# ADVANCED MANUFACTURING A NEW DEFINITION FOR A NEW ERA



By focussing on innovation through R&D, use of state of the art technology and smart business models the AMGC has clearly demonstrated that a new Advanced Manufacturing future is within Australia's grasp.

Dr Keith McLean, Director Manufacturing, CSIRO

D+I believe that the future success of Australian manufacturing depends on its ability to embrace innovative design and technology. This report, and the work of the AMGC in general, provide valuable support and guidance for any manufacturer committed to implementing innovative design and technology in their business.

Murray Hunter, Founder, Design + Industry

AMGC debunks the gloomy prospects seen in mainstream media to provide with success stories, insights and paths for Australian manufacturers, no matter their size or sector. It gives the end-to-end supply chain the place it deserves as a value enabler that supports advanced manufacturing – in its modern definition.

Thomas Vandenbogaerde, Director, Freelog Australia Pacific

This report defining the meaning of Advanced Manufacturing is long overdue and lapplaud the initiative of the AMGC in tackling this project.

Geoff Crittenden, Chief Executive, Welding Technology Institute of Australia

We will not survive competing on cost & we will not survive competing amongst ourselves, but, we will thrive by aligning our excellence across the nation and competing on the global stage. The AMGC understands this and proactively connects and enables our pockets of excellence to advance and position the entire sector with this globally competitive edge.

Dr Nathan Kirchner, Future Robotics Lead, Laing O'Rourke – Engineering Excellence Group

The AMGC acknowledges input and support from the Australian Government Department of Industry, Innovation and Science for this report.

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This AMGC report provides more clarity by focusing on the niche manufacturing activities and the value add manufacturing service offerings that necessarily surround the production. I believe this broader and frankly more exciting narrative will capture the imagination of the current generation of Australian government and industry leaders, as well as the next generation of manufacturers.

Chris Williams, Managing Director, HiFraser Group

MHG Asia Pacific's vision is to manufacture a better tomorrow than today. It also speaks to the impact that a strong and vibrant manufacturing sector has on our nation's long term prosperity and the opportunities this creates for future generations. We applaud AMGC's efforts in this space and fully support the recommendations in this report.

Dean Haritos, Group Managing Director, MHGroup

I was very impressed with the depth of thought and coverage of the topic and especially how it relates to Australian Manufacturers.

The employment opportunities created within manufacturing and leveraged by training, consulting and marketing professionals will follow at a level commensurate with manufacturing growth.

Neil Wilson, Managing Director, Romar Engineering

CSR welcomes the AMGC initiative in defining a new era in which manufacturing in Australia adopts principles which reach well beyond just production. CSR is pleased to see that AMGC has recognised the importance of knowledge. CSR employees understand that knowledge is particularly beneficial when it is shared with our customers, our suppliers and the industry.

Bill Thompson, Research and Development Manager, CSR Building Products

An insightful report for manufacturers on where they should focus their business and digital transformation initiatives across the extended manufacturing value chain to become truly advanced, remain competitive and deliver new outcomes through the digital disruption cycle.

Bruce Sneddon, DXC Technology – Manufacturing

**Australian** manufacturing is larger and more diverse than thought

Supporting **1,27 million** jobs in both its workforce and the inputs it purchases



A manufacturer is more advanced when it uses



В

Advanced business models

[based on an analysis of 3,000 global companies]

Being advanced is not what a manufacturer makes, but how

**Australian** manufacturers need to compete on value, not

**On cost** 

**Investment in** innovation, modern machines and trade is highly concentrated

5% make up of companies

**99%** of the industry's export value

# Every single manufacturer in Australia has the potential to be advanced





# FOREWORD

When you ask ten people what is Advanced Manufacturing, you'll probably end up with eleven different answers. The team at the Advanced Manufacturing Growth Centre (AMGC) found it was about time to bring well substantiated clarity to the matter. With this report, *Advanced Manufacturing, a new definition for a new era*, we demystify what it means to be an advanced manufacturer.

One common misperception of our industry, supported by current measurements, points to a narrow view of advanced manufacturing and it excludes the so-called traditional sectors. However, backed by our analysis and reason, we can unequivocally argue that being advanced relies little on what you make but how you make it.

This report offers a comprehensive view on Australian manufacturing. We demonstrate that manufacturing is more than production. Manufacturing today comprises of R&D, design, supply chain and logistics, mass customised goods, post-sales support and services.

Australia has advanced manufacturers across the entire spectrum – from textiles to welding to medical technology and aerospace. Companies across all areas can innovate and compete through offering exceptional technical solutions or services, making them less dependent on pure production.

Our sector has grown to almost 1.3 million manufacturing employees, representing close to 10 per cent of the Australian workforce when considering the entire value chain of manufacturing activities.

We believe that transforming our industry to become more advanced must be led by industry. Transformation can be achieved through implementing one or a combination of the following traits:

Advance knowledge: continuously innovate with a high degree of R&D investment.

**Advance process:** focus on using state-of-the-art technology, become familiar with digitalisation.

Advance business model: offer niche solutions, often highly customised and highly valuable.

A consistent theme throughout this report echoes our earlier research, the AMGC's 2017 *Sector Competitiveness Plan* – to compete on value, not on cost. Our definition of advanced manufacturing reinforces this message.

A new era of manufacturing requires a new definition to accurately measure where we stand and how we benchmark our progress. We have learnt through our analysis that our sector is larger and more dynamic, yet there remains ample opportunity to grow.

I believe this report captures the true nature of our sector and celebrates the potential for every Australian manufacturer to be advanced.



**Dr Jens Goennemann Managing Director** Advanced Manufacturing Growth Centre Ltd



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# **EXECUTIVE SUMMARY**

### **INTRODUCTION**

Manufacturing is undergoing a historic transformation across the industrialised world. Firms are creatively diversifying their focus across different stages of the manufacturing process, both before and after goods are produced. As production activities are gradually being outsourced to developing countries offering cheap labour, more Australian manufacturers are recognising the need to compete on value rather than cost. Most commonly, this involves contributing innovative products, components or services within global supply chains.

It is against this background that AMGC seeks to provide a more contemporary understanding of manufacturing in Australia and to clarify the definition of an 'advanced manufacturer'. Building on the directions contained in AMGC's Sector Competitiveness Plan, this will more accurately capture the sector's overall role in Australia's economy and form a credible basis for ongoing policy, regulatory and funding reform. AMGC is also keen to guide local firms seeking to reinvent themselves and seize new opportunities along the value chain. Every single manufacturer in Australia has the potential to be advanced.

### **TOWARDS A NEW DEFINITION**

Advanced manufacturing is currently defined by the Australian Government as "any manufacturing process that takes advantage of high-technology or knowledge-intensive inputs as an integral part of its manufacturing process". The Government further stipulates that advanced manufacturing includes chemical and medicinal manufacturing, as well as vehicle and transport, professional and scientific equipment, computer and electronic, and specialised machinery and equipment manufacturing. However, AMGC's analysis of more than 3,000 global manufacturing companies finds that belonging to a certain sub-industry, whether or not it is officially classified as 'advanced', says little about a company's ability to complete and remain profitable in an increasingly challenging market environment. This means it may be time to update and expand the current definition of what it means to be an advanced manufacturing firm. A starting point would be to recognise that manufacturers across the developed world succeed not because they make certain products, but because they have adopted sophisticated business models and production techniques. They typically use a combination of three factors to remain competitive: advanced knowledge, advanced processes and advanced business models.

A new, broader definition of advanced manufacturing would focus on the sophistication of businesses, rather than on the products they make. It would emphasise that there is no hard line separating advanced manufacturers from others and recognise that there could be degrees of advancement in every single sub-industry, not just in some.

Under this new approach, an apparel manufacturer, a typical business operating outside the ABS' current classification of "advanced manufacturing" industries, could still be considered advanced if it employs innovative production techniques and business strategies. For example, a manufacturer that uses 3D printing technology, a high level of automation, or customises its products to a niche market segment would - under the new definition proposed in this report - gualify as an advanced manufacturer. Another benefit of defining manufacturing more broadly is to include workers along the value chain in research and development (R&D) and design, logistics, and sales and service occupations. These are people who serve manufacturing indirectly but are now employed in supporting companies. Properly accounting for them increases the size of Australia's direct and indirect manufacturing workforce to an estimated 1.27 million: significantly more than the 905,000 currently counted by the Australian Bureau of Statistics (ABS).

### THE CHARACTERISTICS OF SUCCESSFUL MANUFACTURERS

Chapters 2 to 4 of this report translate this revised understanding of manufacturing into practical guidance for Australian firms and government. Using the latest Compustat and ABS Business Longitudinal Analysis Data Environment (BLADE) business survey data, AMGC's analysis of successful global and Australian manufacturers finds they share a range of advanced characteristics.

- Advanced knowledge: successful manufacturers, tend to be innovation leaders, scoring highly on measures such as R&D spending, information and communication technology (ICT) intensity, patent portfolio size, employee qualifications and research collaboration.
- Advanced processes: many successful manufacturers are also *process winners* who make smarter use of technology, scoring highly on measures such as capital intensity, use of automation, energy and water efficiency, and having newer equipment.
- Advanced business models: finally, successful manufacturers tend to lift the value of their products by acting as *niche market players* or *service champions*, scoring highly on measures such as trade intensity, linkages with other firms and greater share of services in total revenue.

### **RECOMMENDATIONS FOR COMPANIES**

The development of an empirically robust profile of successful manufacturers should significantly inspire Australian firms. There is a golden opportunity to pick one or more areas of focus and seek to advance by emulating best practice traits. Manufacturers should closely examine their current business models, strengths and growth prospects. AMGC's qualitative and quantitative research further indicates that they would do better to concentrate on improving their performance on a small number of advanced metrics, rather than progressing on all characteristics simultaneously.

Most Australian manufacturers have considerable room to grow in developing advanced characteristics. Currently, just 5% of firms drive 94% of the sector's entire capital spending and 54% of its entire R&D spending. This group are responsible for virtually all the nation's manufacturing exports. BLADE data covering the 2014–15 period further shows that upwards of 80% of Australian manufacturers could break new ground to collaborate with academic researchers, increase their ICT spend, introduce a new product-related service or use patents to protect their novel ideas.

