



VET, Artificial Intelligence and Structural Change

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June 2024

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Executive Summary

Whether we like it or not, artificial intelligence is going to transform our 21st century society in a similar fashion to electricity, steam and the printing press in previous centuries Gottlieb, The Australian, April 11. 2024

Progress in Artificial Intelligence (AI) has been such that, in some areas, its output has become indistinguishable from that of humans. These rapid developments, combined with the falling costs of producing and adopting these new technologies, suggest that OECD economies may be on the cusp of an AI revolution which could fundamentally change the workplace Broecke (2023).

In this paper I explore the impact of Artificial Intelligence (AI) on the structure of the labour market and the implications for VET. Are the occupations that VET services going to be seriously impacted? Or is AI but one force that drives the occupational structure of the labour market?

According to Wikipedia: *Artificial intelligence in its broadest sense, is intelligence exhibited by machines, particularly computer systems.*

There is a considerable literature on linking AI to occupations. In my reading of the literature a number of points emerge. The first is that AI is likely to impact more on professional occupations rather than on those associated with VET. The second is that there is little evidence to suggest that AI will lead to job losses. This is because AI has the potential to increase productivity in particular occupations and this could lead to an increase in employment rather than a decrease. In any case those professional occupations which are likely to be impacted by AI have been growing strongly. A further point is that AI is only one aspect of technological change, and that automation - as distinct from AI - is likely to impact more on lower skilled occupations.

The occupations most likely to be exposed to AI are: Business professionals, Managers, Chief executives, Science and engineering professionals, Business, administration associate professionals, Legal, social and cultural professionals and Production managers.

By contrast the occupations most threatened by automation are those in construction and extraction, farming, fishing and forestry, production, transportation and material moving, installation, maintenance and repair, building and grounds cleaning and maintenance, food preparation and service related occupations.¹

In addition, there are other structural changes occurring such as globalization of services, and changes in demand due to demographic forces, responses to climate change and so on.

The overall point is that AI is just one factor which impacts on occupational structure and hence its impact in terms of job creation and destruction should not be exaggerated.

A separate threat to VET is the increasing dominance of degrees as the main qualification within occupations, with the exception of the trades where certificates III and IV remain the definitive qualifications.

¹ These lists are extracted from Georgieff and Hye (2021) and Lassebie and Quintini (2022), respectively. Interpretation is clouded a little because the two lists use different occupational classifications.

To put these various factors in perspective we looked at occupational change between 2011 and 2021, interacting occupations with qualifications. The device we used was to rank occupations (at the 2 digit ANZSCO level) by the degree of association with VET, as defined by the proportion of employment with a certificate III or IV.² According to this ranking the occupations most closely associated with VET are Automotive and Engineering Trades Workers, Electrotechnology and Telecommunications Trades Workers, Construction Trades Workers, Other Technicians and Trades Workers, Skilled Animal and Horticultural Workers, Food Trades Workers, Construction and Mining Labourers, Carers and Aides, Machine and Stationary Plant Operators, Engineering, ICT and Science Technicians. Of some interest here is that two of these occupations have more persons with diplomas and degrees than persons with a certificate III or IV in 2021 (Carers and Aides with 39.9% with a diploma or degree compared to 32.2% with a certificate III or IV, and ICT and Science Technicians with 50.8% with a diploma or degree compared to 28.2% with a certificate III or IV).

We undertook a shift share analysis of the change in employment by occupation and qualification level over 2011-2021 in order to better understand what was going on. In aggregate the number of employed persons with a certificate III or IV grew by 15% compared to 42% of persons with a diploma or degree. The difference in growth rates is driven by two factors. First, occupations associated with the certificates grew more slowly than average while occupations associated with diplomas and degrees grew more rapidly. Second (and by far the more important factor), the proportion of people within an occupation with a diploma or degree grew at the expense of the proportion with a certificate III or IV.

A world of increasing credential levels is a challenge to the VET sector, and certainly more of a threat than AI. I have argued elsewhere that VET needs to become a player by creating institutions which focus on vocational education at the degree level, as contrasted with current universities that all aspire to become large, comprehensive research universities. Unless this happens, VET as we know it will become a residual sector offering industry directed training servicing the trades. And the trades have not been areas of high employment growth. I would also argue that AI if anything is likely to increase an emphasis on analytical ability and general skills as distinct from narrowly defined technical skills. This puts pressure on the training package model of VET and argues for greater attention to general education.

² Diplomas are currently quite important in VET but my view is that inevitably diplomas will morph into degrees. For example, regulatory arrangements in childcare/early child education have driven the increase in diplomas in early childhood education and it is only a matter of time before there are calls for a degree to be the primary entry level qualification.

Introduction

Whether we like it or not, artificial intelligence is going to transform our 21st century society in a similar fashion to electricity, steam and the printing press in previous centuries writes Robert Gottlieb in his column in The Australian, April 11. 2024.

The OECD also sees artificial intelligence (AI) as a hot topic and has been recently publishing a raft of papers on it.³ Broecke (2023) writes in the OECD's 2023 Employment Outlook

Progress in Artificial Intelligence (AI) has been such that, in some areas, its output has become indistinguishable from that of humans. These rapid developments, combined with the falling costs of producing and adopting these new technologies, suggest that OECD economies may be on the cusp of an AI revolution which could fundamentally change the workplace.

In this paper I explore the implications of Artificial Intelligence (AI) for that part of the labour market which is serviced by vocational education and training. No doubt AI will influence the skills that VET needs to deliver⁴, and most likely the way training is delivered, but I am not an educationalist and will leave that aspect to others.⁵ My interest is its impact on the structure of the labour market. Are the occupations that VET services going to be seriously impacted? Or is AI but one force that drives the occupational structure of the labour market?

I begin with a brief discussion of what AI is and then focus on how AI interacts with occupations. I then look at occupational structural change with an emphasis on the interaction between occupations and credentials. My general argument is that AI is not the only game in town and cannot be considered in isolation from other structural changes. While AI has implications for 'VET' occupations, there are other structural changes that are likely to be more important. Of particular salience is the declining importance of certificates III or IV and the increasing dominance of degrees. I conclude with a discussion.

As a matter of principle I thought I should employ AI in writing this paper. I have included a number of questions which I submitted to ChatGPT, a conversational AI model⁶, beginning with the definition of AI.

