market conditions which are more conducive to increasing digital skills.

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