Transforming Australian Manufacturing:

Preparing businesses and workplaces for Industry 4.0

pwc

SIEMENS
Ingenuity for life

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SWINBURNE UNIVERSITY OF TECHNOLOGY

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EXECUTIVE SUMMARY

While Industry 3.0 focused on the automation of single machines, functions and processes, Industry 4.0 (the 'fourth industrial revolution') encompasses end-to-end digitalisation and data integration of the value chain: offering automation, machine-to-machine and human-to-machine communication, rapid technological improvements and full scale digitalisation in manufacturing using Industrial Internet of Things (IIoT) platforms.[1]

Industry 4.0 is poised to deliver growth and change, with digitalisation and smart automation expected to add 14 per cent (US$15 trillion) to global GDP gains by 2030.[2] However, in order to grasp these opportunities, businesses must transform themselves and their workforces to thrive in this new environment. Whilst some Australian manufacturing businesses have begun this transformation and are seeing the benefits catalysed by the fourth industrial revolution, the majority are only starting to understand how they can integrate these technologies into their business and transform their workforce to engage in new ways of working.

Australian manufacturing businesses urgently need a 'call to action' to understand why they must invest more in their workforces, research and technology to thrive in the next industrial revolution. This report identifies how the Australian manufacturing industry is changing as a result of Industry 4.0, and the ways in which manufacturing businesses and workforces must adapt and evolve. These findings are based on research and consultation and have been shaped by domestic and international best practice. They emphasise the need for changing workplace culture and norms, new skills and knowledge for the manufacturing workforce, investment in research and innovation, and the need for businesses to become skilled collaborators.

This report aims to provide practical information and advice for all stakeholders that will play a role in encouraging and facilitating the transition of Australian manufacturing businesses and workers towards Industry 4.0. This includes Commonwealth and State governments, industry, unions and peak employer bodies, and education/research institutions. Each of these stakeholders need to be made aware of their role in an environment of Industry 4.0 principles and practices, the benefits of adopting new technologies, the risks of inaction, and practical steps as to how they can encourage manufacturing businesses and workforces to thrive in the fourth industrial revolution.

Progress in the advanced manufacturing industry in Australia will be economically beneficial to the Australian economy as a whole. As argued by Dr Jim Stanford, "Manufacturing carries a strategic economic importance out of proportion to its absolute size."[3] Therefore, support for Australian manufacturing businesses to make this transition is of critical importance.

Recommendations:

- Commonwealth Government to facilitate the development and release of a manufacturing Industry 4.0 strategy.
- Develop a new online portal that provides consolidated and easy to access information on government incentives and programs for manufacturing businesses.
- Establish hubs for Industry 4.0 commercial manufacturing activity focused on priority industry sectors.
- Continue to remove barriers between Vocational Education and Training (VET) and Higher Education in Australia's tertiary education system to facilitate collaboration opportunities and seamless learner pathways.
- Establish a workforce transformation leadership program.
- Create funding and accreditation models to support lifelong learning, reskilling and upskilling throughout the work lifecycle.
- Enhance the integration of manufacturing business supply chains through strategic procurement.

1. For further information see: Australian Government, Department of Industry, Innovation and Science. (2019) *Industry 4.0* [online]. Available at: https://www.industry.gov.au/funding-and-incentives/manufacturing/industry-40 [Accessed 28 March 2019].
2. PwC. (2018) *Global Digital Operations Study 2018: Digital Champions* [online]. Available at: https://www.strategyand.pwc.com/media/file/Global-Digital-Operations-Study_Digital-Champions.pdf [Accessed 5 Apr. 2019].
3. Stanford, J. (2016) *Manufacturing (Still) Matters: Why the Decline of Australian Manufacturing is NOT Inevitable, and What Government Can Do About It* [online]. Available at: http://www.tai.org.au/sites/default/files/Manufacturing%20Briefing%20Paper%20FINAL.pdf.

Contents

1 Introduction and objectives

1. INTRODUCTION AND OBJECTIVES

1.1. Introduction

Industry 4.0 is dramatically changing Australian businesses and the way Australians work. This is particularly evident in the manufacturing sector, where the disruption and growth catalysed by Industry 4.0 will fundamentally change the structure of the industry and ways of working within it.

What is Industry 4.0?
Industry 4.0, also known as the fourth industrial revolution, encompasses end-to-end digitisation and data integration of the value chain: offering automation; machine-to-machine and human-to-machine communication; continued technological improvements; and digitalisation in advanced manufacturing. This is a complex framework based on the fusion of cyber physical systems where machines are interconnected and able to independently communicate and cooperate throughout the end-to-end manufacturing and production process.

At the very heart of the concept of Industry 4.0 is the idea that we can produce a 'batch of one' through highly flexible and intelligent manufacturing processes. This is enabled by a production line communicating and making adjustments in real time to mass produce a unique product. The increased flexibility of Industry 4.0 manufacturing is evident in discrete industries such as automotive, with the plethora of choices available in new cars, but also in process industries, such as at the new Dulux Australia plant in Victoria, where the business can now produce batches 1/50th of the size in 1/8th of the time.

A key enabler of this increased power and flexibility is the concept of the 'digital twin'. A 'digital twin' is a digital image/copy of a physical product, process or operation and is brought about through advanced industrial software, new data platforms, increased processing power and analytics. The use of a digital twin means that everything can be designed, built and tested in a virtual world before it is produced in the physical world. This brings substantial benefits, such as rapid prototyping and testing, and reduced time and cost to bring a product to market; cars, motorbikes, aircraft engines, golf clubs and even vacuum cleaners come to life now in half the time and at half the cost. Indeed, by having a digital twin of their physical assets, the Manila Water Authority has been able to simulate natural disasters and subsequently build in greater resilience and reduce their annual insurance premium by $30 million.

For further information see: Australian Government, Department of Industry, Innovation and Science. (2019) Industry 4.0 [online]. Available at: https://www.industry.gov.au/funding-and-incentives/manufacturing/industry-40 [Accessed 28 March 2019].

To date, much of the Industry 4.0 commentary in the social, political and academic realms has focused on what the future of work will look like in this new environment, not the journey businesses and workers will need to go on to get there. However, the successful and sustainable transition to this future will only be achieved through the transformation of the workforce and current business structures and practices to meet these emerging needs. Indeed, before the future of work in the manufacturing industry is actualised, businesses must be supported to integrate Industry 4.0 technologies and ways of working into their businesses. Additionally, the manufacturing workforce must be equipped with the right skills and knowledge to thrive in the future work environment, in which manufacturing businesses have been altered by Industry 4.0 technologies and ways of working. Therefore, it is critical that commentary and guidance focus on what needs to be done now in order to support the achievement of this future state in the manufacturing industry.

Failure to prepare manufacturing businesses and workers for the fundamental changes driven by Industry 4.0 will severely limit the capacity for Industry 4.0 technologies and ways of working to be embedded in the Australian manufacturing industry. In a global economy in which Industry 4.0 is rapidly taking hold, this would result in further stagnation of the Australian manufacturing industry and the inability to compete internationally in terms of innovation, productivity, cost and potentially, quality.

This report stems from the work undertaken by the Industry 4.0 Advanced Manufacturing Forum - Testlabs and Future Work, Education And Training Workstream, co-chaired by Professor Aleksandar Subic and Andrew Dettmer.[4]

4. For further information see: Industry 4.0 Advanced Manufacturing Forum. (2019) About [online]. Available at: http://i4amf.aigroup.com.au/about/ [Accessed 29 April 2019].

1.2. Objectives of the paper

Internationally, substantial research and thought leadership has been published on the evolution of Industry 4.0. This report contributes to this discussion by focusing on the Australian manufacturing industry and the impact of Industry 4.0 on its workforce and businesses; offering practical, implementable recommendations.

The key objectives of this report include:

01 Understanding the **impact of Industry 4.0 disruption** and implementation on the businesses and workforce of the Australian manufacturing industry.

02 Identifying the **business and workforce transformation issues** that need to be considered by all stakeholders in order to ensure smooth transition to a successful Industry 4.0 economy in the manufacturing industry.

03 Collecting examples of international and national **best practice across various industries** to showcase how business and workforce transformation can be achieved.

04 Identifying **guiding principles and recommendations** for business and workforce transformation arising from the impacts of Industry 4.0 in the manufacturing industry.

1.3. Our approach

Evidence has been collated from both primary and secondary sources to inform findings and the development of practical Australian-specific recommendations. The research methodology for this report was threefold: desktop literature review, quantitative survey analysis, and one-on-one interviews with key stakeholders.

A survey was developed in collaboration with key stakeholders to assess the perceived impact of Industry 4.0 on the Australian manufacturing industry. The survey was publicly released to those in the manufacturing industry, as well as made available for access through key stakeholders' LinkedIn and subscriber networks. The insights obtained from the survey are a primary data source for the opinions of Australians on the impact of Industry 4.0 on themselves, their workplaces and their sector.[5]

Findings and recommendations were also informed by one-on-one interviews with industry leaders, peak bodies, union leaders, government departments, leaders within the manufacturing and education sectors, and experts in the Industry 4.0 sphere, nationally and internationally. Interviews were undertaken with a wide range of stakeholders to provide a balanced perspective of the impact of Industry 4.0 in the micro and macro contexts. Stakeholders included CEO's of major multinational corporations, Professors at Australian universities, educators within the Vocational Education and Training (VET) system, trade union leaders, key regulators, international experts, and businesses, as well as those well positioned to provide key insights on the opportunities and needs of the manufacturing sector in Australia.

Recommendations have been co-created with stakeholders and informed by the findings and insights from the survey and interviews. They are supported by case studies of best practice in the domestic and international sphere.

This paper is not seeking to assess potential costs and benefits of recommendations in quantitative terms. Rather, it aims to progress the discussion on the impact of Industry 4.0 in Australia and provide practical recommendations for policy makers, the education sector, and industry leaders on how to prepare manufacturing businesses and the workforce for an industrial transformation that has already begun. Indeed, countries such as Germany, with the establishment and success of Plattform Industrie 4.0, as well as the United States (US) and Singapore have already taken significant steps to prepare for the disruption and opportunities enabled by Industry 4.0, with government strategies developed to proactively tackle the need for workforce transformation plans, workforce skills needs, and governing frameworks.

We would like to thank the following organisations for their input and support:

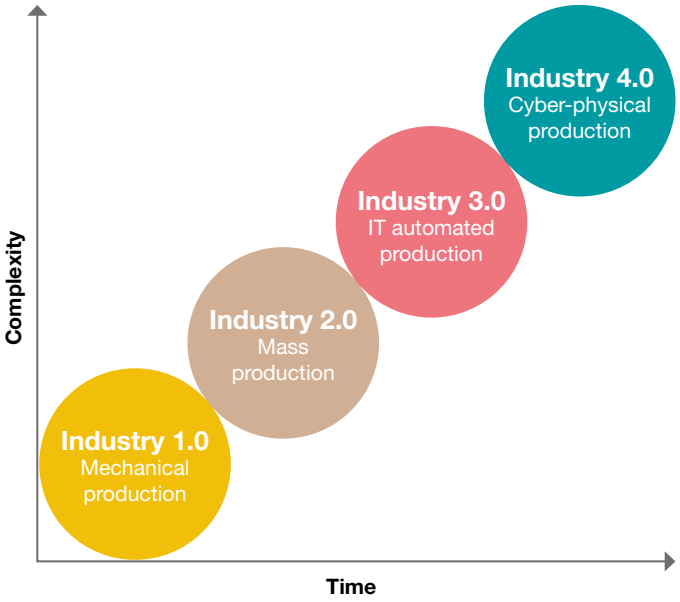
- Plattform Industrie 4.0
- Centre for Future Work
- IMCRC (Innovative Manufacturing CRC)
- Standards Australia
- Oventus
- TAFE Directors Australia
- GPC Electronics
- CSIRO
- TAFE Queensland
- Fraunhofer IAO
- Australian National University
- Ai Group
- SEMMA (South East Melbourne Manufacturers Alliance)
- ANCA
- Facility Management Association of Australia
- Engineers Australia
- IBSA (Innovation & Business Skills Australia)
- IG Metall

5. The survey was available for completion from mid-December 2018 until mid-February 2019. 91 survey responses were received.

