ADVANCED MANUFACTURING GROWTH CENTRE
SECTOR COMPETITIVENESS PLAN 2017

TAKING AUSTRALIAN INGENUITY TO THE WORLD

AMGC
ADVANCED MANUFACTURING
GROWTH CENTRE LTD

> The Advanced Manufacturing Growth Centre's Sector Competitiveness Plan is an insightful report that will help boost capability, while developing global opportunities for Australia's manufacturing industry. As Australia's Chief Scientist, I will support the work of the Advanced Manufacturing Growth Centre.

Dr Alan Finkel, Australia's Chief Scientist

ACKNOWLEDGEMENTS

The AMGC wishes to acknowledge representatives and alumni from the following manufacturing companies, industry associations, government bodies, research institutions and universities for their valuable input into the Sector Competitiveness Plan. These organisations have not endorsed the contents of this plan.

COMPANIES
(including through alumni)

A&I Coatings
ACS Australia
Aerosonde
Air Radiators
Airbus Australia
Alchin Long Group
AlphaBeta Advisors
Amcor
Aquacell
Atcor
Austal
Beurteaux Seating Solutions
Boeing International
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Ceramisphere
Chute Technology
Cochlear
CSC
CSL
CSR Building Products
Dow Chemical Australia
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Hedweld
HI Fraser
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GOVERNMENT BODIES

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Business Council of Australia
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Geelong Manufacturing Council
Furniture Cabinet Joinery Alliance
HunterNet
Manufacturing on the Move
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Midlands Aerospace Alliance
NSW Business Chamber
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Regional Development Australia
Regional Development Victoria
South East Melbourne Manufacturers Alliance

RESEARCH INSTITUTIONS

Advanced Composite Structures Australia
Ausbiotech (CSIRO Clayton)
Australian National University
CSIRO
Innovative Manufacturing CRC
Manufacturing Skills Australia
University of New South Wales
University of Technology Sydney
Western Sydney University

FOREWORD

The Advanced Manufacturing Growth Centre (AMGC) was established by the Australian Government in 2015 as a key plank of its Industry Innovation and Competitiveness Agenda, and we passionately believe that a strong and vibrant manufacturing sector is critical to Australia's future.

Members of the AMGC team met with small and large manufacturers from around the country to understand not only their unique sources of competitiveness and their aspirations for growth, but also their challenges. We have consulted with other members of Australia's manufacturing ecosystem, including international customers, entrepreneurs, academics, researchers and representatives at all levels of government.

What has become clear from these discussions is that there is significant potential for Australia to grow its manufacturing sector and become more globally competitive. However, we have also come across a number of common misconceptions about the sector that need to be addressed.

The biggest of these misconceptions is that Australian manufacturing entails production alone. The reality is that the term 'manufacturing' now covers a much broader range of activities than those performed in traditional factories where people made thousands of identical units on long production lines. Today, manufacturing centres on complex research and design work in the pre-production phase. There are also many value-adding post-production opportunities in the form of ongoing services. This means that a significant amount of relevant activity might not be sufficiently captured and counted in analysis of the manufacturing sector. Recognising the importance of these activities will greatly expand the potential areas where Australian manufacturing can compete.

Many Australian manufacturers have already found ways to compete internationally, and successfully sell final products or intermediate components into the supply chains of other local or global manufacturers. For these manufacturers, cost is often a less important source of competitive advantage than delivering value to customers through technical leadership and service offerings.

Another view is that Australian manufacturing possesses enough managerial talent to create globally competitive manufacturing businesses. Unfortunately, our research indicates that while we have a large and talented cohort of managers, many of them lag behind their international counterparts in some areas. This gap needs to be highlighted so that it can be closed.

A further misconception is that government can and needs to single-handedly 'fix' manufacturing. While government can play an important role, we believe that industry must take the lead in driving the sector's future growth. This report aims to provide practical advice to help companies achieve this goal and to allow government to assist.

Australian manufacturing has a bright future if it focuses its efforts and takes advantage of its strengths. We are home to many of the creative and service-oriented skills that are now in demand. Our traditional disadvantage of distance from major markets is becoming less relevant in the digital age. Most importantly, we have a community of entrepreneurs, governments, research institutions, investors and others that are focused on driving growth and customer satisfaction by building great businesses and exporting our ingenuity to the world.

Finally, let us emphasise that this Sector Competitiveness Plan is aimed at encouraging all Australian manufacturers to continuously advance and become or remain globally competitive.

Dr Jens Goennemann
Managing Director
Advanced Manufacturing Growth Centre Ltd

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It is essential that any analysis of competitiveness looks beyond product cost.

1 EXECUTIVE SUMMARY

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1.1 CONTEXT

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.

The Advanced Manufacturing Growth Centre Ltd (AMGC) is a not-for-profit organisation, distinct from but supported by the Australian Government. It was created to champion an industry-led approach to transforming Australian manufacturing.

The AMGC has created a 10-year Sector Competitiveness Plan (SCP) with input from companies and industry associations, research organisations and governments to enhance the competitiveness of Australia's manufacturing sector. The purpose of this Plan is to take a strategic look at manufacturing over the next decade to:

- Identify and analyse opportunities to lift the competitiveness of Australian manufacturing
- Set out actions for companies, governments and research organisations to realise these opportunities and transform the manufacturing sector
- Articulate the role of the AMGC in facilitating this transformation and begin the process of aligning diverse stakeholders around this national challenge.

> Where Australia has achieved success in global markets, it has often related to an innovation in product performance.

1.2 SECTOR COMPETITIVENESS DIAGNOSIS

Studies of the manufacturing sector tend to focus primarily on cost as the key driver of competitiveness. While cost is undoubtedly important, it is far from the only dimension of competitiveness, especially for Australian manufacturers in global markets. In fact, when international customers choose to purchase from an Australian company rather than a cheaper or geographically closer competitor from another country, they are usually doing so because the Australian product offers something different. This difference could stem from innovative design features, an exceptional reputation for reliability and collaboration, or an outstanding service offer.

In recognising this feature of Australian manufacturing success, it is essential that any analysis of competitiveness looks beyond product cost competitiveness – that is, costs that drive final price. The analysis should also consider value differentiation, or sources of value beyond unit cost; and market focus, such as 'where we play' in the value chain, in global markets and in skill-intense products.

Our analysis of manufacturing competitiveness, which is summarised in this Plan, is based on in-depth analysis of two sub-industries: medical technology and aerospace. It reveals that Australian manufacturing has existing competitive advantages and opportunities for improvement in each of three dimensions of competitiveness:

- **Lifting competitiveness by reducing Australian manufacturing's production costs:** Australian manufacturing has a production cost disadvantage relative to benchmark industrial countries. The size of the disadvantage varies by product group, but is estimated at between 7.3 and 15.1 percentage points in the two sub-industries analysed. The disadvantage in other sub-industries may well be higher. The factors contributing to this disadvantage include labour costs, material input costs, capital efficiency and overheads. Overall, while Australia is unlikely to become the lowest-cost location for manufacturing production, there are a number of opportunities to increase cost competitiveness. First, high-skill labour is significantly cheaper in Australia than the international benchmark. For example, in the medical devices industry, management and professional wages are 38% lower in Australia than in the United States (US). However, this often doesn't flow through to lower overall labour costs because Australia's high-skill workers have a more limited mix of skills (e.g. only 17% of Australian aerospace workers have bachelor's degrees compared with 44% in the US). Second, Australia has an opportunity to lift its competitiveness in capital efficiency and overheads. It can do this by improving management quality in areas where Australia lags significantly behind other nations, and by collaborating more to overcome the challenges of scale. Australia's manufacturing firms are small relative to major competitors, even allowing for differences in market size. Third, Australian manufacturing can reduce costs through increased productivity by adopting advanced production processes, involving higher capital intensity, automation and 'Industry 4.0' techniques.

- **Lifting competitiveness by increasing the value differentiation of Australia's manufactured products and associated services:** While Australian manufacturers may not often be the lowest-cost producers, they can and do compete on sources of value other than cost. A panel of international purchasing managers and customers interviewed for this report identified a number of reasons why they choose to buy manufactured goods from Australia. These included product quality (design and technology leadership), reliability and reputation (on-time and in-full delivery, flexibility, safety and transparency) and service support (pre- and post-production). This finding is confirmed by the tendency in recent years for more value to stem from non-production parts of the value chain, including research and development (R&D) and services (see Exhibit 2). Australia's export performance confirms the importance of these factors. Where Australia has achieved success in global markets, it has often related to an innovation in product performance. Examples include ResMed's capturing of 40% of the global market for sleep disorder devices, or Cablex carving out a niche in tailoring cable harness solutions for small runs of aircraft.

However, Australian businesses currently spend relatively little on R&D, and government support for business-led R&D is not optimally designed. In fact, the current funding mix is not likely to maximise investment by firms in R&D across different risk profiles, spillover benefits and time horizons. Australia is an outlier in the mix of assistance that it provides for business-led R&D, with heavy reliance on 'indirect' forms of assistance such as the federal government's R&D Tax Incentive. Further, the current design of the R&D Tax Incentive does not ensure that public expenditure goes towards R&D activity that would have otherwise not happened. Australian manufacturing can also increase its competitiveness by providing value-adding services associated with manufactured goods, building on our skills and strengths in service sectors.

- **Lifting competitiveness by shifting Australian manufacturing towards higher-potential markets:** Australian manufacturers can reduce the cost and improve the value of the products they sell on global markets, and they can also improve their competitiveness by shifting their focus towards the highest-potential markets and playing to our national strengths. Some manufacturing sub-industries under-serve a number of key export markets, including markets for intermediate goods. Additionally, Australian manufacturers are poorly connected into global value chains, with among the lowest level of backward linkages among OECD (Organisation for Economic Co-operation and Development) countries.

Industry 4.0

'Industry 4.0' refers to the suite of digital technologies augmenting industrial processes, including '1) the rise of data volumes, computational power and connectivity; 2) emergence of business-intelligence capabilities; 3) new forms of human-machine interactions; 4) improvements in transferring digital instructions to the physical world, e.g. 3D printing'.

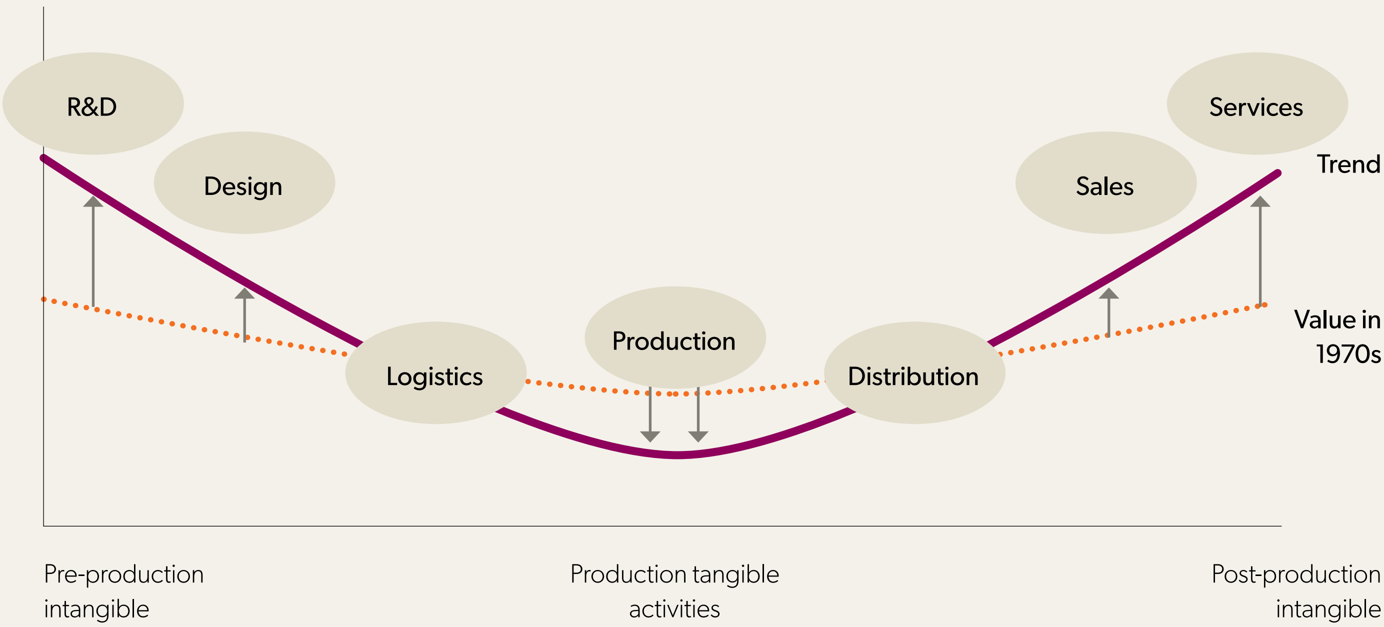
1 EXECUTIVE SUMMARY

Exhibit 1 – Competitiveness in manufacturing is driven by three factors

Three sources of competitiveness	Examples of ways to drive competitiveness, as explored in this plan
1 **Reduce cost**	Manufacturers can increase their competitiveness by reducing their costs. For example: – Manufacturers can reduce their costs by reducing the **cost of their inputs**, such as transport, energy and materials, etc. – More **advanced production techniques** that enable greater output with existing resources can improve efficiency and reduce costs per unit – Manufacturers can reduce their costs per unit by **increasing their scale** and fractionalising overheads and other fixed costs
2 **Improve value**	Manufacturers can increase their competitiveness by improving their value proposition to customers. For example: – Manufacturers can focus on **innovation and technological improvements** that give their products a distinctive performance value proposition – Manufacturers can increase the value of their products by providing **value-adding services** that improve their function, utility and longevity
3 **Shift market focus**	Manufacturers can increase their competitiveness by moving into higher-potential products and markets in which their proposition is more distinctive. For example: – Manufacturers can identify and enter **high-growth or high-value product segments** – Manufacturers can identify and enter **under-served geographies** and participate in **global value chains**

Exhibit 2 – Value in manufacturing is shifting from production to pre- and post-production intangibles such as R&D and Services

Value added, illustrative



Source: Curve adapted from: 'Interconnected economies benefiting from global value chains', OECD 2013

1 EXECUTIVE SUMMARY

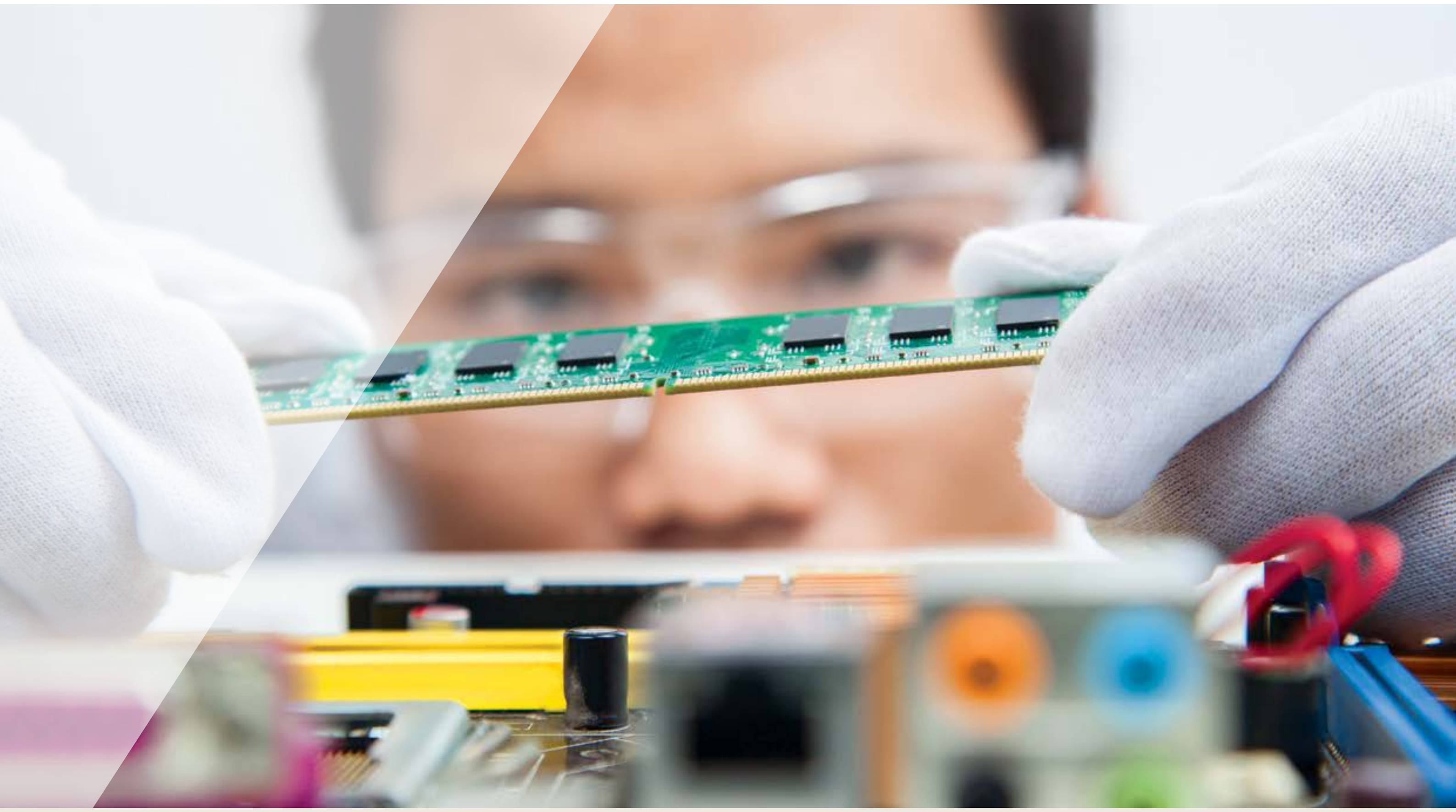
1.3 AUSTRALIA'S MANUFACTURING OPPORTUNITY

Global data confirms that the world's most competitive companies succeed by increasing value differentiation, improving market focus and optimising product cost and processes. For example, global companies ranked in the top 25% for productivity, compared with the bottom 25%, exhibit 3.17 times the R&D intensity, 1.75 times the patent portfolio, 1.08 times the share of services in revenue, 1.61 times the capital efficiency, 1.50 times newer equipment and 1.30 times the plant automation.

"Every Australian manufacturer, big or small, high-tech or lower-tech, can improve its operations by employing advanced knowledge, processes and business models.

However, there is no single formula for success. In fact, we observed that Australian manufacturers follow a range of practices to differentiate themselves, including:

- **Focusing on increasing value differentiation.** These manufacturers are:
  - '*Innovation leaders*': those that use high-skill workforces and R&D investments to develop distinctive value in their products, such as Cochlear, ResMed and Quickstep, or
  - '*Servitised firms*': those that have evolved their model beyond a pure product, with an often high-skilled workforce and a high share of services in revenue, such as Invetech and Ford Australia.
- **Focusing on identifying untapped or niche markets.** These companies are '*market finders*', seeking out under-served markets in which they have strategic advantages, and using high value-density products or mass customisation to meet consumer needs. Examples include Codan, Cablex and Textron Systems Australia.



- **Focusing on reducing cost.** These companies are '*process winners*'. They differentiate through process excellence and cost competitiveness, using capital efficiency, automation and process improvement. An example is Amcor.

Every Australian manufacturer, big or small, high-tech or lower-tech, can improve its operations by employing advanced knowledge, processes and business models. This concept of 'advanced manufacturing' deliberately departs from the current Australian Bureau of Statistics (ABS) definition, which places manufacturing firms in either 'advanced manufacturing' or 'basic manufacturing' categories according to industry codes associated with the products they produce. Our definition recognises that manufacturing firms can adopt advanced techniques irrespective of what they produce and that there is no hard line separating 'advanced' firms from other manufacturers. All firms can aspire to continuously improve their production processes and evolve their business models.

While there are many examples of successful Australian companies, not all of Australian manufacturing exhibits the 'advanced' characteristics identified above. In fact, the majority of Australian companies do not report characteristics such as R&D collaboration; the introduction of new goods, services or processes; the use of science, technology, engineering and maths – or STEM – skills; supply of overseas markets; or increasing IT expenditure.

The rewards for success in advancing manufacturing are substantial. The current size of Australian manufacturing (in the year to June 2016) is $97.7 billion, with 886,800 employed persons and an estimated 331,000 people employed in other sectors as a direct result of manufacturing activity. Analysis of the potential 'size of the prize' in improving manufacturing competitiveness suggests that Australia can capture a 25–35% increase in value added by 2026 (see Exhibit 3).[1] This figure is driven primarily by improvements in value differentiation, which would account for a 14–20% improvement; and shifts in market focus, which would account for a 7–9% improvement. Improvements in cost competitiveness would account for the smallest component of the potential uplift, at 4–6%.

1 The base case size of manufacturing in 2026 uses the 2006–14 compound annual growth rate as the average annual growth rate through to 2026. For detailed methodology of this estimate, see Section 3.2 and Annex B.