Currently, just 5% of firms drive 94% of the sector's entire capital spending and 54% of its entire R&D spending.

### RECOMMENDATIONS FOR GOVERNMENTS

It is vital that Australia moves boldly into a future typified by sustainable, high-value-added manufacturing. The nation must also accurately monitor the impact of manufacturing activities on other industries in an increasingly service-based economy. Based on the findings contained in chapters 1 to 3, AMGC recommends three urgent actions:

- Developing a new statistical tool to track whether Australian manufacturers are advancing. Alongside traditional metrics such as output, jobs and exports, this would monitor short- and medium-term changes in the prevalence of key advanced characteristics among Australian firms, such as R&D intensity, patent use, collaboration, relative wage levels, ICT expenditure, capital intensity, new goods or services, new marketing or operational processes, and trade intensity.
- Changing how Australia's manufacturing output and jobs growth are reported. Official data on Australian manufacturing should fully capture all activities linked to the sector, instead of disaggregating the value chain and counting ancillary functions as part of 'services'. The United States Bureau of Labor Statistics, which constructs annual employment tables for 168 sub-industries, provides an example of how to measure manufacturing jobs and

output that are created both directly and indirectly.

Better target industry assistance. Governments should ensure that business capability-building initiatives are designed to increase the prevalence of traits associated with more advanced and successful companies. Evaluation criteria should be adjusted accordingly for programs offering financial incentives or support. Initiatives that could be better targeted include the Entrepreneurs' Programme; Industry Skills Fund; Education and Training Advisors; Innovation Connections; the R&D Tax Incentive; the Cooperative Research Centres Programme; the Tradex Scheme; venture capital programs; and state-based industry assistance funds.

# 1 AUSTRALIAN MANUFACTURING TRANSFORMS

### **1.1 OVERVIEW**

Manufacturing is undergoing a historic transformation across the industrialised world. Instead of mass-producing identical factory lines of finished goods, firms are contributing specific components that are then assembled by others in complex and global supply chains. Work practices are also changing rapidly in the digital age, exemplified by innovative techniques such as 3D printing. Importantly, manufacturers are diversifying so they can add value at different stages of the manufacturing process, both before and after goods are produced.

It is against this background that AMGC seeks to provide a more contemporary understanding of manufacturing in Australia and provide clarity to the definition of an 'advanced manufacturer'. This will help governments and the public better recognise the manufacturing sector's overall role in Australia's economy and its contribution to innovation. Building on the directions contained in AMGC's Sector Competitiveness Plan, it will also form a credible basis for ongoing policy, regulatory and funding reform. Given its strong commitment to industryled transformation, AMGC is keen to guide local manufacturing companies that are looking to reinvent themselves and seize new opportunities beyond the production line. This is by no means an exclusive category. Every single manufacturer in Australia has the potential to be advanced.

Using the latest Australian labour market and business survey data, this chapter examines the challenges involved in defining manufacturing and why a new understanding is needed to capture the full extent of the sector's activity.

### **1.2 THE CURRENT DEFINITION**

The Australian Government, including both the ABS and the Department of Industry, Innovation and Science, currently defines advanced manufacturing by "two 'input' proxies for 'advanced' which were the relative Research and Development and skill level intensity of each sub-sector". In particular, the definition stipulates that advanced manufacturing includes chemical and medicinal manufacturing, as well as vehicle and transport, professional and scientific equipment, computer and electronic, and specialised machinery and equipment manufacturing.<sup>1</sup>

This definition has an opportunity to reflect the transformation taking place across the entire manufacturing sector by being more inclusive of manufacturers exhibiting advanced characteristics. Currently, the ABS definition consists of entities that operate within a few Australian and New Zealand Standard Industrial Classification (ANZSIC) codes defining manufacturing sub-industries as 'advanced' depending on what the manufacturer produces specifically. Considering the manufacturing transition, these categories can expand and include successful Australian manufacturing companies with advanced characteristics operating in a variety of industries. For example, aerospace manufacturing is classified as 'advanced' due to its highly technical product, while apparel manufacturing, not currently included in the ABS, could be added due to its advanced processes.

As shown in Exhibit 1, AMGC's analysis of more than 3,000 global manufacturing companies illustrates that belonging to

 Australian Bureau of Statistics, Characteristics of Businesses in Selected Growth Sectors, Australian 2013–14, Catalogue No: 8170. Available at: http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/8166.0.80.001Main%20Features22013-14?opendocument&tabname=Summary&prodno=8166.0.80.001&issue=2013-14&num=&view=. a certain sub-industry, whether or not it is typically regarded as 'advanced', says little about a company's ability to compete and remain profitable in an increasingly challenging market environment.<sup>2</sup> For example, research into what constitutes a 'successful' company shows that only 4% of global manufacturing companies in the electrical equipment sub-industry would be considered highly competitive, even though many people might associate this industry with high-tech products and think of it as 'advanced' (see Chapter 2 for further discussion). By contrast, 13% of companies involved in textile milling and 10% of apparel manufacturers rank highly on this metric of success, even though both sub-industries were not classified as w'advanced' by ABS standards.

#### Exhibit 1

#### There are successful international manufacturers across all industries

#### Our analysis shows successful manufacturers in almost every manufacturing sub-industry

Fraction of sub-industry in top quartile of total factor productivity\* Percentage of sub-industry

'Manufacturing' industries in ABS definition 'Advanced' industries in ABS definition Petroleum and coal products 48 Beverages and tobacco 21 Textile mills 13 Food 11 Apparel 10 Leather products 6 Non-metallic mineral products 6 Primary metals 3 Fabricated metal products 3 Plastics 2 Paper 2 Textile product mills 0 Wood products 0 Printing 0 Furniture 0 Computers and electronics Chemical 16 Misc (inc. med equip.) 13 Machinery 12 Transportation 8 Electrical equipment 4

\* Calculated by determining total factor productivity for each firm, disaggregating into quartiles and selecting all firms in the top quartile. The fraction of firms in each sub-industry that fell in this top quartile was then determined.

Source: Compustat. Analysis conducted by AlphaBeta Advisors and McKinsey & Co. May 2017.

2 This analysis was based on the Compustat database of around 3,000 global manufacturing companies. See the Appendix for more information about the methodology.



# 1.3 MORE THAN PRODUCTION

A crucial consideration in defining advanced manufacturing is that the sector, particularly in industrialised economics, now covers a much broader range of activities than production alone.

As shown in the so-called 'smiley curve' (Exhibit 2), the traditional assembly line is becoming disaggregated as global systems integrators outsource key functions and individual firms move to specialise along different parts of the manufacturing process. In this fast-changing landscape, the key opportunity for manufacturers is to offer differentiated value propositions both before and after goods are produced – and to feed distinctive products, components and services into global supply chains.

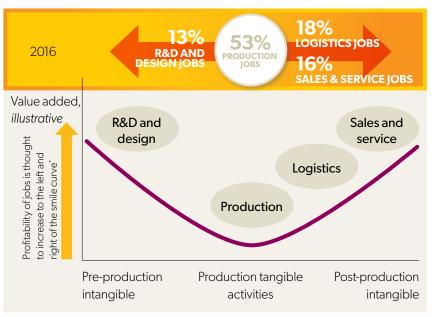
Digital innovations such as 3D printing, which allows goods to be produced anywhere at any time, overlay the new

manufacturing value chain and are accelerating the reinvention of the assembly line. Industry 4.0 technologies denote a broader paradigm shift in which intelligence and machine learning are embedded across the entire manufacturing cycle.

In the pre-production stages, manufacturers can contribute value through research and development (R&D) or complex planning and design work. In the post-production phase, they can contribute value-adding services that support or complement products and help establish long-term relationships with customers. This shift to 'manufacturing as a service' involves focusing on customer needs, potentially by providing a capability or solution rather than just selling physical goods. For example, General Electric (GE) uses a software platform to collect real-time data from aeroplane engines. This helps pilots maximise fuel efficiency based on insights from sensors that log vast quantities of data on every flight.

### Exhibit 2

# Nearly half of jobs in Australian manufacturing are outside production roles



Note: The estimates employment in supporting industries, which was estimated using input-output tables provided by the ABS. \*Adapted from Stan Shih's smile curve Source: ABS, US Bureau of Labor Statistics, analysis conducted by AlphaBeta Advisors. May 2017.

Several industrialised, higher-wage economies such as Germany, Japan and South Korea have made the leap to becoming advanced manufacturing nations that do not simply rely on mass production. Within these countries, 85-90% of total national R&D funding by all businesses in their economy is spent within the manufacturing sector.<sup>3</sup> No longer as competitive at hiring low-skill labour, these countries have shifted to using a higher skilled workforce and more efficient technologies.<sup>4</sup> The challenge for Australia, where manufacturers only funded about 27% of total national R&D investment in 2013–14<sup>5</sup>, is to replicate this success. This will be achieved by transitioning from a cost-based model of competitiveness to one that seeks to one that seeks to differentiate on value.<sup>6</sup>

- 3 Organisation for Economic Co-operation and Development, *OECD Science, Technology and Industry Outlook 2014.* Available at: http://www.oecd.org/science/oecd-science-technology-and-industry-outlook-19991428.htm
- 4 CEDA, 2014, Advanced Manufacturing: Beyond the production line. Available at: http://www.ceda.com.au/Research-and-policy/All-CEDA-research/ Research-catalogue/Advanced-Manufacturing-Beyond-the-production-line
- 5 Australian Department of Industry, Innovation and Science, Manufacturing Data Card September Quarter 2015.
- Available at: https://industry.gov.au/industry/ManufacturingPerformance/Pages/ManufacturingDataCard.aspx#.
- 6 For further background on value differentiation, see the Advanced Manufacturing Growth Centre's Sector Competitiveness Plan 2017, Taking Australian Ingenuity to the World. Available at: https://www.amgc.org.au/Attachment?Action=Download&Attachment\_id=15

### 1.4 BROADENING THE SCOPE

A revised definition of advanced manufacturing must begin with the understanding that manufacturers in Australia and other industrialised countries today succeed through a combination of three factors: advanced knowledge, advanced processes and advanced business models (the evidentiary basis for this finding is established in Chapter 2). This might make it possible to consider an apparel manufacturer advanced when it uses high levels of automation or unique materials, or customises its offerings to suit a niche market segment. For example, the Australian company Dresden Optics can customise reading glasses in-store using 3D printing prototypes and advanced and recycled materials.