1.4. Understanding Industry 4.0

Industry 4.0 is the fourth in a progression of industrial revolutions that have fundamentally changed industries and societies as a whole. The first industrial revolution centred on the use of coal, water and steam to enable large scale production in the 1700s. This was followed by the second industrial revolution in the late 1800s to early 1900s which drew on electricity to enable mass production. The third industrial revolution began in the 1950s, utilising computers and digital systems to drive new ways of working.[6]

Figure 1: Global industrial revolutions to date



The fourth, and current, industrial revolution centres on 'cyber-physical systems', with the Department of Industry, Innovation and Science identifying the following as key enablers of Industry 4.0:[7]

- Rising data volumes, computational power and connectivity
- Emerging analytics and business-intelligence capabilities
- New forms of human-machine interaction
- Improvements in transferring digital instructions to the physical world.

Examples of Industry 4.0 technologies and processes:

Industrial Internet of Things (IIoT): embedded technology for machines to communicate, record, and interact with the external environment using the Internet as a means of communication.

Artificial intelligence (AI): increased autonomy in machinery.

Augmented and virtual reality: information and images overlayed onto real images.

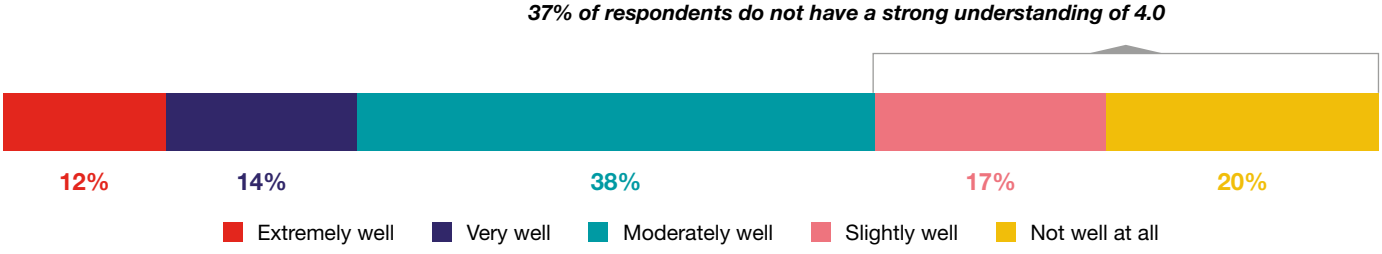
Automation: use of machines to undertake tasks once performed by humans.

Big data analytics: powerful technology able to examine large data sets to reveal insights.

3D printing (additive manufacturing): production of solid objects from a digital model to enable rapid prototyping and custom creation of products.

There is no set formula or single 'playbook' for the implementation of Industry 4.0 technologies. Rather, businesses typically adopt Industry 4.0 technologies and ways of working specific to the needs of their business. This approach to the implementation of Industry 4.0 was evident in the results of the survey conducted for this report, which showed that businesses varied in the implementation of differing Industry 4.0 technologies. However, it should be noted that 20 per cent of survey respondents indicated they do not understand Industry 4.0 well, and 17 per cent only understand it slightly well. These results illustrate the lack of understanding around Industry 4.0 as a concept.

Figure 2: Survey responses: 'How well do you understand Industry 4.0?'[8]



6. PwC. (2019) *1,2,3… Here comes the 4th Industrial Revolution* [online]. Available at: https://www.digitalpulse.pwc.com.au/fourth-industrial-revolution-guide/ [Accessed 31 March 2019].
7. Australian Government, Department of Industry, Innovation and Science. (2019) *Industry 4.0* [online]. Available at: https://www.industry.gov.au/funding-and-incentives/manufacturing/industry-40 [Accessed 28 March 2019].
8. Due to rounding.

1.5. Australian manufacturing and the impact of Industry 4.0

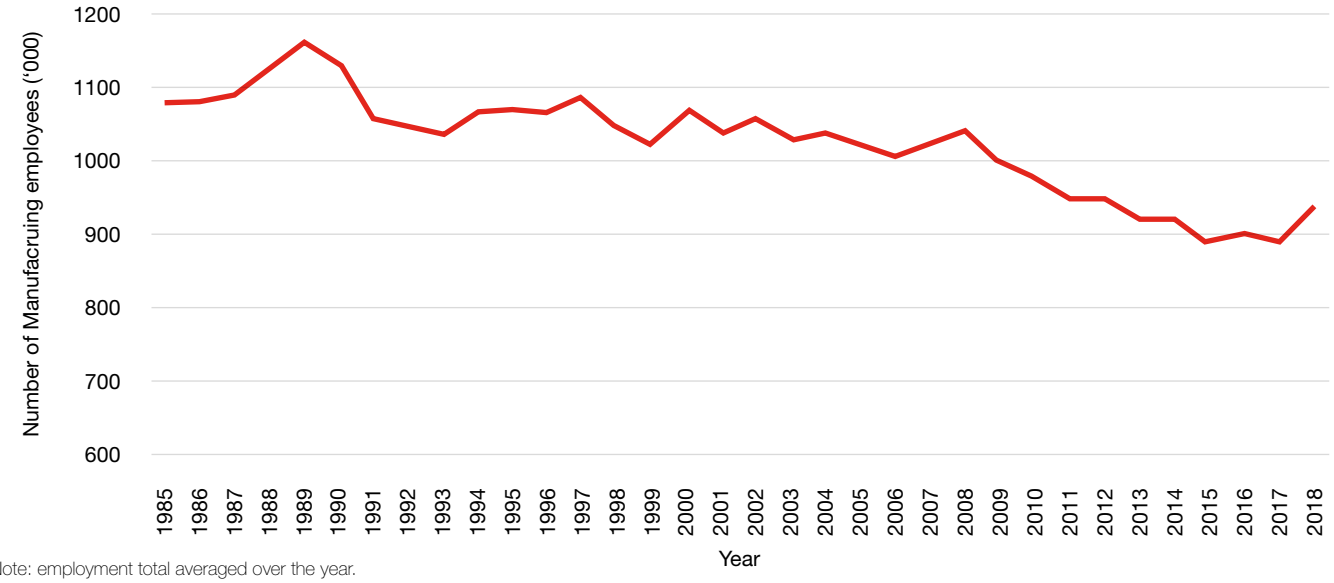
The last 30 years have seen a reduction in the size of the Australian manufacturing workforce. As illustrated in Figure 3, in just the last decade, the workforce decreased by over 100,000 people, from 1,044,800 in 2008, to 933,900 in 2018.[9] A range of factors have contributed to this change, including government and business policies and the offshoring of manufacturing operations, for instance with the cessation of large-scale automotive manufacturing production in Australia by Holden, Ford and Toyota. Concurrent with this downturn, research shows capital spending in the manufacturing sector has also been decreasing since 2011.[10]

When compared to the international landscape, this pattern is not the norm. As Dr Jim Stanford notes, "Australia's manufacturing crisis has been uniquely negative, qualifying Australia as a statistical outlier in the sample of industrialized economies. It is not credible to argue that what is happening in Australia is happening 'everywhere'."[11]

It is important to note that, despite the downwards trajectory of the size of the manufacturing labour force since 1989, total figures have stabilised in recent years, with some green shoots of activity in the industry. Indeed, the total manufacturing workforce increased by 46,375 from 2017 to 2018, as seen in Figure 3.

9. Australian Bureau of Statistics. (2019) *Labour Force, Australia, Detailed, Quarterly,* 'Table 04. Employed persons by Industry division of main job (ANZSIC) – Trend, Seasonally adjusted, and Original', time series spreadsheet, cat. no. 6291.0.55.003. Available at: http://www.abs.gov.au/Ausstats/abs@.nsf/mf/6291.0.55.003 [Accessed on 27 March 2019].
10. Stanford, J. (2016) *Manufacturing (Still) Matters: Why the Decline of Australian Manufacturing is NOT Inevitable, and What Government Can Do About It* [online]. Available at: http://www.tai.org.au/sites/default/files/Manufacturing%20Briefing%20Paper%20FINAL.pdf.
11. Stanford, J. (2016) *Manufacturing (Still) Matters: Why the Decline of Australian Manufacturing is NOT Inevitable, and What Government Can Do About It* [online]. Available at: http://www.tai.org.au/sites/default/files/Manufacturing%20Briefing%20Paper%20FINAL.pdf.
12. Australian Bureau of Statistics. (2019) *Labour Force, Australia, Detailed, Quarterly,* 'Table 04. Employed persons by Industry division of main job (ANZSIC) – Trend, Seasonally adjusted, and Original', time series spreadsheet, cat. no. 6291.0.55.003. Available at: http://www.abs.gov.au/Ausstats/abs@.nsf/mf/6291.0.55.003 [Accessed on 27 March 2019].
13. Australian Bureau of Statistics. (2019) *Labour Force, Australia, Detailed, Quarterly,* 'Table 04. Employed persons by Industry division of main job (ANZSIC) – Trend, Seasonally adjusted, and Original', time series spreadsheet, cat. no. 6291.0.55.003. Available at: http://www.abs.gov.au/Ausstats/abs@.nsf/mf/6291.0.55.003 [Accessed on 27 March 2019].

Figure 3: Size of the Australian manufacturing workforce, 1985 – 2018[12]



Note: employment total averaged over the year.

Perhaps more fundamental than the changes in overall size of the workforce are the changes in the composition of manufacturing sub-sectors. As seen in Figure 4, between 2008 and 2018 there was a decline in the demand for manufacturing workers in transport equipment (decrease in 36,226 workers) and primary metal manufacturing (decrease of 27,939 workers). However, the food manufacturing sector increased its dominance of the Australian manufacturing landscape, with an additional 19,726 workers employed in the sector in 2018 as compared to 2008.