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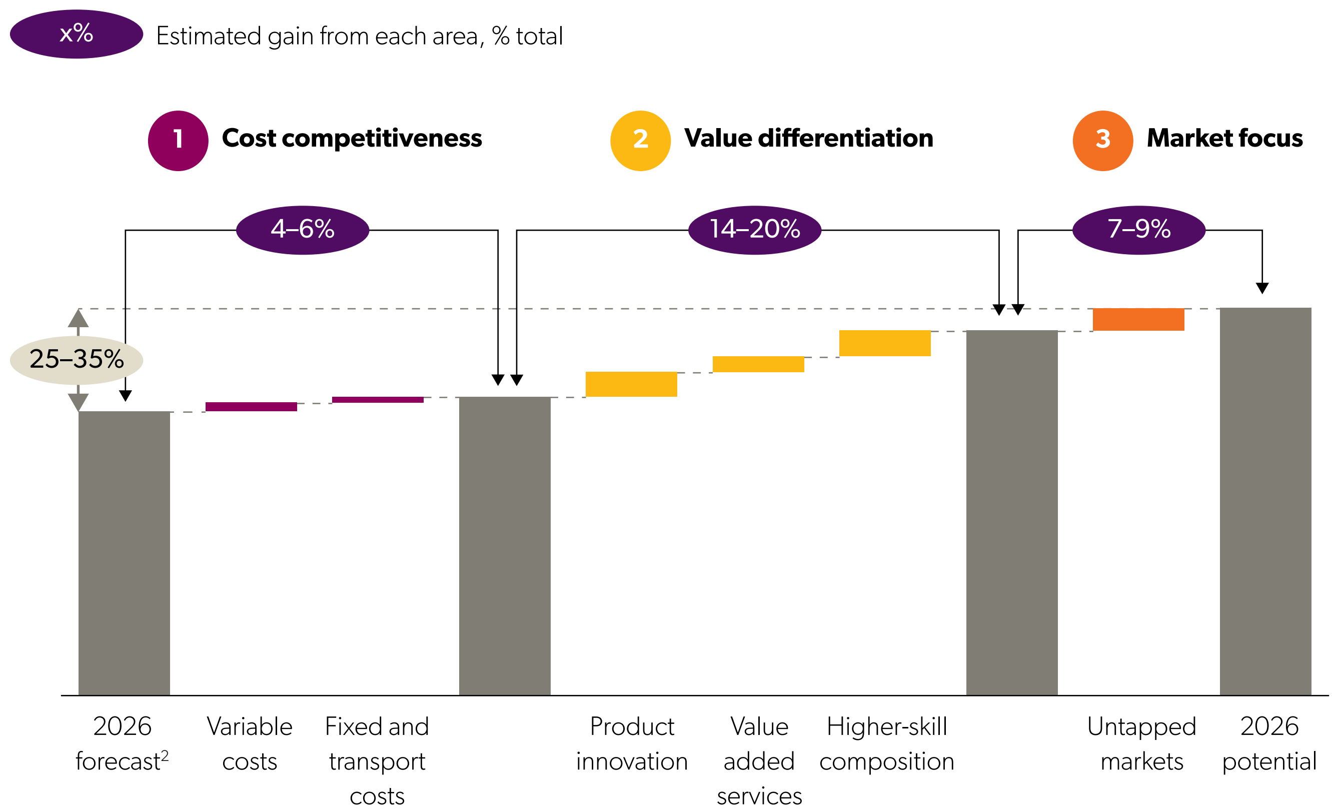
Exhibit 3 – Growth in manufacturing can be achieved by focusing on greater value differentiation and improved market focus, not cost alone

Estimated potential value gain across advanced manufacturing
Percentage of value added in 2026 relative to straight-line trend projection[1]



Notes
- Benchmarking 'landed' product cost against other high-cost countries revealed a 9–14% cost gap
- Improvement estimates based on different scenarios of closing the cost gap and either banking savings as profit or passing through lower prices
- Value estimate triangulated through assessing sub-category export improvement potential in each vertical, and through comparing firm-level profit margins for highly innovative vs average firms
- Product focus from matching US proportion in high skill industries
- GVC integration based on uplifting exports in key markets to Australian average category share.

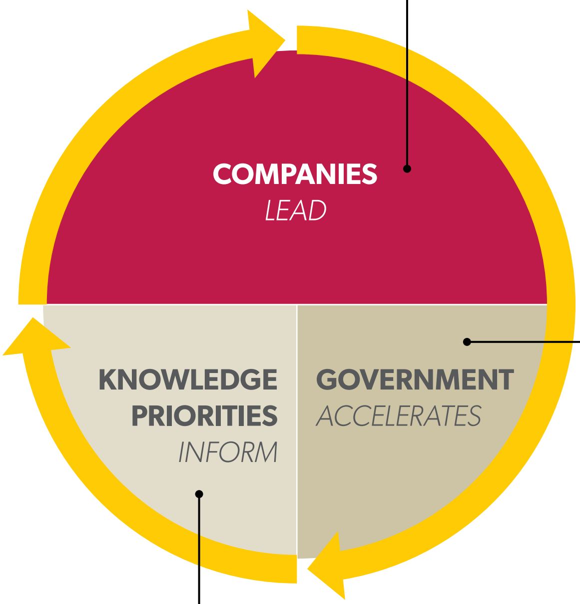
1 Increase based on extrapolation from aerospace and med tech analysis.
2 Base growth projected using 10-year historic CAGR for ANZSIC sub-divisions 18, 23 and 24. See appendix for full methodological details.
Source: AlphaBeta/McKinsey analysis

1.4 ACTION PLAN FOR AUSTRALIAN MANUFACTURING

The AMGC's vision is to develop an internationally competitive, dynamic and thriving Australian advanced manufacturing sector that boosts the long-term health of the economy and the nation. Achieving this vision will not be easy. While the Plan will require national effort from multiple stakeholders across industry, government and research, the transition, critically, must be led by companies. The Plan identifies key actions for industry to achieve this transformation, and identifies how governments can help accelerate the change and how certain Knowledge Priorities defined by the AMGC can better guide industry and researchers.

Exhibit 4 – Companies must lead the transition to competing on value, supported by government and informed by Knowledge Priorities

Objective: Australian manufacturers need to compete through product and service differentiation, and better target export markets



Companies will lead the transition by:

- Increasing technical leadership
- Increasing value-adding services
- Improving market focus by reaching untapped markets and integrating into global value chains
- Lifting scale and management quality.

Many Australian businesses are already making this transition.

Government can accelerate the transition to new value-based business models by:

- Optimising support for business-led R&D
- Using smarter defence and civil procurement
- Designing assistance to target 'more advanced' characteristics
- Changing measurement of manufacturing.

Knowledge Priorities will inform and fuel the transition by:

- Identifying R&D Priorities: e.g. robotics, advanced materials and composites, digital design and rapid prototyping
- Identifying Business Improvement Priorities: e.g. workforce skills requirements, management capability, building international linkages and driving Industry 4.0 uptake.

Source: Competitiveness analysis

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Actions for industry: Australia has many world-class manufacturing companies of which we can be proud. However, industry as a whole must evolve to focus on rapid innovation, develop new business models to include services across the value chain, engage in global supply chains and build highly skilled workforces.

This Plan articulates an industry-led transformation focused around four objectives, with a series of actions that will support achieving the objectives:

- **Enhance value differentiation by increasing the technical leadership of Australian manufacturing.** When Australian firms succeed in global markets, it is usually by providing the best products rather than just the cheapest products. Australian manufacturers tend to be most competitive when they have distinctive products offering superior performance that deliver value for money. The single biggest opportunity for Australian manufacturing is to increase our technical leadership and improve the distinctive value of our products across the manufacturing industry. To achieve technical leadership, Australian manufacturers should focus on lifting their technical leadership in three ways. First, they must increase expenditure on R&D, which is a core enabler of value differentiation. Australian businesses' expenditure on R&D as a proportion of gross domestic product (GDP) is well below that of many key OECD competitors. Second, Australian firms should increase their collaboration with research institutions. This is particularly important for smaller businesses that exhibit lower levels of collaboration, potentially constraining the development of technical leadership. Seeking out project-specific partnerships, and sharing personnel and investing resources can all assist in ensuring Australian companies can access and build on the latest ideas and technical leadership. Third, Australian manufacturing companies can exploit Australia's cost advantage in high-skilled labour and drive technical leadership and service offerings by lifting the skill mix of their workforce.
- **Enhance value differentiation by increasing service offerings within Australian manufacturing.** Australia has a significant opportunity to complement our manufactured products with value-adding services that open growing revenue streams and improve the value differentiation of our products. With a highly skilled, English-speaking workforce, Australia's manufacturing

industries are well placed to execute the shift to service-enhanced offerings. Manufacturing sub-industries that have already made the shift are growing faster than those industries still focused on the production parts of the value chain. To achieve this, Australian firms will need to focus on developing compelling service offerings, identifying and building new markets for their services and shifting the mix of their workforce towards service skills.

- **Improve market focus by reaching untapped markets and segments, and integrating into global value chains.** Australian manufacturing firms should not only focus on improving the cost and value of what they produce today; they should also continue to identify new markets and product segments. There is a significant opportunity for Australian companies to grow by identifying niche products or service markets, or under-served export markets. Australian manufacturers are underweight in a number of key export markets, including for intermediate goods. Australian companies are currently poorly linked into global value chains, using among the lowest levels of foreign inputs in generating output that is then exported.

- **Lift scale and management quality to improve cost competitiveness.** While cost will usually not be the main reason Australian manufacturing firms are successful in global markets, efficiency is always important to ensure sustainable profitability. To improve their cost competitiveness, Australian firms have three priorities. The first is closing the management skill deficit, as Australian manufacturing companies have a lower share of high-performing managers than other successful economies. Reducing the deficit is vital to reducing cost and improving productivity. The second is collaborating more with other companies and pooling resources to cover their relative size disadvantage. Collaboration should help improve capital efficiency and reduce overhead costs. The third is to take advantage of Australia's significant cost advantage in skilled labour to increase the focus on technical leadership.

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Actions for governments: While companies must be the lead players, federal and state governments can play a significant role in supporting the actions that companies need to undertake and accelerate the transformation. This report articulates a number of areas for government action, including several priority actions:

- **Improve government support for business-led R&D and encourage industry–research collaboration:** Support for R&D and research collaboration have underpinned Australia's export successes, particularly in sub-industries like medical technology. If more companies are to experience similar success, governments should improve the R&D Tax Incentive to increase support for R&D activity that would have not otherwise happened (i.e. increase 'additionality') and boost support for both medium-risk, short-term R&D through the Tax Incentive, and higher-risk, longer-term R&D through more direct forms of grant assistance. For the government to achieve these objectives it would need to tighten eligibility criteria and consider using the savings to both simplify application processes to drive take-up and shift the mix of support towards more direct forms of grant assistance. Further, with tighter leadership and collaboration between companies and universities, Australia's strong research pipeline will be better translated into commercial outcomes.
- **Use smarter procurement and smarter programs to drive advancement:** Federal and state governments have the opportunity to leverage their procurement to drive innovation and collaboration between firms, and to create opportunities for Australian firms in global supply chains. Government procurement support should be focused on boosting technical leadership, ideally in areas where Australian manufacturing has a current or potential future comparative advantage, which could be developed to scale through guaranteed demand. Critically, support should not be provided to prop up industries that were once competitive but are no longer viable in their current setting. Innovation requirements can be established so that the technology or product will be a globally distinctive offering. Other industry assistance and capability-building programs offered by federal and state governments could also be better designed to target the characteristics associated with advancement in manufacturing.

- **Change the lens on the role and measurement of manufacturing in the economy:** Governments and the public at large must recognise that manufacturing is more than production. A dynamic manufacturing sector might include more services and less local production output, more offshoring and less domestic assembly. Rather than measure the manufacturing sector narrowly through production output in a set of Australian and New Zealand Standard Industrial Classification (ANZSIC) codes, new metrics are needed to establish whether manufacturing is advancing and identify its wider impact on the economy. This includes tracking whether the prevalence of key 'advanced' characteristics is increasing and the indirect impact of manufacturing on employment.

Taken together, these policy changes amount to a fundamental shift in the focus, balance and operation of government support, to help ensure that Australia's manufacturing sector is able to thrive in the future.

Knowledge Priorities: The company-led transformation can be supported by further investigation of knowledge gaps in R&D and business capabilities identified by the sector. The Knowledge Priorities were identified through a competitiveness analysis, a literature review and industry consultation, including a survey of more than 50 industry respondents.

- **R&D priorities:** The sector has identified detailed knowledge gaps in the fields of robotics and automated production processes; advanced materials and composites; digital design and rapid prototyping; sustainable manufacturing and life cycle engineering; additive manufacturing; sensors and data analysis; materials resilience and repair; bio-manufacturing and biological integration; nano-manufacturing, micro-manufacturing and precision manufacturing; and augmented or virtual reality systems.
- **Business improvement priorities:** The sector has identified detailed knowledge gaps about business capabilities in the areas of drivers of the management capability gap; understanding current and future workforce skills requirements; building better international linkages; driving Industry 4.0 uptake; and leveraging government procurement.

1.5 ROLE OF THE AMGC AND NEXT STEPS

The role of the AMGC is to harness its unique capacity as an industry-led but government-supported Growth Centre to help advance Australian manufacturing. There are three key ways that the AMGC will deliver on this promise:

- **Direction:** The AMGC will set a direction to advance manufacturing in Australia through its annual Sector Competitiveness Plan, complementary sub-annual analytical investigations, and materials on Knowledge Priorities. Over the next 12 months, the AMGC will undertake a number of specific actions to progress this role, including conducting additional sub-industry analysis, regularly updating the Knowledge Priorities, mapping employer demand for skills to build an evidence-based industry-led skills plan and assessing Australian manufacturing against 'advanced' characteristics.
- **Demonstration:** The AMGC will demonstrate ways to achieve this direction through projects and hubs. It will co-fund projects that implement the identified priorities for the sector. These projects will serve as 'demonstrations' of best practice to advance manufacturing in Australia and pave the way for other actors in the sector to replicate. The AMGC will use hubs to demonstrate how firms can develop shared technical leadership and collaborate to overcome scale challenges. The AMGC has already supported two hubs (the Australian Carbon Fibre and Composite Technologies Hub, and the Additive Manufacturing Collaboration Hub), which are leveraging the geographical proximity of firms in key industrial areas in Victoria. Over the next 12 months, the AMGC will identify further projects and hubs in other states and content areas.

- **Impact:** To pursue this direction, the AMGC will seek to influence the strategies pursued by companies and governments. Companies, which will lead the transition, require a comprehensive understanding of the capabilities and requirements needed to shift towards more advanced manufacturing. Over the next 12 months, the AMGC will seek to assist companies by creating tools for companies to benchmark themselves against the key characteristics of advanced manufacturers, communicate the characteristics associated with advancement, communicate the findings laid out in the Plan, showcase examples of businesses that have servitised, and communicate the skills needed today and in the future. Likewise, governments are able to accelerate the transition that companies need to undergo. As an industry-led but government-supported body, the AMGC is well positioned to ensure that government policy and assistance best supports the transition. The AMGC will work with the relevant government departments to improve their support for business-led R&D; inform procurement officers about key levers of competitiveness; ensure a strong industry-policy role in upcoming defence procurement; ensure evaluation criteria for relevant assistance are aligned with 'advanced' characteristics; ensure programs that offer capability-building target the development of 'advanced' characteristics; and modify how manufacturing is measured.

The analysis and actions contained in this report will help lift the Australian manufacturing sector to another level. The AMGC will work with companies, governments and other stakeholders to implement this Plan and harness the under-utilised potential of Australian manufacturing.

> The Plan will require national effort from multiple stakeholders across industry, government and research, the transition, critically, must be led by companies.

> The importance of skill mix suggests that a shift towards higher-skill composition or skill-intense production will be important if Australian manufacturers are to be more competitive in the future.

2 SECTOR COMPETITIVENESS DIAGNOSIS

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2.1 RETHINKING COMPETITIVENESS

> The biggest force acting on our business is low-cost competition from foreign producers. The only way we can succeed is by building smarter versions of our product and finding smarter ways to deliver it.
>
> **Industry participant**, AMGC consultation[2]

Cross-country studies of manufacturing capability focus primarily on cost as the main driver of competitiveness. While cost is undoubtedly important, it is far from the only dimension of competitiveness, especially for Australian manufacturers in global markets. Australian products normally succeed in global markets because they offer something different – perhaps innovative features, or an exceptional reputation for reliability, or outstanding after-sales service. The reality of Australia's high-wage economy and distance from global markets is that its manufacturers often succeed by being better, not just cheaper, than their competitors.

The framework for competitiveness in this section of the Plan includes not only product cost competitiveness (costs that drive final price), but also value differentiation (sources of value beyond unit cost) and market focus ('where we play' in the value chain, in global markets and in skill-intense products) – see Exhibit 5.

1. **Product cost:** The composition of costs that drive the final price of a produced good, including variable costs (labour, materials, energy and transport), tax and fixed costs (capital and overheads). Product cost has been the commonly prioritised concept in manufacturing competitiveness studies.

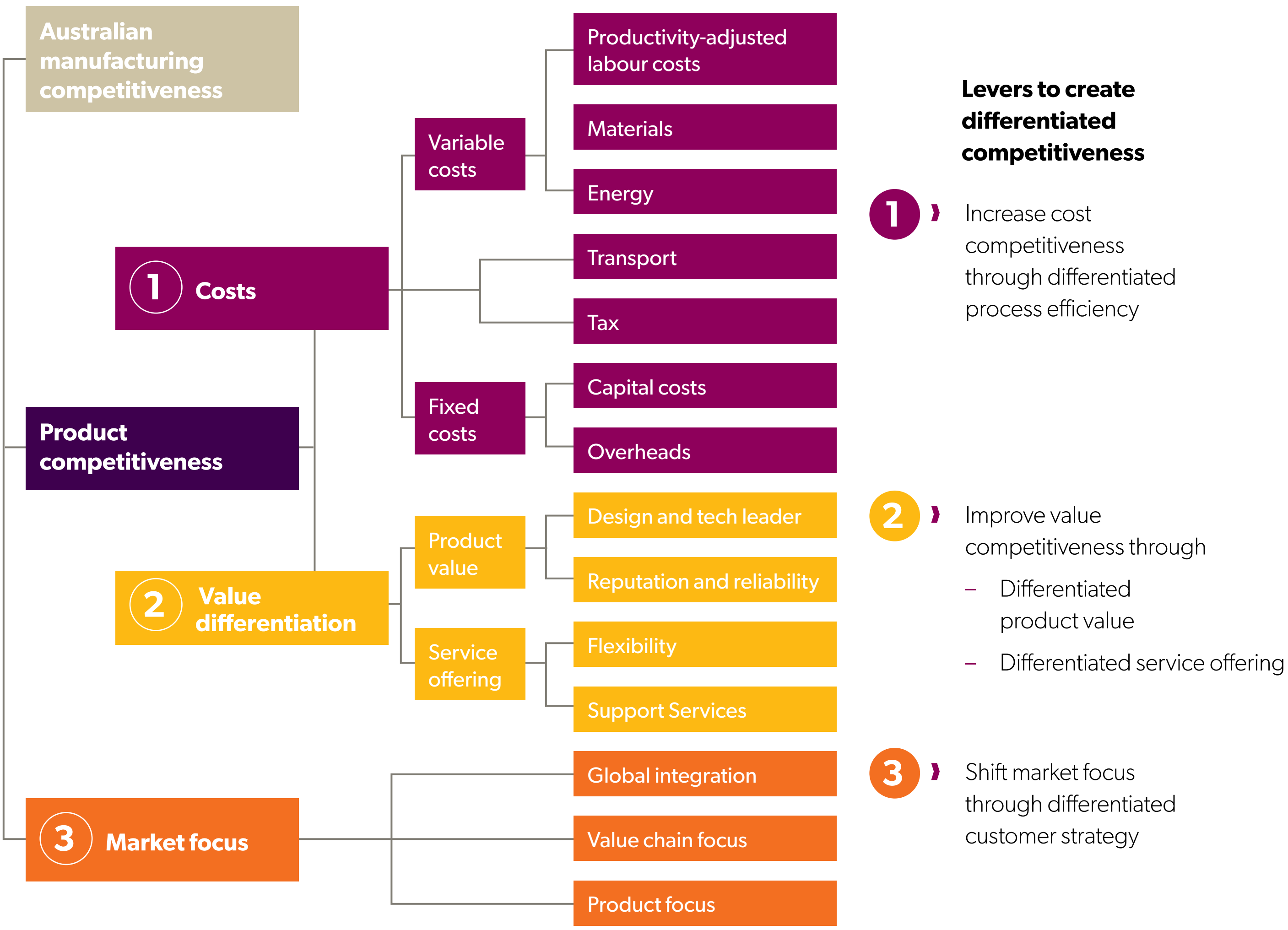
2. **Value differentiation:** The sources of value creation for customers beyond product cost, such as product leadership, reputation and reliability, flexibility and service offering. Hard-to-replicate sources of differentiation (such as world-leading technology protected by patents, or a reputation for unrivalled quality or reliability) can create a source of competitive advantage, resulting in larger and more sustainable margins than those that can be achieved by manufacturers who compete on production cost alone.

3. **Market focus:** How manufacturers can boost competitiveness by changing where they 'play'. This includes whether they serve growing customer segments or markets, and whether they are focused on skill-intensive product niches. Shifting to the highest potential markets that play to Australian manufacturing's strengths can significantly increase value and our overall competitiveness.

2 This comment was recorded during AMGC's early consultation with industry members. It was made by the manager of an Australian SME engaged in mechatronics manufacturing.

Exhibit 5 – We better understand ways Australian manufacturers can boost competitiveness by thinking more broadly than cost, looking also to 'value' and 'market focus'

Competitiveness framework



Source: Based on >25 interviews with final customers/international purchasing managers about what matters most and analysis of successful characteristics of 3,040 global manufacturing firms. AlphaBeta/McKinsey analysis

2 SECTOR COMPETITIVENESS DIAGNOSIS

This framework was developed for the purposes of this Plan and to guide the AMGC's approach. It has been developed using information from an international panel of manufacturing purchasing managers and customers, analysis of the success characteristics associated with more than 3,000 global firms[3], and other research conducted in the process of creating this Plan.

In order to analyse the current competitiveness of Australian manufacturing, we have initially focused on two specific sub-industries: aerospace and medical technology. We do so in recognition of the fact that manufacturing is a broad sector made up of numerous sub-industries that exhibit very different characteristics, but also that any analysis of the drivers of competitiveness demands the investigation of real data at the sub-industry level. Medical technology and aerospace were selected for a number of reasons. First, these sub-industries are often considered 'more advanced' and we were eager to examine what was working in more successful, export-oriented industries and how to expand this success. Second, they offered variation in insights due to different industry structures, barriers to success, and innovation models. Going forward, the AMGC will conduct further sub-industry analyses to ensure actions are informed by every part of the industry.

The analysis of manufacturing competitiveness summarised in this Plan reveals that Australia has competitive advantages as well as opportunities for improvement in three dimensions of competitiveness: cost, value differentiation and market focus.

> Skill mix, management practice and business size help to explain Australia's disadvantage in labour costs.

2.2 LIFTING COMPETITIVENESS BY REDUCING COSTS

2.2.1 Australian manufacturing has a product cost disadvantage relative to the international benchmark

Product cost refers to the composition of costs that drive the final price of a produced good, including variable costs (labour, materials, energy and transport), fixed costs (capital and overheads) and tax. In order to estimate the landed cost, this Plan used a range of data sources to identify relative costs for Australian manufacturers versus an international benchmark.[4]

Australian manufacturing has a product cost disadvantage relative to the international benchmark of between 15.1 percentage points in aerospace and 7.1 percentage points in medical technology, due primarily to differences in labour costs, transport costs and overheads (see Exhibit 6). The US was selected as the benchmark country for both aerospace and medical technology because it is a leading developed competitor and exporter in each category. A sizeable proportion of the gap compared with the international benchmark (3.0–9.1 percentage points) is driven by labour costs.[5]

Productivity-adjusted labour costs are a combination of both wage levels and labour productivity. Importantly, Australian manufacturing's labour unit cost disadvantage is not primarily the result of higher wages but more the nature of production in Australia. Specifically, factors such as Australian manufacturing's skill mix, management practice and business size help to explain Australia's disadvantage in labour costs (see Section 2.2.3).

3 Standard & Poor's (2016), Compustat Database (accessed: August 2016).

4 The model calculated the price required to generate a fixed return on invested capital equivalent to the cost of capital. The relative size of each cost category for aerospace and medical technology companies was estimated using detailed data from the 2014 US Census of Manufacturers. For each cost category, industry-specific benchmarks were used to identify the relative cost (higher or lower) for Australian firms, resulting in an overall product cost comparison. This research draws on data sets including the OECD STAN database, EU KLEMS database, ABS and BLS data, and other reports on manufacturing.