Ending the focus on sub-industries would conclusively establish that every Australian manufacturer, large or small, has the potential to become more 'advanced', irrespective of what they deliver. It would also make it clear that there is no hard line separating advanced manufacturers from others. In fact, it is helpful to think of all companies moving along a continuum from less to more advanced as they employ a range of techniques and strategies adapted to their circumstances. The destiny of manufacturers is not static; each can aspire to continuously improve processes and evolve business models.

### 1.5 ACCURATELY MEASURING MANUFACTURING ACTIVITY

Another benefit of embracing a more encompassing understanding of manufacturing is being able to identify the full contribution of the sector. According to official ABS labour market data, Australian manufacturing directly employs 905,000 people in industries involving production such as aerospace parts, furniture and food.<sup>7</sup> However, as noted above, the trend for companies to specialise within global value chains and outsource non-core functions mean that many workers who might once have been directly employed by manufacturers are now employed in supporting companies.

These indirect jobs cater to demand for services related to direct manufacturing activity, and include roles across sectors such as retail, logistics and professional services.

7 Australian Bureau of Statistics, Detailed Labour Force, cat no 6291.0.55.003, May 2017. Available at: www.abs.gov.au/ausstats/abs@.nsf/ mf/6291.0.55.001.



# AUSTRALIAN MANUFACTURING TRANSFORMS

For example, manufacturing companies, which purchase professional services worth around \$14 billion annually, help sustain the equivalent of 53,000 professional services jobs, many of which were previously counted as manufacturing jobs. Some manufacturers outsource cleaning work to building management companies, while others hire visual designers to create virtual diagrams of product prototypes. Manufacturing companies once hired these people directly, and they would be indistinguishable from other employees. Now they are employed by non-manufacturing companies contracted to provide services to manufacturers, and are thus excluded from official estimates of the sector's size.

These additional workers, who represent an estimated 360,000 people, or almost 30% of the total manufacturing workforce, are critical to the Australian manufacturing sector.<sup>8</sup> Adding this to the ABS count of 905,000 manufacturing employees, it is more accurate to state that the Australian manufacturing sector employs 1.27 million people directly and indirectly (see Exhibit 3).

AMGC's analysis shows that almost half (47%) of Australia's manufacturing workforce is employed in jobs related to R&D, design, logistics, and sales and service functions, as opposed to core production roles.<sup>9</sup> This can be broken down further as follows:

- R&D and design-related occupations such as materials engineers, chemists, graphic and product designers, and lab assistants, account for 13% of jobs in manufacturing. These are the employees who help identify what new products to make and how to make them.
- Logistics occupations such as purchasing managers, crane operators and packagers, account for 18% of the workforce and are key to connecting the Australian manufacturing sector with its markets and global supply chains.

Sales and service occupations such as telemarketers, customer service assistants, sales managers and product trainers, account for 16% of the workforce. These people are tasked with finding markets for their employers' goods, and they incorporate client feedback into the design and product development processes.

It quickly becomes clear that manufacturing involves many more roles than those undertaken by workers and machines on the factory floor.

### **SUMMARY**

- Manufacturing is undergoing a historic transformation across the industrialised world.
- A more expansive definition of manufacturing activity is required that captures the ability of firms to contribute at different stages of the value chain, not only production, irrespective of what sub-industry they belong to.
- This new understanding is vital to establish the true contribution of Australian manufacturing today, reflected in employment numbers and output in the economy.

<sup>8</sup> Indirect employment was calculated as part of this analysis, based on ABS input and output tables, and the average labour productivity of each industry.

<sup>9</sup> As part of the analysis conducted for this paper, more than 400 occupations were classified across four occupational categories: R&D, production, logistics, and sales and service. Some occupations can be easily positioned on the value chain. For example, a machinist sets up and operates tools to produce parts and instruments, which places them in the production category. Other occupations are more difficult to classify because they involve multiple parts of the value chain. For example, a mechanical engineer might work in technology research and development, but also be directly involved in the manufacturing process. Where necessary and reasonable, such occupations were allocated proportionately across different components of the value chain.

Manufacturing wholly supports ~1.27 million jobs in Australia; of which ~30% are outside manufacturing in industries providing direct inputs

### Manufacturing directly employs 867,400 workers in manufacturing classified sub-industries

Number of workers employed within manufacturing industries ('000)



Note: Indirect employment was calculated using input-output tables and the average labour productivity of each industry. Source: ABS and analysis conducted by AlphaBeta Advisors. May 2017.

### Manufacturing indirectly supports 360,000 workers outside manufacturing

56

53

54

53

Number of workers employed providing direct inputs to manufacturing ('000)

# 2 THE CHARACTERISTICS OF SUCCESSFUL MANUFACTURERS

### 2.1 OVERVIEW

Chapter 2 of this report is designed to translate a revised understanding of manufacturing into practical guidance for Australian manufacturers. It does this by studying the characteristics of global and Australian firms which have made the transition to become more advanced. Using the latest data from Compustat and the ABS Business Longitudinal Analysis Data Environment (BLADE), the most competitive manufacturing companies around the world were screened to identify any similarities in the way they succeed. Findings from this global study were then tested against Australian manufacturers.<sup>10</sup> (See Box A for more details on methodology).

### Box A – Methodology

The investigation involved:

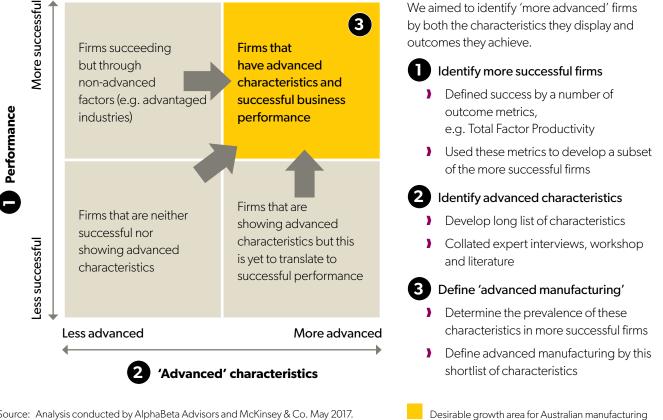
- developing a long list of business features typically associated with 'advanced' manufacturing, drawing on extensive interviews with industry experts, a literature review, and workshops conducted with the Department of Industry, Innovation and Science. The research team then narrowed down the list for feasibility of inclusion in empirical analysis.
- 2. constructing a model of 'success' against which the team ranked a sample of 3,040 global manufacturing companies in the Compustat database.<sup>11</sup> Success was defined by several outcome-based metrics including total factor productivity, gross margin, return on investment, earnings before interest and tax (EBIT) margin, and labour productivity.
- 3. analysing the extent to which these global manufacturing companies displayed business features commonly associated with being more advanced. This allowed the researchers to create a short list of the most effective advanced characteristics that differentiate top performing international manufacturers from their less successful peers.
- 4. testing the characteristics found in the global data against Australian data, using BLADE.

<sup>10</sup> To check if global findings are applicable in Australia, the analysis drew on data from BLADE with a sample size of roughly 50,000 Australian manufacturing companies from across all industries.

<sup>11</sup> Compustat is a database of financial, statistical and market information on global companies, provided through S&P Global Market Intelligence. Available at: http://marketintelligence.spglobal.com/client-solutions/.

### Our methodology for defining advanced manufacturing combines both 'advanced' characteristics and successful performance

#### **Spectrum of Australian manufacturing firms**



Source: Analysis conducted by AlphaBeta Advisors and McKinsey & Co. May 2017.

12 Based on the Commonwealth Department of Industry, Innovation, and Science's definition of innovation. Available at: https://www.business.gov.au/info/run/research-and-innovation.

# THE CHARACTERISTICS OF SUCCESSFUL MANUFACTURERS

## 2.2 CHARACTERISTICS OF GLOBAL ADVANCED MANUFACTURERS

AMGC's analysis reveals that the most successful global manufacturers share a range of advanced characteristics, broadly fitting into three categories: advanced knowledge, advanced processes and advanced business models (see summary in Exhibit 5).

### Advanced knowledge

# Business characteristics of companies with advanced knowledge

- > Higher spending on R&D
- Higher information and communication technology (ICT) intensity
- ) Larger patent portfolio
- More collaboration with research institutions
- More collaboration with other manufacturers
- > Higher relative salaries and wages
- > Better qualified employees
- More staff with science, technology, engineering and maths (STEM) skills

Above all, successful manufacturers are often 'innovation leaders', as companies that use specialised skills and R&D investment to develop products with distinctive value.<sup>12</sup> These manufacturers know that the strength of the product depends on investing in the development of cutting-edge products and technologies, and the originality of staff members' ideas. They are also more likely than their less-competitive peers to hire more highly paid workers who are better qualified in STEM disciplines. The R&D intensity of these manufacturers (their ratio of R&D spending to sales) is more than three times greater than those of their less successful peers, and their patent portfolios are 1.75 times larger. In addition, these companies are more likely to collaborate closely with research institutions and other firms that belong to related value chains.

#### Advanced processes

# Business characteristics of companies with advanced processes

- ) Greater capital intensity
- ) Newer equipment
- More automation
- Smarter inventory management
- Better energy efficiency
- Better water efficiency

Many successful manufacturers are also 'process winners'. They make smarter use of technology, so they can operate with greater capital intensity. For example, a manufacturer may deploy robots to complete repetitive and routine tasks. Research shows that successful companies have an automation rate on average 1.3 times greater than that of less successful companies. In addition, their capital efficiency is on average 1.6 times greater, and they use new equipment on average 1.5 times more often than their less successful counterparts. Top-performing manufacturers also tend to use water and electricity more efficiently, which helps them to lower overall production costs and be more sustainable in the long run.

#### Advanced business models

# Business characteristics of companies with advanced business models

- Higher product value density (by weight)
- > Higher marketing expenditure
- ) Higher trade intensity
- More extensive backward links
- > Larger geographical reach
- ) Greater share of services in total revenue

Successful manufacturers tend to lift the value of their products by carving out a distinctive place as either 'service champions' or 'niche market players'. These manufacturers differentiate themselves from their low-cost, high-volume peers by offering more personalised products and customised services, claiming a share of services 1.08 times greater than their lower performing competitors. In addition, they tend to sell products at higher prices for given weights, with a 'price density' 1.09 times greater than that of lower performing peers.