Figure 4: Manufacturing workers in Australia by sector, 2008 – 2018[13]

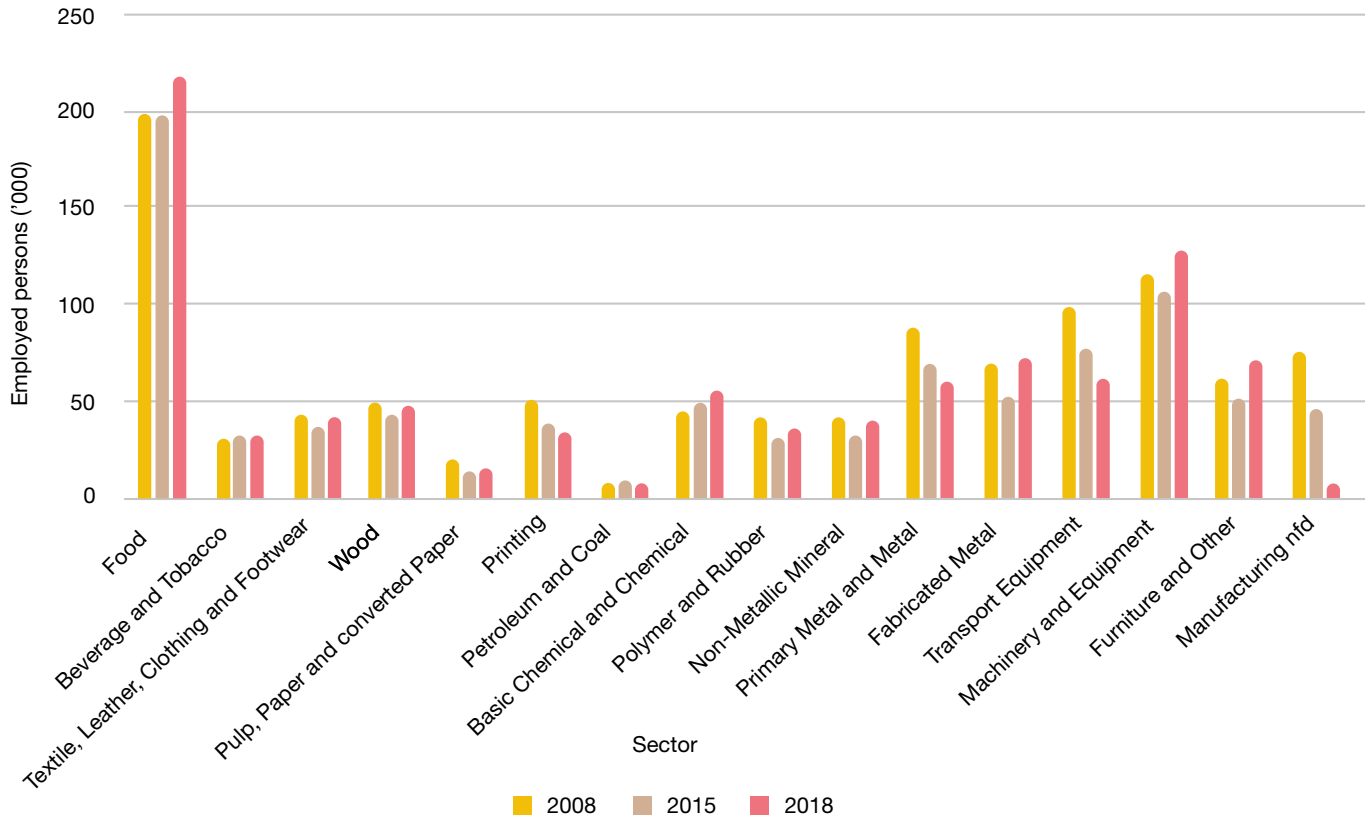
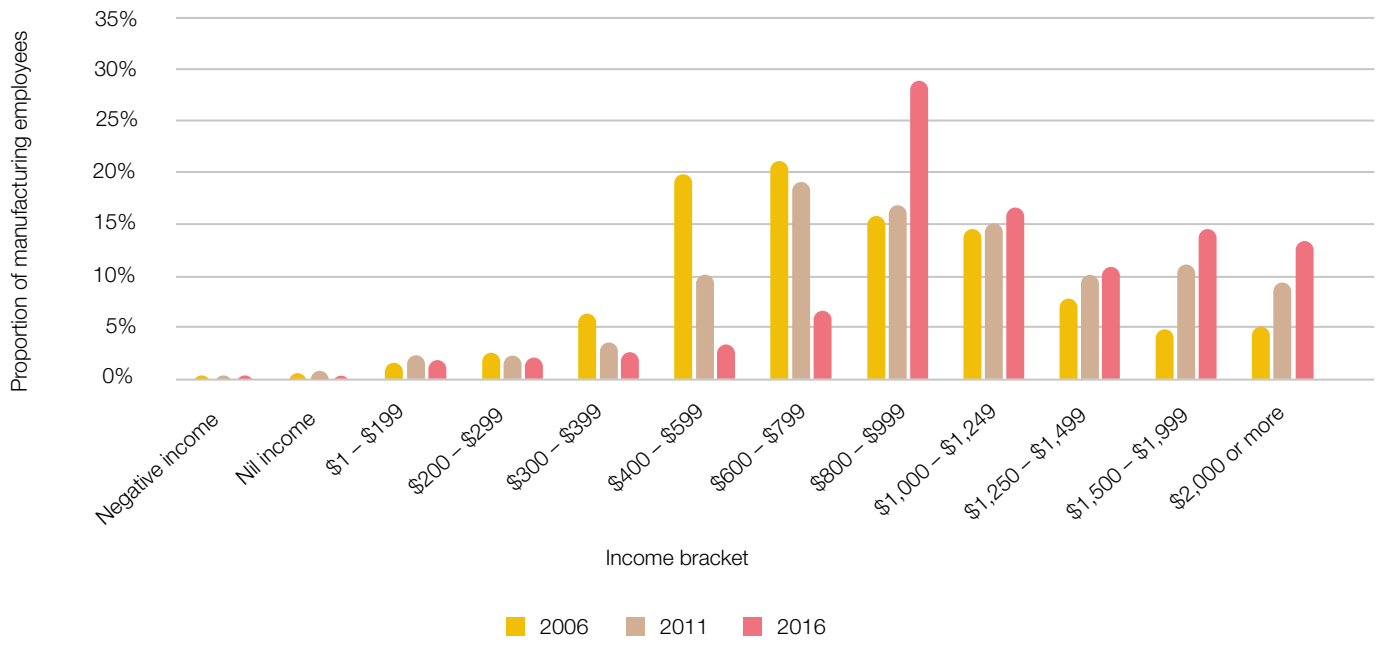


Figure 5: Proportion of manufacturing employees within weekly income brackets, 2006, 2011 and 2016[15]



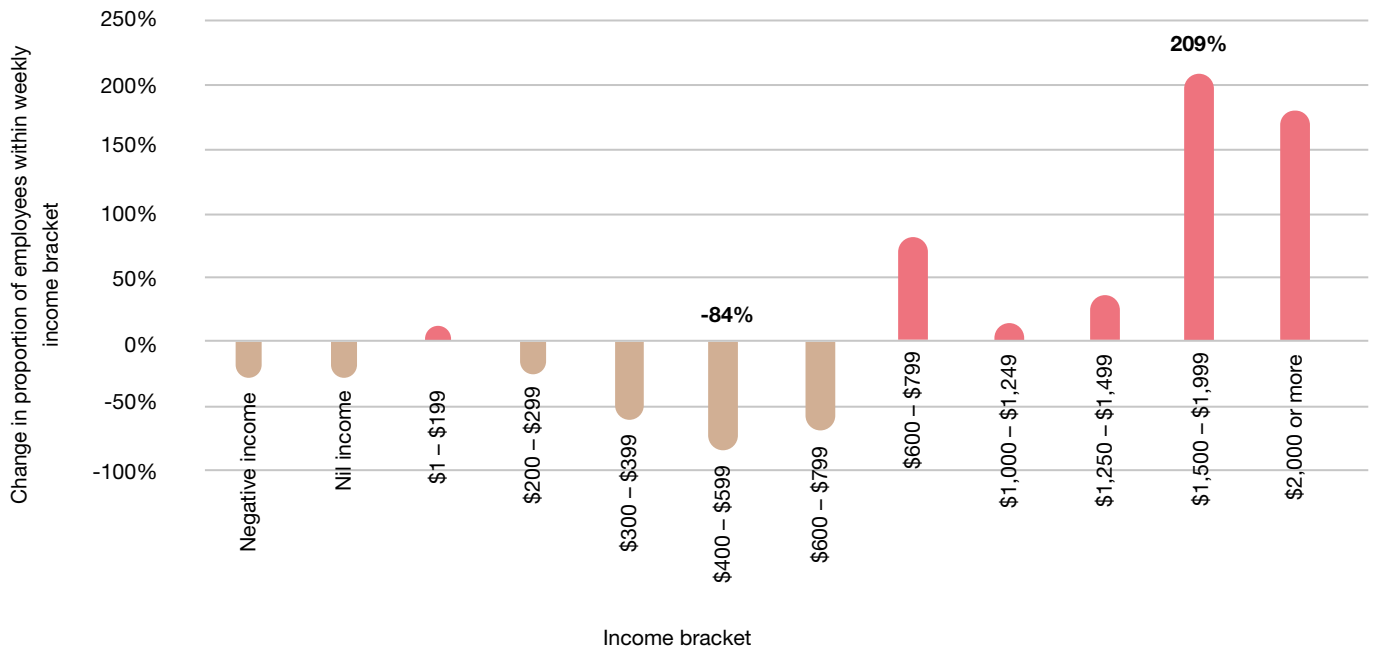
Stakeholder consultation suggests there has been a shift occurring in the industry, with Australian manufacturing becoming progressively focused on priority sectors. Additionally, business focus is increasingly on high value, high quality products as the key competitive differentiator, particularly in the international market.

As the structure and focus of the manufacturing sector changes, there has been a shift in the skills required of the workforce. Businesses are increasingly seeking employees with critical thinking and higher-level problem solving skills,[14] as well as highly specialised skills in research, software engineering, and data science. Concurrent with this trend has been a shift in industry wage distribution – see Figure 5 and Figure 6 – with the proportion of manufacturing workers earning higher salaries increasing. This change in wages is likely to be, at least in part, correlated with the changed profile of base qualifications and skill requirements.

14. Jobs Queensland. (2018) *Advancing Manufacturing Skills: A Skills, Training and Workforce Development Strategy for the Manufacturing Industry in Queensland* [online]. Available at: https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/.

15. Australian Bureau of Statistics. (2006) *Australia (POW), INDP Industry of Employment, INCP Total Personal Income (weekly).* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019]; Australian Bureau of Statistics. (2011) *Australia (POW), INDP Industry of Employment, INCP Total Personal Income (weekly).* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019]; Australian Bureau of Statistics. (2016) *Australia (POW), INDP Industry of Employment, INCP Total Personal Income (weekly).* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019]; PwC analysis of Australian Bureau of Statistics 2006, Australian Bureau of Statistics 2011, Australian Bureau of Statistics 2016 and Australian Bureau of Statistics 2017, *Household Income and Wealth, Australia, 2015-16*, 'Table 6.4 GROSS AND EQUIVALISED DISPOSABLE HOUSEHOLD INCOME', Gross income quintiles, data cube: Excel spreadsheet, cat. no. 6523.0. Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6523.02015-16?OpenDocument [Accessed 29 January 2019].

Figure 6: Change in proportion of employees within weekly income brackets, 2006 to 2016[16]



Over the past 20 years, the Australian manufacturing workforce has become smaller, educated to a higher level, more condensed in urban areas, better remunerated, and more diversified in terms of specialism. However, despite these changes, perceptions of the industry are rooted in the past.

A 2013 report prepared for the Commonwealth Government found Australians are pessimistic about the stability and security of employment in the manufacturing industry and are unlikely to recommend the industry as a career path. The report found only 29 per cent of people were inclined to recommend the manufacturing industry as a career for young people.[17] This issue of perception of the manufacturing industry is not confined to Australia, with the report finding these low figures were replicated in the United States (35 per cent) and Britain (20 per cent).

16. Australian Bureau of Statistics. (2006) *Australia (POW), INDP Industry of Employment, INCP Total Personal Income (weekly).* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019]; Australian Bureau of Statistics. (2011) *Australia (POW), INDP Industry of Employment, INCP Total Personal Income (weekly).* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019]; Australian Bureau of Statistics. (2016) *Australia (POW), INDP Industry of Employment, INCP Total Personal Income (weekly).* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019]; PwC analysis of Australian Bureau of Statistics 2006, Australian Bureau of Statistics 2011, Australian Bureau of Statistics 2016 and Australian Bureau of Statistics 2017, *Household Income and Wealth, Australia, 2015-16,* 'Table 6.4 GROSS AND EQUIVALISED DISPOSABLE HOUSEHOLD INCOME', Gross income quintiles, data cube: Excel spreadsheet, cat. no. 6523.0. Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6523.02015-16?OpenDocument [Accessed 29 January 2019].