5 AlphaBeta/McKinsey manufacturing product cost competitiveness model.

Exhibit 6 – Product cost benchmarking suggests that Australian manufacturing has a cost disadvantage of 15.1 percentage points (ppt) in aerospace and 7.1 ppt in medical devices

	Aerospace			Medical technology		
	Share of unit cost	Gap to benchmark	Total ppt contribution	Share of unit cost	Gap to benchmark	Total ppt contribution
Productivity adjusted labour	28%	+32%	9.1	30%	+9.8%	3.0
Materials	48%	+3%	1.5	44%	+2.2%	1.0
Energy	1%	+48%	0.5	1%	+48%	0.5
Transport	8%	+13%	1.1	4%	+11%	0.4
Tax	1%	7 ppt	0.6	1.5%	7 ppt	0.5
Capital	4%	+33%	1.3	5%	+9.8%	0.5
Overheads	10%	+11%	1.0	14%	+10.0%	1.4
		Total unit cost difference =	**15.1**		Total unit cost difference =	**7.3**

Australia's unit labour cost disadvantage is **driven by lower labour productivity** (value added per hour), **not wages**. In both aerospace and medical devices, Australian productivity is lower than in the US; while in medical devices Australia has a **wage advantage**

Transport cost differential driven by relative cost to export to key EU markets, including internal freight. For **small, high-value medical devices the difference is smaller**

Higher overheads for Australian firms driven by **significantly smaller average firm size**, where overheads are a greater proportion of cost

In **aerospace**, the total cost difference is 15.1 ppt, driven primarily by differences of 9.1 ppt in labour, 1.1 ppt in transport and 2.3 ppt in capital/overheads.

In **med tech**, the total cost difference is 7.3 ppt, driven primarily by differences of 3.0 ppt in labour, 1.9 ppt in capital/overheads and 1.0 ppt in inputs.

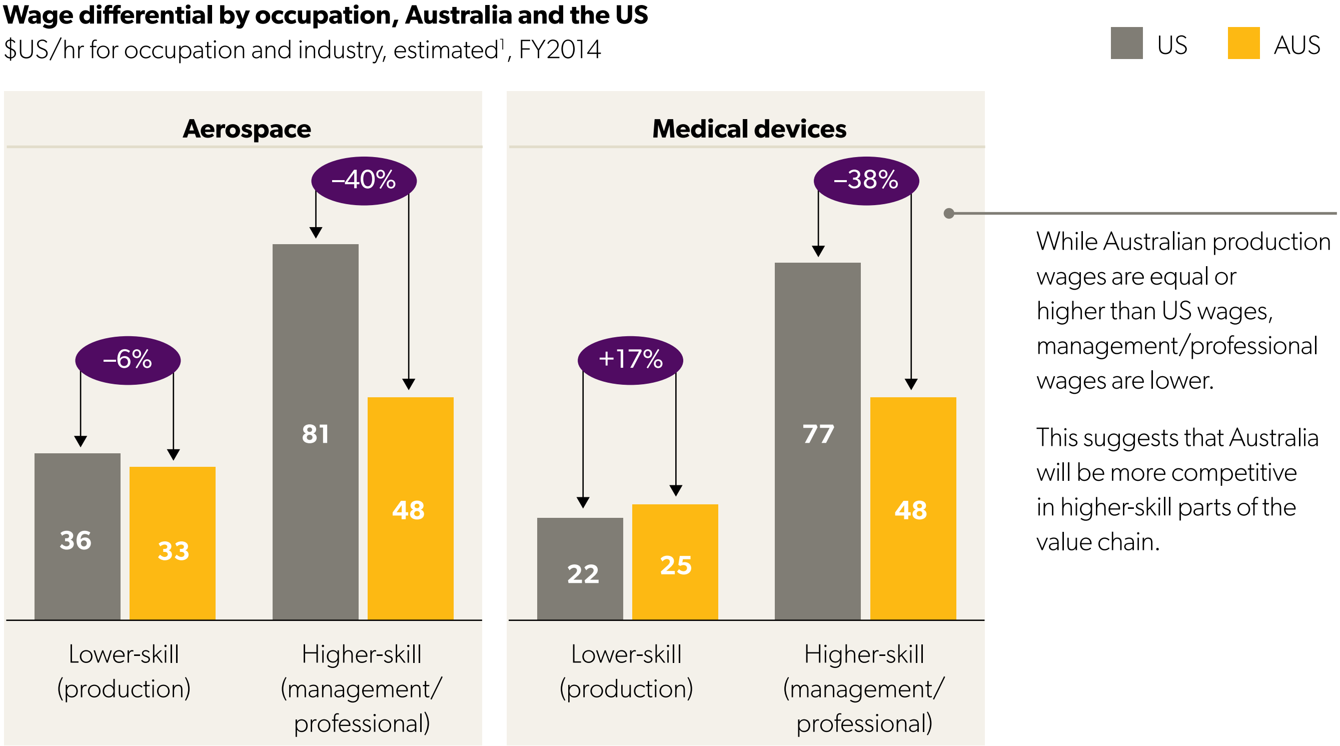
Source: McKinsey/AlphaBeta competitiveness model; various cost input sources

2.2.2 Australian manufacturing has a cost advantage in high-skill labour, which some sub-industries do not exploit

In general, Australian manufacturing is unlikely to be able to compete on labour cost for low-skill jobs. Even relative to high-cost countries such as the US, Australian low-skill labour is comparatively more expensive: 9.8% higher than benchmark in medical technology and just under benchmark in aerospace. However, Australia has a wage cost *advantage* for high-skill workers: 38% below benchmark in medical technology and 40% below in aerospace (Exhibit 7).[6] This means that the most competitive Australian manufacturing companies will often be those that have higher proportions of high-skill workers than foreign competitors. The decision by Ford to retain over 1,000 design and engineering staff despite ceasing production offers evidence of this cost advantage in Australia.

This can be seen in the cases of aerospace and medical technology. Australia's competitiveness in medical technology can be partly explained by its higher proportion of high-skill workers (26% of workers have a bachelor's degree or higher versus 18% in the US).[7] By contrast, the larger gap in labour costs in aerospace can be partly explained by the relatively low-skill composition of the aerospace workforce (17% with a bachelor's degree or higher versus 44% in the US), thereby failing to capitalise on our labour cost advantage (Exhibit 8).[8] The importance of skill mix suggests that a shift towards higher-skill composition or skill-intense production will be important if Australian manufacturers are to be more competitive in the future.

Exhibit 7 – Australia has a significant cost advantage in higher skill workers

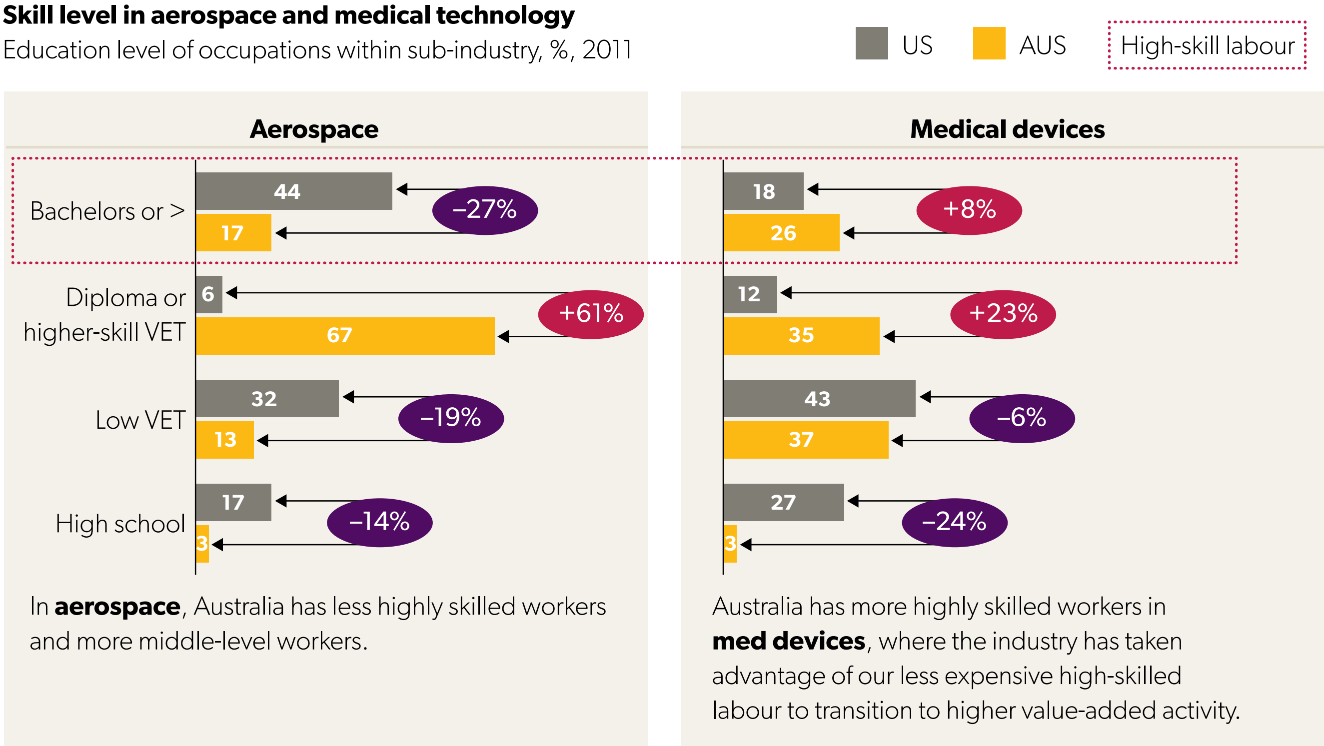


1 US estimates based on US Census Bureau's Annual Survey of Manufactures.
2 Australian estimates based on mapping average wages for roles to mix of roles in each industry; 10-year average exchange rate of $0.88 AUD/USD.
Source: ABS series 6306; US Census Bureau Annual Survey of Manufacturers (ASM) 2014; RBA Forex data; McKinsey/AlphaBeta analysis

6 ABS series 6306, US Census of Manufacturers 2014, RBA Forex data, McKinsey/AlphaBeta analysis.
7 Australian Census (2011), US BLS Occupation-Industry Matrix (2011), calculated by mapping education levels to occupations at 1-digit level, AlphaBeta/McKinsey.
8 ibid.

Exhibit 8 – Some Australian industries do not take advantage of our cost advantage in high-skill workers

Skill level in aerospace and medical technology
Education level of occupations within sub-industry, %, 2011



Note
Higher-skill VET defined as Cert III or IV in Australia and 'Some college, no degree' in US.
Source: Australian Census (2011); US BLS Occupation-Industry Matrix (2011). Calculated by mapping education levels to occupations at 1-digit level. AlphaBeta/McKinsey analysis

2.2.3 Capital efficiency and productivity are lower, in part driven by challenges around management quality, firm size and Industry 4.0

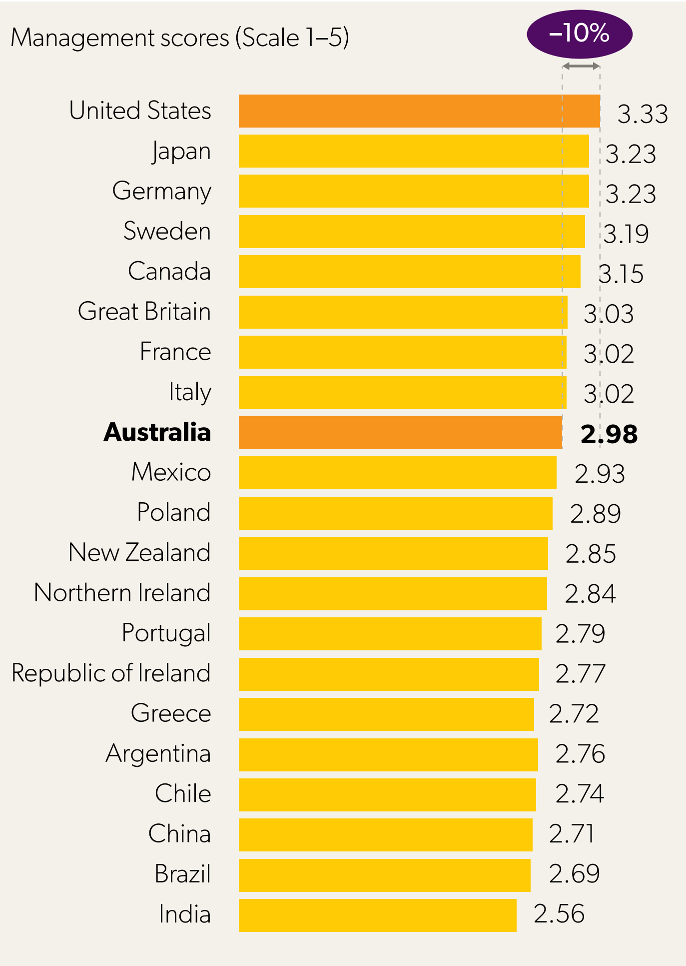
Labour productivity in Australian manufacturing is only 60–65% the level of the international benchmark[9], more than offsetting the wage cost advantage in high-skill workers. Key drivers of this include management capability, which impacts efficiency; and firm size, which impacts economies of scale and potentially the uptake of automation, capital intensity and Industry 4.0 processes.

A study of more than 6,000 manufacturers across 21 countries evaluated national management performance against a set of common benchmarks including lean operations, performance management and talent management.[10] This research revealed that Australia has a larger tail of low-performing manufacturing companies than other advanced economies (Australian scores were 10% lower than US scores on average, for instance; see Exhibit 9) and a shortage of managers with university degrees. Other countries have sought to boost the skill level and proportion of the workforce with tertiary education through such policies as encouraging greater enrolment in STEM subjects, attracting more workers into manufacturing, and skilled migration.[11]

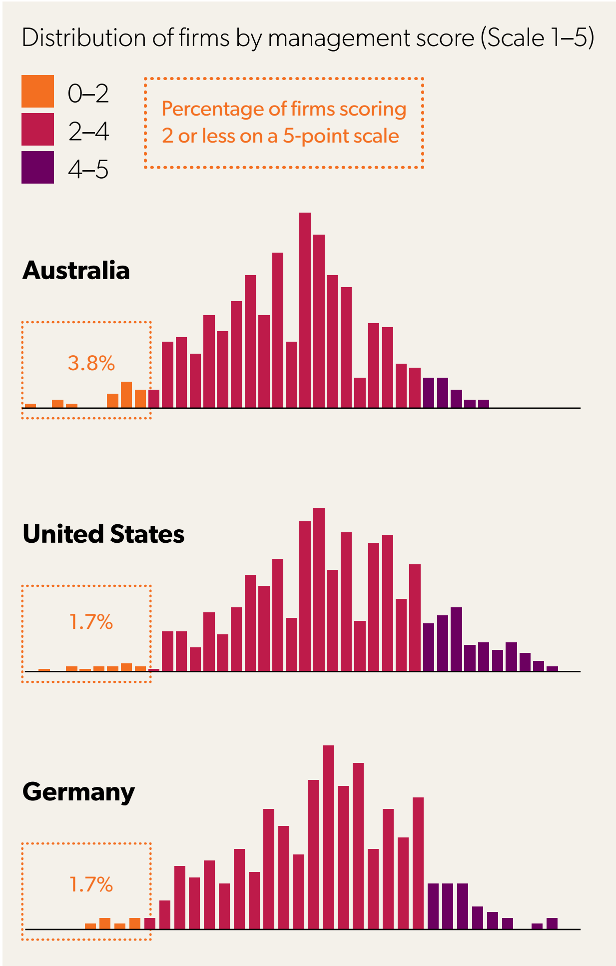
9 AlphaBeta/McKinsey manufacturing product cost competitiveness model.
10 Bloom, Nick et al. (2007), 'Management Practice and Productivity: Why They Matter', *Management Matters*. Available at: http://www.growingjobs.org/downloads/management_practice.pdf
11 McKinsey & Company (2009), *Management Matters*.

Exhibit 9 – Management practice among Australian manufacturers requires improvement

Australia lags significantly behind the US in manufacturing management practice …



… with a larger share of underperforming managers compared with other countries

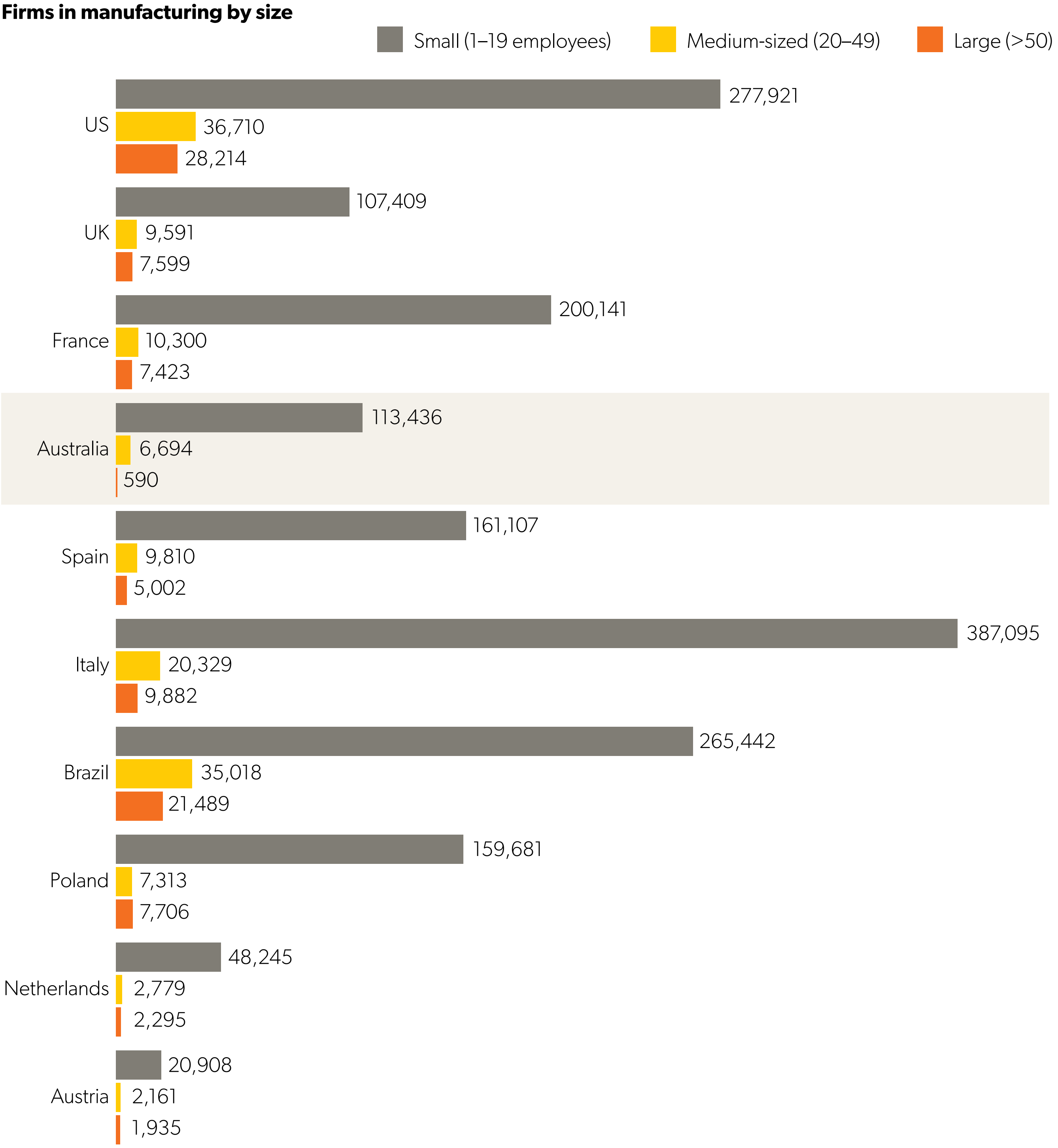


Source: McKinsey & Company, *Management Matters* 2008, 2009

Firm size: Achieving economies of scale in manufacturing has been a challenge for Australia, driven by limited local demand and distance from world markets. This, coupled with a system that encourages sole traders to incorporate, has resulted in a market dominated by small firms (see Exhibit 10). In aerospace manufacturing, Australia has 42 medium-sized companies and two large companies versus 472 medium-sized companies and 280 large companies in the US.[12] In medical technology manufacturing, Australia has 44 medium-sized companies and six large companies, compared with 792 medium-sized companies and 667 large companies in the US.[13] The implication is that overheads are not spread across large volumes, and shorter production runs make it harder to optimise production. Other countries have sought to overcome scale challenges by encouraging collaboration between companies, consortium formation in bidding for government contracts or entering export markets, and the pooling of R&D resources.

12 OECD Structural and Demographic Business Statistics (2012).
13 ibid.

Exhibit 10 – Australia has a reasonable number of manufacturing SMEs but very few large firms



Note

Australia has numerous small firms in part as a result of a system which encourages sole traders to incorporate.

Source: OECD Structural and Demographic Business Statistics (2012)

Automation, capital intensity and Industry 4.0:
The gap between Australian manufacturing productivity and that of our peers can be partially explained by differences in capital intensity, automation and the uptake of Industry 4.0 technologies and processes. A number of key commentators in Australia have suggested that Australian firms lag in their capital investment and intensity.[14] 'Industry 4.0' refers to the suite of digital technologies augmenting industrial processes, including '1) the rise of data volumes, computational power and connectivity; 2) emergence of business-intelligence capabilities; 3) new forms of human-machine interactions; 4) improvements in transferring digital instructions to the physical world, e.g. 3D printing'.[15] Studies in international contexts have indicated potential productivity gains of up to 25% in excess of conversion costs, and an overall gain of 5–8% from the adoption of Industry 4.0 technology.[16] While similar studies are yet to be completed in an Australian context, and we do not have good-quality data on the uptake of Industry 4.0 in Australia versus other countries, the possibilities enabled by Industry 4.0 map closely with the sources of competitiveness identified by our analysis. The greater integration of digital production, automation and data analysis will improve production processes and allow more distinct value offerings.

> Australia needs to appeal to international purchasing managers.

2.3 LIFTING COMPETITIVENESS BY INCREASING VALUE DIFFERENTIATION

2.3.1 Overview of value differentiation strategies

In addition to making better use of potential cost advantages in high-skill labour, Australian manufacturers can compete by offering differentiated sources of value. This is most often driven by some kind of technology or design innovation that results in materially improved performance or an enhanced bundled service offering that makes products easier to use, upgrade or tailor to customer needs.

2.3.2 International customers care about value differentiation including technical leadership and service offering

To understand sources of value to customers beyond product cost, we asked a panel of approximately 30 industry experts and international purchasing managers to identify and weight other factors that influenced the selection or procurement of a final good or intermediate component from Australia. These factors included product innovation, design, reputation, flexibility and service support (see Exhibit 11).