³ See for example Georgieff and Hye (2021), Broecke (2021), Squicciarini and Nachtigall (2021), OECD 2023, Manca (2023), Collett et al 2022, Milanez (2023), Lane and Saint-Martin 2021.

⁴ See for example Mandala Partners & Future Skills Organisation 2023.who argue that the primary impact will be at the university level. In VET higher level qualifications are more likely to face disruption.

⁵ The conference circuit has been quick to focus on AI. See for example the AI in Education Conference, Darling Harbour 13 May 2024

⁶ ChatGPT is part of the GPT (Generative Pre-trained Transformer) series developed by OpenAI. It is designed to understand and generate human-like text based on the input it receives.

So what is AI?

Define artificial intelligence in a paragraph.

ChatGPT

Artificial intelligence (AI) refers to the development of computer systems that can perform tasks that typically require human intelligence. These tasks include understanding natural language, recognizing patterns in data, solving problems, making decisions, and learning from experience. AI encompasses a wide range of techniques and approaches, including machine learning, deep learning, natural language processing, and computer vision, among others. By mimicking human cognitive functions and behaviors, AI enables computers to analyze vast amounts of data, derive insights, and make autonomous decisions or recommendations. AI technologies are used in diverse domains, including healthcare, finance, transportation, manufacturing, and entertainment, with the potential to revolutionize industries, improve efficiency, and enhance decision-making processes.

According to Wikipedia: *Artificial intelligence in its broadest sense, is intelligence exhibited by machines, particularly computer systems.*

ChatGPT's response seems pretty sensible although it is rather long winded – not nearly as succinct as Wikipedia's definition. One thing I found interesting about the Chat GPT response is the way it concludes with the sort of assessment beloved by bureaucrats *AI technologies are used in diverse domains,, with the potential to revolutionize industries, improve efficiency, and enhance decision-making processes.*

Implication of AI for occupations

Which occupations will be affected by artificial intelligence?

ChatGPT

Artificial intelligence (AI) is poised to impact a wide range of occupations across various industries. Some of the most affected occupations include:

Routine manual tasks: Jobs involving repetitive tasks such as assembly line work, packaging, and simple data entry are susceptible to automation through AI-powered robots and software.

Transportation: With the advent of self-driving vehicles, jobs like taxi and truck drivers may face significant changes or even displacement.

Customer service: AI-powered chatbots and virtual assistants are increasingly handling customer inquiries, potentially reducing the need for human customer service representatives.

Retail: Automated checkouts and AI-driven inventory management systems are altering the retail landscape, potentially reducing the need for traditional retail workers.

Finance: AI algorithms are increasingly used for tasks like fraud detection, risk assessment, and algorithmic trading, potentially impacting roles in banking and finance.

Healthcare: AI is revolutionizing healthcare with applications in medical imaging, diagnostics, personalized treatment plans, and administrative tasks, which may affect roles ranging from radiologists to administrative staff.

Legal services: AI-powered document analysis and contract review systems are changing the way legal research and documentation are done, potentially affecting paralegals and legal assistants.

Manufacturing: AI-driven predictive maintenance and quality control systems are streamlining manufacturing processes, potentially reducing the need for manual inspection and maintenance workers.

Journalism and content creation: AI can generate news articles, reports, and even creative content like music and artwork, potentially impacting traditional journalism and content creation roles.

Education: AI-driven personalized learning platforms and virtual tutors are changing the way education is delivered, potentially impacting roles of teachers and educational assistants.

While AI has the potential to automate certain tasks within these occupations, it's important to note that it also creates new opportunities and the demand for skills related to AI development, maintenance, and oversight. Additionally, many jobs will require a combination of human and AI capabilities for the foreseeable future.

There is a considerable literature on linking AI to occupations. Georgieff and Hye (2021) adapted the methodology of Felten, Raj and Seamans (2018) to construct the level of exposure to AI for individual occupations. The measure reflects the progress made by AI in specific applications (such as image recognition, translation, speech recognition) and the extent to which those applications are related to skills required in an occupation. They rank abilities by progress made by AI in respect of that ability over the period 2010-2015.

Their general conclusion is that AI has made the most progress in applications required to perform non-routine cognitive tasks (such as information ordering, memorisation and perceptual speed) and

the least progress in applications that affect physical and psychomotor abilities, supporting Lane and Saint-Martin's (2021) argument that AI is capable of performing cognitive, non-routine tasks.

To derive the implication for occupations the abilities need to be mapped onto occupations. These mappings involve data from the Programme for the International Assessment of Adult Competencies.

Table 1 lists the ISCO occupations by level of exposure to AI.

Table 1: Occupations (2 digit ISCO-08) ranked by exposure to AI

Business professionals
Managers
Chief executives
Science and engineering professionals
Business, administration associate professionals
Legal, social and cultural professionals
Production managers
General and keyboard clerks
Teaching professionals
Customer services clerks
Numerical, material recording clerks
Science, engineering associate professionals
Hospitality services managers
Protective services workers
Health professionals
Legal, social, cultural, related associate professionals
Health associate professionals
Other clerical support workers
Sales workers
Electrical, electronic trades workers
Handicraft, printing workers
Personal service workers
Personal care workers
Metal, machinery workers
Drivers, mobile plant operators
Food processing, wood working, garment, other craft workers
Skilled agricultural workers
Building workers
Skilled forestry, fishery, hunting workers
Stationary plant machinery operators
Assemblers
Refuse workers, other elementary workers
Labourers
Food preparation assistants
Agricultural, forestry, fishery labourers
Cleaners, helpers

Source: extracted from Figure 4 of Georgieff and Hye 2021

Georgieff and Hye conclude that the kind of abilities AI has made the most progress in are mainly used in highly-education and white collar occupations (see also Broecke 2021, and the Great Britain Department for Education Unit for Future Skills 2023). By contrast, occupations with the lowest exposure to AI typically have an emphasis on physical tasks such as cleaners and helpers.

The key issue that Georgieff and Hye were interested in is whether the growth of AI is likely to have a detrimental impact on employment – will AI make certain workers redundant? Their conclusion

was that, at least for the period 2012-2019, there was no clear relationship between AI exposure and employment growth.

The above discussion is concerned with the idea of computers mimicking human intelligence and therefore making some workers redundant. However, there is a related idea that is relevant to the outlook for occupational employment. This is automation, with workers being replaced by machines, with no real notion that artificial intelligence is necessarily being utilised. The classic reference point is the advent of the industrial revolution with textile workers being replaced by machines – hence the Luddites who protested against the introduction of mechanized looms.