#### Exhibit 5

### Top international manufacturers use advanced knowledge, processes and/ or business models

Ratio of median of more successful to less successful international manufacturing firms\*

# Average prevalence of characteristic in more successful firms where success is measured by total factor productivity and gross margin $^{\dagger}$

	R&D intensity	3.17
	Patent portfolio	1.75
	Wage level‡	1.06
Advanced knowledge	Employee qualifications <sup>‡</sup>	1.12
	STEM skill intensity <sup>‡</sup>	1.09
2 Advanced processes	Capital efficiency Young capital equipment Automation Energy efficiency <sup>‡</sup>	1.30 1.25
3	Water efficiency <sup>‡</sup>	1.25
Advanced business models	Price density Share of services	1.09 1.08

\* Where more advanced is classified as top quartile in the total factor productivity or gross margin metric and less advanced is bottom quartile.

† Ratio shown is an average of the ratio using total factor productivity and then gross margin.

‡ Metrics calculated using the average of the sub-industry classification values.

Source: Manufacturing firms in the Compustat database. Analysis conducted by AlphaBeta Advisors and McKinsey & Co. May 2017.



# 2.3 CHARACTERISTICS OF AUSTRALIAN ADVANCED MANUFACTURERS

AMGC's analysis finds that Australian manufacturing champions share many of the features of globally successful manufacturing firms (see summary in Exhibit 6).<sup>13</sup>

- Advanced Australian knowledge. Australia's most successful manufacturers, like top performers globally, tend to employ more workers with crucial STEM skills. These companies also work continuously on innovations to improve product offerings. For example, analysis (see Exhibit 6) shows that the most successful Australian manufacturers invest on average 1.24 times more in R&D than less-successful companies. They also pay salaries and wages that are on average 1.28 times higher than those offered by less-successful peers, making them more likely to attract the best and brightest talent.
- Advanced Australian processes. Australia's most successful manufacturing businesses focus on using state-of-the-art technology. They invest heavily in information and communication technology (ICT), as well as new operational processes. They are among the pioneers using Industry 4.0 technologies to prepare for the automation age.<sup>14</sup> These process winners on average invest 1.27 times more in ICT and other modern technologies than their less-successful peers, and are 1.29 times more likely to introduce new operational structures.
- Advanced Australian business models. Some of the most successful Australian manufacturers are service champions that add value to their products by bundling them with services. This strategy allows them to cover a wider range of customer needs and unlock fresh revenue streams from activities beyond core production, such as design, customisation, training, repair, maintenance and customer support. Specifically, the analysis found that successful Australian companies are on average 1.34 times more likely than their less successful peers to offer novel goods or services. It also found that Australia's most successful manufacturers are on average 1.19 times more likely than their less-successful counterparts to engage in global trade. These companies often succeed as niche players, exporting highly customised and highly valuable products and services into specialised or underserved markets.

13 Success is measured by labour productivity.

14 Typical technologies associated with Industry 4.0 are those that integrate automation, digitisation and data analysis.



# Success in Australian manufacturing is less about what you make and more about how you run your business – with 14 characteristics strongly linked to success

Ratio of median of more successful to less successful international manufacturing firms\*



\* Where more advanced is classified as top quartile in labour productivity and less advanced is bottom quartile.

† Census dataset

Source: BLADE, analysis conducted by AlphaBeta Advisors. May 2017.

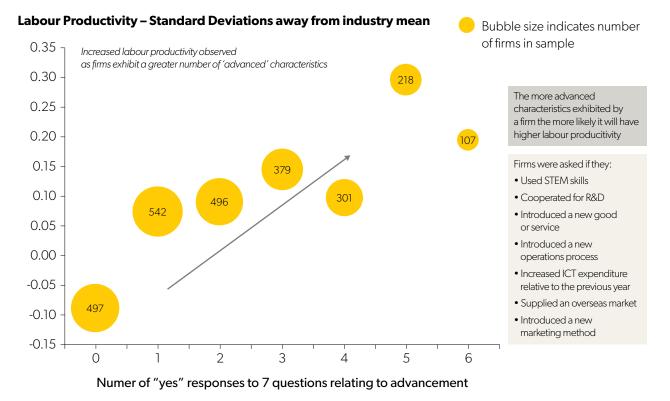


# THE CHARACTERISTICS OF SUCCESSFUL MANUFACTURERS

AMGC's overall observation is that the more advanced an Australian manufacturer, the better its business prospects. For example, a company that exhibits many 'advanced characteristics' is likely to have higher labour productivity than a company displaying fewer advanced characteristics, where labour productivity is a measure of success.<sup>15</sup> This difference in labour productivity can be substantial (see Exhibit 7). For example, companies exhibiting one or more of these advanced characteristics display higher labour productivity compared to companies displaying fewer characteristics.

#### Exhibit 7

# Australian manufacturers that displayed one or more advanced characteristics were more likely to have higher labour productivity



Source: BCS Survey (ABS), analysis conducted by AlphaBeta Advisors. May 2017.

15 Mankins, Michael (2017) Great Companies Obsess Over Productivity, Not Efficiency, Harvard Business Review, March 2017. Available at: https://hbr.org/2017/03/great-companies-obsess-over-productivity-not-efficiency

#### Examples: Successful Australian companies pursuing advanced knowledge

# **CIUS**

#### **Ocius Technologies**

Ocius Technologies occupies a valuable position in a fast growing global niche market: building high-tech self-powered devices that help oil and gas companies, environmental groups and defence forces monitor and protect the world's oceans.

The company's unmanned surface vehicles (USVs) – small vessels that combine features of ships, drones and buoys – complete vital nautical tasks without the inconvenience of employees getting seasick, hungry or tired. For example, the USVs' built-in sensors can check offshore pipelines for leaks, measure water pollution levels, and detect hostile submarines and torpedoes. Unlike other USVs, Ocius's devices are fuelled entirely by the sun, wind and waves. A 'solar sail', conceived and patented by Ocius CEO Robert Dane, harnesses wind and solar energy for propulsion and to power onboard equipment.

Demand for these drone-like vessels is strong, particularly from the military. Researchers expect global USV sales to increase by more than 16% to US\$922 billion by 2020.<sup>16</sup> The Australian Government, through one of its defence industry innovation support programs, recently contracted Ocius to develop and build a new USV to bolster the nation's maritime surveillance and anti-submarine warfare capability. Ocius is now collaborating with a range of specialist manufacturers including defence electronics producer Thales Australia, as well as researchers at the University of Wollongong, University of Sydney and University of New South Wales.

Ocius started focusing on unmanned surface vehicles in 2008. Its first commercial success using the innovative solar sail was with the tourism industry, allowing dolphin-watch cruises to silently glide through the ocean without startling marine life. It took the company seven years of deep R&D on propulsion systems, collision avoidance and sensory informatics before its first autonomous drone could be deployed off the Australian coast.

The Sydney-based company, winner of the Best Advanced Manufacturing Company award in the 2015 Australian Technology Competition, is now working with the Australian Government to improve its export readiness before expanding into global markets.

16 GosReports, "Global unmanned surface vehicle market expected to reach US\$922 billion by 2020", October 26, 2016. Available at www.gosreports.com/global-unmanned-surface-vehicle-usv/



# THE CHARACTERISTICS OF SUCCESSFUL MANUFACTURERS

# JUNCLEFY

#### Junglefy

Australian company Junglefy is a highly successful specialist manufacturer with a green thumb and sharp eye for market demand that has allowed it to make a living with plants. Founded in 2009 by husband-and-wife team Jock and Hanna Gammon, the company employs urban infrastructure experts who design, install and maintain green walls, roofs and façades for buildings, including hospitals, hotels, restaurants and high-rise apartment blocks. One of its most prestigious projects involved building Australia's highest vertical garden, brought to life with more than 35,000 plants, at the One Central Park residential building in Sydney. The green roof and wall industry is still in its infancy in Australia. However, it is expanding rapidly as property developers move to satisfy growing customer demand for sustainable living spaces. Junglefy was among the first to tap into this niche market and continues to refine its offering through extensive R&D. For example, the company collaborates with experts, including researchers at the University of Technology Sydney, to continuously improve the water efficiency and durability of its green wall modules. Each unit is made from recyclable polyethylene and designed to endure the harsh Australian sun.

Junglefy also succeeds due to its strong focus on services. In addition to its core products, it offers maintenance, repair and replanting support for installed green roofs and walls.



### **SUMMARY**

- It is important to translate a revised understanding of manufacturing into practical guidance for Australian firms.
- Analysis of global and Australian firms that have made the transition to become advanced shows that they exhibit one or more of advanced knowledge, advanced processes and advanced business models.
- This includes traits such as higher R&D intensity and ICT investment, better qualified employees, broader geographic reach and higher share of revenue in services.
- A company with more advanced characteristics is likely to have more success than a company with fewer ones.

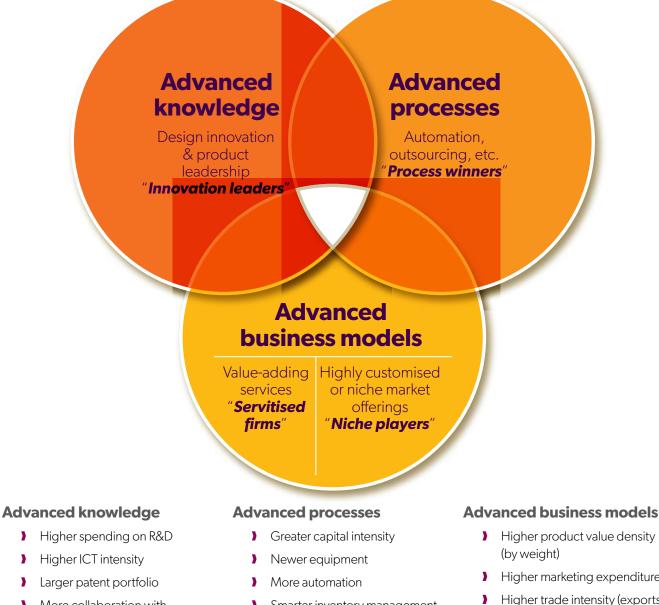


# 3 RECOMMENDATIONS FOR COMPANIES

### 3.1 OVERVIEW

Chapter 2 of this report identified the advanced characteristics that are most strongly linked to manufacturing success. In chapter 3, further analysis by AMGC establishes that despite some evidence of progress, the majority of Australian companies have room to grow in developing advanced characteristics. Companies can use these insights to observe the features of the most successful manufacturers, globally and in Australia. They can also pick one or more areas of focus and seek to advance by achieving these characteristics.