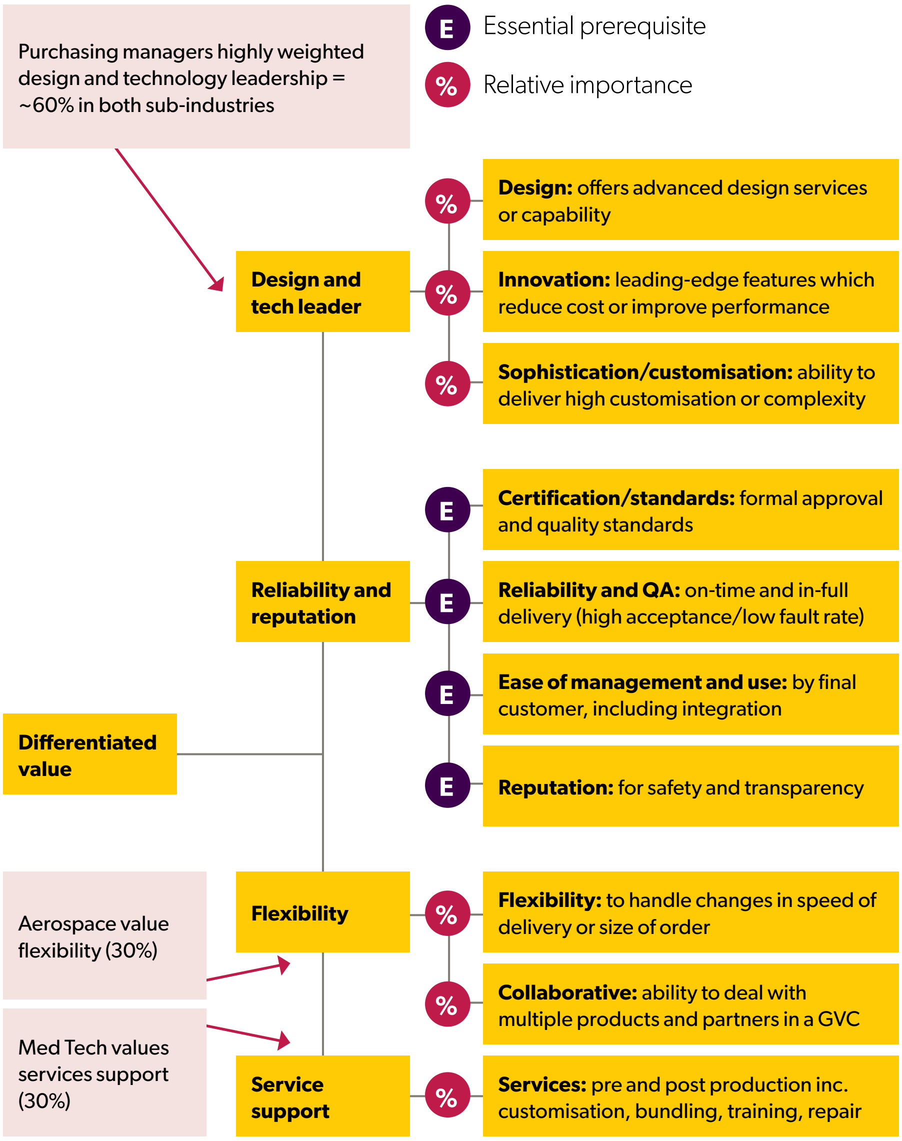
Purchasing managers and customers identified technology and performance leadership as the most important factors other than cost, with an approximate 60% weighting collectively. With a small domestic market and cost disadvantages, Australia needs to appeal to international purchasing managers with innovative design and leading technology across a smaller-scale and niche product line. Flexibility and services were respectively considered key for aerospace and medical technology customers, with an approximate 30% weighting collectively.

14 AiG and AAMC have commented that Australian manufacturers urgently require capital investment and upgrades.

15 McKinsey & Company (2015), *Manufacturing's Next Act*. Available at: http://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act

16 Boston Consulting Group (2015), *Industry 4.0: The future of productivity and growth in manufacturing industries*. Available at: https://www.bcgperspectives.com/content/articles/engineered_products_project_business_industry_40_future_productivity_growth_manufacturing_industries/

Exhibit 11 – International purchasing managers report that technical leadership and the availability of service support are the main reason they buy Australian products



Key insights and quotes

- **Aerospace:** *"Companies need to develop solutions targeting real problems facing the industry"*
- **Aerospace:** *"Value to end user is critical in competitive aircraft market, e.g. weight reduction can be worth far more than the component itself"*
- **Med Tech:** *"Hospitals of tomorrow will want equipment customised to their information systems"*
- **Aerospace:** *"Certification to required standards is a given"*
- **Med Tech:** *"This is essential given poor patient outcomes"*
- **Aerospace:** *"This is table stakes" "There are high-costs to faults and schedule disruption"*
- **Med Tech:** *"Purchasing managers care most about product safety, given risks of poor patient outcomes"*
- **Aerospace:** *"Assessing bid proposals ultimately boils down to trust"*
- **Aerospace:** *"Ability to ramp up production quickly is of great value but rarely need to ramp down"*
- **Aerospace:** *"The ability for suppliers to work with other suppliers makes things much easier for the prime or OEM"*
- **Med Tech:** *"Final customer cares a lot about simplicity in accessing services and managing product. This is a key differentiating factor."*

Notes:
For aerospace, relevant experts were international purchasing managers in OEMs and primes. For med tech, relevant experts were final customers and exporters' view of what mattered to their final customers.
Source: Interviews

2.3.3 Australian companies do not spend highly on R&D or employ a large share of high-skill workers

Despite the clear importance of technical leadership, Australian companies do not spend a lot on R&D and, compared with the US, many Australian manufacturing sub-industries do not employ a large share of high-skill workers.

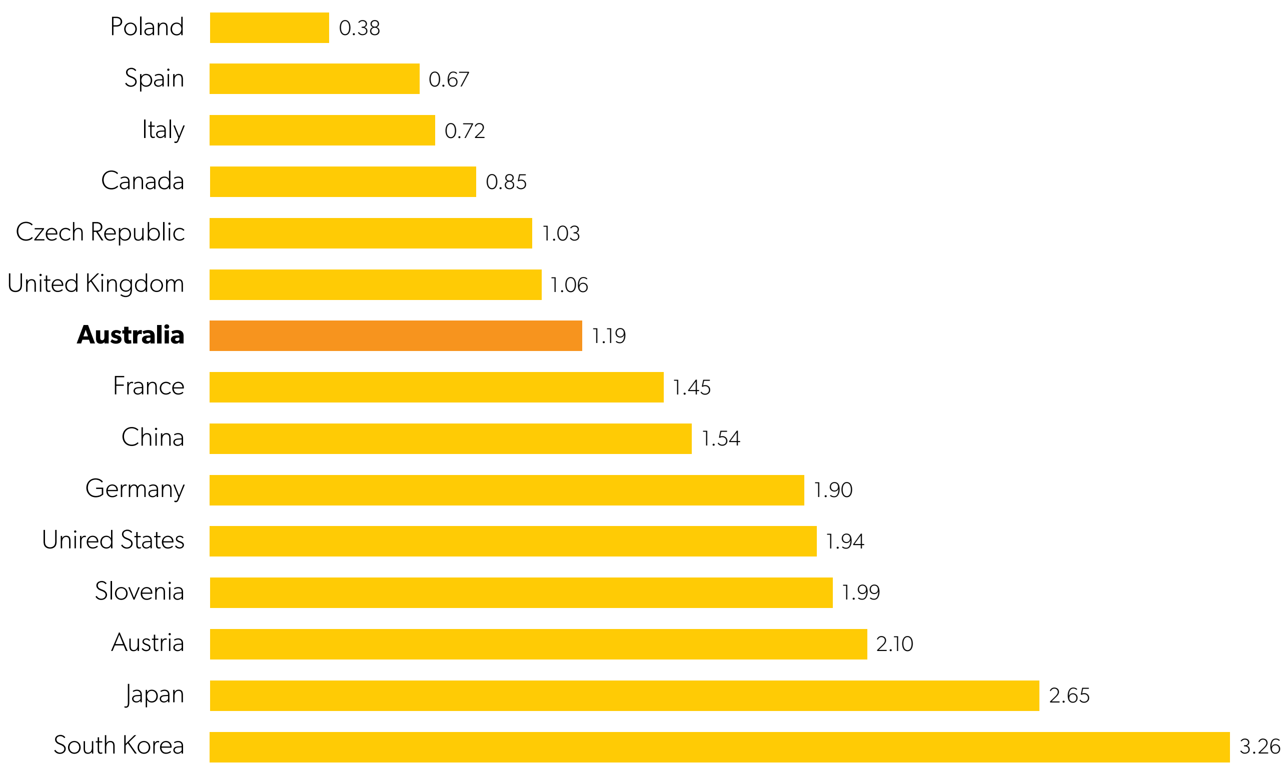
While Australian businesses spend more on R&D as a proportion of GDP than peers like Canada or the United Kingdom (UK), Australian firms index well below many key OECD competitors (see Exhibit 12). For example, Australian businesses' expenditure on R&D is the equivalent of 1.19% of GDP, while in Germany it is 1.90%, US 1.94%, Japan 2.65% and South Korea 3.26%.

In a number of manufacturing sub-industries, Australia has a low utilisation of high-skill workers relative to the US (see Exhibit 13). The proportion of workers with higher skills is larger in the US than in Australia in computer and electronics manufacturing (by 46 ppt), photographic and optical manufacturing (by 34 ppt), and aircraft manufacturing (by 31 ppt). These skill deficits are particularly stark given that Australia has a significant cost advantage in higher-skilled workers: as much as 40% in some industries. Given our wage advantage in higher-skill roles, shifting a larger proportion of our employment into non-production roles and more skill-intense sub-industries represents an opportunity to improve competitiveness and increase productivity.

Exhibit 12 – Australian business expenditure on R&D is weaker than that of many key OECD competitors

Business expenditure on R&D (BERD) as a proportion of GDP

%, 2013

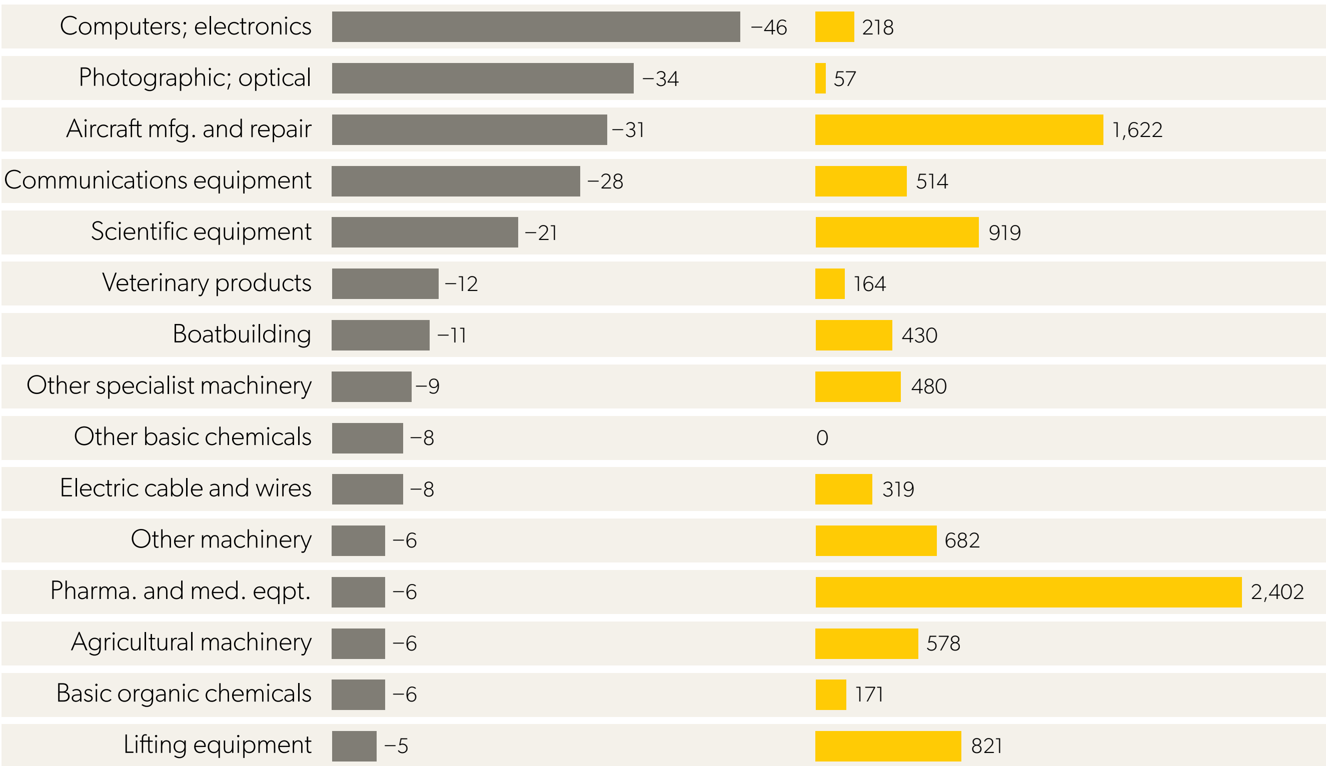


Source: OECD Main Science and Technology Indicators

Exhibit 13 – A number of sizeable manufacturing industries in Australia have large skill gaps compared with US equivalents, implying significant upside from boosting skill levels

Top 15 advanced manufacturing sectors by skills gap
Delta % in proportion of high skill workers

Australian size
2014 GVA, A$ millions



Source: ABS table builder OCCP – 1 Digit Level by INDP – 4 Digit Level; ABS 8155.0; BLS statistics; AlphaBeta/McKinsey analysis

2.3.4 Government and industry-led ‘ingredients’ can support technical leadership, but current R&D programs are not optimally designed

To understand which government and industry-led actions matter most to companies developing their technology and performance, we analysed 50 successful Australian aerospace and medical technology companies. Specifically, we looked at whether public research, government support for commercial R&D, collaborative R&D with universities, industry collaboration, government procurement, private financing or policy changes materially contributed to the development of their initial position of technology or performance leadership (see Exhibit 14).

This firm-level analysis of Australian success stories revealed five key ingredients that have helped to create technology leadership in Australia’s top firms: public research funding, commercial R&D support, university collaboration, capability transfer from another industry, and strategic government demand. However, despite the prevalence of these ‘success ingredients’, there were significant differences across the two sub-industries. In aerospace, 44% of successful exporters had technology or performance leadership support from capability transfer, 28% from university collaboration, 20% from strategic government procurement and 20% from Australian content requirements (see Exhibit 15).[17] By contrast, in medical technology, 60% had technology or performance leadership support from university collaboration, 56% from R&D grants or tax incentives, and 44% from research grants.[18]

17 AlphaBeta/McKinsey analysis of 50 firms, using expert interviews, company websites and press search.
18 ibid.

2 SECTOR COMPETITIVENESS DIAGNOSIS

Exhibit 14 – To understand what enables technical leadership, we analysed 50 successful Australian aerospace and med tech manufacturers

Question: what materially contributed to the firm developing the technology that made it successful?

Public research	Fundamental research grant	Was there an original grant for fundamental research (e.g. from ARC, NHMRC) that materially contributed to development?
Govt support for commercial R&D	R&D tax incentive	Did an R&D tax incentive materially contribute to development?
	Targeted R&D	Was there a targeted R&D or other grant that materially contributed to development?
Collaborative R&D	University/institute collaboration	Was there a relationship with a university or a research institution (CSIRO, CRC) that materially contributed to development?
	University talent spin-out	Was there a talent spin-out from a university or research institute that materially contributed to development?
Industry collaboration	Cluster	Did a cluster or partnership materially contribute to development?
	Coordination	Was there direction coordination by an industry body that contributed to development?
	Firm spin-out	Did the development come as a spin-out from a local or foreign firm?
	Capability transfer	Did a capability transfer from another industry or company materially contribute to development?
Govt procurement/ participation	Government procurement	Was the development materially supported by a government procurement contract?
	Australian content requirements	Was the development materially supported by Australian or SME participation requirements?
Private financing	Foreign direct investment	Was the development initially funded by foreign direct investment?
	Venture capital	Did the idea receive early-stage/VC funding?
	Anchor private contract	Was the development materially supported by an anchor private contract?
Policy or other	Regulatory change	Was there a regulatory change that supported the development?
	FTA/Export	Did an FTA or export assistance unlock a critical market to enable scale in development?
	Other	Other government or philanthropic assistance

Source: AlphaBeta/McKinsey analysis

Med Tech

Aerospace

Companies

Exhibit 15 – Technical leadership in Australian manufacturing firms was enabled by government R&D support and procurement policies

What factors materially impacted development of technology	**Aerospace** Proportion of firms	**Med Tech** Proportion of firms
Fundamental research grant	0%	44%
R&D tax incentive	0%	52%
Targeted R&D	12%	56%
University/institute collaboration	28%	60%
University talent spin-out	8%	28%
Cluster	20%	20%
Coordination	4%	0%
Firm spin-out	0%	20%
Capability transfer	44%	4%
Government procurement	20%	12%
Australian content requirements	20%	4%
Foreign direct investment	8%	0%
Venture capital	8%	56%
Anchor private contract	20%	24%
Regulatory change	0%	12%
FTA/Export	8%	16%
Other	28%	8%

Frequently cited
Less cited factor

In aerospace, the biggest enablers of technology/ performance leadership were government/ private demand, research collaboration and capability transfer from another industry.

In med tech, the biggest enablers of technology/ performance leadership were research grants, commercial R&D incentives, university collaboration and VC funding.

Different innovation models in these sub-industries may explain the different factors. In aerospace, the innovation model relies on complex systems. In med tech, the innovation model relies on advances in science.

Source: Expert interviews; company websites; press search. AlphaBeta/McKinsey analysis

The differences between the factors that contributed to success stories in each sub-industry are likely based on different models for innovation. Academic research has previously identified that sub-industries with different modes of innovation require different policy instruments to help overcome barriers and maximise spillover benefits.[19] Aerospace and medical technology have very different modes of innovation. The mode of innovation in aerospace requires the development of complex systems, which involves high levels of collaboration and high externalities. Potential policy instruments to encourage this mode of innovation include a secure source of demand and improved collaboration with universities. In contrast, the mode of innovation in medical technology requires the application of high-science-content technology, which involves high financing costs for high-risk efforts and the commercialisation of research. Potential policy instruments to encourage this mode of innovation include support for basic research, support for business-led R&D, venture capital, and improved collaboration with universities.[20]

This section has identified the importance of collaboration between research and universities to drive technical excellence, and government support for both basic research and business-led R&D in promoting technical excellence in some sub-industries.

Low rates of industry–research collaboration

International data suggests Australian manufacturing could improve its industry–research collaboration, which would help to drive technical excellence among firms.[21] Australia ranks poorly on OECD measures of industry–research collaboration.[22] However, a number of commentators have noted problems with these statistics. Some have taken issue with the definition of 'innovation-active' businesses. Others have suggested the ranking is driven, in part, by a long tail of sole traders and micro-businesses (0–4 employees) that are not well suited to collaborative research projects with large research organisations due to a mismatch in size and capacity. Similarly, it is argued that the ease of incorporation in Australia has driven many sole-trader service providers to register as manufacturing companies. As such, it is argued, Australia's ranking reflects the make-up of Australia's manufacturing sector rather than underperformance in collaboration.

Instead, we can gain insights from domestic data (not just research) on all businesses collaborating with any institution. If we exclude micro-businesses, we see weak collaboration among small businesses and improved levels of collaboration among medium-sized and larger businesses. Specifically, 18.6% of manufacturing firms with 5–19 employees are estimated to collaborate for the purpose of innovation with any other entity (including other firms and research institutions), compared to 18.4% of firms with fewer than five employees, and 19.7% of all manufacturing firms.[23] Larger firms collaborate significantly more, with 24.6% of firms with 20–199 employees and 34.2% of firms with 200+ employees collaborating with other entities, including researchers. Further, in 2013–14, only 9.5% of companies registering projects under the R&D Tax Incentive program indicated they had collaborated with another organisation.[24] The relatively low rate of collaboration among small businesses is problematic given that the vast majority of Australian manufacturing firms are small.

Sub-optimal design of government support for R&D

While the importance of government support for R&D is clear, that support is not currently optimally designed to meet the intended objectives. Governments support R&D because "market failures generally cause enterprises to underinvest in research … [where] the private rate of return to R&D investments is lower than the social rate of return".[25] The Australian Government is providing $10.1 billion in support of research and experimental development in 2016–17, to be delivered via 15 government departments and agencies. This expenditure includes $3.3 billion (33%) for R&D led by businesses, $1.9 billion (19%) for R&D led by government bodies, $1.4 billion (14%) for research led by multiple sectors, and $3.4 billion (34%) for research led by higher education institutions (see Exhibit 16).

19 Martin, S. (2000), 'The nature of innovation market failure and the design of public support for private innovation'. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.196.7452&rep=rep1&type=pdf

20 ibid.

21 Department of Industry (2016), 'R&D Tax Incentive Review Issues Paper', Canberra. Available at: https://www.business.gov.au/~/media/Business/RDTI/Review/Research-and-Development-Tax-Incentive-Issues-Paper-PDF.ashx?la=en

22 OECD (2016), 'Innovation Statistics and Indicators'. Available at: http://www.oecd.org/innovation/inno-stats.htm#indicators

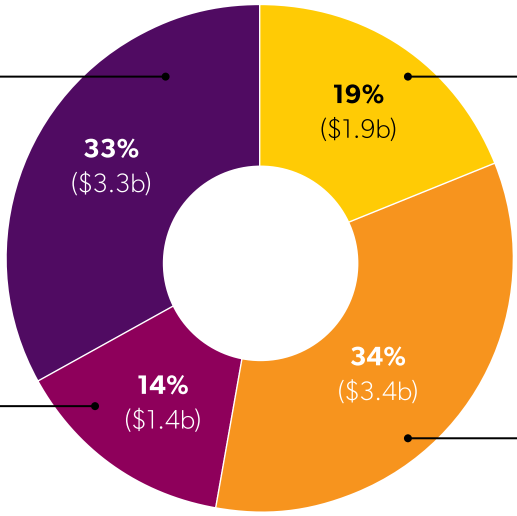
23 ibid.