In the plethora of literature on this topic, a comprehensive recent study is that of Georgieff and Milanez (2021). They looked at what happened to jobs vulnerable to automation over the last decade, across 21 countries. They found that employment growth has been lower in jobs at high risk of automation, although there was no evidence of overall job destruction. However, it is self-evident that automation and the increased use of machines has been the driving force behind the decline of employment in agriculture, the growth of manufacturing and more recently the decline in manufacturing employment. The ‘no evidence of overall job destruction’ is consistent with economic theory that implies that labour markets adjust to equate supply and demand (and the corollary that structural unemployment is caused by frictions in the labour market that prevent demand and supply reaching an equilibrium). This is not to say that individual jobs do not disappear –we know that they do. Obvious examples are the extinction of accounting machinists and the virtual disappearance of blacksmiths. A favourite example of mine is that of the mathematicians who laboured over the construction of logarithmic and trigonometric tables. They became completely redundant.

A forward looking exercise has been undertaken by Lassebie and Quintini (2022), who created a rich dataset on the automatability of some 100 skills and abilities and mapped these to occupations. They point out that advances in AI some skills and abilities previously defined as ‘bottlenecks’ are now more susceptible to automation. Examples given are reading comprehension, deductive and inductive reasoning skills. However, high level management and social interaction are currently still not amenable to automation. So they conclude that construction and extraction, farming, fishing and forestry and production and transportation occupations are at risk of automation while the least exposed jobs include management and community and social service occupations. However, the ‘takeaway’ in their parlance is that ‘most occupations rely importantly on both bottleneck and highly automatable skills and abilities’.

Lassebie and Quintini’s methodology was based on the views of an expert group of leading researchers in AI and robotics. An index of automatability was created by weighting the degree of automatability (according to the experts) of an ability by the importance of that ability in a job, based on O*NET data. Examples of skills and abilities at the bottom of the automatability scale include: management of personnel resources, complex problem solving, negotiation, social perceptiveness and assisting and caring for others. Examples at the top of the scale include number facility, memorization, wrist-finger speed, selective attention, static strength and dynamic strength.

Table 2 ranks occupations by the degree of automatability as derived by Lassebie and Quintini.

Table 2: Occupations (2 digit SOC) ranked by degree of automatability

Construction and Extraction
Farming, fishing and Forestry
Production
Transportation and material moving
Installation, maintenance and repair
Building and grounds cleaning and maintenance
Food preparation and service related occupations
Protective service
Healthcare support
Personal care and service
Office and administrative support
Arts, Design, entertainment, sports and media
Healthcare Practitioners and technical occupations
Life, physical and social science
Sales and related technologies
Architecture and engineering
Computer and mathematical
Business and financial operations
Legal
Educational instruction and library
Management
Community and social service

Source: Figure 3, Lassebie and Quintini 2022

This list is very different from the earlier list presenting occupational exposure to AI, and points to a fundamental change in expectations. The impact of AI on occupations is rather different from the impact of automation. Broeke (2021) comments the expansion of AI has tended to be in highly skilled occupations as contrasted with earlier automating technologies that tended to take over routine tasks performed by lower skilled workers.

What is the outlook for occupations

What is the outlook for occupations?

ChatGPT

The outlook for occupations is influenced by a variety of factors including technological advancements, economic conditions, demographic shifts, and societal trends. Here are some key trends that may shape the outlook for occupations: **Automation and AI:** Automation and artificial intelligence (AI) are expected to continue transforming the workforce, with routine and repetitive tasks increasingly being automated. This will likely lead to changes in job roles and skill requirements across various industries. **Emerging Industries:** New industries and sectors are expected to emerge, driven by technological innovation, such as renewable energy, biotechnology, advanced manufacturing, and digital services. Occupations within these industries may experience growth opportunities. **Digitalization:** The ongoing digitalization of economies is expected to create demand for workers with skills in data analysis, cybersecurity, software development, and digital marketing. Occupations related to information technology (IT) and digital services are likely to be in high demand. **Healthcare and Aging Population:** As populations age in many countries, there will be increased demand for healthcare services and eldercare. Occupations in healthcare, including nursing, home health aides, and medical technology, are expected to experience growth. **Green Economy:** Concerns about climate change and environmental sustainability are driving growth in green industries such as renewable energy, energy efficiency, and sustainable agriculture. Occupations related to environmental science, renewable energy installation, and sustainability consulting may see increased demand. **Remote Work:** The COVID-19 pandemic has accelerated the adoption of remote work arrangements. Even as economies recover, remote and flexible work options are expected to remain prevalent, influencing the demand for occupations that can be performed remotely. **Globalization and Trade:** Globalization continues to shape the global economy, influencing the demand for occupations related to international trade, logistics, supply chain management, and cross-cultural communication. **Skills Shortages and Reskilling:** Many regions are experiencing skills shortages in certain sectors, while other occupations face redundancy due to automation. Efforts to reskill and upskill workers to meet evolving job demands will be crucial for addressing these challenges.

Overall, the outlook for occupations is dynamic and influenced by a complex interplay of factors. Adapting to these changes will require ongoing investment in education, training, and workforce development initiatives.

I guess we should not be surprised that ChatGPT lists *Automation and AI* as the first in the list of factors impacting on occupational employment. While AI has had a great deal of recent attention, there are clearly numerous factors that will drive employment growth at the occupational level.

First, technological innovation can improve productivity and this can have an ambiguous impact on occupational employment. An increase in productivity may be associated with a decrease in employment because fewer individuals are required to produce the same output. However, innovation can lead to changes in prices and the development of new products so it is possible that labour demand actually increases in some occupations. It is also the case that developments may not be orderly. For example, Kanazawa et al (2022) point to an interesting application of AI in the taxi industry and concludes that AI can assist drivers with finding customers, and thereby improving drivers' productivity, but such gain accrues only to low-skilled drivers. In this example there is an improvement in overall productivity rather than job displacement. However, the example may be ephemeral with any improvement in productivity of drivers becoming immaterial if AI leads to driverless cars.

Second, other factors play a role. An obvious one is globalization with teleworkers enabling service work to be undertaken in one country and delivered to another. Richard Baldwin (2019) sees this as a particular threat to social cohesion because of its threat to the wages and conditions of workers in developed countries.