17. Wallis Consulting Group. (2013) *Public Perceptions of Manufacturing: Final Report* [online] Available at: http://resources.news.com.au/files/2013/10/09/1226736/461973-131010-manufacturing.pdf.

2 Findings

2. FINDINGS

Consultation and research were undertaken to understand how manufacturing businesses and workforces need to transform to thrive in an Industry 4.0-enabled manufacturing industry. Three key findings were identified: industry, education institutions and government must collaborate to drive innovation; ongoing education and training for the manufacturing workforce must be supported; and internal culture and new ways of working within manufacturing businesses must be fostered.

2.1. Finding 1: Businesses must become skilled collaborators in the Industry 4.0 environment

New technology and ways of working are continuing to emerge in the Industry 4.0 environment, and collaboration will be critical for businesses to understand Industry 4.0 and the future of the industry as a whole.

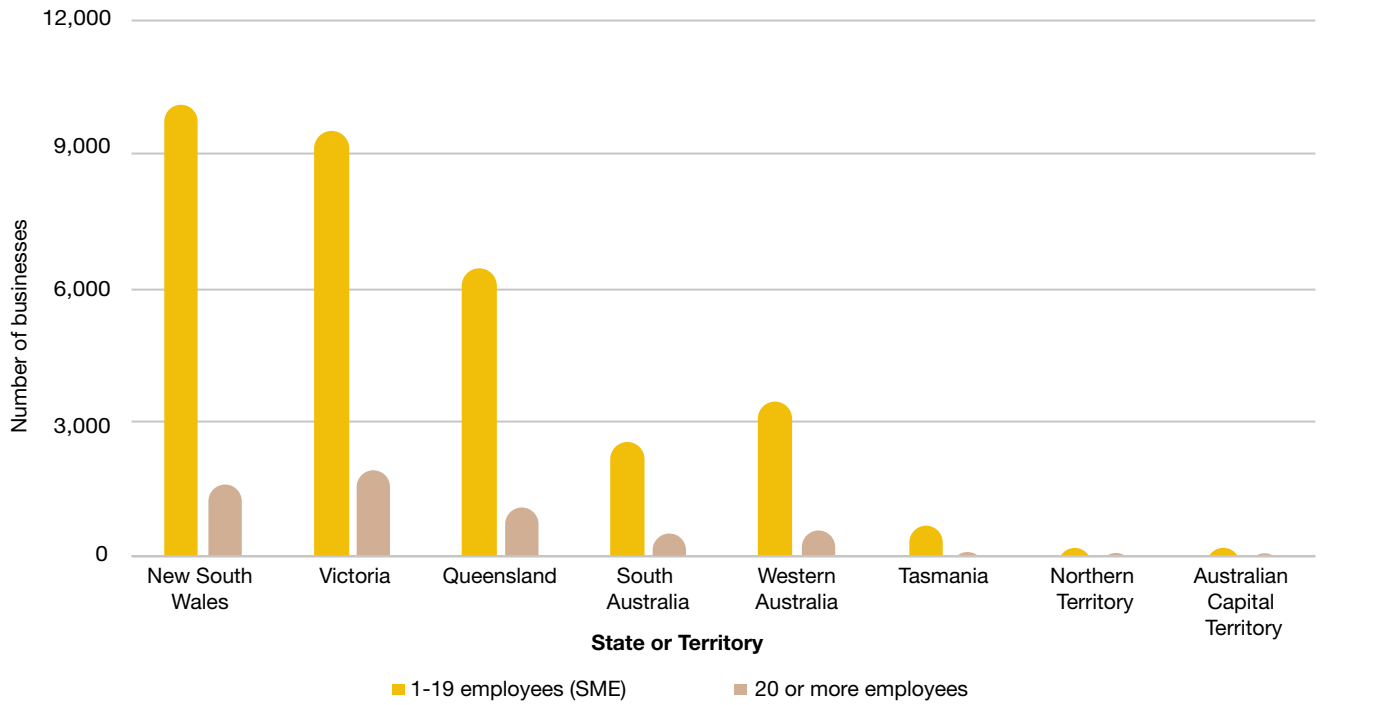
There are a range of opportunities for Australian manufacturing businesses to collaborate, including with other businesses, education/research institutions, unions, peak employer bodies and governments. In particular, Government has a role to play in this collaboration, with the capacity to facilitate and encourage parties and provide platforms for engagement.

2.1.1. Business-to-business collaboration

Manufacturing business-to-business collaboration enables businesses to learn from one another and draw on the innovations and processes adopted by others. It also allows businesses to see new technologies and systems in action, with consultation highlighting that businesses learn when they see technology and processes at work in another business.

Inter-business collaboration is particularly relevant to the Australian manufacturing industry, which has an overwhelming number of Small to Medium Enterprises (SMEs – organisations with fewer than 20 employees), as seen in Figure 7.

Figure 7: Number of businesses by size and location within the Australian manufacturing industry, 2016[18]



18. Australian Bureau of Statistics. (2016) *Main Statistical Area Structure (MAIN ASGC) (POW), EMPP Number of employees*. Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019].

SMEs typically have less capacity than larger organisations to engage in research and development (R&D) practices and incorporate Industry 4.0 technologies into their businesses.[19] Engaging with other organisations provides SMEs with the opportunity to see the value and relevance of Industry 4.0 and learn how it can be implemented. Some larger organisations are already taking on this role as an exemplar of Industry 4.0 and engaging with SMEs. These practices should be recognised for the value they bring and replicated to reduce the challenges faced by SMEs.

2.1.2. Business and education/research institution collaboration

There are a range of opportunities and rationales for businesses and education/research institutions to collaborate in the Industry 4.0 environment. For example, education institutions can work with industry in the co-creation and development of education and training content to skill the manufacturing workforce for Industry 4.0. Such collaboration is beneficial for both parties, with education providers more likely to produce job ready graduates, and industry able to draw in a timely manner on learner cohorts that have relevant and meaningful skills.

CASE STUDY:

Industry 4.0 Apprenticeship Program

In 2016, Swinburne University of Technology, Ai Group and Siemens Ltd commenced the development of a new apprenticeship model that specifically sought to prepare learners to engage in the advanced manufacturing industry. Students in the apprenticeship benefitted from the integration of trade skills into higher qualifications, gaining skills in high-level technology and tools, and emerging from the apprenticeship program with a Diploma and Associate Degree in Applied Technologies from Swinburne University. The program and qualifications were co-developed with industry to ensure students gained the most relevant skills.

The program is unique in its focus on Industry 4.0 and the use of higher level qualifications, which expands on the traditional apprenticeship model and seeks to appeal to a broader group of students. Students also gain first-hand work experience throughout the course to ensure the development of practical workplace skills.

Graduates from the first apprenticeship group have moved into a diverse range of job roles, including: engineering system architect in future tech; predictive data analyst; digital service engineer; application services engineer; cyber security sales support professional; digital engineering technician; and digital customer service sales consultant.

Key learning:

Education and industry collaboration can be used to develop education offerings that better meet future workforce requirements.

Benefits:

Additionally, collaboration between businesses and education/research institutions can be pursued to improve knowledge sharing and promote innovation that takes advantage of the strengths and insights of each party.[20] This was the case when Oventus (an SME) and the CSIRO teamed up to collaborate on the use of 3D printing to manufacture sleep apnoea mouthguards.

CASE STUDY:

Oventus and the CSIRO

In 2013, Oventus was a small medical device business that had designed a revolutionary strong and lightweight mouthguard to treat sleep apnoea. The business reached out to developers of 3D printers in the international sphere and was ultimately put in touch with the CSIRO as a possible collaboration partner given the CSIRO had a range of Advanced Manufacturing facilities and expertise that could be drawn upon.

Oventus and the CSIRO began collaboration in 2013, with the first mouthguards developed in November 2014. Critical to this collaboration was the innovation in software development that allowed the manipulation of a 3D printed mouthguard to meet specific customer needs. Such personalisation demonstrates the power of 3D printing operations to add value to a standardised manufactured product.

The collaboration between the CSIRO and Oventus expanded beyond the use of technology, with the CSIRO supporting the development of marketing and communications for the product. This multidisciplinary approach supported the commercial and technological success of the product, and, having been trained on the software and technology by the CSIRO staff, in 2016, Oventus purchased its own 3D printer operations and set up a Hub in Clayton, Melbourne. This allowed Oventus to continue collaboration with the CSIRO, whilst pursuing commercial manufacturing of the mouthguard.

The success of the 3D printed mouthguard has been significant. Oventus was listed on the ASX in July 2016 and is now operating out of both the United States and Australia.

Key learning:

The collaboration between Oventus and the CSIRO enabled the transfer of multidisciplinary knowledge and access to Industry 4.0 technologies that supported an emerging SME manufacturer to grow its business.

Benefits:

19. Advanced Manufacturing Growth Centre. (2018) *Industry 4.0: An Opportunity for Every Australian Manufacturer* [online]. Available at: https://www.amgc.org.au/wp-content/uploads/2018/11/AMGC_Industry-4.0-An-opportunity-for-every-Australian-Manufacturer-.pdf.
20. NSW Government, Department of Industry. (2018) *NSW advanced manufacturing industry development strategy* [online]. Available at: https://www.industry.nsw.gov.au/__data/assets/pdf_file/0007/159388/NSW-advanced-manufacturing-industry-development-strategy.pdf.

Despite these benefits, collaboration between industry and education providers is not as prevalent as it should be, particularly in the manufacturing sector. Nationally, only five per cent of SME manufacturers actively pursue R&D partnerships with universities, and only 16 per cent of manufacturing businesses that innovated in the last 12 months have formal research agreements in place.[21]

This is not to suggest that Australian education and research institutions are not engaging in R&D and the Industry 4.0 space. The 2017 Organisation for Economic Co-operation and Development (OECD) Science, Technology and Industry Scoreboard found Australia is the eighth largest producer of most-cited scientific documents on machine learning.[22] Additionally, the 2017 OECD report found that between 2002 and 2016, Australia was ranked third behind Switzerland and the United States in attracting the largest number of scientists.[23] As summarised by the report, "…analysis of net entry and exit flows of scientific authors over time can be highly informative, especially with regard to a science system's response to events and policies adopted by countries linked to the funding of scientific research, support for scientific international mobility and policies designed to attract the highly qualified."[24] Therefore, collaboration is not limited by a lack of R&D by education and research institutions.

2.1.4. The role of government and peak bodies in collaboration

Commonwealth and State governments, unions and peak employer bodies have a role to play in facilitating the above collaboration between businesses and education/research institutions, as well as working with relevant parties to establish the framework for Industry 4.0 in Australia.

Incentivising businesses and their workers to engage with Industry 4.0

Government can play a key role in encouraging manufacturing businesses and workers to engage in the Industry 4.0 environment through collaboration. The Commonwealth Government has already stepped into the role of incentivising collaboration with initiatives such as the R&D tax incentive that provides tax offsets for eligible R&D activities,[25] the Industry 4.0 Testlabs pilot, and the Australian Research Council Linkage Program, which supports the initiation and development of research alliances between higher education organisations and industry with grants through 'Linkage Projects'.[26] Additionally, the Commonwealth Government's Entrepreneurs' Programme includes a range of initiatives to support business competitiveness and productivity,[27] including the following:

- Incubator Support: provides funding to incubators that deliver support to Australian start-ups looking to engage in international markets.
- Innovation Connections: provides businesses with expert support to identify business gaps and opportunities.
- Accelerating Commercialisation: provides businesses with guidance and grants to support the commercialisation of products, processes and services.
- Business Management: delivers business advice and grants to support uplift in areas such as business capability and capacity.