24 Department of Industry (2016), op. cit.

25 OECD (2003), 'Tax Incentives for Research and Development: Trends and Issues'. Available at: http://www.oecd.org/science/inno/2498389.pdf

Exhibit 16 – Technical leadership in Australian manufacturing firms was enabled by government R&D support and procurement policies

Australian Government support for R&D, by channel
Budget estimate 2016–17, % of total R&D expenditure



Business-led research:
- R&D Tax measures (31%)
- Business innovation and other R&D (2%)

Australian Government-led research:
- CSIRO (8%)
- Defence Science & Tech Group (4%)
- Other Aust Gov (7%)

Multi-Sector-led research:
- NHMRC (Govt, Hospital) (2%)
- Other Health (2.5%)
- CRCs (1.5%)
- Rural (3%)
- Energy & Enviro (3%)
- Other (2%)

Higher education-led research:
- ARC (7%)
- NHMRC (University) (6%)
- Performance-based block funding (20%)

Source: 2016–17 Australian Government 'Science, Research and Innovation' Budget Tables

Government support for business-led R&D

This section has outlined the importance of government support for business-led R&D in many of Australia's success stories. The Australian Government's primary form of support for business-led R&D is the $3.3 billion R&D Tax Incentive scheme (see Exhibit 16), which is complemented by other smaller programs to support business innovation. These include CRCs and CRC-Ps, Accelerating Commercialisation, the new BRII pilot program[26] and the ARC Linkage Projects[27] program. However, the current mix of funding types and the design of the R&D Tax Incentive does not maximise the achievement of objectives including:

- Encouraging investment by firms in R&D with different risk profiles (both medium and higher risk) and different time horizons (both short- and longer-term)
- Ensuring that minimal government funding is provided to R&D activity that would have occurred without the incentive.

The funding mix is not likely to maximise investment by firms in R&D across different risk profiles, spillover benefits and time horizons.

26 The Business Research and Innovation Initiative provides grants to eligible businesses to address five selected challenges. For further information, see: http://www.minister.industry.gov.au/ministers/hunt/media-releases/grants-help-businesses-meet-public-sector-challenges

27 The Australian Research Council's Linkage Projects provide funding to eligible organisations to support R&D initiatives that are undertaken to acquire new knowledge, and that involve collaboration and risk or innovation. For further information, see: http://www.arc.gov.au/linkage-projects

Australia is an outlier when it comes to the mix of assistance it provides for business-led R&D. This assistance can be broadly categorised as 'direct' or 'indirect'. The OECD defines direct assistance as the provision of grants and payments for R&D services, and indirect assistance as the provision of tax incentives including allowances and tax credits.[28] A high proportion (~90%) of the Australian Government's assistance for business-led R&D is provided via indirect means, primarily through the R&D Tax Incentive (see Exhibit 17). This weighting toward indirect assistance is much higher than in other OECD countries such as Germany (0%), the US (27%) and the UK (50%). A peer country with a similar level of indirect assistance, Canada (at 86%), recently opted to streamline its tax incentive and transition to a higher proportion of direct support.[29]

The potential challenge with the existing funding mix is that different types of support for business-led R&D, namely direct assistance versus indirect assistance, are designed to respond to different market failures and stimulate different types of R&D expenditure.[30] Specifically, the OECD suggests that "tax credits are used mostly to encourage short-term applied research, while direct subsidies are directed to more long-term research"[31] and that tax-based measures, "unlike direct funding of business R&D … do not typically allow governments to direct business R&D into areas with high social returns (e.g. technological fields with significant spillovers)".[32] There are still good reasons to use indirect forms of assistance, such as tax credits, allowing markets to determine the allocation of R&D investment and administrative simplicity. However, the current mix may limit the potential for government to incentivise and promote investment by firms in longer-term, higher-risk R&D that might have high spillover benefits and deliver similar successes to those outlined in this Plan.

The current design of the R&D Tax Incentive scheme does not insure against public expenditure on activity that would have happened even without that public support (infra-marginal activity). Analysis conducted by the Centre for International Economics on the R&D Tax Incentive found additionality[33] of 0.3–1.0 per dollar of tax forgone for large companies and 0.9–1.5 per dollar of tax forgone for SMEs.[34] The R&D Tax Review conducted by Finkel, Ferris and Fraser (hereafter 'the Review') noted that "these magnitudes imply that around 10–20 percent of the total R&D registered would not be undertaken in the absence of the program".[35] These figures do not imply strong additionality. While the Review acknowledges that there "are limits in the ability to target additional R&D in a volume-based scheme", there are ways to improve the effectiveness of the scheme, which are explored further in Section 4.

> The OECD suggests that 'tax credits are used mostly to encourage short-term applied research, while direct subsidies are directed to more long-term research'.

28 OECD (2003), 'Tax Incentives for Research and Development: Trends and Issues'. Available at: http://www.oecd.org/science/inno/2498389.pdf

29 OECD (2012), Science, Technology and Industry Outlook, 'Tax incentives for R&D and Innovation'. Available at: https://www.oecd.org/media/oecdorg/satellitesites/stie-outlook/files/policyprofile/STI%20Outlook%2012_%20PP%20Actors_RD%20Tax%20incentives.pdf

30 OECD (2010), 'R&D Tax incentives: rationale, design, evaluation'. Available at: http://www.oecd.org/innovation/policyplatform/48141363.pdf

31 ibid.

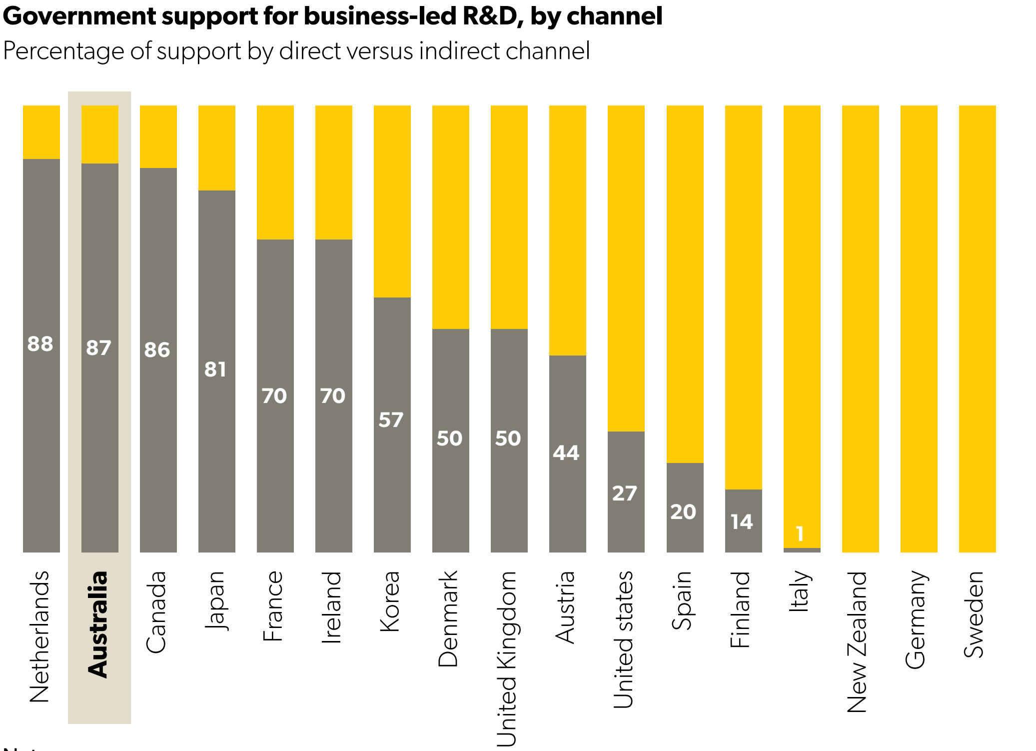
32 OECD (2003), 'Tax Incentives for Research and Development: Trends and Issues'. Available at: http://www.oecd.org/science/inno/2498389.pdf

33 Additionality refers to the increased private investment in R&D that occurs due to the program. See: Finkel, Ferris, Fraser (2016), *Review of the R&D Tax Incentive*. Available at: https://www.business.gov.au/assistance/research-and-development-tax-incentive/review-of-the-randd-tax-incentive

34 Centre for International Economics (2016), *R&D Tax Incentive Programme Review*.

35 Finkel, Ferris, Fraser (2016), *Review of the R&D Tax Incentive*. Available at: https://www.business.gov.au/assistance/research-and-development-tax-incentive/review-of-the-randd-tax-incentive

Exhibit 17 – Australia is an outlier in how it publically supports business-led R&D, with ~90% of funding provided via indirect channels



Direct R&D support
The OECD defines direct R&D support as the provision of research grants and payment for R&D services

Indirect R&D support
The OECD defines indirect R&D support as the provision of tax incentives, e.g. tax allowances, credits, deductions for R&D services

Note:
Sample of 17 of 35 countries shown here.
Source: OECD R&D Tax Incentives Indicators, based on 2013 OECD-NESTI data collection on tax incentives support for R&D expenditures and OECD, National Accounts and Main Science and Technology Indicators, 15 December 2014; AlphaBeta/McKinsey analysis

Alignment between public research and business-led R&D

The relationship between public research funding and commercial research could be stronger, in part through increased collaboration. While there are many categories of public research funding, with different societal and economic objectives, a high-level comparison of public research and business-led R&D indicates weak overlap in the areas of expenditure (see Exhibit 18). For example, 10.4% of public research funding (including for research led by not-for-profit, higher education and government institutions) is spent on engineering, versus 39.7% of business-led R&D.[36] Similarly, medicine and health sciences receive 28.8% of public research expenditure, versus 6.0% of business-led R&D expenditure. There are good reasons for this, including Australia's historic research strengths and the societal benefits associated with advances in health care. However, Australian medical technology/pharmaceutical exports account for a significantly smaller share of overall exports – implying a weaker relationship between research investment and our ability to commercialise discoveries in this area.[37]

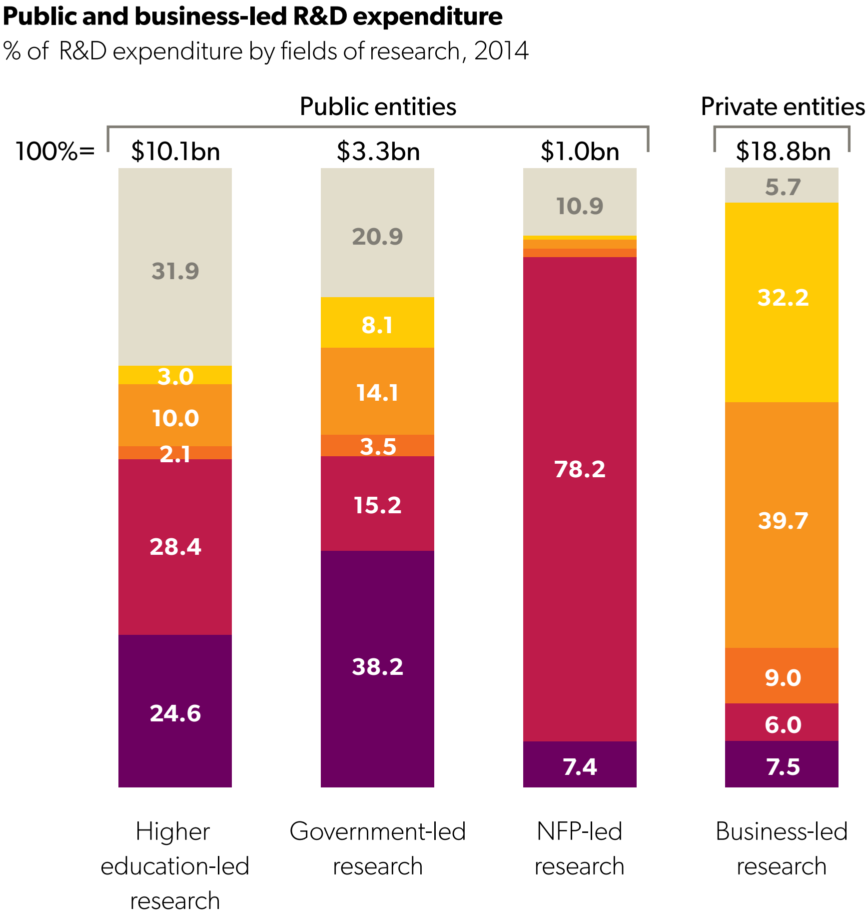
This Sector Competitiveness Plan does not consider whether this alignment is problematic. Further analysis could be undertaken in subsequent plans. However, we note that some other countries allocate funds more widely, to sectors with potential for commercial growth. For example, South Korea has focused more explicitly on advanced manufacturing. Other small countries adopt 'fast follower' strategies in some sectors, with a focus on translational research.[38] The weak alignment in Australia could be explained, in part, by collaboration rates between research and industry.

36 ABS series 'Research & Experimental Development' 8104.0 (Business), 8109.0 (Government & Private NFP), and 8111.0 (Higher Education Institutions).

37 Australian Technology Network/Ai Group (2015), *Innovate to Prosper: Ensuring Australia's Future Competitiveness through University-Industry Collaboration.* Available from: https://www.atn.edu.au/siteassets/publications/atninnovateprosper.pdf

38 The Government of the Republic of South Africa (2002), South Africa's National Research and Development Strategy, Pretoria. Available at: http://www.cepal.org/iyd/noticias/pais/0/31490/Sudafrica_Doc_1.pdf

Exhibit 18 – There is minimal overlap between the fields of research targeted by public research entities and commercial entities



R&D conducted by public entities, such as higher education, government and NFP bodies, targets different fields of research to business-led R&D.

For example, 29% of total research by **public entities** is expended on medical science versus 6% of business-led research.

While there are good reasons for variation in expenditure, the absence of alignment is worthy of further investigation.

Note:
R&D expenditure includes capital expenditure, scholarship and labour costs, experimental product development etc.
Source: ABS series 8111.0 'Research & Experimental Development, Higher Education Institutions'; ABS series 8104.0 'Research & Experimental Development, Business'

2.3.5 Service-enhanced manufacturing is another key source of value

Another avenue to increase competitiveness is to provide customers with value-adding services associated with manufactured goods. Servitisation is the provision of services to clients by manufacturing firms[39], with services typically supporting or complementing products and helping manufacturers to establish long-term relationships with consumers. The shift has comprised both (i) structuring sales to focus on customer needs – for example, providing a capability or solution rather than selling a piece of equipment; and (ii) bundling services that are typically conducted by the customer or third parties in the outbound supply chain – for example, training, support, repairs, data monitoring and analytics. In aerospace, Rolls-Royce has moved to offering its customers 'power by the hour' – monitoring engines remotely, conducting repairs, and providing training and support to local engineers. The company recently reported

39 Visnjic, I. and Van Looy, B. (2012), *Servitization: Disentangling the Impact of Service Business Model Innovation on Manufacturing Firms Performance*, ESADE Business School Research Paper, No. 230. Available at: http://proxymy.esade.edu/gd/facultybio/publicos/1393004444807Servitization_Disentangling_the_impact_of_service_business_model_innovation_on_the_performance_of_manufacturing.pdf

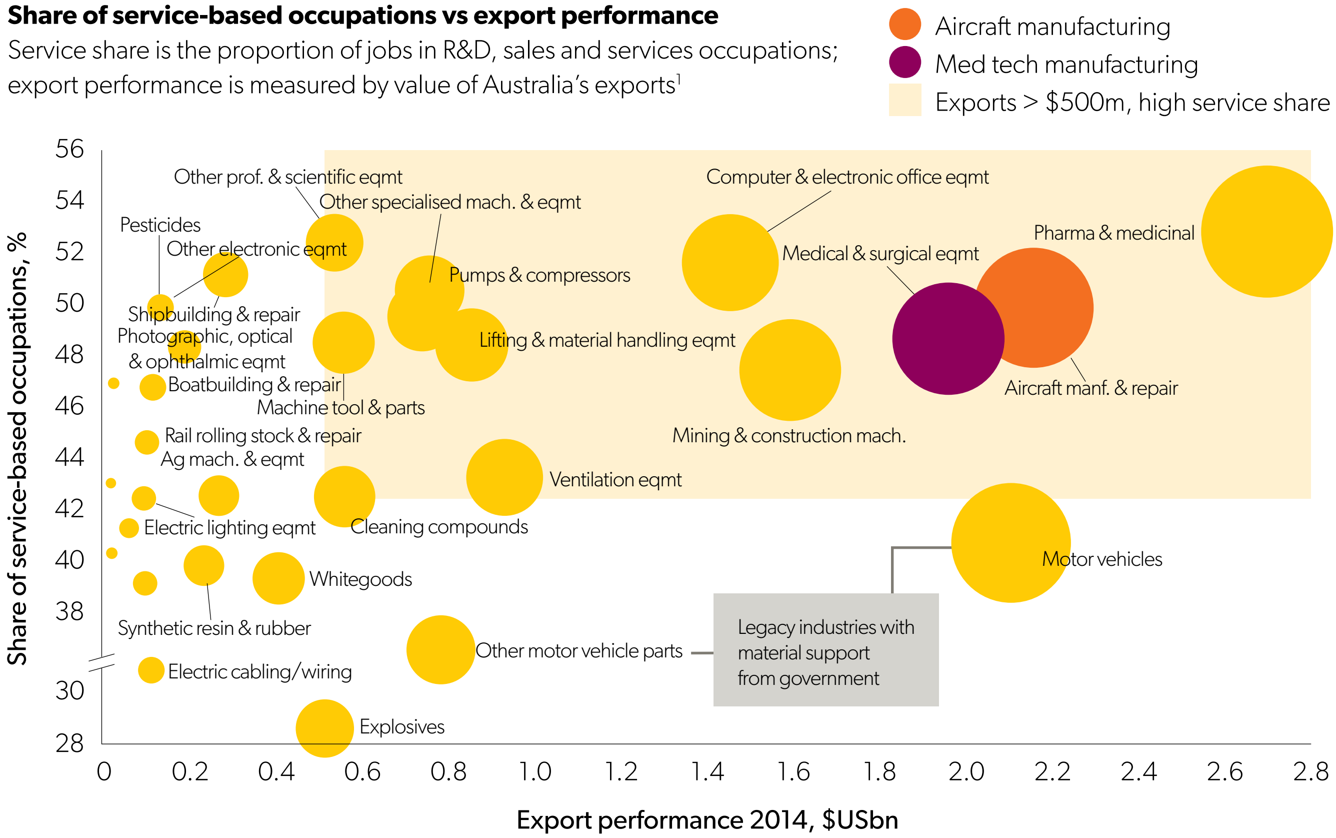
that nearly half of its revenue (49%) is derived from services. This servitisation of manufacturing reduces the impact of high production costs by elevating the need for new skill sets in customer engagement, ICT, data management and analytics. It also encourages the customer to explicitly consider the lifetime benefit of the combined product–service offering.

Australia's strength in service delivery and our highly skilled workforce make us well placed to increase the share of non-production activity such as design, engineering, sales and value-added services. Australian manufacturing has enjoyed export success where firms have transitioned to service-enhanced manufacturing. Exhibit 19 suggests that, apart from legacy industries that have enjoyed material support from the government, such as the automotive industry, the sub-industries that have the highest share of non-production occupations have exhibited the strongest export performance.[40]

Exhibit 19 – Australian manufacturing industries that have created non-production capabilities exhibit the strongest export performance

Share of service-based occupations vs export performance

Service share is the proportion of jobs in R&D, sales and services occupations; export performance is measured by value of Australia's exports[1]



1. 42 sub-industries defined by the ABS as an interim definition for advanced manufacturing

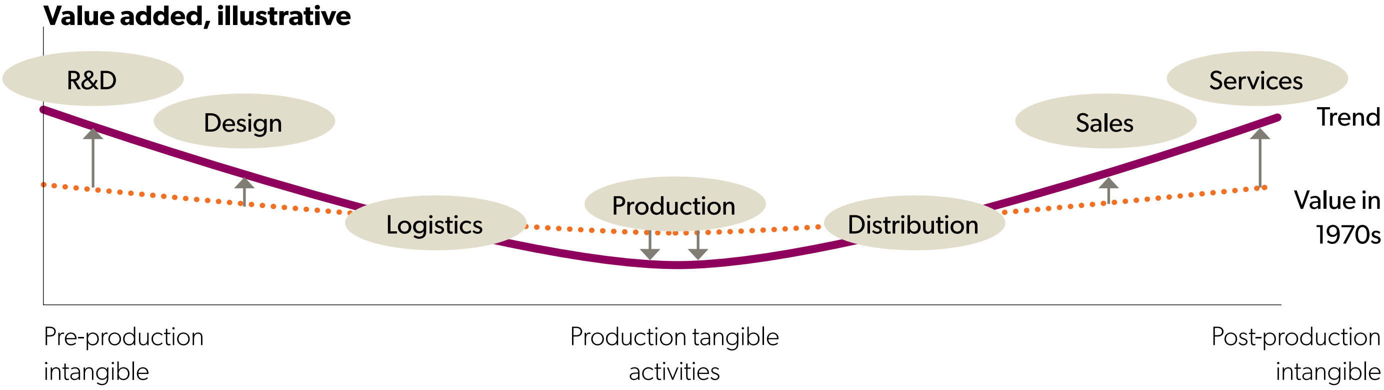
Note:
Bubbles represent size of Australia's exports. The chart draws correlation between share of services and export performance but not a causal relationship.
Source: UN Comtrade; ABS. AlphaBeta/McKinsey analysis

40 UN Comtrade, Australian Bureau of Statistics, AlphaBeta/McKinsey analysis.

Likewise, some sub-industries are making the transition to a service-enhanced manufacturing model faster than others, as can be seen in the comparison of medical technology and aerospace. Here, medical technology is growing at a faster rate in non-production roles such as design (45% growth over 2006–11), sales (40% growth) and services (26% growth). In aerospace, employment is declining fastest in service-based occupations like design, sales and after market services (see Exhibit 20).[41]

A comparison to the US is instructive and reveals the differential performance of the sub-industries. Compared to the US, Australia is relatively weak in R&D and design jobs in aerospace, but on par in medical technology (see Exhibit 20).[42] Likewise, Australian medical technology is transitioning more quickly to service-based occupations than in the US. However, in aerospace, Australia is losing jobs in these parts of the value chain faster than the US (see Exhibit 21).[43]

Exhibit 20 – Compared to the US, Australian manufacturing is relatively weak in R&D/design in aerospace but stronger in medical technology