The most successful manufacturing companies in the industrialised world have adopted similar strategies to remain competitive: they all use advanced knowledge, advanced processes and/or advanced business models



- More collaboration with research institutions
- More collaboration with other companies
- ) Higher relative salaries and wages
- Better qualified employees
- More staff with STEM skills N

- Smarter inventory management )
  - Better energy efficiency
- Better water efficiency )

)

- Higher product value density
- > Higher marketing expenditure
- Higher trade intensity (exports)
- More extensive backward links .
- Larger geographical reach 3
- 3 Greater share of services in total revenue



### 3.2 PROGRESS BY AUSTRALIAN MANUFACTURERS

Australia is home to numerous resilient and innovative manufacturers that use world-leading technology and expertise to remain globally competitive. Nonetheless, AMGC's analysis of a sample of 1,500 small and medium-sized Australian manufacturing companies, using BLADE data, indicates there is significant room to increase adoption of advanced characteristics (Exhibit 8).<sup>17</sup> Some key findings:

- Few Australian manufacturing companies appear to focus on 'advanced knowledge' to try and beat their competitors with innovative products and services. For example, in 2014–15 only 4% seized the opportunity to collaborate with academic researchers, and only 9% used patents to protect their novel ideas.
- Several Australian manufacturing companies are already focusing on modernising their production structures, but more could be doing so. Corporate data shows that around one-fifth (19%) of Australian manufacturing companies increased their IT spend in 2014–15, while just over one-quarter (27%) invested in an operational overhaul.
- a majority of Australian manufacturing companies have yet to adopt more advanced business models. For example, only 8% introduced a new product-related service in 2013–14. This is a sign that many are missing the opportunity to become 'service champions'.
- similarly, there is still room for Australian manufacturers to compete by producing highly specialised niche products for the global market, since only 6% currently use product complexity to compete in this way.



#### 17 2014–15 ABS Business Characteristics Survey

There is significant room for Australian manufacturers to increase their adoption of advanced characteristics



Advanced characteristics refers to metrics in the BCS database that relate to advanced knowledge, processes or business models.

\* 2013–14 data

Source: BCS Survey (ABS). Analysis conducted by AlphaBeta Advisors. May 2017.

# RECOMMENDATIONS FOR COMPANIES

There are signs that Australian manufacturing companies may be moving too slowly to shore up their businesses against rapidly increasing competitive pressure from the global market. Exhibit 9 shows that over the seven years through to 2014–15:

- Companies were slightly more focused on advancing their knowledge bases: the share of those applying for patents, for example, grew by roughly 3 percentage points (from 9.1% to 11.8% of companies).
- The momentum to invest in advanced manufacturing processes has stalled: the share of companies spending more on ICT fell by roughly 5 percentage points (from 22.2 % to 17.6% of companies) and capital intensity declined from 3.7% to 2.9%.
- The uptake of strategies associated with advanced business models was mixed: more Australian companies introduced new marketing methods (from 18.5% to 25% of companies) and new products (from 20.6% to 24.3% of companies) over the period, but overall trade intensity fell from 13.3% to 10%.
- the willingness to become a more service-focused manufacturer and offer complex niche products appears to have declined.

Only a small number of Australian companies appear to have truly embraced the key characteristics of more advanced manufacturers (see Exhibit 10). For example, analysis using BLADE data reveals that just 5% of firms drive 94% of the sector's entire capital spending and 54% of its entire R&D spending. This group is also responsible for virtually all the nation's manufacturing exports. The surprisingly concentrated level of investments in innovation, modern machines and global trade links further highlight the need for more Australian manufacturing companies to advance.

The surprisingly concentrated level of investments in innovation, modern machines and global trade links further highlight the need for more Australian manufacturing companies to advance.



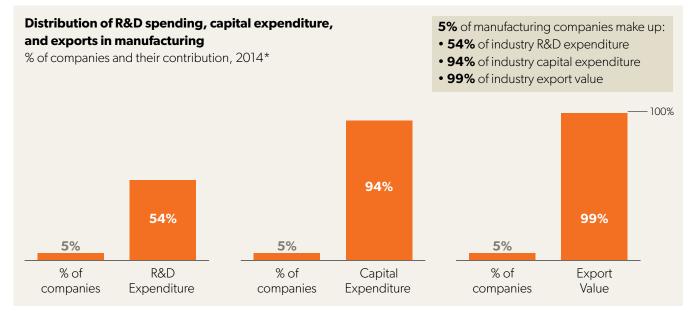
Australian manufacturers have made small improvements to advance their knowledge, but have been slower to improve processes and business models

	Characteristic	<b>Change</b> (2006–07 – 2013–14	l; ppt)
	<b>R &amp; D intensity</b> Ratio of R&D expenditure in manufacturing to total sales/service income	g	0
	<b>Use of patents to protect IP</b> Proportion of firms that used patents to protect their IP		3
Advanced knowledge	<b>Collaboration for R&amp;D</b> Proportion of firms that collaborated with other firms for R&D		
Kilowiedge	<b>General collaboration</b> Proportion of firms that collaborated with other firms		Australian manufacturing firms are increasing some aspects of advanced
	Relative wage levelRatio of the average weekly wage in manufacturing to the industry average	5	knowledge (albeit limited growth)
	Increase in ICT expenditure Proportion of firms that spent more on ICT relative to the previous year	-5	
2 Advanced	<b>Capital intensity</b> Ratio of total gross capital formation in manufacturing to total sales/service incor	-1	but have been
processes	<b>New operational process</b> Proportion of firms that introduced a new operational process		o business processes
	<b>New good offering</b> Proportion of firms that offered a new goo	od	4
	<b>New service offering</b> Proportion of firms that offered a new serv	vice -2	
Advanced business	<b>Use of product complexity to protect</b> Proportion of firms that used product complexity to protect their IP	-2	and have a
models	<b>Trade intensity (exports)</b> Ratio of total value of manufacturing good exported to total sales/service income	ls -3	mixed performance on improving business models
	<b>New marketing methods</b> Proportion of firms that introduced new marketing methods		7

Source: BCS Survey (ABS), analysis conducted by AlphaBeta Advisors. May 2017.



Just 5% of manufacturing companies are highly concentrated in R&D, capital expenditure, and total exports



\* R&D Expenditure combines 2012 and 2014 data for sample size adequacy Source: BLADE, analysis by AlphaBeta Advisors. May 2017.



### 3.3 SELECTING A FOCUS

AMGC's interviews with global manufacturing experts, including former and current executives, support the data analysis in this report. These qualitative insights help identify the concrete steps Australian manufacturing companies can take to advance their businesses and become globally successful, profitable and competitive manufacturing leaders.<sup>18</sup> They also indicate that Australian manufacturers could easily pursue a range of strategies to suit their unique circumstances.

The key takeaway is that companies should examine their current business models, strengths and growth opportunities, and pick an area of focus. Companies would do better to concentrate on improving their performance on a small number of advanced metrics, rather than trying to make progress on all characteristics simultaneously.

A further cluster analysis of global firms reinforces AMGC's conclusion that the world's most advanced manufacturing companies pursue different strategies to remain competitive in a rapidly changing world (see Appendix for more details).<sup>19</sup> Exhibit 11 illustrates the findings. For example, one group of global companies (shaded in purple) focused on acquiring knowledge characteristics such as R&D intensity, and now exhibit almost three times the median R&D intensity in the manufacturing sector (R&D intensity of 26.4% versus 7.2%). Another group of companies (shaded in pink) is most likely to be competitive because they continuously improve their production methods to become more efficient.

These companies exhibit high levels of capital efficiency and automation, and invest in R&D to achieve process excellence. A third group of companies (shaded in orange) appears to be winning customers by bundling products with services. These companies earn an average of 42% of their revenue from services, compared to the median of 5.7%.

Generally, the groups only vary substantially from the median in a small number of characteristics. This shows that they focused on selected advanced characteristics, depending on their unique circumstances, rather than trying to exhibit all characteristics simultaneously. Indeed, there are good examples of Australian companies that have pursued this strategy successfully.

Companies would do better to concentrate on improving their performance on a small number of advanced metrics, rather than trying to make progress on all characteristics simultaneously.

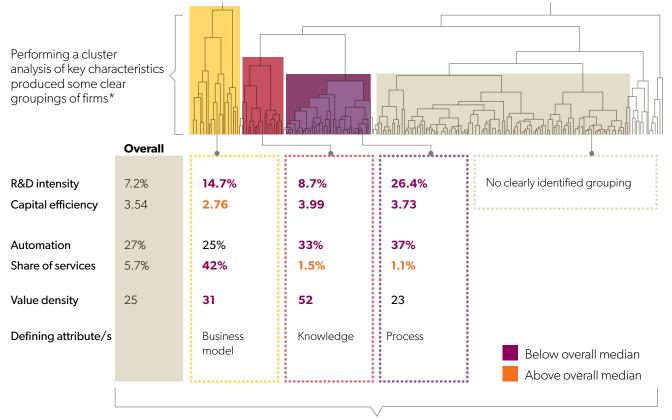
18 Twenty global manufacturing experts participated in these surveys, including former executives of large manufacturing companies, thought leaders and academics.

19 This hierarchical clustering was developed by constructing a dissimilarity matrix, which contains dissimilarity scores for any pair of firms. The dissimilarity scores are based on the distances among the set of variables (R&D intensity, value density, share of services, and automation and labour productivity). For any pair of firms, the further these metrics are from each other the more dissimilar each firm is. The researchers then created a tree diagram, where firms at the bottom are closer to each other (less dissimilar), and firms further up are further apart (more dissimilar). The different clusters were selected by cutting the tree diagram at specific points.