21. NSW Government, Department of Industry. (2018) *NSW advanced manufacturing industry development strategy* [online]. Available at: https://www.industry.nsw.gov.au/__data/assets/pdf_file/0007/159388/NSW-advanced-manufacturing-industry-development-strategy.pdf.
22. OECD. (2017) *Highlights from the OECD Science, Technology and Industry Scorecard 2017 – The Digital Transformation: Australia* [online]. Available at: http://www.oecd.org/australia/sti-scoreboard-2017-australia.pdf.
23. OCED. (2017) *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation* [online]. Available at: https://www.oecd-ilibrary.org/docserver/9789264268821-en.pdf?expires=1554443978&id=id&accname=guest&checksum=BD3812EDDFB8D270C158A318F80A9237 [Accessed 31 March 2019].
24. OCED. (2017) *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation* [online]. Available at: https://www.oecd-ilibrary.org/docserver/9789264268821-en.pdf?expires=1554443978&id=id&accname=guest&checksum=BD3812EDDFB8D270C158A318F80A9237 [Accessed 31 March 2019].
25. Australian Taxation Office. (2017) *Research and development tax incentive* [online]. Available at: https://www.ato.gov.au/Business/Research-and-development-tax-incentive/ [Accessed 5 April 2019].
26. Australian Research Council. (2018) *Linkage Projects* [online]. Available at: https://www.arc.gov.au/grants/linkage-program/linkage-projects [Accessed 5 April 2019].
27. Australian Government, Business. (2019) *Entrepreneurs' Programme* [online]. Available at: https://www.business.gov.au/assistance/entrepreneurs-programme [Accessed 5 April 2019].

CASE STUDY:

Industry 4.0 Testlabs

Following the Prime Minister's Industry 4.0 Taskforce adoption of the 'Industry 4.0 Testlabs strategic initiative', in cooperation with the German Plattform Industrie 4.0, 6 Universities around Australia have been selected for the National Industry 4.0 Testlab pilot program. The program provides funding for the establishment of Industry 4.0 Testlabs at a number of universities involving industry clusters in select priority sectors and application areas:

University of Tasmania – Food Integrity

University of South Australia – Defence Manufacturing

University of Queensland – Green and Smart Energy

University of Technology Sydney – Intelligent Biomanufacturing Accelerator

University of Western Australia – Energy and Resources Digital Interoperability

Swinburne University of Technology – Advanced Manufacturing Open Demonstrator as well as a Testlab focused on the 3D Printing of Composites

Each of these Testlabs are required to provide open access to industry to engage in and learn about Industry 4.0 technologies and how these might be applied to their business. By bringing business on campus, industry has the opportunity to learn and engage with current education and training offerings and R&D expertise.

The Australian Testlab Network is being undertaken in consultation with Germany's Labs Network Industrie 4.0 (LNI4.0), an association that connects SMEs to a network of companies and testlabs/testbeds using Industry 4.0.

Key learning:

The establishment of dedicated collaboration and research spaces can facilitate valuable innovation opportunities for manufacturing businesses and universities.

Benefits:

Collaboration Innovation

Similarly, state government programs in the Industry 4.0 space have also continued to emerge. For example, the Victorian Government's $200 million Future Industries Fund, which includes the Future Industries Manufacturing Program, provides grants to businesses seeking to implement new manufacturing technologies and processes.[28] The Tasmanian Government has also launched a five year Advanced Manufacturing Action Plan that seeks to enable growth in the advanced manufacturing sector through innovation, collaboration, education, market access and awareness raising.[29]

CASE STUDY:

Advanced Manufacturing Industry 4.0 Hub program in Victoria

In 2018, the Victorian Government funded the establishment of an Advanced Manufacturing Industry 4.0 Hub in Melbourne. The hub is located within the Swinburne University 'Factory of the Future', and seeks to support manufacturing SMEs to future-proof their operations by increasing their business capabilities to be ready for new, advanced manufacturing systems and technologies.

Each year a minimum of 100 companies go through the Hub program aimed at: increasing their Industry 4.0 knowledge; assessing their Industry 4.0 readiness; developing new business model, product and technology strategies; and defining training, design, research, prototyping and translation and innovation needs. Through the Factory of the Future, participants in this program also have access to Industry 4.0 training, state-of-the-art facilities, specialist studios, advanced tools and new technologies, to support innovative product development, rapid prototyping and new manufacturing business options.

The hub initiative was developed with input from a range of bodies, including collaboration with the Innovative Manufacturing CRC.

Key learning:

Collaboration between state governments, industry sector specific organisations and education institutions can support SMEs to access knowledge, technologies and tools.

Benefits:

Collaboration Innovation

This support for collaboration and innovation in the Industry 4.0 space by Australian State and Commonwealth governments is similar to initiatives in the international sphere, where collaboration between government, industry and education providers are helping to bridge gaps in knowledge, technology access and/or funding. This is a central feature of Plattform Industrie 4.0 in Germany, as seen through the Testbeds program.

28. Victorian Government. (2019) *Future Industries Fund: Manufacturing Program* [online]. Available at: https://www.business.vic.gov.au/__data/assets/pdf_file/0009/1219356/Future-Industries-Manufacturing-Fact-Sheet.pdf [Accessed 5 April 2019].
29. Tasmanian Government, Department of State Growth. (2019) *Tasmanian Advanced Manufacturing Action Plan* [online]. Available at: https://www.stategrowth.tas.gov.au/__data/assets/pdf_file/0011/136568/Tasmanian_Advanced_Manufacturing_Action_Plan.pdf [Accessed 5 April 2019].

CASE STUDY:

Plattform Industrie 4.0 Testbeds

Testbeds have been established in Germany by Plattform Industrie 4.0 to support businesses in the testing of Industry 4.0 components. Testbeds have been set up at universities and other research institutions throughout Germany, with realistic conditions so components can be tested for production and investment, and bring them to market maturity.[30] Testbeds recognise businesses are already developing components for Industry 4.0, but need the opportunity to test and evaluate them in real conditions.

Key learning:

Businesses benefit from opportunities to test and evaluate ideas and products prior to large-scale development and investment.

Benefits:

Collaboration Innovation

Another set of levers that governments can use to encourage innovation and R&D are strategic procurement practices. Strategic procurement can be used by governments to stimulate certain business sectors or activities. For instance, the Indigenous Procurement Policy was initiated in 2015 and stipulates a target number of Commonwealth contracts that must be awarded to Indigenous businesses.[31] The policy has been a catalyst for growth within the Indigenous business sector, with over 1000 Indigenous businesses winning contracts since the inception of the Policy in 2015, compared to just 30 businesses winning contracts in 2012-2013.[32]

Additionally, the use of strategic procurement to drive R&D and collaboration has been growing in the Australian Defence industry. The Commonwealth Government now includes the requirement for an 'Australian Industry Capability (AIC) Plan' in defence materiel procurements where the tender value is equal to or exceeds $20 million, or where procurement will impact a priority or strategic industry capability.[33] The aim of the initiative is to maximise the involvement of Australian industries in meeting Australia's defence capability goals, with the AIC Plans committing the tenderer to a certain level of Australian industry involvement during the lifecycle of the program.

Policies and standards

In the Industry 4.0 environment, technologies connect beyond the boundaries of a single organisation, with information flowing throughout the supply chain enabled by digitalised processes. While legislation is being developed by the National Data Commissioner to address the needs of a more digital Australia,[34] at present, there is a lack of government and industry guidance and standards to regulate the sharing of data in a digitalised environment with people-to-machine and machine-to-machine interactions.

A lack of guidance may present a barrier to engagement, with some businesses hesitant to participate without clear structures, or concerned about the risks of data breaches, including cyber-crime attacks and cyber sabotage of industrial processes. In 2016, the Symantec Internet Security Threat Report found the manufacturing sector to be among the top three industries globally that is likely to be targeted.[35] Indeed, in 2014, a German steel mill experienced a cyber-attack, with hackers gaining access to the plant's network and production systems to sabotage the equipment. This resulted in "massive damage" and the uncontrolled shutdown of a blast furnace.[36]

Avenues for industry and government to collaborate and determine the parameters of necessary Industry 4.0 policies and standards should be pursued to alleviate concerns and minimise risks.

Supporting telecommunications infrastructure

The successful implementation of Industry 4.0 is only possible if there is an appropriate telecommunications system to support the requirements of technology, such as data speed, reliability and stability. Government must work with industry, education and telecommunications organisations to understand the parameters of Industry 4.0 and the requirements of the telecommunications system. None can achieve the desired outcome alone, and each has a role to play in framing the development of a system that is suitable.

It is relevant to note this is not just a consideration for Australia. One of the pillars of the German G20 presidency in 2017 was a focus on high quality and competitively priced access to communications infrastructure as a method to support the digital revolution.[37] Similarly, the UK Government has developed a whole of government strategy which, amongst other things, guides the development of next generation digital infrastructure.[38]

30. Plattform Industrie 4.0. (2019) *Testbeds: Easing access for SMEs* [online]. Available at: https://www.plattform-i40.de/I40/Navigation/EN/InPractice/Testbeds/testbeds.html [Accessed 31 March 2019].
31. Australian Government, Department of the Prime Minister and Cabinet. (2015) *Indigenous Procurement Policy* [online]. Available at: https://www.pmc.gov.au/indigenous-affairs/economic-development/indigenous-procurement-policy-ipp [Accessed 31 March 2019].
32. Scullion, N. (2018) *Strengthening the Indigenous Procurement Policy and increasing engagement | Ministers Media Centre* [online]. Available at: https://ministers.pmc.gov.au/scullion/2018/strengthening-indigenous-procurement-policy-and-increasing-engagement.
33. Australian Government, Department of Defence. (2019) *Australian industry capability* [online]. Available at: http://www.defence.gov.au/SPI/Industry/AIC.asp [Accessed 5 April 2019].
34. Australian Government, Office of the National Data Commissioner. (2019) *National Data Commissioner* [online]. Available at: https://www.datacommissioner.gov.au/ [Accessed 1 March 2019].
35. Symantec. (2017) *Smarter Security for Manufacturing in The Industry 4.0 Era* [online]. Available at: https://www.symantec.com/content/dam/symantec/docs/solution-briefs/industry-4.0-en.pdf.
36. Federal Office for Information Security. (2014) *The State of IT Security in Germany 2014* [online]. Available at: https://www.bsi.bund.de/SharedDocs/Downloads/EN/BSI/Publications/Securitysituation/IT-Security-Situation-in-Germany-2014.pdf;jsessionid=8208842A52F09C1C711D2F1485EA63BD.1_cid369?__blob=publicationFile&v=3.
37. HuffPost. (2019) *Policy 4.0: Bringing the People on Board in a Digital World* [online]. Available at: https://www.huffpost.com/entry/policy-40-bringing-the-pe_b_14114510 [Accessed 15 January 2019].
38. UK Government, Department for Digital, Culture, Media and Sport. (2017) *UK Digital Strategy* [online]. Available at: https://www.gov.uk/government/publications/uk-digital-strategy [Accessed on 9 April 2019].