Another factor is the shape of consumer demand. An obvious example is the change in the demographic structure. In particular the aging of the baby boomer cohort is going to have a huge impact on the demand for health and aged care services. This will occur irrespective of any advances in AI. On the other hand, technology will no doubt play a role in addressing the need for assistance to the elderly, especially if labour becomes tight or expensive. Automatic monitoring systems are an obvious example of technology assisting care.

Another example is the impact of policies that are aimed at reducing carbon emissions. Any policy shift that changes relative prices and capital allocation will inevitably impact on the structure of employment. One can also point to the impact of exogenous shocks, such as COVID 19, that can have a significant impact on employment overnight.

An underlying assumption typically made by economists is that structural change – whether caused by technological change or changes in consumers' preferences' – will impact on the structure of employment but not on aggregate employment, at least in the long run. This assumption is based on having flexibility in the labour market and appropriate social security settings. In this context, we note that employment levels are currently high and hence whatever impact AI (and other structural factors) has had on individual jobs, overall unemployment is not a particular issue. Interest rates are more likely to impact on employment than the application of AI.

Will artificial intelligence lead to higher unemployment?

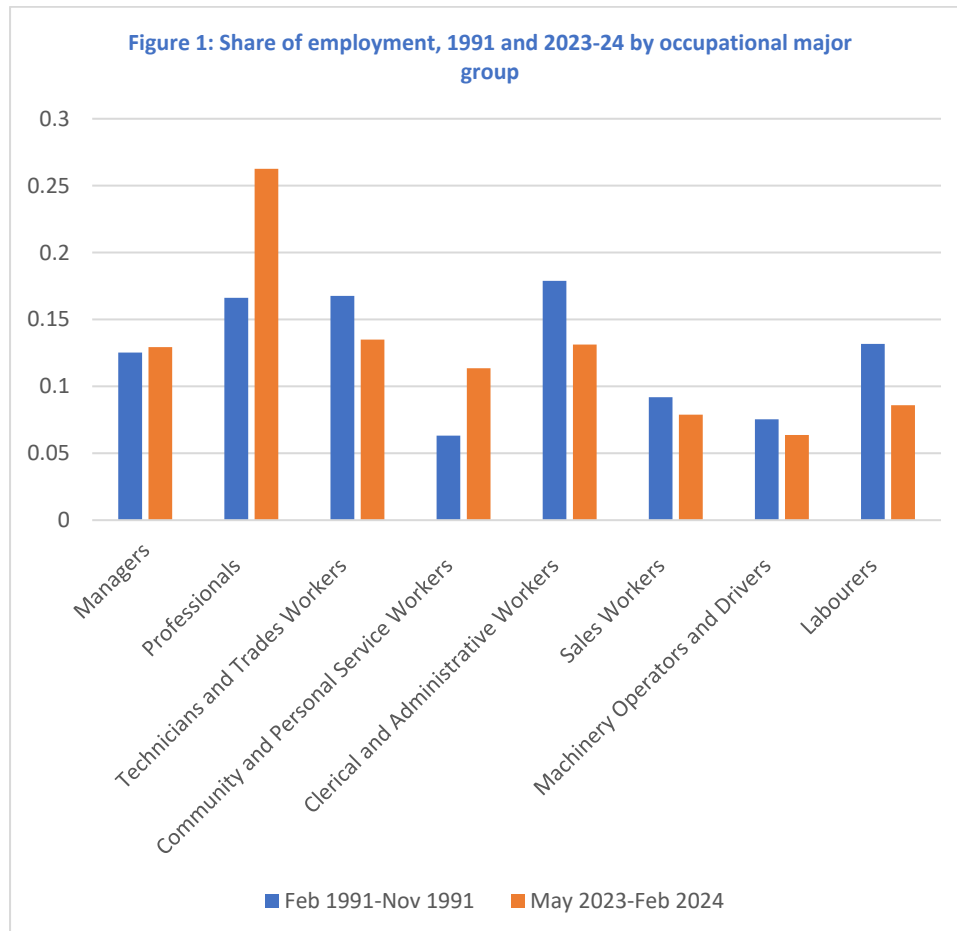
ChatGPT

The impact of artificial intelligence (AI) on employment and unemployment is a topic of ongoing debate among economists and experts. While AI has the potential to automate certain tasks and roles, leading to job displacement in some sectors, it also creates new opportunities and can increase productivity, innovation, and economic growth, which can contribute to job creation in other areas.

In summary, while AI has the potential to lead to job displacement in certain sectors, it also creates new opportunities and can contribute to economic growth and innovation. The overall impact on employment and unemployment will depend on a variety of factors, including the pace of technological advancement, workforce adaptation, and policy responses to address potential challenges such as income inequality and job displacement.

Occupational change in Australia 2011 to 2021

While it is foolish to try to predict the future, historical data provide an indication of trends that are emerging. For example, the decline in agricultural workers evident over the couple of hundred years is unlikely to cease. To provide a longer term context, we show how shares of employment have changed over the last 30 years or so, at the one digit ANZSCO level.



Source: ABS 6291.0.55.001 Labour Force, Australia, Detailed

We see that the occupational structure of employment has changed very significantly over the last thirty years or so with very large increases in Professionals and Community and Personal Service workers, minor growth in Managers and declines in the shares of all other occupational groups. The point is that the growth of AI is just one structural force that will impact on occupations and therefore there is little point in becoming too concerned about the impact of AI on VET. Moreover, it appears that AI will have a larger impact on professional occupations than on the occupations associated with VET.

However, we wish to examine the prospects for occupations associated with VET a little more closely. Before doing this, we note that there is another force at play that is also of direct relevance to VET. This is the trend to increasing levels of qualification, and in particular a move toward degrees as being the most common qualification. While the trades have remained firmly 'VET', as defined by the possession of a certificate III or IV, a number of occupations are increasingly being undertaken by persons with a degree rather than a certificate. This trend is likely to narrow the occupations which are associated with VET.

While we cannot with any certainty predict the future, we can observe the past, and one would expect that long term trends are likely to continue in the future. Thus it is instructive to see how occupational employment has changed over the last decade or so and in particular the impact on occupations associated with VET. We can also observe how the relationship between occupations and credentials has also changed. The lens we use is to interact occupations with credentials, and this assists us in identifying the impact of occupational change on VET and Higher Education separately.