# Cluster analysis of international manufacturers confirms that there are different strategies for successfully advancing

#### Median value by characteristic



Firms can be grouped by their focus on different 'advanced' characteristics. For example, one group of firms earned 42% of their revenue from services.

\* Hierarchical clustering was developed by constructing a dissimilarity matrix, which contained dissimilarity scores for any pair of firms. The dissimilarity scores were based on the distances among the set of variables (R&D intensity, value density, share of services, and automation and labour productivity). The further any pairs of firms were from each other the more dissimilar each firm was. A dendogram was then created in which firms at the bottom have a smaller distance from each other (hence are less dissimilar), and firms further up have a greater distance (hence are more dissimilar). The different clusters were selected by cutting the dendrogram at select points.

Source: Manufacturing firms within Compustat database. Analysis conducted by AlphaBeta Advisors and McKinsey & Co. May 2017.

#### Example: Successful Australian companies pursuing advanced processes



#### Orora

Orora proves that there is nothing humdrum about making cement bags, wine bottles and kiwifruit boxes. The company is one of Australia's most advanced manufacturers, whose forward-thinking production methods have been seen it included in the Most Innovative Companies list of business publication The Australian Financial Review.

Spun out of packaging giant Amcor in 2013, Orora invests heavily in smart new machinery and factories. This helps the firm, which generates about half of its revenue in Australasia and the other half in North America, to maintain its edge in an increasingly competitive market.

Confronted with lacklustre economic conditions and rising input costs, Orora continues to make investments to support growth through its \$45 million Global Innovation Initiative, particularly in new technologies to produce highly individualised packaging. For example, at its glass bottle sleeving facility in South Australia Orora can create customised bottles in any form, size, colour or design. Using a special shrink sleeve technique, bottles can be transformed into a powerful marketing tool. This is also cost-effective, as it allows Orora to make use of off-coloured glass which would otherwise need to be re-melted. Elsewhere, a new can decoration centre of excellence which Orora uses to create customer samples and recently even a personalised six-pack of beer for Hollywood director Quentin Tarantino, has enabled Orora to halve the time taken to deliver new can designs to market.

Other recent improvements include a new dairy-bag production line in Victoria, complete with state-of-the-art machines that digitally glue and seal bags. In New Zealand factories, robotic arms are also being used to assemble kiwifruit boxes.

#### **SUMMARY**

- Despite some progress, the majority of Australian manufacturers have room to grow in developing advanced characteristics.
- For example, more manufacturers could break new ground by offering innovative products and services, modernising their production structures by investing more in ICT, or developing niche offerings for the global market.
- Further analysis illustrates that Australian firms should focus on improving their performance on a small number of advanced metrics, rather than progressing on all characteristics simultaneously.

20 Orora, "Orora awarded in the 2015 BRW Most Innovative Companies", August 18, 2015. Available at: https://www.ororagroup.com/system/downloads/ files/000/000/096/original/Orora\_awarded\_in\_the\_2015\_BRW\_Most\_Innovative\_Companies\_-\_18\_August\_2015.pdf?1480651008

## 4 RECOMMENDATIONS FOR GOVERNMENT

## 4.1 OVERVIEW

It is vital that Australia moves boldly into a future typified by sustainable, high-value-added manufacturing. The nation must also accurately monitor the impact of manufacturing activities on other industries in an increasingly service-based economy. Based on the findings contained in chapters 1 to 3, AMGC recommends three urgent actions:

- developing new tools to track whether Australian manufacturers are advancing,
- moving to more accurate statistical measures of Australian manufacturing output and jobs, ensuring that Australia is accurately reporting the key indicators that policymakers, business leaders and economists should care about, and that can be used to help shape further reform, and
- better targeting business and industry assistance programs to help firms become more advanced.

## 4.2 NEW TOOLS TO MEASURE ADVANCEMENT

As outlined in Chapter 1, the Australian Government, especially the Department of Industry, Innovation and Science, and ABS surveys, currently reserves the term 'advanced manufacturing' for a limited number of manufacturing subindustries. It most commonly measures progress in advanced manufacturing against the conventional metrics of employment, exports, labour productivity and output.<sup>21</sup> AMGC recommends moving away from the ABS focus on classifying only a few select sub-industries as advanced. Every company in the Australian manufacturing sector – regardless of what products it makes, what services it offers and what sub-industry it belongs to – has a chance to advance.

In line with this new definition, AMGC also recommends measuring the extent to which the whole of Australia's manufacturing sector is advancing. This would require tracking the three key characteristics that this report found most relevant for manufacturing success: advanced knowledge, advanced processes and advanced business models. Specific indicators could include R&D intensity, patent use, collaboration, relative wage levels, ICT expenditure, capital intensity, new goods or services, new marketing or operational processes, and trade intensity.<sup>22</sup>

Exhibit 12 presents an example scorecard tool the Government could use to measure whether the manufacturing industry is becoming more advanced, using actual data from the past five years. This tool could track short- and medium-term changes in advanced characteristics outlined in this report. It could sit alongside the traditional measures of output, jobs and exports.

- 21 AMGC gained this feedback based on interviews with Department of Industry, Innovation and Science personnel and through searching internal documentation.
- 22 Each of these indicators is currently measured in BLADE except for the share of revenue represented by services. This indicator could be added to an existing survey format.

#### Exhibit 12

## Governments could use a scorecard tool to measure the *inputs* to manufacturing success (advanced characteristics)

	Characteristic	Change (ppt)		
		l yr	3 yr	5 yr
	<b>R &amp; D intensity</b> Ratio of R&D expenditure in manufacturing to total sales/service income	↔ -0.1	↔ 0.1	<b>↔</b> 0.1
	<b>Use of patents to protect IP</b> Proportion of firms that used patents to protect their IP	↑ 2.2	↑ 3.3	↑ 1.2
Advanced	<b>Collaboration for R&amp;D</b>	<b>↑</b>	↔	<u>↑</u>
	Proportion of firms that collaborated with other firms for R&D	1.9	-0.6	2.3
knowledge	<b>General collaboration</b>	<b>↑</b>	<b>↓</b>	<b>↑</b>
	Proportion of firms that collaborated with other firms	3.5	-1.2	6.5
	<b>Relative wage level</b> Ratio of the average weekly wage in manufacturing to the industry average	+ -1.8	-4.8	<b>↓</b> -7.4
	<b>Increase in ICT expenditure</b> Proportion of firms that spent more on ICT relative to the previous year	<b>↑</b> 4.1	↑ 1.3	<b>↔</b> -0.4
Advanced	<b>Capital intensity</b>	↔	<b>↔</b>	↔
processes	Ratio of total gross capital formation in manufacturing to total sales/service income	0.0	-0.4	-0.3
processes	<b>New operational process</b>	<b>↑</b>	<b>↔</b>	<b>†</b>
	Proportion of firms that introduced a new operational process	5.6	0.6	2.2
	<b>New good offering</b>	<b>↑</b>	<b>↑</b>	<b>†</b>
	Proportion of firms that offered a new good	5.7	3.2	1.5
	<b>New service offering</b>	<b>↑</b>	<b>†</b>	<b>†</b>
	Proportion of firms that offered a new service	5.3	2.0	2.8
3	to protect their iP	<b>↑</b>	↑	<b>↑</b>
Advanced		1.6	1.7	1.1
business	<b>New marketing methods</b>	<b>↑</b>	<b>↑</b>	<b>↑</b>
models	Proportion of firms that introduced new marketing methods	1.3	2.0	1.1
	<b>Trade intensity (exports)</b> Ratio of total value of manufacturing goods exported to total sales/service income	<ul><li>↔</li><li>0.1</li></ul>	<b>.</b> -4.3	<b>↓</b> -3.8

Source: Analysis conducted by Compustat, analysis conducted by AlphaBeta Advisors and McKinsey & Co. May 2017.

# RECOMMENDATIONS FOR GOVERNMENT

## 4.3 FULLER REPORTING OF MANUFACTURING OUTPUT AND JOBS

AMGC further recommends a practical change to how Australia's manufacturing output and jobs growth are reported. As noted in Chapter 1, these traditional metrics are problematic given the increasing prominence of services and flexible sourcing of labour in today's more fragmented economy, including in areas such as design, accounting, marketing and cleaning. New reporting standards are required that consider the precise level of manufacturing activity in the Australian economy rather than loosely categorising these activities in a broadly defined 'services' sector together with industries such as education and tourism. In short, data on output and employment in the Australian manufacturing sector should include all activity that is entirely dependent on manufacturing.

New reporting standards are required that consider the precise level of manufacturing activity in the Australian economy rather than loosely categorising these activities in a broadly defined 'services' sector together with industries such as education and tourism.

There are sound international examples for alternative ways to attribute output and employment to multiple sectors. For example, the United States the Bureau of Labor Statistics constructs annual employment tables for 168 sub-industries. These tables indicate the number of jobs supported directly and indirectly, based on the sale of goods and services worth US\$1 million. The Bureau of Labor Statistics also publishes annual input and output tables, depicting sales generated by a range of sectors and based on demand from other sectors. This makes it possible to observe the reallocation of output to upstream sectors.<sup>23</sup>

Accordingly, AMGC recommends drawing on this type of approach to create a modified measure of output and employment that captures the direct and indirect impacts of manufacturing.

## 4.4 BETTER TARGETING POLICY

Australian governments should help companies acquire the characteristics of advanced knowledge, advanced processes and advanced business models. Where possible, existing government policies and industry assistance can be modified to support these different but proven 'ways to win'.

Exhibit 13 outlines some of the business and industry assistance programs funded by the Australian Government and relevant to local manufacturers. They include the Entrepreneurs' Programme; venture capital programs; the Industry Skills Fund; Education and Training Advisors; Innovation Connections; the R&D Tax Incentive; the Cooperative Research Centres Programme; and the Tradex Scheme. Manufacturing companies also have access to numerous state-based industry assistance funds and initiatives that complement these federal programs.

AMGC strongly urges the Australian federal and state governments to ensure programs are best aligned with the goal of promoting and encouraging manufacturers to become more advanced. Specifically:

- business capability programs should be targeted at increasing the prevalence of characteristics associated with more advanced and successful companies.
   For example, the Entrepreneur's Programme could focus on the ability of companies to introduce new goods and services, which is one of the advanced business model characteristics
- Where government programs offer incentives or support, the evaluation criteria should preference companies pursuing advanced characteristics.