CASE STUDY:

United Kingdom's Digital Strategy

In 2017, the UK Government released the UK Digital Strategy. The strategy is comprised of seven strands, one of which is "Building world-class digital infrastructure for the UK". This includes investment in extensive fibre networks, commitments to better use of the radio spectrum, and 5G research and trials, including the establishment of a 5G strategy outlining how the UK will engage in next generation mobile connectivity.

The digital strategy also establishes forums for engagement with the community to understand their digital needs. For example, the Business Connectivity Forum will bring together businesses, local authorities and communications providers to develop collaborative solutions, enabling businesses to access fast and reliable broadband.

Key learning:

Drawing on collaboration with industry stakeholders, governments can play a key role in establishing and supporting the development of relevant telecommunications and digital systems.

Benefits:

Policy Collaboration

The role of unions and peak employer bodies

In addition to governments, peak employee and employer bodies can play an important role in encouraging and facilitating collaboration and engagement in the Industry 4.0 space. Unions have valuable insights into worker skills and can provide guidance on workforce transformation needs. Moreover, they represent the interests of a key manufacturing stakeholder group that may be impacted by Industry 4.0, and will have an important role to play in facilitating workforce engagement.

Unions have been involved in initial Industry 4.0 activities in Australia, with Andrew Dettmer, National President of the Australian Manufacturing Workers Union, co-chairing the Industry 4.0 Advanced Manufacturing Forum -Testlabs and Future Work, Education And Training Workstream. This union engagement is reflective of the German landscape, in which IG Metall – the country's largest union – has been a key player in the Industry 4.0 evolution, with the Union's President, Jörg Hofmann, part of the management team for Plattform Industrie 4.0.[39] Given the Industry 4.0 environment of transition and change, trade unions will be valuable in consultation on workforce planning and skills.

Industry associations can similarly play a role in supporting collaboration and engagement, as seen through the work of the Facility Management Association in Australia.

CASE STUDY:

Facility Management Association (FMA)

Industry 4.0 technologies are increasingly utilised in the facilities management sector. For example, predictive maintenance and self-diagnosing machines have emerged in the market over the last five years, and are significantly changing the parameters of facilities management. The emergence of these technologies has seen a shift from a technical 'hands-on' industry, to one that is more focused on data analysis and management skills. Moreover, it has meant a shift to increasingly pre-emptive, rather than reactive, activities in areas such as occupant comfort, space management and maintenance, with data being used to predict workplace indoor environmental activities. One example is the use of sensor technology for bins to alert a cleaner to a full bin that requires emptying. This is significantly more time- and cost-effective than previous practices, where a cleaner would need to manually check all bins for emptying.

In this changing landscape, the Facility Management Association (FMA) has played a key role in supporting member businesses and organisations to understand the impact of Industry 4.0 on the sector, job roles and the future ways of working. The Association operates education and professional development sessions to upskill members, as well as facilitating collaboration forums between businesses to support knowledge sharing and capability development.

Key learning:

Peak industry bodies can play a primary role in facilitating collaboration between businesses, and in educating businesses about Industry 4.0 disruptions and opportunities.

Benefits:

Collaboration Workforce development Education and Training

39. Plattform Industrie 4.0. (n.d.) *Management of the Plattform Industrie 4.0* [online]. Available at: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation-gesamt/composition-industrie-4-0.pdf?__blob=publicationFile&v=14 [Accessed 31 March 2019].

2.2. Finding 2: Industry 4.0 will demand new skills and knowledge from the manufacturing workforce

The fourth industrial revolution is generating new knowledge and skills needs, automating tasks and creating new job roles across a range of sectors and industries. For example, in the banking sector, Robotic Process Automation (RPA) uses rule-based processes to perform repetitive tasks historically undertaken by humans. The implementation of these processes has resulted in a shift in skill needs in the industry, with disruption to jobs roles that were typically comprised of routine tasks.

The manufacturing industry is no different, with the job roles and skills needs of workers undergoing fundamental changes. In this environment, the need for appropriate education and training to ensure the workforce can meet the changing needs of industry is essential. This was reflected in the results of the survey undertaken for this report, which found 86 per cent of respondents agree that traditional job roles are changing and 88 per cent believe that specialised training will be needed to prepare the workforce for the Industry 4.0 environment.

2.2.1. What are the emerging skills needs of the manufacturing industry?

The skills needed by modern manufacturing workers are changing. As new technologies are implemented, core functions of manufacturing job roles have been automated and new skills are required to engage with the technology and systems. The skill needs of these new job roles are in flux as new technologies continue to emerge. However, consultation with stakeholders for this report indicated there will be an increase in demand for the following skills:

- **Intelligent data analytics skills** – Industry 4.0 technologies, such as sensors, create immense amounts of data. However, in order to derive value, this data must be connected, interpreted and analysed. Intelligent data analytics skills, such as interpretation and data driven decision making, are therefore increasingly sought after in the manufacturing workforce.
- **Digital literacy** – The manufacturing workplace will increasingly be a "technology-rich" environment.[40] Workers will need to have the skills to make decisions and solve problems in this environment, understanding how data, systems and machines fit together.
- **Advanced cognitive skills** – Cognitive skills such as critical thinking, problem solving and design thinking will be important in an Industry 4.0-enabled environment in which workers must engage with complex subject matter and solve complex issues.[41] Individuals engaging with Industry 4.0 technologies will need to be able to respond to complex problems, and be agile and innovative in their approach to new ways of working. Woven into these cognitive skills will be the demand for skills such as communication, empathy, leadership and teamwork, all of which will be important in a changing workplace and with job roles increasingly focused on non-routine tasks.

All job roles in the manufacturing industry will be impacted by changing skill and knowledge needs. This will necessitate upskilling by those in management and executive positions, as well as those in front line operations. Manufacturing business leaders will need the knowledge and skills to understand the digitalisation process and how it can be applied to their business operations. Without this understanding, there will be little drive for the transformation of the industry and workforce as a whole.

2.2.2. How can these new skills be developed?

Preparing the manufacturing workforce to meet the skills needs highlighted above can be approached through the upskilling of existing workers to fill job roles, as well as the recruitment of new entrants to the manufacturing workforce.

Upskilling existing workers

Where possible, retaining existing workers in the manufacturing industry is beneficial for a business as they bring with them an immense foundational knowledge of manufacturing processes and systems, as seen in the GPC Electronics Case Study. It is recognised that these workers may need additional skills and knowledge to move into emerging job roles, however, this should be supported through internal and external upskilling programs.

40. Jobs Queensland. (2018) *Advancing Manufacturing Skills: A Skills, Training and Workforce Development Strategy for the Manufacturing Industry in Queensland* [online]. Available at: https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/.
41. Jobs Queensland. (2018) *Advancing Manufacturing Skills: A Skills, Training and Workforce Development Strategy for the Manufacturing Industry in Queensland* [online]. Available at: https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/.

CASE STUDY:

GPC Electronics

GPC Electronics is a leading contract electronics manufacturing business, with factories in Australia, New Zealand and China. The process the business used for circuit board manufacturing had previously involved multiple manual inspections of the product. This task was undertaken by workers who would visually inspect the product at various stages throughout the manufacturing process. However, the small size and significant number of parts that needed to be visually inspected meant that defects were easily missed. To improve this process and increase yield, Automated Optical Inspection (AOI) technology was implemented to review the products for defects at the end of the manufacturing process. The technology was redeveloped to recognise what the product should look like using electronic CAD (computer-aided design) files and could then identify defects in approximately 20 seconds per circuit board.

Workers who had previously undertaken visual inspections were retained and transitioned into AOI operator roles. It was found that the skills the workers had in understanding the required standards and the manufacturing process meant they could interpret the results of the AOI errors and identify how to fix the cause of the problem. This meant that frequent errors could be fixed at their root cause in the manufacturing process, thereby decreasing the overall defect rate: from 100-200 parts per million to approximately 40 parts per million. The improved yield, throughput and productivity has meant that GPC electronics has won new contracts and has subsequently hired more staff.

Key learning:

The relationship between the application of new technologies and existing worker skills should be investigated to determine whether they can complement each other and be used to drive innovations.

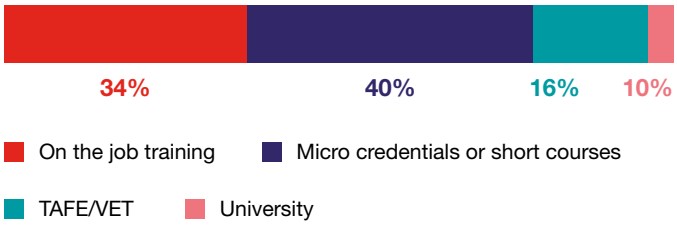
Benefits:

With the rapid evolution and continued advancement of Industry 4.0 technologies, there are benefits to upskilling existing manufacturing workers on a 'just in time' and 'as needs' basis. This is not to suggest the removal, or diminished importance, of full qualifications as pathways into and through the industry. However, shorter form training, such as micro-credentials or skill sets, can provide a vehicle for manufacturing workers to develop specific skills that complement an existing skill base.

The survey highlighted the benefits of shorter form training in meeting the needs of the manufacturing workforce in the Industry 4.0 environment, with 40 per cent of respondents believing micro-credentials/short courses should be used as a method for upskilling, and only 2 per cent believing employees should be upskilled through traditional full degree university pathways. Micro-credentialing options are currently being explored by a number of Australia's universities, including the University of Melbourne, which is in the process of developing a strategy for micro-credential learning.[42]

However, critical to the success of short courses and micro-credentials are appropriate safeguards and systems to monitor content and delivery. Consideration must be given to how such courses will be recognised so they are portable and transferable between job roles and industries. Additionally, it must be determined how they can be incorporated into skills recognition and classification programs to ensure benefit for the learner. These issues present significant barriers to the use of micro-credentials and short courses, and, whilst there has been substantial commentary to date on the future use of these training options, their potential is yet to be reached.

Figure 8: Survey responses: 'How should the workforce be upskilled to engage with Industry 4.0?'