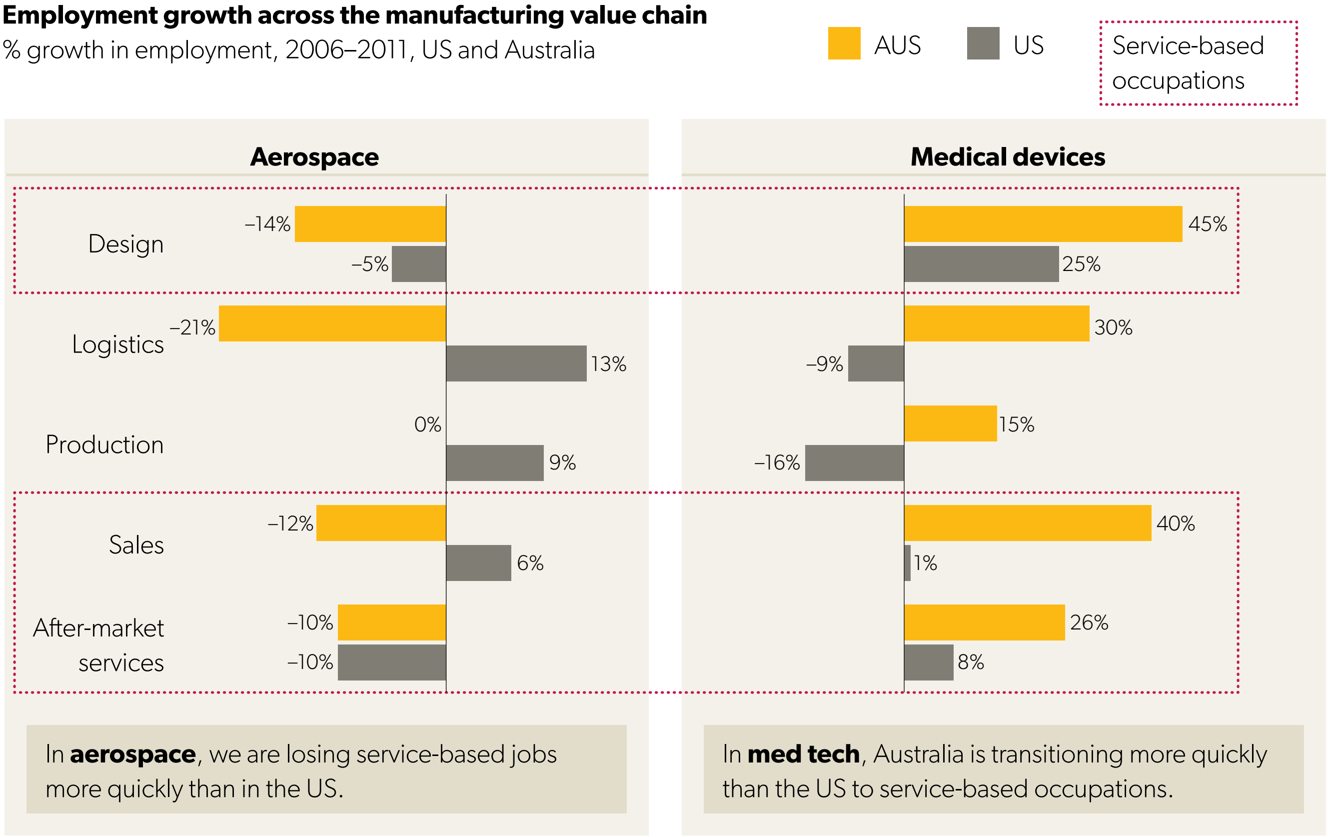
Proportion of jobs along value chain, % total industry (estimated), 2011						
	Design	**Logistics**	**Production**	**Distribution**	**Sales**	**Services**
Aerospace						
AUS	8%	4%	36%	4%	9%	38%[1]
US	13%	7%	46%	8%	6%	20%
Med Tech						
AUS	9%	5%	41%	15%	15%	25%
US	7%	6%	48%	7%	13%	18%

1 High share of services in aerospace due to local maintenance and repair of Australian domestic fleets and low levels of domestic production.
Source: Curve adapted from: 'Interconnected economies benefiting from global value chains', OECD 2013; Data for estimation drawn from ABS Census (2011); US BLS (2014); Calculated by allocating occupations to parts of the value chain at 4-digit occupation level; AlphaBeta/McKinsey analysis

41 Australian Census (2006 and 2011). Calculated by portioning employment at 4-digit occupation level to the 4 digit industry.
42 Curve adapted from: 'Interconnected economies benefiting from global value chains', OECD 2013; data for estimation calculation drawn from ABS Census (2011); US BLS (2014); calculated by allocating occupations to different parts of value chain at the 4-digit occupation level. AlphaBeta/McKinsey analysis.
43 Australian Census (2006 and 2011), US Industry-Occupation matrix, by industry (2011), calculated by portioning employment at 4-digit occupation level to the 4-digit industry. AlphaBeta/McKinsey analysis.
Job loss in aerospace in both the US and Australia is in part due to the life cycle of the industry being related to demand cycles from Tier 1 companies.

Exhibit 21 – In Australia, med tech is transitioning to service-based occupations more quickly than the US, but aerospace lags behind the US

Employment growth across the manufacturing value chain
% growth in employment, 2006–2011, US and Australia



Source: Australian Census (2006 and 2011). US Industry-Occupation matrix, by industry (2011). Calculated by portioning employment at 4-digit occupation level to the 4 digit industry. AlphaBeta/McKinsey analysis

2.4 LIFTING COMPETITIVENESS BY SHIFTING MARKET FOCUS

2.4.1 Overview of market focus

Thus far we have analysed Australian manufacturing's competitiveness in terms of its relative cost and its ability to offer differentiated value through product quality and associated services. But there is another dimension of competitiveness which relates less to 'how you compete' and more to 'where you compete'. Specifically, we examine whether Australia serves key export markets and whether it is integrated into global value chains (GVCs).

2.4.2 Australian manufacturing under-serves some key export markets, including for intermediate goods

Australian manufacturers must focus on high-potential export markets, including markets for intermediate goods, if they are to survive. The importance of clear export ambition and orientation to the sustainability of advanced manufacturing is well established. Empirical evidence demonstrates that productivity, profitability and wage benefits accrue to firms that export either directly or indirectly via suppliers to exporters.[44] Analysis of the export markets of Australian aerospace and medical technology manufacturing companies indicates some clear success in export market development and some areas where we do not capture our fair share of exports to key markets.

In aerospace, Australian exports of aircraft components to the US are very strong while our exports to key markets in Europe and Canada are underweight (relative to our total share of global imports in aerospace of 1.3%), as shown in Exhibit 22. While some of this is historic (e.g. after Boeing acquired Hawker de Havilland it stopped selling components to Airbus), these markets represent key leading aircraft manufacturing hubs (Original Equipment Manufacturers) and Tier 1 contractors and strongly imply untapped opportunities for Australian firms.

In medical technology, our exports to the UK and the US are strong, as shown in Exhibit 23, with a reasonable share in the small but growing Indian and Singaporean markets. However, our exports to the powerhouse markets of Germany, Japan and China are underweight, relative to our total share of global imports in medical technology of 0.7%.[45] The other key driver of market access is the progressive removal of trade barriers. For example, China's tariff on hearing aids and implantable medical devices has been removed under the China-Australia Free Trade Agreement.[46] Taking advantage of these opportunities to grow as further trade liberalisation occurs will be critical to claiming a growing share in emerging markets.

Global Value Chains

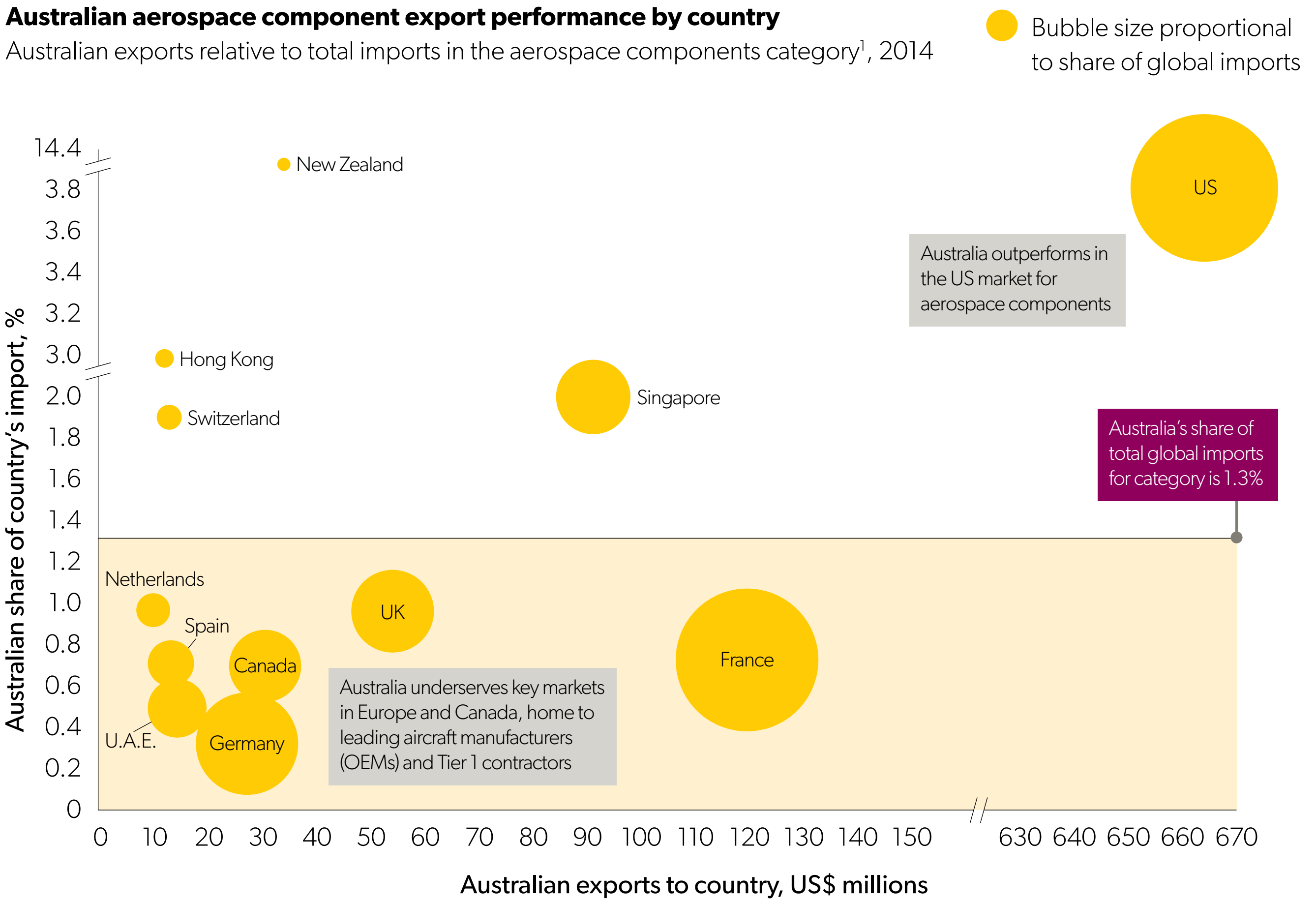
Firms try to optimise their production processes by locating the various stages across different sites. The past decades have witnessed a strong trend towards the international dispersion of value chain activities such as design, production, marketing and distribution. (OECD)

44 OECD and World Bank Group (2015), *Inclusive Global Value Chains: Policy options in trade and complementary areas for GVC Integration by small and medium enterprises and low-income developing countries*, p. 14. Available at: http://www.oecd.org/tad/tradedev/OECD-WBG-g20-gvc-report-2015.pdf

45 UN Comtrade. AlphaBeta/McKinsey analysis.

46 Department of Foreign Affairs and Trade (2016), 'China-Australia Free Trade Agreement Fact Sheet', Canberra. Available at: http://dfat.gov.au/trade/agreements/chafta/fact-sheets/Documents/fact-sheet-investment.pdf

Exhibit 22 – Australian aerospace component exports to the US are strong, but underperform in the key OEM markets of Europe and Canada

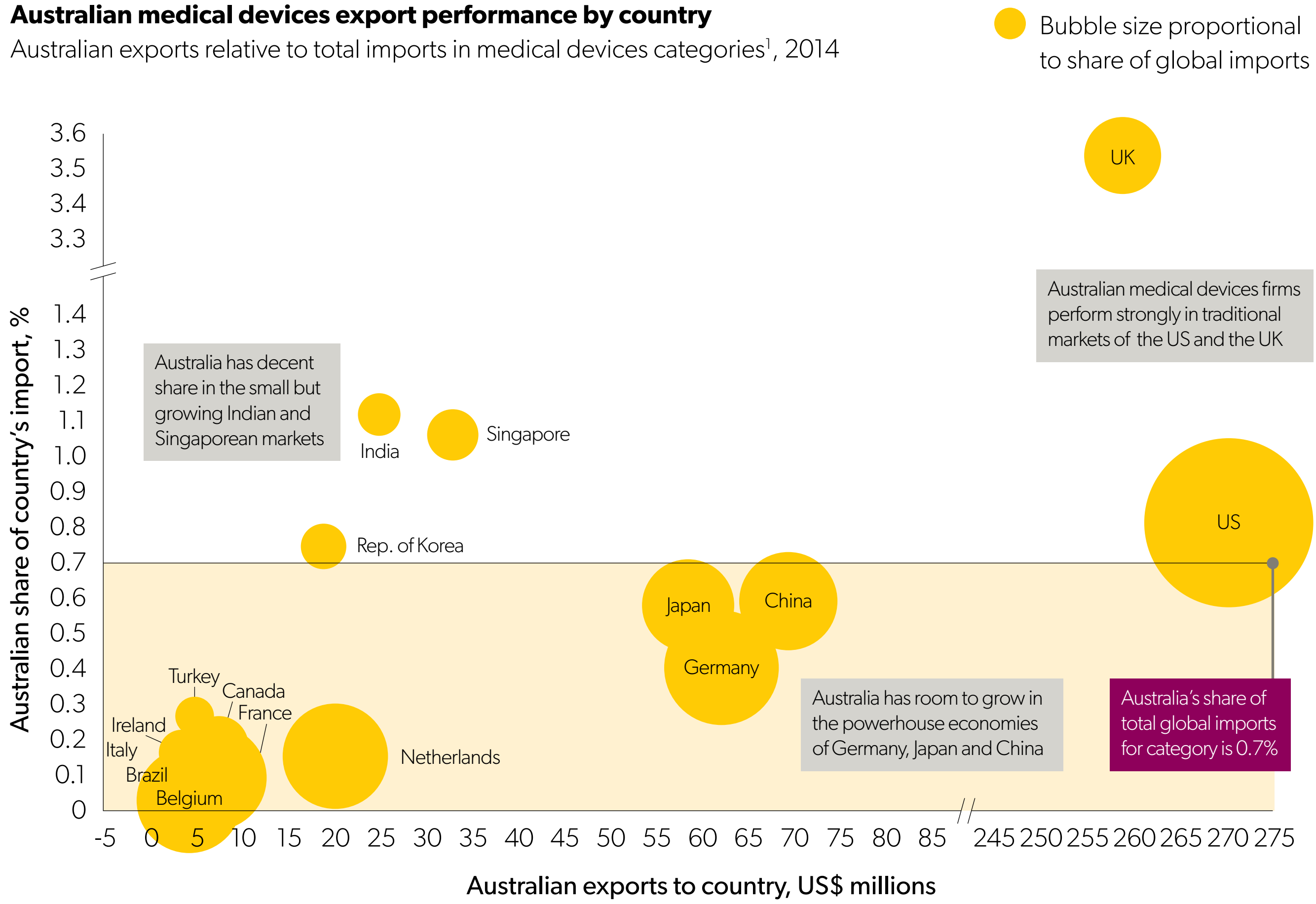


1 'Components' includes parts for aeroplanes, helicopters, spacecraft or spacecraft launch vehicles, corresponding to HS category 8803.

Source: UN Comtrade. AlphaBeta/McKinsey analysis

Exhibit 23 – Australian medical devices exports are still heavily skewed to traditional UK and US markets, with room to grow in Japan, Germany and China

Australian medical devices export performance by country
Australian exports relative to total imports in medical devices categories[1], 2014



1 Medical devices here defined as HS categories 9018 (instruments used in medical, surgical dental or vet. Sciences), 9020 (breathing apparatus), 9021 (orthopedics, implants, hearing aids) and 9022 (X-ray apparatus).

Source: UN Comtrade. AlphaBeta/McKinsey analysis

2.4.3 Australian manufacturing is weakly connected into global value chains

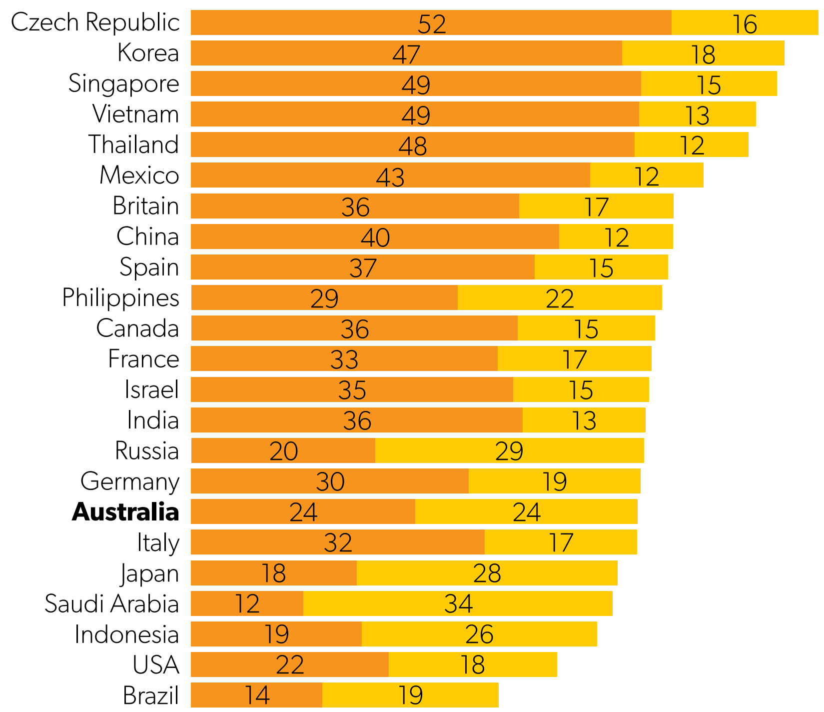
Manufacturing is increasingly occurring across global value chains, where the different functions of design, production, marketing and services occur across different countries. Analysis of Australia's backward and forward linkages helps us to understand the extent of our integration into global value chains. Backward linkages denote the use of foreign inputs to produce goods and services for export. Forward linkages denote the export of domestically produced goods or services to global companies further downstream.

Australia has among the weakest backward linkages of any major economy (see Exhibit 24). This suggests Australian manufacturers are missing opportunities to reduce costs, to drive innovation through the transformation of inputs, and sell into new markets. In particular, the OECD and World Bank argue that imports play an important role in the economic activity of a country by "making available 'world-class' inputs and capital goods … and providing incentives for firms to innovate as they adopt knowledge, ideas, know-how and best practices from abroad".[47]

Exhibit 24 – Australian manufacturing is weakly engaged in global manufacturing value chains, especially with low use of foreign inputs in our exports

Global value chain (GVC) participation in manufacturing

Backward: % of foreign value added in exports; Forward: % of domestic value added in foreign exports, 2011



Backward GVC Linkage
This reflects the extent to which foreign inputs are used in creating Australia's exports

Forward GVC Linkage
This reflects the extent to which exports are used by other countries as an intermediary product in their exports

Australia's participation in GVCs is measured as the percentage point sum of forward and backward linkages.

Australia's low ranking is because it has among the weakest 'backward linkage' of economies globally.

Source: UN Comtrade (2014). AlphaBeta/McKinsey analysis

47 OECD and World Bank Group (2015), *Inclusive Global Value Chains: Policy options in trade and complementary areas for GVC Integration by small and medium enterprises and low-income developing countries*, p. 15. Available at: http://www.oecd.org/tad/tradedev/OECD-WBG-g20-gvc-report-2015.pdf

> The AMGC defines 'advanced manufacturing' as the application of leading-edge technical knowledge and expertise to the creation of products, production processes and associated services for the purpose of sustaining high growth and customer satisfaction.

3 THE OPPORTUNITY FOR AUSTRALIAN MANUFACTURING

3 THE OPPORTUNITY FOR AUSTRALIAN MANUFACTURING

> Manufacturing can be a force for growth in this country. We have gotten complacent in thinking about it as an old-fashioned industry of the past, but it is becoming obvious globally that advanced countries are fighting to become competitive in this sector.

Industry participant, AMGC consultation[48]

3.1 REDEFINING ADVANCED MANUFACTURING

Global manufacturing data confirms that the world's most competitive companies succeed by increasing value differentiation, improving market focus and optimising product cost. The characteristics used to gauge the success of companies were selected by identifying advanced features of production that were prevalent in the most successful firms, where success was defined in terms of productivity and profitability.[49] Exhibit 25 shows the characteristics that were more prevalent in the top 25% of firms versus the bottom 25% of firms.[50] For example, global firms in the top 25% for productivity, compared with the bottom 25% of firms, exhibit 1.16 times more capital efficiency, 1.50 times newer capital, 1.30 times more automation, 3.17 times higher R&D intensity, 1.75 times the patent portfolio, 1.06 times the wage levels, 1.12 times higher employee qualifications, 1.09 times the STEM skill intensity, and 1.08 times the share of services in revenue. This analysis redefines how we think about advanced manufacturing.

Redefining Advanced Manufacturing

Differentiation is a key factor to Australian manufacturing competitiveness.
This may be offering a product with an innovative design, or having an exceptional reputation for reliability and collaboration, or delivering outstanding services along the entire value chain of manufacturing, not only in production.

48 This comment was recorded during AMGC's consultation with industry members. It was made by the representative of a regional industry association.

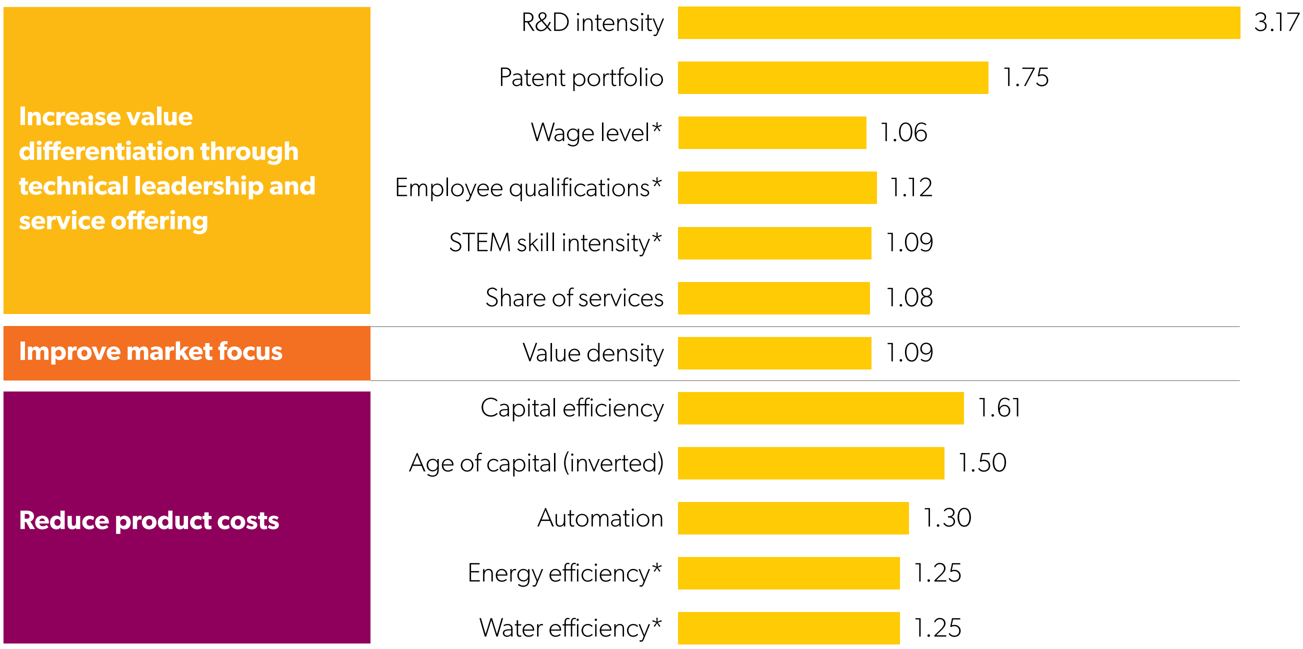
49 Productivity refers to total factor productivity and measures joint productivity of capital and labour. It is not directly observable, and was derived by the residual of the regression of gross value added against capital and labour. Profitability refers to gross margin.