There are sound international examples for alternative ways to attribute output and employment to multiple sectors.

23 US Bureau of Labor Statistics, Employment Projections. Available at: www.bls.gov/emp/ep\_data\_emp\_requirements.htm.

#### Exhibit 13

## Government assistance in the "Business Services Pathway" could better target advanced characteristics

Dept. of Industry Business Pathway	Example programs and their current approach	How the programs could target advanced characteristics in manufacturing
STARTING	Australian Small Business Advisory Services: provides advice on funding avenues and digital engagement	Focus on increasing advanced characteristics such as ICT spending
	Venture Capital programs: tax concessions	Preference companies pursuing advanced characteristics such as collaboration
RUNNING	<b>Entrepreneurs Programme:</b> provides business quality advice and support	Focus on increasing advanced business model characteristics such as introducing new goods and services
RUNNING	<b>Business Management:</b> provides recommendations on improving business operations	Focus on increasing advanced processes characteristics such as introducing new operational processes
	<b>Education and Training Advisers:</b> provides advice on skills and training options	Focus on increasing advanced knowledge characteristics such as collaboration
EMPLOYING	Industry Skills Fund: provides skills advice and co-contribution grants	Preference companies pursuing advanced knowledge characteristics such as R&D intensity
	<b>Accelerating Commercialisation:</b> provides advice on overcoming challenges with new goods and processes	Focus on increasing complementary advanced characteristics such as the use of patents
GROWING	<b>Innovation Connections:</b> provides advice on growth opportunities and funding to support collaboration	Focus on increasing collaboration between companies
EXPORTING	<b>Tradex:</b> provides cash-flow advantage through up-front customs duty and GST exemptions	Preference companies pursuing advanced characteristics, particularly those that complement an increase in trade intensity
EAPORTING	<b>TradeStart network:</b> provides small and medium sized exporters with local face-to-face assistance	Assist companies to increase advanced characteristics that complement higher trade intensity

Source: Department of Industry, Business Pathway. May 2017.

# RECOMMENDATIONS FOR GOVERNMENT

There are two ways for governments to assist Australian manufacturers on their journey to becoming more advanced. Firstly, they could focus on providing assistance to spur growth in those advanced characteristics that matter most, but which Australian manufacturing companies have so far been slow to adopt.

Secondly, governments could more generally focus on assisting less advanced manufacturers because they could notch significant progress quickly. Less advanced companies are typically younger and smaller, and export less (Exhibit 14). They also tend to employ a smaller staff, and often earn just a fraction of the sales revenue of more advanced manufacturers. The differences between more advanced and less advanced companies can be stark. For example, companies that have more advanced knowledge have average annual export sales of \$39.92 million, whereas those with less advanced knowledge export only \$2.31 million.

Small businesses have differing levels of ambition. According to one recent Australian analysis, they can variously be classified as 'stress-free stability-seekers', 'financially constrained growth-aspirers' and 'technology-oriented growth achievers. Many of these firms are good candidates for becoming more advanced. For example, financially constrained growth-aspirers are typically younger businesses that are seeking but struggling to expand. Targeted assistance from governments could help these companies overcome some of the issues affecting their pursuit of growth, such as access to finance and managing cash flows.<sup>24</sup>

## SUMMARY

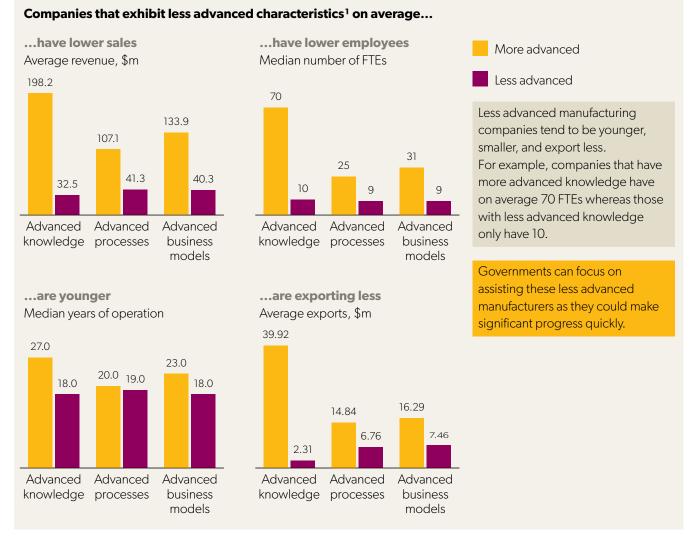
- AMGC recommends the Australian Government develops a scorecard tool to create a brand new measure of whether Australian manufacturing as a whole is advancing.
- Statistical data collection and analysis of Australian manufacturing output and employment should be modified to take into account both direct and indirect manufacturing activities.
- Business and industry assistance programs should be better targeted to help firms become more advanced.
- This could either involve promoting growth in the most important advanced characteristics or helping less advanced manufacturers make quick and impactful progress.



24 Holmes, Scott and Gupta, Dhruba (2015) Opening Aladdin's Cave: Unpacking the Factors Impacting on Small Businesses, RBA Conference Paper.

#### Exhibit 14

Governments can generally identify less advanced manufacturing companies by their age, size, and export levels



1 More advanced firms are defined as firms that were more advanced (answered yes) to more than 50% of relevant characteristics in the category. Source: BLADE, analysis conducted by AlphaBeta Advisors. May 2017.

## **5 CONCLUSION**

The terms of Australia's manufacturing success are changing – and with it the foundations of the nation's future economic strength. While the old definition of manufacturing centred on production, today's manufacturing workforce is spread along a complex value chain involving research, design, logistics and after-sales service. Incredibly, almost half of its members are performing non-production roles. When included, the number of jobs in the economy that rely on manufacturing grows from 905,000 to 1.27 million.

Australian manufacturers who are aspiring to become more advanced should take inspiration from this report's key findings.

- The best indicator of being more advanced is the sophistication of the business, not the sector: successful manufacturers can be found in every corner of the economy, not just in industries that are widely regarded as advanced, such as aerospace or medical equipment manufacturing. Crucially, a firm can be considered advanced if it exhibits advanced knowledge, advanced processes or advanced business models. Performance indicators such as R&D expenditure, export intensity and automation rate, measured across an aggregate of individual companies, offer a more holistic view on whether the manufacturing sector is advancing.
- Advanced manufacturing is on a continuum every company can and should become more advanced: manufacturing success is not static, nor limited to a few highly technologically advanced companies. Any Australian manufacturer can leave the trodden path and embark on the journey to advanced knowledge, processes or business models. This could involve hiring more innovation-minded workers or implementing cost-efficient ICT-driven production processes. Even if a company considers itself advanced today, it may not remain so if it fails to keep up.
- There is no one-size-fits-all strategy: manufacturing companies can pursue different strategies to become more advanced. Some focus on advanced knowledge or advanced processes, while others combine strategies.

The characteristics that make a manufacturer more advanced will change over time: what is considered advanced today may look different in the future as technology and production techniques evolve. Therefore, it is vital for firms to continue reviewing their business features to ensure they remain competitive in the modern market.

The transformation of manufacturing has major implications for policymakers. Most of all, a new method of gauging manufacturing strength is needed. Governments can develop richer and more useful metrics to assess whether the sector is advancing. These metrics should take into account characteristics such as skills mix, R&D intensity, capital efficiency and share of services. This is essential to guide future policy and regulatory reform and better target funding support. The time for action is now. AMGC believes that both firms and governments, working together, have a role to play in creating a dynamic, export-oriented manufacturing sector. This will secure the nation's prosperity and deliver high-wage jobs for generations of Australians to come.



## **6 APPENDIX**

#### 6.1 MEASURING GLOBAL MANUFACTURING SUCCESS

Section 2 of this report summarised the method for measuring global manufacturing success and determining the characteristics associated with becoming more advanced. AMGC used Compustat, a global database containing firm-level indicators on 3,040 manufacturing companies, to identify the top-performing global companies for analysis.<sup>25</sup> The research team grouped together global manufacturing companies and other companies that invested in similar characteristics, from a list that included R&D intensity, capital efficiency, automation, services orientation and price density.<sup>26</sup> The researchers then removed missing values and outliers from the sample (see Exhibit A.1)<sup>27</sup>, and found that top performers, by gross margin, earnings before interest and tax (EBIT), return on investment or labour productivity were also more likely to be top performers by total factor productivity. Based on this, total factor productivity<sup>28</sup> is the most realistic primary metric for success as it represents a key driver of competitiveness among Australian companies.

- 25 The analysis included all companies in the Compustat database that are primarily classified as manufacturers.
- 26 This hierarchical clustering was developed by constructing a dissimilarity matrix, which contains dissimilarity scores for any pair of firms. The dissimilarity scores are based on the distances among the set of variables (R&D intensity, value density, share of services, and automation and labour productivity). For any pair of firms, the further these metrics are from each other the more dissimilar each firm is. The researchers then created a tree diagram, where firms at the bottom are closer to each other (less dissimilar), and firms further up are further apart (more dissimilar). The different clusters were selected by cutting the tree diagram at specific points.
- 27 Outliers, based on the criteria of being 3.5 times the median absolute deviation away from the median, were selected and removed from the sample.

28 AMGC selected total factor productivity as the primary metric as it is more comprehensive than labour productivity (including capital productivity). Total factor productivity measures the joint productivity of capital and labour. It is not directly observable or measurable, so was derived by the residual of the regression of gross value added against capital and labour.

#### Exhibit A.1

## Success was defined by five metrics – total factor productivity, gross margin, ROI, EBIT and labour productivity

Total number of firms <b>3,040*</b>	Total factor productivity (TFP) metrics	Gross margin metrics	ROI metrics	EBIT% metrics	Labour productivity metrics
Approach 1: Removing missing values	1,965	2,695	2,263	2,324	2,628
Approach 2: Removing outliers <sup>†</sup>	1,893	2,380	2,113	2,037	2,411
Approach 3: Identifying top quartile	474	595 2	529	510	603
	1 Assessing s	uccess as beir	3 ng in the top quarti	le for TFP produc	es <b>474</b> firms
Three approaches as to how we determine successful firms	3 Assessing s TFP, GM, RC	uccess as beir DI or EBIT – pr	ng in the top quarti oduces <b>574</b> firms	le in at least two o	-

\* All firms in Compustat database primarily classified as manufacturers. Refer to appendix for details on calculation of success metrics.