In Table 3 we present, from the 2021 Census employment, the proportion of employed persons with a certificate III or IV and the proportion of employed persons with a diploma or a degree for each 2-digit (ANZSCO) occupation. Our decision to combine diplomas and degrees is based on the idea that going forward, degrees will inevitably subsume diplomas (see Karmel 2022) as has happened in the Higher Education Sector, and that under the current education sector structures VET will be defined by the delivery of certificates III or IV. We have sorted the occupations by the proportion of employed persons with a certificate III or IV, so that the occupations at the top of the list are strongly associated with VET training, while the occupations at the bottom of the list have little association with VET training.⁷

⁷ We have excluded from this list persons who were not assigned a two digit code – the not further defined category. The numbers in these categories are relatively small.

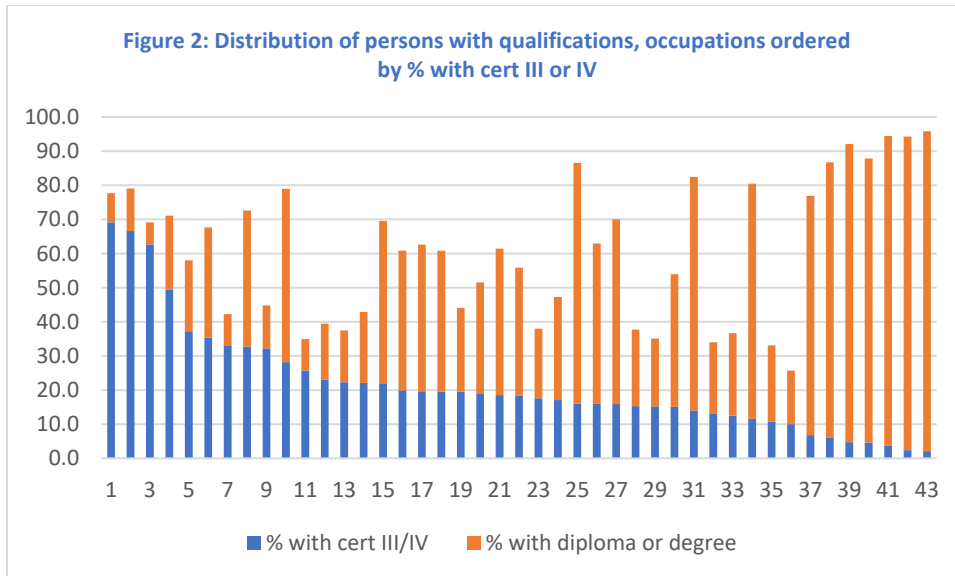
Table 3: Percentage of employed persons with a certificate III or IV and a diploma or degree, 2021 Census

	% with cert III or IV	% with a diploma or degree
1 Automotive and Engineering Trades Workers	69.1	8.6
2 Electrotechnology and Telecommunications Trades Workers	66.6	12.5
3 Construction Trades Workers	62.6	6.5
4 Other Technicians and Trades Workers	49.4	21.7
5 Skilled Animal and Horticultural Workers	37.2	20.8
6 Food Trades Workers	35.4	32.3
7 Construction and Mining Labourers	33.1	9.1
8 Carers and Aides	32.8	39.9
9 Machine and Stationary Plant Operators	32.2	12.6
10 Engineering, ICT and Science Technicians	28.2	50.8
11 Mobile Plant Operators	25.7	9.2
12 Other Labourers	23.1	16.3
13 Farm, Forestry and Garden Workers	22.3	15.2
14 Road and Rail Drivers	22.1	20.8
15 Protective Service Workers	22.0	47.5
16 Sports and Personal Service Workers	19.9	40.9
17 Sales Representatives and Agents	19.7	42.9
18 Hospitality, Retail and Service Managers	19.5	41.3
19 Farmers and Farm Managers	19.5	24.6
20 Inquiry Clerks and Receptionists	19.0	32.5
21 Other Clerical and Administrative Workers	18.5	42.9
22 General Clerical Workers	18.4	37.4
23 Storepersons	17.6	20.4
24 Clerical and Office Support Workers	17.1	30.2
25 Health and Welfare Support Workers	16.0	70.6
26 Numerical Clerks	15.9	47.0
27 Office Managers and Program Administrators	15.9	54.1
28 Cleaners and Laundry Workers	15.3	22.4
29 Factory Process Workers	15.3	19.8
30 Personal Assistants and Secretaries	15.1	38.8
31 Specialist Managers	14.0	68.4
32 Sales Assistants and Salespersons	13.2	20.8
33 Hospitality Workers	12.5	24.1
34 Chief Executives, General Managers and Legislators	11.6	68.9
35 Sales Support Workers	10.8	22.3
36 Food Preparation Assistants	10.0	15.7
37 Arts and Media Professionals	6.8	70.1
38 Business, Human Resource and Marketing Professionals	6.1	80.5
39 Design, Engineering, Science and Transport Professionals	4.7	87.4
40 ICT Professionals	4.6	83.2
41 Legal, Social and Welfare Professionals	3.7	90.7
42 Education Professionals	2.4	91.8
43 Health Professionals	2.1	93.7

Source: ABS Table Builder, 2021 Census

We see that the trades tend to be at the top of the list, and the professions at the bottom of the list. However, we see that a sizable proportion of non-professional jobs have persons with a certificate III or IV such as Construction and Mining Labourers, Carers and Aides, Machine and Stationary Plant Operators, Engineering, ICT and Science Technicians, Mobile Plant Operators (all with 25% or more persons with a certificate III or IV). Of this list two (Carers and Aides, and Engineering, ICT and Science Technicians) are notable in having a higher proportion with a diploma or degree than the proportion with a certificate III or IV.

In Figure 2 we plot the data from Table 3, showing the distribution of qualifications across the 43 occupations.