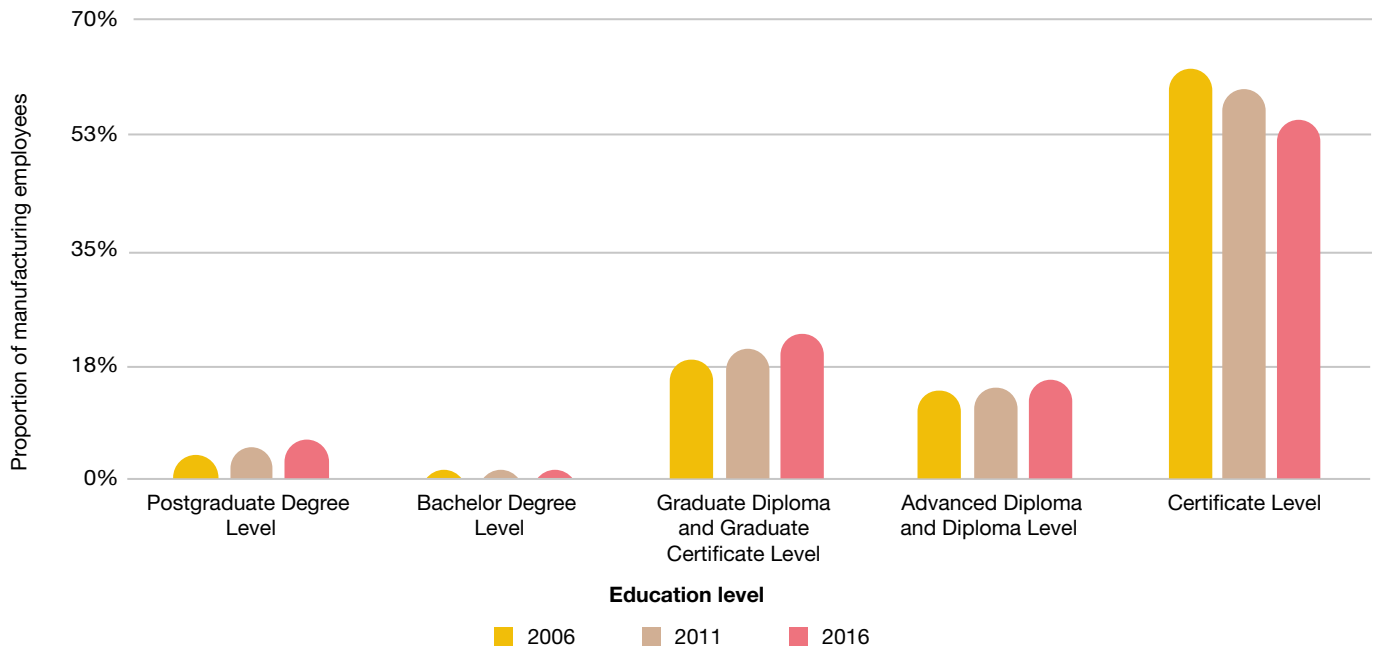
The Australian VET sector has already made progress towards the incorporation of this style of education and training in the VET landscape. Skill sets are a combination of units of competency that are targeted to meet a specific industry capability need, such as a licensing requirement or emerging skill need. They are increasingly being utilised in nationally accredited training packages to supplement larger qualification structures. Skill sets can be drawn upon for a variety of purposes, including as a method to support the transition of workers between occupations with a common skill base. However, their use is limited by an absence of consistent funding.

Creating pathways into the manufacturing sector for new entrants

In addition to upskilling existing workers in the manufacturing sector to meet new and emerging skill needs, consideration must be given to the requirements placed on new workers entering the manufacturing industry. Raising awareness of the changing nature of the industry and the new and emerging job roles and skills needed to undertake these roles will help to attract a diverse pipeline of potential recruits. Further, as illustrated in Figure 9, though still dominant, traditional Certificate-level qualification pathways into manufacturing job roles are decreasing, with the demand for higher level qualifications growing. Therefore, new entrants should be sought from a range of education and training backgrounds.

42. The University of Melbourne. (n.d.) *Micro-credentialing* [Online]. Available at: https://about.unimelb.edu.au/teaching-and-learning/innovation-initiatives/pedagogy-and-curriculum-innovation/micro-credentialing [Accessed 5 April 2019].

Figure 9: Proportion of manufacturing employees with tertiary education qualifications[43]



Steps can also be taken to support the development of knowledge and interest in the manufacturing industry from a young age. More can be done throughout the entirety of the education and training system to encourage learners to prepare for an economy and workforce that will be driven by Industry 4.0 technologies, innovations and principles. This drive to encourage early exposure to the manufacturing industry and Industry 4.0 ways of working can be seen in the 'Maker Movement' in the United States.[44] The movement enables students to engage with digital tools and technologies from an early age, thereby promoting interest in careers that draw on these skills.

Creating industry-led training

For both new entrants to the manufacturing workforce and the upskilling of existing workers, education and training must be appropriately aligned to industry practices within the manufacturing workplace. To enable this, employers, peak employer associations, unions and education organisations must be involved in the co-design, development and ongoing updating of education and training standards and programs.

The notion of industry-led training is well established in the VET sector, with VET qualifications designed in line with job roles. Under the Training Package Development and Endorsement Process Policy,[45] training products – qualifications and units of competency – in the VET system are frequently reviewed for industry currency and relevance, with significant emphasis placed on consultation with industry to understand whether training standards are up-to-date and relevant to current and future job roles. However, this process for creating and reviewing training products can be time consuming and lead to speed-to-market issues.

This can be problematic when new technologies emerge in an industry and quick development of training is required to ensure learners have the appropriate skills for the workplace. Mechanisms to create education options at all levels that adequately balance quality and reflect contemporary industry practices with speed-to-market need to be refined.

Supporting workers transition out of the industry

A potential outcome of the structural transformation of manufacturing businesses and the workforce may be the transition of workers out of the industry or to different manufacturing organisations through redundancy programs. Upskilling workers before they leave an organisation, or the industry as a whole, can play a key role in ensuring individuals are best placed to embark on a new career and reduce the likelihood of long term unemployment for those individuals. Supporting successful transition out of the industry for workers is also an important factor in tackling broader perception issues the industry faces. Successful transitions demonstrate that there are pathways into and out of the manufacturing industry, with the industry facilitating the development of common skills.

43. Australian Bureau of Statistics. (2006) *Australia (POW), INDP Industry of Employment, QALLP Non-School Qualification: Level of Education.* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019]; Australian Bureau of Statistics. (2011) *Australia (POW), INDP Industry of Employment, QALLP Non-School Qualification: Level of Education.* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019]; Australian Bureau of Statistics. (2016) *Australia (POW), INDP Industry of Employment, QALLP Non-School Qualification: Level of Education.* Available at: https://auth.censusdata.abs.gov.au [Accessed 29 January 2019].
44. The White House, President of Barack Obama. (2014) *Nation of Makers* [online]. Available at: https://obamawhitehouse.archives.gov/nation-of-makers [Accessed 9 April 2019].
45. Australian Industry and Skills Committee. (2016) *Training Package Development and Endorsement Process Policy* [online]. Available at: https://docs.education.gov.au/system/files/doc/other/training_package_development_and_endorsement_process_policy.pdf.

A holistic workforce transition scheme that drew on government, industry, union and education/training stakeholders was of critical importance in the automotive manufacturing industry when Ford, Holden and Toyota ceased large scale manufacturing operations in Australia. This process resulted in redundancies and the need to support workers to find new employment and career opportunities. A range of initiatives were developed to support workers in this transition, including a $155 million Growth Fund established by the Commonwealth Government and contributed to by organisations and State governments; for example, Toyota contributed $15 million to the Growth Fund.[46] A number of initiatives within the Growth Fund focused on supporting the reskilling of automotive manufacturing workers.[47] For example:

- **Skills and Training Initiative** – supported workers in the sector to engage in training and build capabilities; and provided assistance to have existing skills recognised.
- **Automotive Industry Structural Adjustment Programme** – provides assistance and career advice to automotive employees that have been retrenched; provides assistance such as resumé advice, interview skills and training to obtain licenses.[48]

The collaborative nature of the automotive manufacturing transition program, with engagement from government, trade unions and employers, demonstrates the roles organisations and bodies can play in supporting workers through transitions.

46. Australian Government, What's Next?. (n.d.) *Changing Lanes: Toyota* [online]. Available at: https://whatsnext.jobs.gov.au/toyota [Accessed 5 April 2019].
47. Australian Government, Minister for the Department of Industry, Innovation and Science. (2014) *$155 million to grow the jobs of tomorrow* [online]. Available at: http://minister.industry.gov.au/ministers/macfarlane/media-releases/155-million-grow-jobs-tomorrow.
48. Australian Government Business. (2018) *Automotive Industry Structural Adjustment Programme* [online]. Available at: https://www.business.gov.au/Assistance/Automotive-Industry-Structural-Adjustment-Programme [Accessed 5 April 2019].

2.3. Finding 3: Internal business culture and ways of working must be strengthened

Internal manufacturing business culture, ways of working and practices will be critical in ensuring successful transformation to the Industry 4.0 environment. Appropriate consultation, time, consideration and support must be given to ensuring workers understand the transformation that is taking place within their workplace and industry, why it is necessary, and the implications for their job role and future.

Fostering a positive internal culture

Given the findings above describing the changes to job roles, working environments, tools, technologies and skills needed as a result of the adoption of Industry 4.0, manufacturing businesses and workers are experiencing a period of tremendous change. This may cause apprehension and anxiety for individuals affected, necessitating an approach that requires meaningful consultation between employers, employees and the unions that represent them.

To encourage worker and business engagement in this environment, internal organisational culture will be of paramount importance. This was highlighted in the survey, with 91 per cent of respondents commenting that internal culture is key to the successful implementation of principles and practices of Industry 4.0.

A positive and agile internal culture can be fostered in a number of ways depending on the specifics of the business. However, clear and transparent communication with employees must be central to any strategy for culture change and improvement. This needs to start at the top with demonstrable commitment from all levels of leadership and management, with employees enabled to take part in active consultation. Manufacturing businesses must ensure employees understand the changes taking place and the rationale for these changes. Workers should be further supported with an understanding of what their role will be as the business develops, and how their knowledge and experience will be drawn upon in the new environment.

CASE STUDY:

Auckland Council RPA

Auckland Council began implementation of Robotic Process Automation (RPA) technology in 2018. The Council was proactive and transparent in communicating the RPA process to employees and ensured that the change management and HR process began before any automation was undertaken. This supported the development of a positive mentality amongst employees towards automation and helped them to be receptive and open minded about the RPA process when it commenced.

The Council also encouraged employees to see the automation process as an opportunity for career and skill growth. In accordance with an opportunity-driven mentality, a competency framework was developed to map employee capabilities and identify gaps in skills. This was paired with on-the-job and free online training to build the skills of employees to undertake new tasks and/or transition into new job roles.

Key learning:

Management need to be open with employees and communicate the changes that are taking placing in their business/organisation. Employees should also be encouraged to see transformation as an opportunity and be supported by management to make the most of emerging options.

Benefits:

Operational efficiency | Workforce development | Workplace support | Education and Training

This process should begin prior to the implementation of new technologies and processes, to allow workers to become comfortable with the parameters of change. The success of this approach was evident in the RPA transformation of the Auckland Council in 2018.

Creating a digital culture and digital ways of working

The adoption of Industry 4.0 technologies will necessitate a greater reliance on and understanding of digital technologies and ways of working. The demand for digital skills and a digital culture is sought by industrial manufacturing organisations internationally, with PwC's 2016 Global Industry survey finding that the biggest challenge for industrial manufacturing companies is the absence of a digital culture and the right training, with 52 per cent of respondents putting it in their top three challenges.[49]

Consultation indicated that digital ways of working are relevant throughout a business, not only for workers that have traditionally engaged with digital systems, tools and processes. To achieve this, businesses must support the development of an internal digital culture, with workers encouraged and enabled to focus both on enhancing digital literacy and digital skills. Workers who have a stronger baseline of digital skills will be more confident and prepared to engage in workplaces that utilise Industry 4.0 technologies and processes.

Supporting an international mindset

Whilst Australia is the 20th largest export economy in the world, our manufacturing industry is in a trade deficit. In 2015, the total value of manufactured products imported was $246 billion, with the value of exports just under $100 billion.[50] Access to global markets encourages businesses to be more competitive and innovative and to adopt new technologies and ways of working. The Department of Foreign Affairs and Trade found that there is a correlation between trade and innovation, with findings from 2016-2017 indicating that "businesses that actively innovated were over twice as likely to export than businesses that did not actively innovate".[51] In light of these figures, manufacturing businesses should seek to foster an international mindset, particularly in regard to engagement in the export market. There is significant opportunity for international trade in the manufacturing space, with two thirds of global merchandise trade in 2015 comprised of manufacturing products, worth $12 trillion.[52]

CASE STUDY:

ANCA

ANCA is a leading Australian manufacturing business engaged in the production of CNC grinding machines, motion controls and sheet metal solutions. Despite being founded in Australia and maintaining the organisation's headquarters in Melbourne, the business primarily engages in the export, rather than domestic, market, with 99 per cent of ANCA products exported. This orientation towards the export market has resulted from market demands with the majority of customers operating outside of Australia. With the significant growth in the international market, ANCA has actively sought to position itself as a technology leader and develop a network of customers from a range of jurisdictions, including the UK, Germany, Korea, China and the USA. As ANCA produces a highly technical product, key to achieving success globally has been establishing strong local teams to ensure the customers always have access to the support they need. Engagement in the international market and listening to their customers' needs has given ANCA the opportunity to continually improve their technology and compete against businesses that operate in the heartlands of manufacturing, such as Germany. This has allowed ANCA to enhance operations and practices, with the business recognised in 2018 on the AFR's "Most Innovative Companies List".