† Outliers are selected and removed based on the criteria of being 3.5 times the absolute deviation from the median.

Source: Analysis conducted by Compustat, AlphaBeta and McKinsey & Co. May 2017.

Characteristics and success metrics in Compustat comprised a mix of directly observable and inferred fields. Exhibits A.2 and A.3 outline the calculation method used.



#### Exhibit A.2

Exhibit A.3

#### Glossary of success metrics in Compustat data

Metric	Calculation method	
Total factor productivity	Measures the joint productivity of capital and labour. It is not directly observable or measurable, and so was derived by the residual of the regression of gross value added against capital and labour.	
Gross margin	(Sales – COGS)/sales	
ROI	EBIT/average capital expenditure over 2013–2015	
EBIT %	EBIT/sales	
Labour productivity	Sales/employment	

Source: Compustat. Analysis conducted by AlphaBeta and McKinsey & Co.



Source: Analysis conducted by Compustat, AlphaBeta and McKinsey & Co.

#### **Calculation method**

- Ratio of R&D expenditure to total sales
- Number of patents by firms. Linked individual firms in Compustat to patents dataset
- Industry average wages weighted by the sales shares across industries by each firm
- Industry average of fraction of employees with bachelor or post-graduate degrees weighted by the sales shares across industries by each firm
- Using O\*Net classification of STEM occupations, found share of these occupations in total employment for each industry, and weighted them by the sales shares across industries for each firm
- Ratio of total sales to plant, equipment and machinery
- Accumulated depreciation/depreciation
- Indicator = 1 if average growth in capital accumulation and labour productivity in the last three years is positive. Zero otherwise
- > Used IO table to determine the value of energy in value of sales. Weighted the industries by the sale shares across industries by each firm
- > Used IO table to determine the value of water in value of sales. Weighted the industries by the sale shares across industries by each firm
- > Used four-digit industry level trade data, calculated value of shipment/weight. Weighted the value densities by the sales shares across industries by each firm
- Industry imports used to make industry exports. BEA IO tables. Weighted result by the sales shares across industries by each firm
- Sales of services/total sales by industry



## 6.2 BACKGROUND ON BLADE

The research team used BLADE to understand the factors associated with success in Australian manufacturing, and the current picture of Australian manufacturing. Variables included in the analysis were primarily from three datasets within BLADE: the tax records of individual companies, the Business Characteristics Survey (BCS) and the Business Expenditure on R&D (BERD) survey.

#### Tax records data

After cleaning the data, there was tax record information for roughly 50,000 manufacturing companies. From this data the research team was able to distil measures of:

- ) labour productivity
- Capital intensity capital expenditure divided by total sales
- automation whether the company experienced growth in real output, and its real investment
- trade intensity total export of sales divided by the total value of sales
- > whether the company exports that is, total export sales are more than zero.

### **BCS data**

About 3,000 companies had BCS information. The following variables were constructed from the data based to measure whether the company:

- ) uses patents to protect its intellectual property
- ) collaborates with any organisation for R&D
- Collaborates for any purpose this includes R&D, joint buying, joint production, joint marketing or distribution, or an integrated supply chain
- uses STEM skills in its core activities, noting that STEM includes Engineering, Science and Research, as well as IT professions, and IT technical support workers.
- ) increased its ICT expenditure
- Introduced a new operational process
- introduced a new or significantly improved good or service
- uses product complexity as a way to protect its intellectual property
- ) introduced a new marketing method.



#### **BERD** data

The BERD data recorded 1,000 unique observations across three years. Based on this data, the researchers developed the following variable: R&D intensity minus R&D expenditure divided by total sales

#### **Success metric**

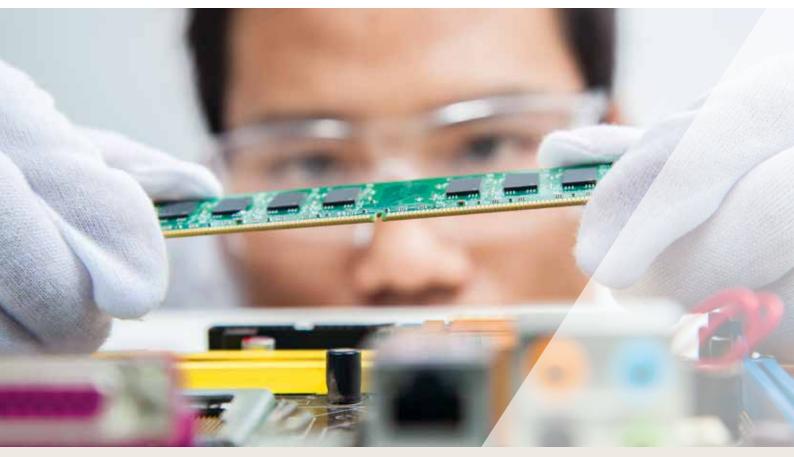
Because the researchers defined success as placing in the top quartile of labour productivity, it was important to make companies from different sectors comparable. It is possible for different sectors to have different levels of labour productivity.

The research team standardised each sector's labour productivity, which involved taking each company's labour productivity, subtracting the industry average and dividing the result by industry standard deviation. They then defined the industry at the level of the ANZSIC group. After constructing the standardised labour productivity measure across the manufacturing sector, companies were separated into quartiles.

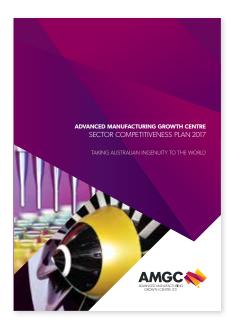
#### Limitations

It was not possible to access the original raw data, so the research team used rules to remove extreme observations. Extreme observations were removed by winsorising the data, removing the top and bottom 5% of companies. This method appeared to remove implausible labour productivity values.

In addition, the researchers pooled BCS data from 2012–14 to ensure there were enough observations to compare the top and bottom quartiles in the manufacturing sector. For companies that had multiple observations, the researchers only retained the year that did not have missing values for all the BCS variables. For companies that had multiple observations with BCS answers, they kept the latest year. To ensure that the nominal variables such as labour productivity were comparable across the years, the researchers deflated each company's sales and value added using the ANZSIC Class Producer Price Index.



## OTHER RECENT PUBLICATIONS FROM ADVANCED MANUFACTURING GROWTH CENTRE



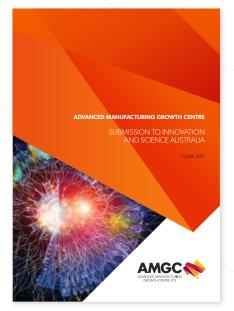
### **SECTOR COMPETITIVENESS PLAN 2017**

Manufacturing has an important role to play as Australia looks to create a diverse, innovative and globally oriented economy. The nature of global manufacturing is changing in ways that provide positive opportunities for Australia, if we are bold enough to seize them.



### **INDUSTRY KNOWLEDGE PRIORITIES 2016**

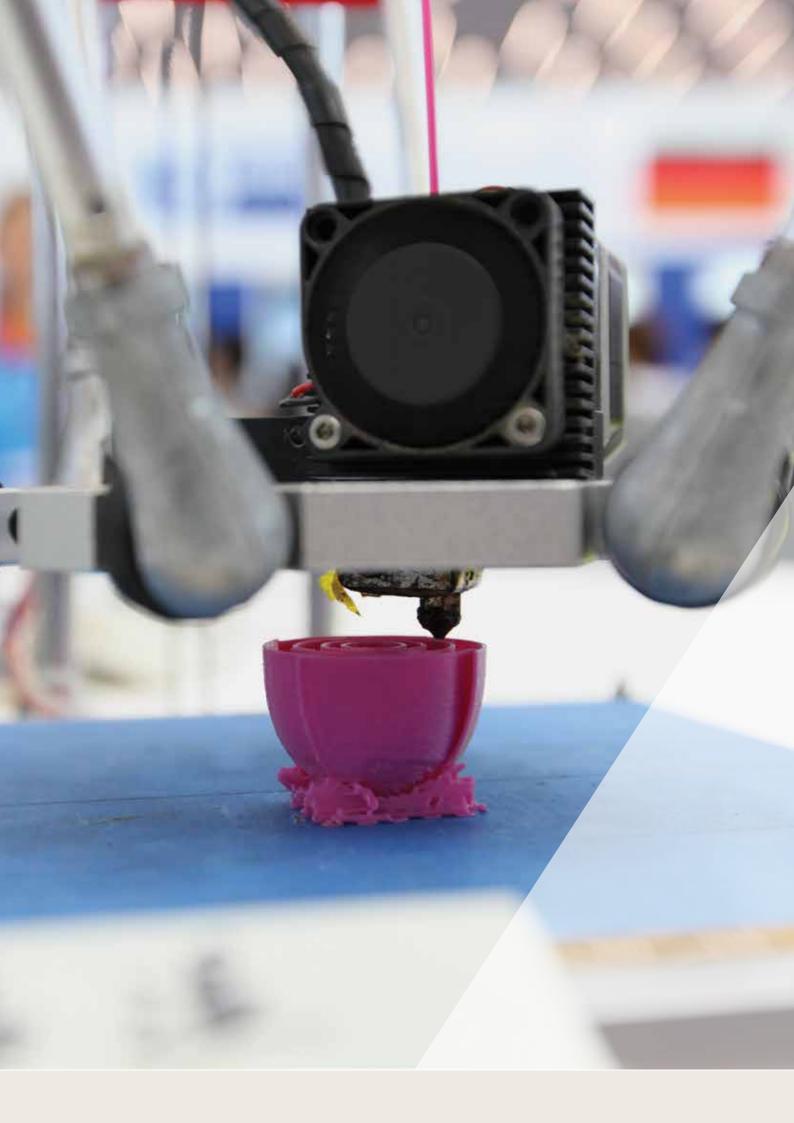
Developing and disseminating knowledge is key to helping Australian manufacturing differentiate itself on value and drive technical leadership. As part of its function as an Industry Growth Centre, the AMGC has identified both Research and Development and business improvement knowledge priorities, to help support research and analytical efforts for the sector.



For a copy of these reports, please visit www.amgc.org.au

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