Source: ABS Table Builder, 2021 Census

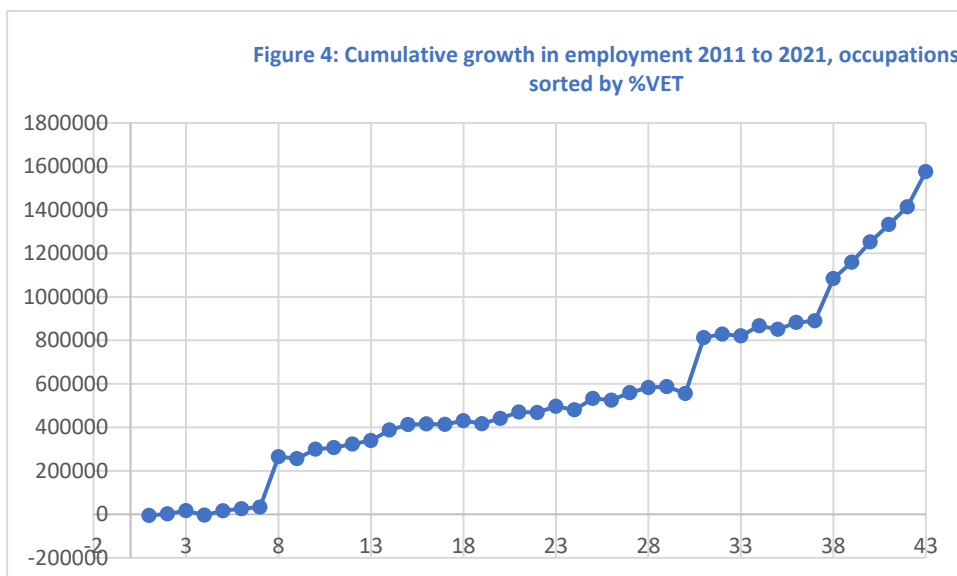
While overall there is a rough inverse relationship between the proportion of persons with a certificate III or IV and the proportion with a diploma or degree, outside the trades and the professions there is little relationship. It also seems to be the case that persons with diplomas and degrees have a larger share than persons with a certificate III or IV in many occupations ranging from Engineering, ICT and Science Technicians to Carers and Aides, Protective Service Workers and Health and Welfare Support Workers. It could be argued that VET's link with large parts of the labour market is fairly weak, and that the provision of certificates is likely to be swamped by diplomas and degrees.

We now look at the relationship between employment growth at the occupation level and its relationship to the strength of the link with VET. In the next figure, we simply plot the employment growth between 2011 and 2021 for each of our 43 occupations. As in the previous figure we sort the occupations by the percentage of persons with a certificate III or IV,



Source: ABS Table Builder, 2011 and 2021 Censuses

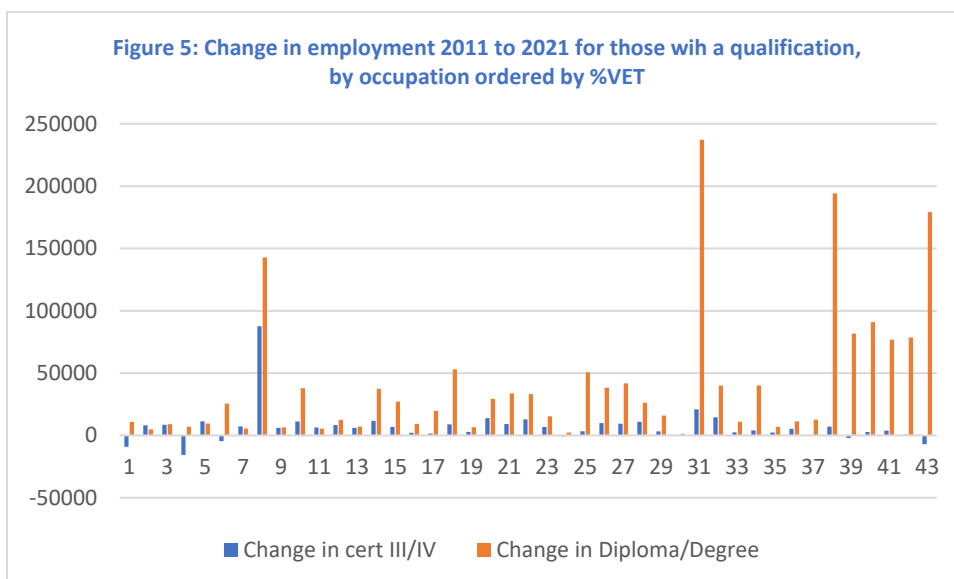
Two features are apparent. The first is that there are four occupations which provided much of the growth, namely Carers and Aides (growth of 232,000), Specialist Managers (257,000), Business, Human Resource and Marketing Professionals (194,000) and Health Professionals (162,000). These four occupations accounted for over half of the overall employment growth. We note that only one of these occupations (Carers and Aides) is an occupation with a strong link to VET. But even here, it is the case that in 2021 there was a higher proportion of persons with a diploma or degree than with a certificate III or IV. This was not the case in 2011 and is indicative of the credential creep whereby higher education is becoming dominant in occupations which traditionally have not required a higher education qualification. The other feature of the above graph is that growth has tended to be low in occupations which are associated with VET. This can be seen more clearly by plotting cumulative employment growth, as is done in Figure 4.



Source: ABS Table Builder, 2011 and 2021 Censuses

We see that there was very little employment growth in the first seven occupations when ordered by the proportion of certificates III and IV (from Automotive and Engineering Trades Workers to Construction and Mining Labourers), and only modest growth in occupations 9 to 30 (Machine and Stationary Plant Operators to Personal Assistants and Secretaries). The strongest growth has tended to be in managerial and professional occupations.

We have referred to the phenomenon of credentialism, whereby qualification distributions within an occupation change over time, with increases in the numbers of people within an occupation with higher level qualifications grow. We now investigate the extent of this, plotting the change in the number of persons with a certificate III or IV on one hand and a diploma or degree on the other.



Source: ABS Table Builder, 2011 and 2021 Censuses

We see that the growth in persons with diplomas and degrees completely swamps the growth in persons with certificates III and IV. In only one occupation did the growth in certificates III/IV exceed that of diplomas/degrees - Skilled Animal and Horticultural Workers. The occupation with the largest growth in persons with certificates III and IV was Carers and Aides (occupation 8), but even in this occupation the growth in persons with diplomas and degrees was significantly greater. The occupation with the second highest growth of persons with a certificate III or IV was Health and Welfare Support Workers, but this growth was dwarfed by the growth in persons with a diploma or degree.

Thus we have several structural changes occurring. One of them is the differential growth in occupational employment, with (apart from Carers and Aides) the managerial and professional occupations growing much faster than other occupations. The second is the much greater growth in persons with diplomas or degrees, even in some occupations traditionally associated with VET.

We now employ a simple shift share analysis to quantify the relative importance of these two structural changes.