50 Characteristics defined as:
R&D expenditure = ratio of R&D expenditure to total sales
Patent portfolio = number of patents by firms. Linked individual firms in Compustat to patents dataset
Wage levels = industry average wages weighted by the sales shares across industries by each firm
Employee qualifications = industry average of fraction of employees with bachelor's or post-graduate degree weighted by the sales shares across industries by each firm
STEM skill intensity = 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
Capital efficiency = ratio of total sales to plant, equipment and machinery
Age of capital = accumulated depreciation/depreciation
Automation = indicator=1 if average growth in capital accumulation and labour productivity in the last 3 years is positive. 0 otherwise
Energy efficiency = used IO table to determine the $ of energy in a $ of sales. Weighted the industries by the sale shares across industries by each firm
Water efficiency = used IO table to determine the $ of water in a $ of sales. Weighted the industries by the sale shares across industries by each firm
Product value density = used 4-digit industry level trade data, calculated value of shipment/weight. Weighted the value densities by the sales shares across industries by each firm
Share of services = sales of services/total sales by industry.

Exhibit 25 – Analysis of >3,000 global manufacturing firms reveals that top performers increase value differentiation, improve market focus and reduce product costs

Ratio of median of more successful to less successful firms[1]

Average prevalence of characteristics in more successful firms where success is measured by total factor productivity and gross margin[2]



1 Where more advanced is classified as top quartile in the respective success metric and less advanced is bottom quartile.

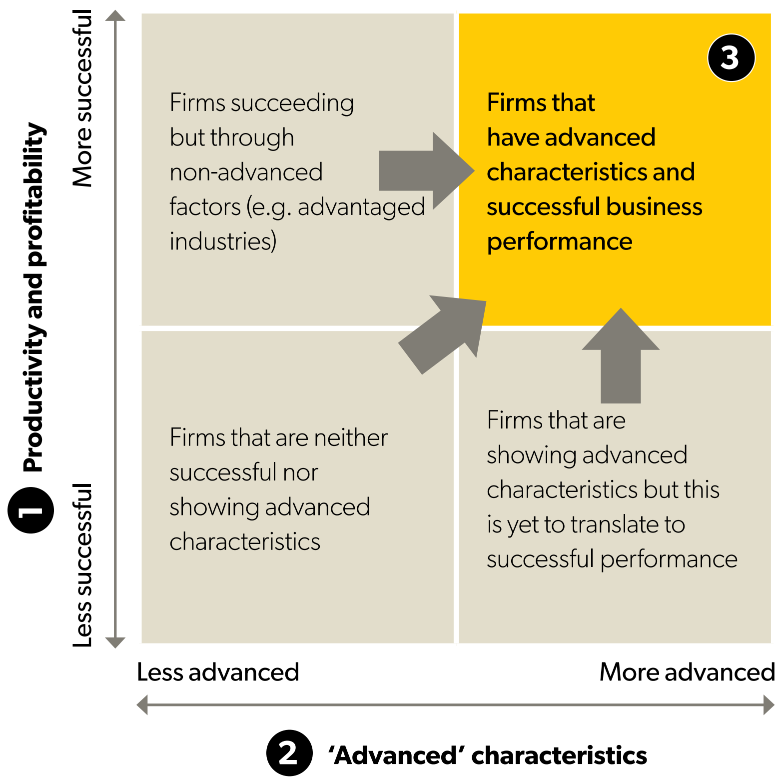
2 Ratio shown is an average of the radio using total factor productivity and then gross margin.

* Metrics calculated using the average of the sub-industry classifications.

Source: Compustat, Alpha/McKinsey analysis

Exhibit 26 – AMGC's mission is to support all Australian manufacturers to succeed by adopting advanced characteristics

Spectrum of Australian manufacturing firms



We aimed to identify 'more advanced' firms by both the characteristics they display and outcomes they achieve.

1 Identify more successful firms

- Defined 'success' by a number of outcome metrics, e.g. Total Factor Productivity
- Used these metrics to develop a subset of the more 'successful' firms

2 Identify 'advanced' characteristics

- Developed 'long list' of characteristics
- Collated expert interviews, workshop and literature

3 Define 'advanced manufacturing'

- Determined the prevalence of these characteristics in more successful firms
- Defined 'advanced manufacturing' by this shortlist of characteristics

Source: AlphaBeta/McKinsey Analysis

Desirable growth area for Australian manufacturing

In putting forward these actions, it is important to recognise that there is no single formula or 'one size fits all' approach to success. Successful Australian manufacturing firms follow a range of different strategies to differentiate themselves from their competitors (see Exhibit 27). These groups are not necessarily mutually exclusive but comprise firms that have a similar approach, which includes:

- Focusing on increasing product performance and value differentiation by being:
  - '*Innovation leaders*': firms that use high skills and cutting-edge technology to develop distinct value in their products. Typical attributes of these firms include a heavy R&D investment in products, highly skilled workforces and high-value products due to superior performance or distinctive features
  - '*Servitised firms*': firms that have evolved their model beyond pure production. Typical attributes include a high share of revenue from services and skilled workforces to deliver services before and after sales
- Focusing on identifying untapped or niche markets by being '*market finders*': firms that skilfully cater to either under-served or niche markets. This includes high-value but small segments or markets in which companies are strategically advantaged and can stay close to key customers. Typical attributes include highly skilled workforces and the use of processes such as mass customisation to meet niche consumer needs
- Focusing on reducing product costs by being '*process winners*': firms that differentiate through process excellence and cost competitiveness. These firms display high levels of advanced characteristics, such as capital efficiency and automation.

Exhibit 27 – Many Australian manufacturers are already succeeding by reducing costs, increasing value or improving market focus

Competitiveness lever	Ways to win	Examples
Increase value differentiation	*Innovation leaders* Design innovation & product leadership	**Cochlear:** World-leading hearing implant technology **Resmed:** World-leading respiratory device technology **Quickstep:** Innovative autoclave-free carbon fibre manufacturing process
	Servitised firms Value-adding services bundled with products	**Invetech:** Engineering design consultancy, with some prototype development **Ford Australia:** After production in Australia ceases, will employ >1,000 designers and engineers
Increase market focus	*Market finders* Highly customised, niche or untapped market offerings	**Codan:** High-value metal detection and mining technology **Cablex:** Tailoring cable harness solutions for small runs of aircraft **Textron Systems Australia:** Design remote piloted aircraft
Reduce product costs	*Process winners* automation, outsourcing	**Amcor:** Compete by efficient production processes – enabled by high levels of plant automation

Source: Company websites; press search, analysis of Compustat data, expert and industry interviews

… it is important to recognise that there is no single formula or 'one size fits all' approach to success.

3 THE OPPORTUNITY FOR AUSTRALIAN MANUFACTURING

Every Australian manufacturer, big or small, high-tech or lower-tech, can improve their operations by employing advanced techniques, technologies and business models. This concept of 'advanced manufacturing' deliberately departs from the current Australian Bureau of Statistics (ABS) definition, which places all manufacturing firms in either 'advanced manufacturing' or 'basic manufacturing' categories according to industry codes associated with the products they produce.

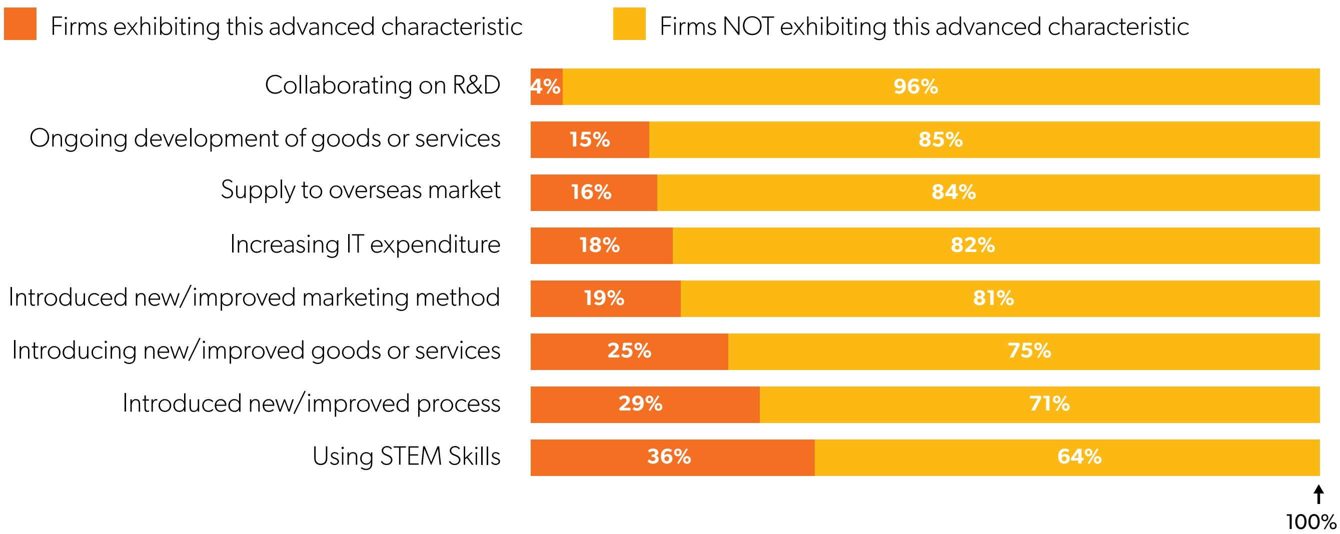
The AMGC defines 'advanced manufacturing' as the application of leading-edge technical knowledge and expertise to the creation of products, production processes and associated services for the purpose of sustaining high growth and customer satisfaction. This definition recognises that manufacturing firms can adopt advanced techniques irrespective of what they produce. It is as possible to employ advanced techniques and business models in furniture manufacturing as it is in aircraft engineering. This definition also recognises there is no hard line separating advanced firms from other manufacturers. Rather, all firms are on a continuum, employing a range of techniques and strategies adapted to their circumstances. Moreover, all firms can aspire to continuously improve their manufacturing processes and evolve their business models. Section 4 recommends changes in how progress in manufacturing is measured to support this definition, and Section 5 outlines how the AMGC will continue to work with the Government on new forms of measurement.

While there are many examples of successful Australian companies, not all Australian manufacturers exhibit the 'advanced' characteristics identified above. In fact, Exhibit 28 demonstrates that a high proportion of Australian firms do not currently optimise cost, value differentiation or market focus. Accordingly, in order to lead the transition, industry will need to take a series of actions that aim to increase value differentiation, improve market focus and reduce product cost.

Exhibit 28 – There is significant room for Australian manufacturers to increase their adoption of advanced techniques

Most Australian manufacturing companies are not engaged in advanced processes and techniques

Weighted average fraction across 2009–13 and 2010–14 panel, %



Source: BCS Survey (ABS) and AlphaBeta analysis

3.2 THE 'SIZE OF THE PRIZE' IS SUBSTANTIAL AND REAL

The rewards for success in advancing manufacturing are substantial. The size of Australia's manufacturing industry in the year to June 2016, in gross value added or output terms, was $97.7 billion.[51] In August 2016, manufacturing employed 886,800 people.[52] It's estimated that an additional 331,000 people are employed in other sectors as a direct result of manufacturing activity.

Analysis of the potential 'size of the prize' in improving manufacturing competitiveness suggests that Australia can capture a 25–35% increase in value added by 2026 (see Exhibit 29).[53] This figure is driven primarily by improvements in value differentiation, which would account for a 14–20% improvement[54], and shifts in market focus, which would account for a 7–9% improvement.[55] Improvements in cost competitiveness would result in a 4–6% increase, the smallest component of the potential uplift.[56] Further detail on the methodology used to estimate the size of the prize is outlined in Annex B.

Manufacturing continues to be an important part of Australia's industry mix; accounting for 6.1 per cent of Australia's GDP and 7.4 per cent of employment. In the 2015–16 financial year, manufacturing generated $100 billion in export income, second only to mining's $117 billion.

51 ABS National Accounts Catalogue 5206.0, Table 6, Manufacturing, seasonally adjusted terms.

52 ABS Detailed Labour Force Catalogue 6291.0.55.003.

53 The base case size of manufacturing in 2026 uses the 2006–14 CAGR as the average annual growth rate through to 2026.

54 The estimated increase through value differentiation was calculated as an average of multiple methods: lifting performance in export categories in select manufacturing sub-industries analysed in the Plan to either the highest or the average level of revealed comparative advantage; closing the gap between the profitability of a sample of successful firms and the average; and increasing the proportion of high-skill workers in select sub-industries to US levels. This is consistent with previous studies that have identified innovation as the key source of competitive advantage for Australian manufacturers. See, for example, Green, R. & Roos, G. (2012), 'Australia's Manufacturing Future: Discussion paper' prepared for the Prime Minister's Manufacturing Taskforce, Sydney. Available at: https://www.uts.edu.au/sites/default/files/Australia's_Manufacturing_Future.pdf

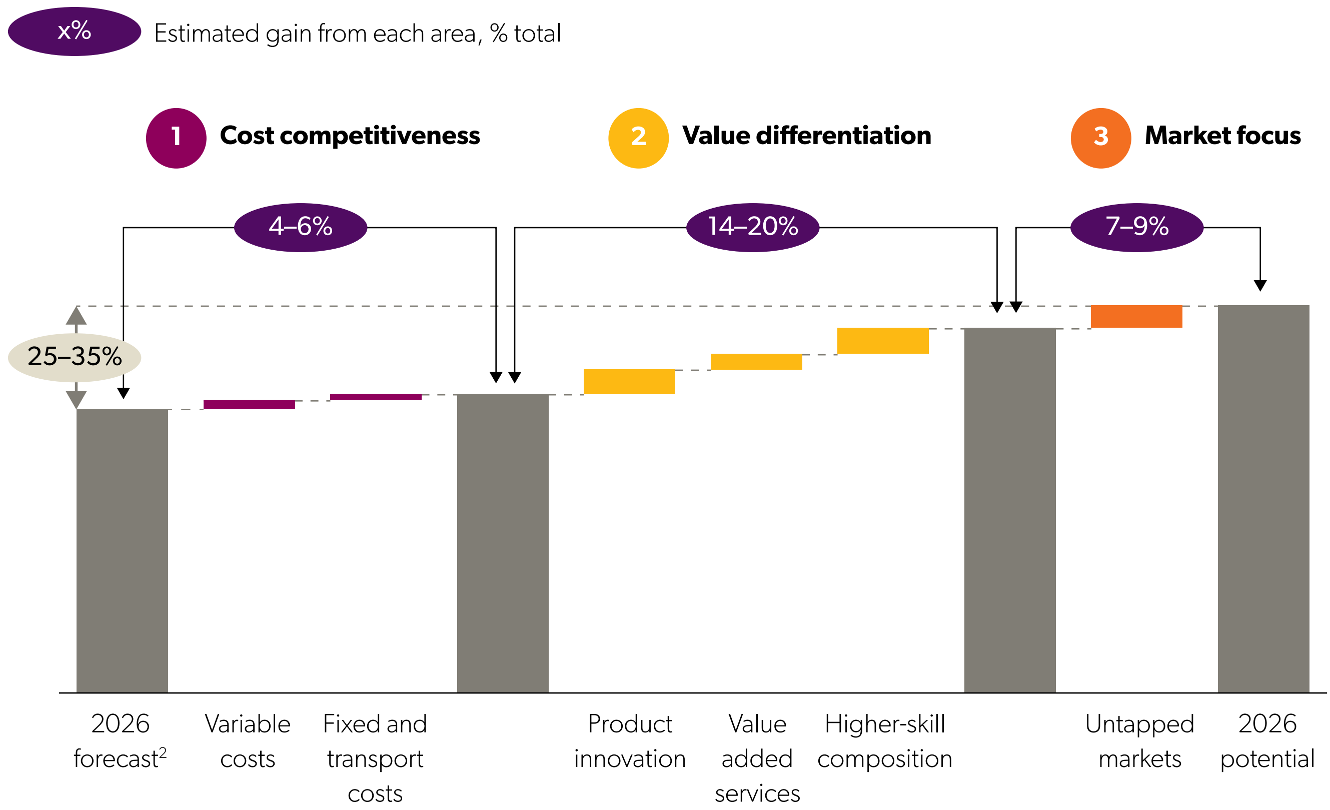
55 The estimated increase through market focus involves closing the gap in select sub-industries in export markets where Australia is underweight relative to Australia's average share for that product category and shifting product mix to more skill-intense sub-industries, where Australia is underweight relative to the US.

56 The estimated increase through product cost was calculated by closing the labour productivity gap for select sub-industries and applying these across the manufacturing sector, and banking the savings alternatively as profit or in the form of a price decrease to customers, with varying elasticities. The annex provides an expanded and detailed methodology on how we estimated the size of the opportunity.

Exhibit 29 – Growth in manufacturing can be achieved by focusing on greater value differentiation and improved market focus, not cost alone

Estimated potential value gain across advanced manufacturing

Percentage of value added in 2026 relative to straight-line trend projection[1]



Notes

- Benchmarking 'landed' product cost against other high-cost countries revealed a 9–14% cost gap
- Improvement estimates based on different scenarios of closing the cost gap and either banking savings as profit or passing through lower prices
- Value estimate triangulated through assessing sub-category export improvement potential in each vertical, and through comparing firm-level profit margins for highly innovative vs average firms
- Product focus from matching US proportion in high skill industries
- GVC integration based on uplifting exports in key markets to Australian average category share.

1 Increase based on extrapolation from aerospace and med tech analysis.

2 Base growth projected using 10-year historic CAGR for ANZSIC sub-divisions 18, 23 and 24. See appendix for full methodological details.

Source: AlphaBeta/McKinsey analysis

Companies must lead the transition by taking a series of actions to compete on value.

4 ACTION PLAN FOR MANUFACTURING

4 ACTION PLAN FOR AUSTRALIAN MANUFACTURING

4.1 OVERVIEW: COMPANIES MUST LEAD THE TRANSITION TO COMPETING ON VALUE

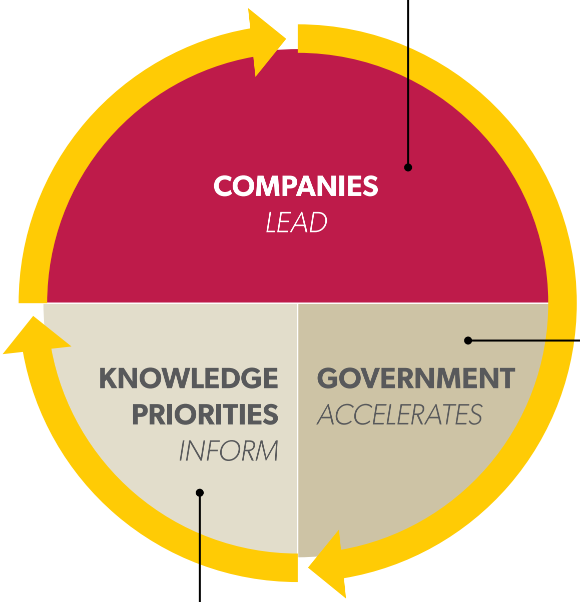
The competitiveness analysis in sections 2 and 3 showed that Australian manufacturers can succeed and grow by competing through product and service differentiation and by better targeting export markets. Achieving this vision will not be easy. It will require a national effort from multiple stakeholders, working together around a clear plan. This report identifies the key actions for industry to achieve this transformation, and identifies how governments can help accelerate the change and how Knowledge Priorities can better guide industry (see Exhibit 30).

> It will require a national effort from multiple stakeholders, working together around a clear plan.

- Companies must lead the transition by taking a series of actions to compete on value. They must focus on rapid innovation, develop new business models to include services across the value chain, engage in global supply chains and build highly skilled workforces. Many Australian businesses are already successfully adopting advanced techniques, but many are yet to make the transition and even the early adopters have room for improvement.
- While the transformation of advanced manufacturing must be industry-led, the Government can accelerate the transition by pursuing key reforms that support actions taken by industry. Suggested reforms relate to improving support for business-led R&D, pursuing smarter procurement and altering the way that progress in manufacturing is measured.
- Regular renewal of Knowledge Priorities will also support and guide the transition. The industry has identified both R&D Knowledge Priorities and knowledge gaps related to business improvement.

Exhibit 30 – Companies must lead the transition to competing on value, supported by government and informed by Knowledge Priorities

Objective: Australian manufacturers need to compete through product and service differentiation, and better target export markets



Companies will lead the transition by:

- Increasing technical leadership
- Increasing value-adding services
- Improving market focus by reaching untapped markets and integrating into global value chains
- Lifting scale and management quality.

Many Australian businesses are already making this transition.

Government can accelerate the transition to new value-based business models by:

- Optimising support for business-led R&D
- Using smarter defence and civil procurement
- Designing assistance to target 'more advanced' characteristics
- Changing measurement of manufacturing.

Knowledge Priorities will inform and fuel the transition by:

- Identifying R&D Priorities: e.g. robotics, advanced materials and composites, digital design and rapid prototyping
- Identifying Business Improvement Priorities: e.g. workforce skills requirements, management capability, building international linkages and driving Industry 4.0 uptake.

Source: Competitiveness analysis

4 ACTION PLAN FOR AUSTRALIAN MANUFACTURING

4.2 ACTIONS FOR INDUSTRY

4.2.1 Overview of actions for industry

The analysis in the previous section identified a number of opportunities to increase Australia's manufacturing competitiveness. Realising these opportunities will require an industry-led transformation focused around four objectives:

- Increase the technical leadership of Australian manufacturing to improve value differentiation
- Increase value-adding services within Australian manufacturing to improve value differentiation
- Improve market focus by identifying under-served segments and linking into global value chains
- Lift scale and management quality to improve cost competitiveness.