Key learning:

Engagement in the export market can expose businesses to new ways of working and innovative practices.

Benefits:

Innovation | Growth | Workforce development

49. PwC. (2016) *Industry 4.0: Building the digital enterprise Industrial manufacturing key findings* [online]. Available at: https://www.pwc.com/gx/en/industries/industrial-manufacturing/publications/assets/pwc-building-digital-enterprise.pdf.
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51. Australian Government, Department of Foreign Affairs and Trade. (2018) *How trade benefits Australia* [online]. Available at: https://dfat.gov.au/trade/resources/Documents/benefits-of-trade-and-investment.pdf.
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3 Levers for change

3. LEVERS FOR CHANGE

Clear, practical information and advice is needed for all stakeholders that will play a role in encouraging and facilitating the transition of Australian manufacturing businesses and workers towards Industry 4.0. These stakeholders include Commonwealth and state governments, industry, trade unions, the education sector and broader society. The following recommendations identify ways in which this support and advice can be provided to businesses and the workforce.

It is noted that a cost-benefit and impact analysis has not been undertaken on the following recommendations. This section only seeks to propose practical steps forward to address the findings discussed and identify the required engagement of various stakeholders.

3.1 Recommendations

Recommendation 1:

Commonwealth Government to facilitate the development and release of a manufacturing Industry 4.0 strategy

The Australian manufacturing industry is evolving in the Industry 4.0 environment to meet challenges and take advantage of opportunities. Yet this evolution and growth is not widely understood, with people both within and outside of the industry unclear on the continued relevance of the manufacturing industry in Australia, the impact of Industry 4.0 on jobs in the sector and their role going forward.

There is a need for a whole of government Industry 4.0 strategy for the Australian manufacturing industry. This strategy should be at the national level to prevent siloed messaging and facilitate a coordinated approach to transformation. The strategy should be formulated involving all key stakeholders, with particular reference to businesses, education/research providers, and peak employee and employer bodies.

The strategy should encompass the following:

1. Demonstrate the ongoing relevance of the Australian manufacturing industry and present the economic case for a productive Industry 4.0-enabled manufacturing industry, and priority manufacturing sub-sectors.
2. Provide an overview of the value proposition for manufacturing businesses to engage with Industry 4.0 technologies and processes by quantifying the benefits and the return on investment.
3. Outline how Commonwealth, state and territory governments will support the development and maintenance of appropriate infrastructure, policies and standards to support an Industry 4.0-enabled manufacturing industry.
4. Establish Commonwealth, state and territory government strategic procurement targets that specify requirements for the engagement of local manufacturing businesses in relevant contracts of a certain scale.
5. Research mechanisms to foster collaboration between Australian manufacturing businesses and international counterparts, and identify processes to encourage manufacturing trade and the expansion of the Australian manufacturing export market.
6. Set the parameters of a communications campaign for the development of a positive narrative regarding the future of the manufacturing industry, providing reassurance around the continued relevance of job roles in the industry, and guidance on the changing skills needs.

Recommendation 2:

Establish a workforce transformation leadership program

Manufacturing leaders need to understand what the potential for disruption is within their business and respond in a proactive way that drives cultural and technological change. Central to the transformation should be the development of a workforce transformation and Industry 4.0 strategy for each business. The development of a strategy would assist businesses to articulate how Industry 4.0 technologies will be utilised and develop a strategic approach to workforce planning to facilitate this.

Navigating the technologically complex Industry 4.0 environment can be difficult, particularly for SMEs, and manufacturing business leaders should be assisted to develop the proposed strategies. Support could be provided through the instigation of programs, delivered locally, to educate leaders on Industry 4.0 and assist them to determine the implications for their own business and workforce. Programs could include the facilitation of sessions on Industry 4.0 technologies, strategic workforce planning, communication strategies and workshops on business strategy development.

This initiative, whilst potentially commissioned by government, could be designed and delivered outside of government by organisations such as education and training providers, peak bodies, unions, and/or businesses.

Recommendation 3:

Develop a new online portal that provides consolidated and easy to access information on government incentives and programs for manufacturing businesses

There are an increasing number of State and Commonwealth Government assistance programs that manufacturing businesses can access, such as the Entrepreneurs' Programme and training and mentoring programs delivered by education providers. A central portal should be developed that consolidates Commonwealth, state and territory government incentives. This would help businesses to find grants, programs and support applicable to their business, and easily access information such as monetary value and eligibility criteria. This 'single-source support' mechanism for programs and projects in the Industry 4.0 space is utilised in Germany, led by Plattform Industrie 4.0. The Plattform provides stakeholders with quick access to information and is "the central point of contact for interested individuals within and outside of Germany".[53]

In Australia, this consolidated view would provide insights into any gaps in the support system that need to be addressed, an element that may be missed with multiple systems. The database could be established and monitored by the Commonwealth Department of Industry Innovation and Science, and whilst initially centred on government initiatives, could evolve to include education and industry-led opportunities. An example of this style of portal already in use in Australia is the Australian New Zealand Clinical Trials Registry (ANCTR), which was established in 2005 with funding from the Commonwealth Government.[54] The purpose of the database is to raise public awareness of current clinical trials, facilitate trial participation, avoid research duplication, identify potential research areas, promote collaboration and improve trial quality.

53. Plattform Industrie 4.0. (2016) *Progress Report: April 2016* [online]. Available at: https://www.bmwi.de/Redaktion/EN/Publikationen/digitization-of-Industrie.pdf?__blob=publicationFile&v=3.
54. Australian New Zealand Clinical Trials Registry. (n.d.) *Frequently Asked Questions* [online]. Available at: http://www.anzctr.org.au/Faq.aspx [Accessed 5 April 2019].

The portal could also be supported through the nomination of an 'Advanced Manufacturing Advocate'. This type of role has existed previously, for example Bruce Griffiths was nominated to the Rail Supplier advocate role in 2009. The purpose of the advocate role was to champion change within the industry and generate financial support. An advanced manufacturing advocate could play a key role in shedding light on Australian manufacturing and the impact of Industry 4.0, as well as fostering a future-focused narrative for the industry.

Recommendation 4:

Create funding and accreditation models to support lifelong learning, reskilling and upskilling throughout the work lifecycle

A limitation of the current Australian post-secondary education and training system in terms of Industry 4.0 is that it has traditionally focused on long format qualifications, in relation to both funding availability and accreditation processes. Individuals seeking to upskill in order to develop new capabilities required by a changing or new job role will not necessarily need to undertake a whole qualification, only certain aspects. A type of shorter form credential that builds on a pre-existing qualification or set of skills is an attractive model from the perspective of the learner and the business. As there is currently limited funding and formal recognition attached to these types of programs, learners and employers can be dissuaded from undertaking them. Whilst some learners may embark on a further qualification, not all learners have the capacity, finances or desire to make this commitment and may avoid upskilling entirely.

Development of a funding and accreditation model that supports lifelong learning in Australia should be undertaken to support and encourage upskilling and reskilling by workers. It is acknowledged that a range of reviews (including of the Australian Qualifications Framework (AQF)) are currently underway. One of the discussion points in scope of the AQF review relates to possible avenues for acknowledgement of shorter form credentials in the AQF. Whether it is determined through this review that short courses should be housed within or outside of the AQF, a set of criteria should be developed so that short courses, regardless of format or naming convention, can be mapped to a commonly understood frame of reference. This would assist consistent delivery and assessment, as well as providing common certification or 'badging' so that learners can show accreditation for their study. Aligning the appropriate funding mechanisms and amounts will also be essential to address existing issues with incentives and to ensure financial viability of the model.

Recommendation 5:

Establish hubs for Industry 4.0 commercial manufacturing activity focused on priority industry sectors

Some Industry 4.0 technologies are expensive and much of that investment is required upfront. For example, an industrial-level 3D printer can be priced well into the hundreds of thousands of dollars. This may pose difficulties for businesses, particularly SMEs that do not have the capital to engage with the technology.

Hubs should be established in major urban centres to provide SME manufacturing businesses access to Industry 4.0 technologies for commercial purposes. This program should be focused on priority manufacturing sub-sectors to encourage and drive growth. There are several options for establishment:

- Peak bodies, governments and/or education institutions could fund the establishment of hubs and rent out the space to businesses.
- SMEs requiring similar technology/resources could form partnerships and pool resources to establish hubs together.
- A collaboration between the parties above.

Seed funding for these initiatives could stem from a range of sources, including government grants, research, industry and venture capitalist investment. Consideration could also be given to the introduction of lower interest rate loans for manufacturing SMEs, thereby allowing businesses to fund their own investments.

Recommendation 6:

Enhance the integration of manufacturing business supply chains through strategic procurement

The vast majority of manufacturing businesses in Australia are SMEs. This means they may be less exposed to Industry 4.0 technologies and practices and subsequently unaware of the opportunities available to their operations.

There is an opportunity to facilitate collaboration and learning through business-to-business exposure when business supply chains are integrated. Working together, businesses can see what works and can incorporate this into their own 'business-as-usual' ways of working. A larger 'prime' organisation can also help the smaller businesses in their supply chain in terms of supporting and delivering training and development, using the latest technologies and other performance improvement measures.

Strategic procurement – by governments, organisations and businesses – can be of particular success in facilitating this integration by mandating ongoing SME involvement in a larger business's manufacturing supply chain. Commonwealth Government procurement already engages in strategic selection, and policies should be developed at the state and national level for the engagement of SME Australian manufacturing businesses in contracts of a certain size.

Recommendation 7:

Continue to remove barriers between VET and higher education in Australia's tertiary education system to facilitate collaboration opportunities and seamless learner pathways.

The siloed structure of the Australian post-secondary education system can prevent effective collaboration between providers and the development of pathways for learners. In an Industry 4.0 economy, both post-secondary education and training options will be critical, therefore, methods to integrate the systems should be pursued.

It is recognised that a review of Australia's post-secondary education system has been proposed on a variety of occasions over the course of several years. For example, the 2008 Bradley Review noted, "There should be better connections across tertiary education and training to meet economic and social needs which are dynamic and not readily defined by sectoral boundaries."[55] However, despite this range of reviews, none have yet driven the necessary change to address this lack of cohesion.

The Industry 4.0 evolution provides the opportunity and necessary catalyst to fundamentally revamp the post-secondary approach to skills development in Australia. The basis of the review should be ensuring that all education and training prepares learners and students for future-orientated careers. This should include, but is not limited to: embedding STEAM (Science, Technology, Engineering, Arts and Mathematics) learning throughout all education and training; establishing better work integrated learning options; developing training options that are more suited to lifelong learning practices in which workers dip in and out of education and training throughout their careers; and building tangible and meaningful pathways for learners between vocational and higher education.

55. Australian Government, Department of Education, Employment and Workplace Relations, prepared by Denise Bradley, et. al. (2008) *Review of Australian higher education: final report* [online]. Available at: https://www.voced.edu.au/content/ngv%3A32134.

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