The formal specification of the analysis is given in Appendix 1, but the gist of it is that we decompose the change in the number of employed persons with a certain qualification into three components:

- the qualification share effect, which captures the impact of the change in the shares that qualification groups have within an occupation.

- the occupational structure effect, which captures the impact of the change in the occupational structure (that is the expansion in particular of managerial and particularly professional occupations).
- the growth effect, which captures the overall growth in the number of employed persons.

The results of this analysis are shown in the following table:

Table 4. Decomposition of the growth in the number of employed persons by qualification, 2011-2021, percentage growth.

	Growth in employment 2011-2021	Qualification share effect	Occupational structure effect	Overall growth effect
Persons with a certificate III or IV	15.3	3.8	-4.2	15.9
Persons with a diploma/degree	42.0	19.5	7.3	15.9
Persons with no post-school qualification	-13.3	-23.3	-5.8	15.9

Note: the sum of the three effects does not precisely equal the overall growth because the decomposition formula is not exact.

Source: Derived from ABS Table Builder, 2011 and 2021 Censuses

The table clearly shows a number of things. First, the very high growth in the number of persons with diplomas and degrees is driven primarily by an increase in qualification levels within particular occupations, but the change in the occupational structure was also very favourable to this growth. We also note that the growth in persons with a certificate III or IV was very close to the overall growth rate with an increase in the proportion of persons within an occupation holding a certificate III or IV largely offset by an unfavourable change in the occupational structure. This change in the occupational structure is largely characterised by very strong growth in professional occupations together with growth in managerial occupations. Such growth is unfavourable to both those with certificates III or IV and those with no post-school qualification.

The group that has been most affected by structural change is those with no post-school qualification. This group has been affected by increase in the proportion of persons with credentials, even in occupations that 'don't really need' a credential, and the change in the occupational structure.

The shift-share analysis summarises the interaction of various structural changes at an aggregate level. However, it is worth looking at the occupations, which have seen enormous growth between 2011 and 2021, notably Carers and Aides, Specialist Managers and Business, Human Resource and Marketing Professionals.

Table 4: Growth in employment, selected occupations, 2011-2021

	Change in cert III or IV	Change in Diploma/Degree	Change in no qualifications
Carers and Aides	87588	142891	1638
Specialist Managers Business, Human Resource and Marketing Professionals	20936	237274	-1343
	7039	194164	-6821

Source: ABS Table Builder, 2011 and 2021 Censuses

We see enormous growth in the number of persons with diplomas/ degrees, even among Carers and Aides who traditionally have been relatively unskilled. It is an occupation that is largely dependent on government funding, and regulatory frameworks have no doubt played a part in the large increase in credentials. We have commented on the influence of credentialism and perhaps it is also possible that we have seen an inflation in occupational labels, with increasing numbers of people aspiring to managerial and professional positions when in earlier days these positions may have been considered as clerical or middle management. In any case, these trends will make it more difficult for those with no qualifications to be competitive in the labour market, and those with certificates III or IV are likely to find themselves at a competitive disadvantage to those with degrees, except in the trades where degree and diplomas have had little traction. On this point, we note that in the 'trade' occupation Other Technicians and Trades Workers, 22% had a diploma or degree in 2021. In the occupation Engineering, ICT and Science Technicians 51% of persons had a diploma or degree.

Discussion

There is a lot of hype around AI, even though there is debate on whether AI is different to automation which has been with us since the birth of the industrial revolution. My conclusion from the literature is that previous technological change has tended to impact more on unskilled occupations (although I am sure this could be debated – for example automation destroyed the jobs of many very skilled artisans) while the current manifestation appears to affect the jobs of professional more than lesser skilled occupations. In this regard, there is little evidence to date that AI is having a negative impact on the employment of professionals.

We have been observing structural change for many decades, driven by a wide range of factors. In terms of occupations which are important for VET, my assessment is that the outlook is not particularly rosy. There are two factors at play. The first is that employment growth has been concentrated in the professions and the service sector. VET's strength in the trades has not been challenged but employment growth has been subdued in the trades and lesser skilled occupations such as machine operators and labourers. For example, in our shift share analysis, we found that between 2011 and 2021 the change in occupational structure had a negative effect of around 4% on the numbers of persons with a certificate III or IV compared to a positive effect of 7% for persons with a diploma or a degree. The second factor is the general tendency for higher level credentials. While VET is maintaining its dominance in the trades it is losing share in other sectors. It is also interesting to note that within ANZSCO major group 3 (Technicians and Trades Workers) the fastest growing 2-digit occupation was Engineering, ICT and Science Technicians (growth of 22% or 43000 persons between 2011 and 2021) and in 2021 50% of persons in this occupation had a diploma or degree compared to 28% with a certificate III or IV. This suggests that higher education may become the preferred pathway for technical roles not associated with an apprenticeship. For trades associated with apprenticeships growth was negative for Automotive and Engineering Trades

Workers, and modest for Construction Trades Workers and Electrotechnology and Telecommunications Trades Workers (growth of 4-5%).

The deteriorating share of qualifications held by certificates III and IV is captured by the qualification share effect in the shift share analysis. Between 2011 and 2021 the number of persons with a certificate increased a little (by around 4%) compared to an increase of almost 20% in the number of persons with a diploma or degree. These increases were balanced by a decline of 23% in the number of persons with neither a certificate III or IV or a diploma or degree. For the VET sector my view is that possibly the biggest challenge is being competitive in a credential driven labour market. A clear example of this is in the fast growing occupation of Carers and Aides, which one would have thought is an occupation with a very strong association with VET. In 2011, the proportion of persons with a certificate III or IV was 30%, and the proportion with a diploma or degree 26%. By contrast, in 2021 the corresponding proportions were 33% and 40%. Sure the proportion with a certificate III or IV has increased, but there has been a change from a situation in which certificates III or IV were the dominant credential to one in which diplomas and degrees dominate. One might argue that I am exaggerating the decline in VET's position because I am conflating diplomas and degrees. My counter to this is that, as I showed in an earlier paper (Karmel 2022), degrees are supplanting diplomas as an entry level qualification in almost all areas. An exception is education where changes in the regulatory framework for childcare drove huge increases in the number of diplomas being delivered. However, in my view it is only a matter of time before degrees in early childhood education will crowd out diplomas.

A world of increasing credential levels is a challenge to the VET sector. Governments have set increasing levels of qualifications as a policy aim and is focused particularly on increasing the proportion of equity groups with a degree.⁸ I have argued elsewhere that VET needs to become a player by creating institutions which focus on vocational education at the degree level, as contrasted with current universities that all aspire to become large, comprehensive research universities. Unless this happens, VET as we know it will become a residual sector offering industry directed training servicing the trades. It will be a minor player in the growing areas of the labour market. I would also argue that AI if anything is likely to increase an emphasis on analytical ability and general skills as distinct from narrowly defined technical skills. This puts pressure on the training package model of VET and argues for greater attention to general education.

My conclusion is that AI is not a particular threat to VET. But other structural changes are.

I finish my dalliance with AI by asking ChatGPT two questions: firstly on the impact of AI on VET and secondly on the challenges faced by VET. The first answer seems to have been drafted by AI's marketing team, while the second takes a fairly populist view of VET. ChatGPT produces text that is bland, has no references and no data to support any claims. ChatGPT also has not yet thought about the impact of credentialism on the VET sector. That is not surprising since, by design, it is an aggregator of documented views rather than an originator of new ideas, and there is little current discussion on the threats to VET posed by the expansion of higher education.

⁸ For example, in the Australian Universities Accord – Budget Summary, the Government *set an overall tertiary attainment target of 80% of working aged people by 2050*. The summary notes that *the Government will also set targets for higher education participation for students from underrepresented backgrounds to set the sector on a trajectory required to achieve parity in 2050*.

What impact will AI have on vocational education and training?

ChatGPT

AI is poised to have a significant impact on vocational education and training (VET) in several ways:

Personalized Learning: AI can analyze vast amounts of data on student performance and preferences to tailor learning experiences to individual needs. This personalized approach can help students learn at their own pace and focus on areas where they need the most improvement.

Skill Assessment and Gap Analysis: AI-powered tools can assess the skills of learners more accurately and efficiently than traditional methods. By identifying skill gaps, educators can design targeted training programs to address specific needs and ensure that students are adequately prepared for their chosen careers.

Interactive Learning Experiences: AI can enhance learning through interactive experiences such as virtual simulations and augmented reality. These technologies provide hands-on training in a safe and controlled environment, allowing students to practice skills and techniques before applying them in real-world settings.

Automation of Administrative Tasks: AI can automate administrative tasks such as course scheduling, grading, and student support. This frees up educators to focus on teaching and mentoring students, leading to a more efficient and effective learning experience.

Content Creation and Curation: AI can assist in creating and curating educational content by analyzing existing materials, generating personalized learning resources, and recommending relevant content to students. This can help educators stay up-to-date with the latest trends and best practices in their fields.

Lifelong Learning and Upskilling: As AI technology continues to evolve, it will increasingly impact the skills required in the workforce. VET programs will need to adapt to provide ongoing training and upskilling opportunities for workers to remain competitive in the labor market.

Overall, AI has the potential to revolutionize vocational education and training by making learning more personalized, interactive, and accessible. However, it's essential to ensure that AI technologies are implemented ethically and inclusively to minimize potential biases and disparities in access to education and training opportunities.

What are the major challenges faced by Vocational Education and Training

ChatGPT

Vocational Education and Training (VET) faces several challenges, many of which are interconnected and require multifaceted solutions. Some of the major challenges include:

Perception and Prestige: VET often suffers from a perception problem, with it being seen as a second-tier option compared to traditional academic pathways. Changing societal attitudes and promoting the value and prestige of vocational education is crucial.

Mismatched Skills: There's often a disconnect between the skills taught in VET programs and the skills demanded by employers. Ensuring that VET curricula are aligned with industry needs and adaptable to technological advancements is essential.

Quality of Training: Maintaining high-quality training standards across various VET programs can be challenging. Ensuring that instructors are adequately trained, facilities are up-to-date, and curricula are relevant is necessary.

Access and Equity: Access to VET programs can be limited, particularly for disadvantaged or marginalized groups. Addressing barriers such as cost, geographic location, and social stigma is crucial for promoting equity in VET.

Transition and Pathways: Providing clear pathways for VET graduates to transition into further education or the workforce is important. Improving articulation between VET and higher education, as well as promoting lifelong learning opportunities, can facilitate smoother transitions.

Industry Engagement: Close collaboration between VET providers and industry stakeholders is essential for ensuring that training programs meet current and future workforce needs. Establishing robust partnerships and mechanisms for industry input is critical.

Technological Integration: Embracing technological advancements in teaching and learning can enhance the effectiveness and relevance of VET programs. However, ensuring equitable access to technology and supporting instructors in integrating it into their teaching practices are challenges.

Changing Workforce Dynamics: The nature of work is evolving rapidly due to factors such as automation, globalization, and the gig economy. VET systems need to be flexible and responsive to these changes, preparing learners for the jobs of the future.

Addressing these challenges requires coordinated efforts from governments, educational institutions, employers, and other stakeholders to ensure that VET remains a viable and effective pathway for skills development and employment.

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Appendix I: Derivation of shift-share decomposition

Denote q_{ij} as the number of employed persons with qualification i in occupation j .

We have three qualifications: certificate III or IV, diploma or degree, and no post-school qualification.

Then $q_{i.} = \sum_j q_{ij} = \sum_j \frac{q_{ij} q_{.j}}{q_{.j} q_{.j}} q_{.j}$ where the dot signifies summation over the relevant index.

Taking percentage changes we get

$$\% \Delta q_i = \sum_j w_{ij} \left(\% \Delta \frac{q_{ij}}{q_{.j}} + \% \Delta \frac{q_{.j}}{q_{.j}} + \% \Delta q_{.j} \right) \quad (1)$$

$$= \sum_j w_{ij} \left(\% \Delta \frac{q_{ij}}{q_{.j}} \right) + \sum_j w_{ij} \left(\% \Delta \frac{q_{.j}}{q_{.j}} \right) + \sum_j w_{ij} (\% \Delta q_{.j}) \quad (2)$$

Where $w_{ij} = \frac{q_{ij}}{q_{i.}}$ and so $\sum_j w_{ij} = 1$

The first term of (2) we label the qualification share effect, the second term the occupational structure effect and the third term the growth effect.

Note that we calculated the percentage change at the mid-point (the average of the observations at the 2011 and 2021 censuses) rather than as a percentage of the first time point. This improves the accuracy of the decomposition.