These objectives will be achieved through a series of actions, some of which are identified in Exhibit 31. Many will support multiple objectives. For example, increasing skill intensity helps to improve technical leadership (which increases value differentiation) as well as how efficiently the business is run (which will help to reduce product cost per unit). The actions also have differing effects on a company's revenue, costs and cost per unit, which determine the overall impact of an action on profitability. For example, while increasing skill intensity may increase costs, revenue and cost per unit should improve.

> Realising these opportunities will require an industry-led transformation.

Exhibit 31 – Companies must lead the transition with a series of actions

4 objectives ...

- **A** Increase technical leadership
- **B** Increase servitisation
- **C** Improve market focus
- **D** Increase scale and management

... jointly supported by 8 actions / **Firm-level impacts**

Action	Objectives	REVENUE	COST	COST PER UNIT
Increase business-led R&D	A D	↑	↑	↓
Increase skill intensity	A B D	↑	↑	↑
Collaborate with researchers	A D	↑	↑	↓
Develop service offers	B D	↑	↑	↑
Reach untapped markets and segments	B C	↑	↑	↓
Integrate into global value chains	C	↑	↑	↓
Improve management capability	A B D	↑	↓	↓
Collaborate to 'play bigger'	C D	↑	↓	↓

Source: Competitiveness analysis

4.2.2 Increase the technical leadership of Australian manufacturing

The analysis in Section 2 concludes that Australia's strongest opportunity in manufacturing is to improve our technical leadership. Australian manufacturing firms succeed on a global scale when they offer unique products that provide customers with distinctive value.

To achieve technical leadership, Australian manufacturing firms should prioritise:

- **Lifting business-led R&D:** Company-led R&D is a core driver of long-term success in manufacturing firms and represents a key channel for developing technical leadership and improving value differentiation. As outlined in Section 3, global manufacturing companies in the top 25% for productivity, compared with the bottom 25%, exhibit 3.17 times higher R&D intensity and 1.75 times the number of patents. As outlined in Section 2.3.3, Australian business expenditure on R&D as a proportion of GDP is well below many key OECD competitors. There is a ripe opportunity for Australian manufacturers to increase expenditure on R&D. This Plan also details suggested actions for Government to drive greater business-led R&D.

VALUE DIFFERENTIATION

ResMed

Company background

ResMed is a medical technology company founded in Australia that has captured approximately 40% of the global market for sleep-aid devices. It employs more than 5,000 employees globally, with manufacturing facilities in Australia, France, Singapore and the US.

Product and service differentiation

In addition to personal products treating sleep apnea, ResMed has developed testing and data collection services such as ApneaLink Air and myAir which helps doctors and patients track the progress of sleep problems. The company's products and treatment options heavily integrate sensors and monitoring technology so that treatment can be monitored in real time. For example, its sleep lab titration system is able to relay information in real time between its testing and treatment devices. The company invested over $114 million in R&D during 2015, and has acted to acquire new expertise when necessary, including the purchase in January 2016 of Inova Labs Inc, which provides innovative oxygen therapy products.

Source: Company websites; press search, analysis of Compustat data, expert and industry interviews

- **Capitalising on Australia's ~40% cost advantage in high-skill labour:** Given Australia's cost advantage in high-skill labour and the need for high-skill labour to drive value differentiation, Australian companies have a substantial opportunity to increase their mix of higher skills. Analysis in Section 2.2.2 identified that some Australian manufacturing sub-industries employ workers with a lower education mix compared with their international counterparts. A workforce with greater levels of formal training and qualifications is the indispensable ingredient in transitioning towards more advanced manufacturing. The AMGC's consultation with companies and other industry representatives repeatedly highlighted the value derived from investing in a highly skilled workforce. In addition to hiring tertiary-educated staff on a permanent basis, companies could consider hiring interns in exchange for an educational scholarship. This strategy was used by a mining equipment manufacturer. Its manager reported: "Two scholarship students were brought on board to automate a key process. Even though it required knowledge outside of their specialty, their aptitude and ability to learn allowed us to get done in-house what would have cost us thrice as much to outsource."[57] This Plan details further action for the AMGC to investigate current and future skill priorities and whether the industry is transitioning.
- **Collaborating with research institutions:** As outlined in Section 2.3.4, Australia could improve the collaboration between the research sector and industry. A lack of such collaboration can constrain the development of technical leadership.[58] Collaboration between universities and industry requires action from both parties. Research by McKinsey & Company into the organisational health of Australian firms found that they performed particularly poorly on building networks of external partnerships and on enabling collaboration and knowledge sharing.

Collaboration can work, and there are great examples internationally and in Australia. These include the collaboration between MDB and the University of Sheffield to develop cutting-edge titanium machining processes to win work on the Boeing 787, and the partnership between Deakin University and Quickstep to develop advanced carbon fibre manufacturing techniques (see Exhibit 32). By engaging proactively on priority projects and investing to support research, and by including international universities, companies can help to ensure that Australia is in the flow of the latest global ideas. This Plan details further action for Government to encourage collaboration.[59]

57 AMGC industry consultation, August 2016.

58 Department of Industry (2016), 'R&D Tax Incentive Review Issues Paper', Canberra. Available at: https://www.business.gov.au/~/media/Business/RDTI/Review/Research-and-Development-Tax-Incentive-Issues-Paper-PDF.ashx?la=en

59 Aggregate analysis of more than 18,000 individual Australian responses to McKinsey's Organisational Health Index (OHI): Lydon, J. et al. (2014), Compete to Prosper: Improving Australia's global competitiveness, McKinsey & Company. Available at: http://www.mckinsey.com/global-locations/pacific/australia/en/latest-thinking/compete-to-prosper

Exhibit 32 – Many global firms have achieved success in advanced manufacturing through industry collaboration and through industry-university collaboration

Aerospace example collaborations	Overview	Key aspects of approach
United Launch Alliance	**Industry–Industry:** A 50–50 joint venture between Lockheed-Martin and The Boeing Company for space launch systems	› Joint venture between two previously staunch competitors › Recognising high-costs and scale effects in space launch, formed joint venture to significantly reduce costs › Regulators approved the joint venture subject to conditions protecting launch access for small satellite manufacturers
Marand/BAE/ Quickstep	**Industry–Industry:** Marand, BAE Australia and Quickstep collaborating to produce ~700 F–35 vertical tail sets	› Marand won contract for ~700 F–35 vertical tails with BAE Systems Plc (UK), sub-contracting titanium components to BAE Australia and carbon fibre components to Quickstep › BAE Systems collaborating with Australian companies on qualification processes
MDB & the University of Sheffield	**Industry–University:** MDB and the University of Sheffield collaboration on advanced titanium manufacturing processes to win 787 landing gear work	› MDB engineers and researchers from Sheffield's Advanced Manufacturing Research Centre worked together to develop advanced titanium machining processes. › This enabled increased use of titanium in main landing gear systems, a weight-saving performance feature, and led to winning the 787 contract for main and nose landing gear
Deakin Carbon Nexus and Quickstep	**Industry–University:** Deakin University and Quickstep collaboration on advanced carbon fibre manufacturing processes	› Quickstep has established its automotive division and global R&D centre on Deakin's Geelong campus, associated with Deakin's Carbon Nexus facility, which brings together 11 industry partners from nine countries › Geelong Region Innovation and Investment Fund provided $1.76 million to establish the automotive division at Deakin

Source: Company websites; *Wall Street Journal*; *Australian Defence Magazine*; UK Government (2012) 'Lifting off: implementing the strategic vision for UK aerospace'; Deakin University; ARC website

- **Closing the deficit in management quality in order to improve productivity and reduce cost:** As outlined in Section 2.2.3, Australia has fewer high-performing managers than other successful countries. Specifically, research by the London School of Economics reported that just 4.7% of Australian firms received a high management grade, compared with 15.5% of firms in the US and 8.0% of firms in Germany.[60] Accordingly, there is an opportunity for Australian manufacturers to address the management quality deficit. Positively, efforts to increase skill intensity have been proven to improve the management capability of Australian manufacturers.[61] This Plan details further investigation that is required to understand drivers of the management capability gap (see Section 4.4.3).

4.2.3 Increase value-adding services within Australian manufacturing

The opportunity for Australia to transition into higher-value service offerings is significant. Analysis in Section 2 revealed that some of Australia's advanced manufacturers are increasing R&D, engineering design, and sales and service roles more quickly than others. To accelerate the transition to services, Australian manufacturers should:

- **Develop compelling service offerings that complement Australia's comparative advantages:** In order for industry to transition to higher-value segments, firms need to develop compelling service offerings that complement products, accelerate their uptake of new manufacturing techniques and secure the talent pipeline. Analysis in Section 2.3.2 revealed that value differentiation through service offerings was a key factor in making Australian manufacturers globally competitive. The transition to services in leading manufacturing firms requires changes to culture, skill mix, and contracting and financing arrangements. Some Australian firms have already transitioned to service differentiation, including MiniFAB and Textron Systems Australia.

VALUE DIFFERENTIATION

miniFAB™
MICRO-ENGINEERING / MEDICAL / MANUFACTURING

Company background

Micro-engineering firm miniFAB produces predominantly medical device solutions, along with food packaging and aerospace products. miniFAB was established in 2002 and now has offices in Europe and the US along with clients worldwide.

Product and service differentiation

miniFAB's services span the length of the value chain, from design and prototyping through to manufacture, assembly and supply chain logistics. The company relies on providing highly customised solutions, working with clients to select the right materials, design and processing solutions. miniFAB has to date worked on over 900 projects.

Source: Company websites; press search, analysis of Compustat data, expert and industry interviews

60 See for example, Green, R. & Roos, G. (2012), 'Australia's Manufacturing Future: Discussion paper', prepared for the Prime Minister's Manufacturing Taskforce, Sydney. Available at: https://www.uts.edu.au/sites/default/files/Australia's_Manufacturing_Future.pdf

61 ibid.

VALUE DIFFERENTIATION

TEXTRON

Company background

Textron Systems Australia is an aerospace company with 50 employees and annual revenue of $5 million to $10 million. It produces small unmanned aircraft for military and civilian use, but adopts a business model that also proactively sells support services.

Product and service differentiation

The company differentiates on service offering in a number of ways. First, its Support Solutions business provides operational support to keep assets functioning, and includes personnel who are directly embedded with their clients worldwide to support their missions. Second, the company offers supply chain management and logistics support which helps the customer track assets, reduce the cost of storage and ownership, and engage in obsolescence planning. Third, the service offering also includes a flight operations business which uses its own unmanned aerial vehicles.

Source: Company websites; press search, analysis of Compustat data, expert and industry interviews

- **Lifting skill intensity, particularly in service-oriented roles:** More jobs within service-enhanced and increasingly digitised manufacturing will require higher educational levels. International studies of workforce growth in manufacturing have noted that "the evidence on the future demand for skills in manufacturing suggests that over the period to 2020 more people, proportionately, will be employed in jobs where a degree is required to gain entry".[62] The shift into greater provision of services will require firms to demand skills related to customer engagement, ICT, data management and analytics. Many of the relevant tertiary qualifications will involve STEM subject matter.[63] Analysis in Section 2.3.3 revealed that Australian firms are not currently employing a sufficient share of high-skill workers. In order to attract these candidates, companies may need to take steps to improve the attractiveness of manufacturing, including showcasing careers as part of courses and connecting with education providers to offer experiential or activity-based learning (including internships, placements and short project-based assignments).

  The shift to greater provision of services will also likely require improved readiness among graduates to deploy work-ready skills. The Productivity Commission recently attributed current rates of STEM under-employment post-graduation to the lack of readiness among graduates to use problem-solving skills in technology-rich work environments.[64] Changes to teaching methods that develop problem-solving skills such as experiential, project-based or employer-connected learning are considered most likely to develop work-ready skills. This Plan details actions for the AMGC to showcase examples of servitisation and to map which parts of the industry have servitised, using job ads data (see Section 5.4).

62 Foresight (2013), 'What type of future workforce will the UK need?', the Government Office for Science, London. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/283910/ep36-manufacturing-future-workforce.pdf

63 ibid.

64 http://www.pc.gov.au/research/completed/digital-disruption/digital-disruption-research-paper.pdf

4.2.4 Improve market focus

The most important thing we can do is be nimble, because we know we need to follow the customer and give them what they want but are not yet getting.

Industry participant, AMGC consultation[65]

Top-performing firms globally exhibit a high level of integration into export markets and offer products with a high-value density (with the top 25% of firms exhibiting a value density 1.09 times the bottom-performing firms). Australian manufacturing firms will need to set high aspirations to enter new markets, and deliver new products and services that offer meaningfully better performance for their customers. One clear message from stakeholder engagement is that Australia's successful exporters were either 'born global' – with export ambitions from day one – or at some point made a very deliberate choice to enter new markets or transform their capabilities.

Improving Australian manufacturing's market focus will require action to:

- **Identify and reach untapped markets and segments (see Section 2.4.2):** Section 2 demonstrates Australian manufacturers are underweight in a number of key export markets, including for intermediate goods. Companies can work further with Austrade and other assistance programs to identify their under-served markets and develop strategies for market entry.

  With regard to niche markets and segments, Australian manufacturers can increase their overall competitiveness by focusing on those products and markets that naturally play to our high-skill workforce and cost advantage in high-skill workers. Australian companies can create a competitive edge by identifying niche markets they are advantaged to serve (e.g. through a highly customised or specialised offering or by finding an under-served market). Some Australian companies, such as Codan, have improved their market focus and found market niches. This Plan proposes actions for Austrade to identify under-served markets, including for intermediate goods, by sub-industry.

MARKET FOCUS

CODAN

Company background

Codan designs and manufactures electronic products predominantly for the telecommunication and mining sectors. The company has been in operation for over 50 years and has customers in 150 countries.

Product and service differentiation

The company engages in global value chain analysis to identify key markets or sectors in which it could offer a comparative advantage. It is then able to cater to these markets with customised design and off-the-shelf products or through outsourcing. Over 90% of Codan's revenue is derived from exports, a fact which reflects the success of Codan's strategy in integrating itself into various global value chains. To maintain cost competitiveness while maximising its advantages, the company produces its low-volume, high-value products in the Australian markets, while outsourcing its high-volume, low-complexity products to an outsourced facility in Malaysia.

Source: Company websites; press search, analysis of Compustat data, expert and industry interviews

- **Link into global value chains (see Section 2.4.3):** Manufacturing is increasingly occurring across global value chains, where the different functions of design, production, marketing and services occur across different countries. Analysis of Australia's backward and forward linkages helps to understand the extent of our integration into global value chains. Backward linkages denote the use of foreign inputs to produce goods and services for export. Forward linkages denote the export of domestically produced goods or services to global companies further downstream. Australia is poorly connected into global value chains, with among the weakest backward linkages of any major economy. In order to reduce product costs and improve value differentiation, companies could use a higher proportion of foreign inputs in their goods and services produced for export.

65 This comment was recorded during the AMGC's consultation with industry members. It was made by the representative of an advanced SME.

4.2.5 Lift scale and management quality

While few Australian firms achieve global success by trying to compete on cost alone, the analysis in Section 2 revealed a number of opportunities for Australian manufacturing to improve its cost position. These included:

- **Increasing company scale to improve capability to deliver complex systems:** This will require collaboration and potentially consolidation within the industry, as well as collaboration with research institutions. As noted in Section 2.2.3, Australian firms may struggle to make substantial investments in capital intensity, in part due to their disproportionately smaller size. In smaller firms, overheads are not spread across large volumes, and shorter production runs make it harder to optimise production. These scale challenges can be mitigated at least partially by firms collaborating, including by pooling R&D resources or capital investments. The AMGC's collaboration hubs represent a mechanism for facilitating the sharing of resources and capabilities between firms that operate in certain geographical areas and are part of similar value chains. To date, hubs have been announced in Clayton and Geelong in Victoria.

  Top global manufacturing firms exhibit high levels of advanced processes, which aim to drive process reliability and quality, as well as cost efficiency and competitiveness. As outlined in Section 3, global companies in the top 25% for productivity, compared with the bottom 25%, exhibit 1.61 times the capital efficiency, 1.50 times newer equipment, 1.30 the rate of automation, and 1.25 times higher energy and water efficiency. In order to shift to advanced processes, Australian manufacturing companies will need to invest in higher capital intensity, newer equipment and higher rates of automation.

- **Improving management quality to lift productivity and reduce cost:** As outlined in Section 2.2.3, Australia has a lower share of high-performing managers than other successful countries. Improving management quality will require proactive investment in the workforce and continued investment in management training and skills. Management skills can be understood as a mix of operations management (adopting lean manufacturing processes), performance management (clear and effective goal-setting), and talent management (incentivising top performance, as well as sustaining innovative workplace cultures and a strong talent mindset).[66] As well as improving technical leadership, as discussed in the previous section, stronger management also supports efficiency and productivity. This Plan details further investigation that is required to understand the drivers of the management capability gap (see Section 4.4.3).

4.3 ACTIONS FOR GOVERNMENT

4.3.1 Overview of actions for Government

Successful Australian businesses have already made the transition to competing more on value and targeting export markets. However, the transition will involve challenges for many individual businesses, including the large up-front costs of investing in innovation and market entry, and small firm size. While industry is the lead player, governments can play a role in accelerating the transformation by helping firms to overcome the barriers required for industry to increase value differentiation, reduce product costs and improve market focus. Exhibit 33 demonstrates how government actions can support what industry must do to transform.

In order to support industry's transition, governments can take action in three areas:

- Improve government support for business-led R&D and encourage industry–research collaboration
- Use smarter procurement and smarter funding programs to drive advancement
- Rethink how progress in the manufacturing sector is measured.

Taken together, these policy changes amount to a fundamental shift in the focus, balance and operation of government support, to help ensure that Australia's manufacturing sector is able to thrive in the future.

> While industry is the lead player, governments can play a role in accelerating the transformation.

66 See, for example, Department of Innovation, Industry, Science and Research (2009), *Management Matters in Australia*. Available at: http://worldmanagementsurvey.org/wp-content/images/2010/07/Report_Management-Matters-in-Australia-just-how-productive-are-we.pdf

Exhibit 33 – Government supporting actions and knowledge priorities can accelerate the transformation by supporting these company actions

What companies must do to transform		Improve support for business-led research	Pursue smarter procurement and smarter programs	Change measurement of manufacturing	R&D knowledge gaps	Business improvement and knowledge gaps
		What government and research can do to support change				
		Government supporting actions			Knowledge priorities	
Increase technical leadership	Increase business-led R&D	✓	✓	✓	✓	
	Increase skill intensity	✓	✓	✓	✓	✓
Increase servitisation	Collaborate with researchers	✓				
	Develop service offerings		✓	✓		✓
Improve market focus	Reach untapped markets and segments		✓			✓
	Integrate into global value chains		✓			✓
Increase scale & management	Improve management capability					✓
	Collaborate to 'play bigger'		✓		✓	

Source: Competitiveness analysis

4.3.2 Improve government support for business-led R&D and encourage industry–research collaboration

As Australia's most successful exporters demonstrate, achieving technical leadership is one of the most critical drivers of competitiveness for Australian manufacturers. As noted in Section 2.3.2, this was overwhelmingly cited by purchasing managers as the key source of value to end customers. Support for R&D and research collaboration have underpinned Australia's export successes, particularly in industries that rely on advances in science and technology as their drivers of innovation.

For more firms to develop technical leadership, the Australian Government must encourage business-led R&D and greater collaboration with research institutions. This does not necessarily need to involve additional funding, but instead requires a redesign of current government support for business-led R&D. Further, with tighter leadership, collaboration and alignment between industry and universities, Australia's strong research pipeline will better translate to commercial outcomes.

Proposed action:
Improve the design of Australian Government support for business-led R&D

Government support for business-led R&D is not optimally designed to achieve different R&D objectives. Section 2 outlined a number of R&D objectives that governments seeks to achieve, including:

- Encouraging investment by firms in R&D with different risk profiles (i.e. both medium and higher risk) and different time horizons (i.e. both short- and longer-term)
- Ensuring that minimal government funding is provided to R&D activity that is infra-marginal (i.e. to investment that would have occurred without the incentive).

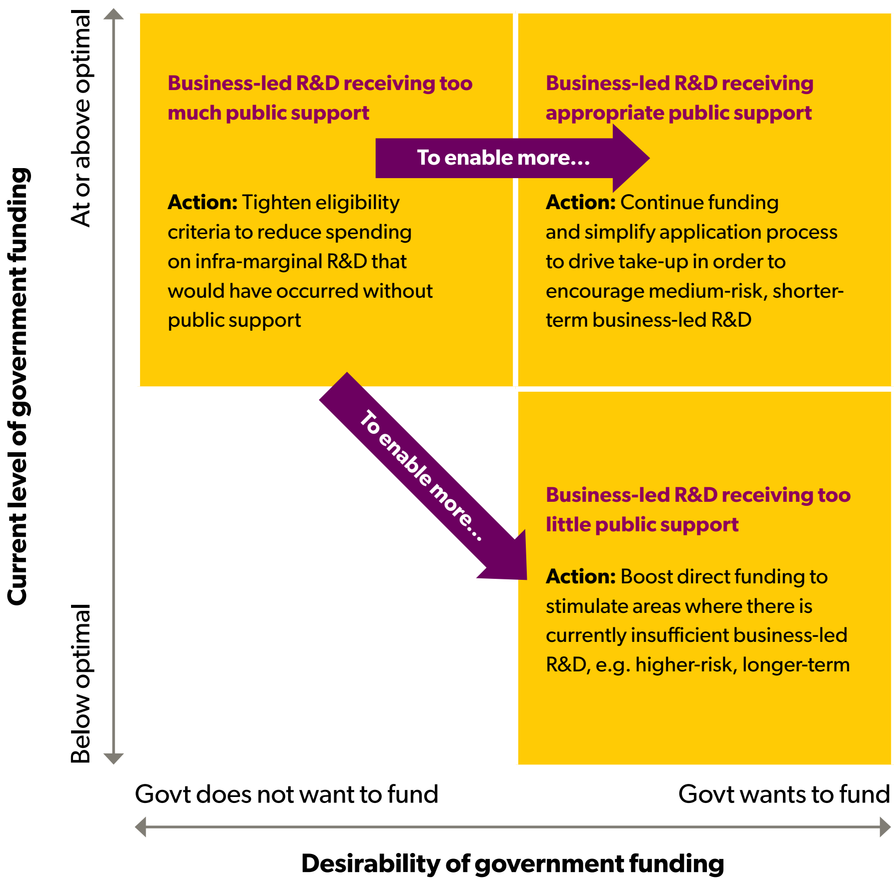
In order to best achieve these objectives, the Australian Government should reduce support for infra-marginal activity and boost support for both medium-risk, short-term R&D through the Tax Incentive, and support higher-risk, longer-term R&D through more direct forms of grant assistance. In order to achieve these objectives (see Exhibit 34):

- Government should tighten eligibility criteria to reduce support for infra-marginal business-led R&D. While acknowledging the challenge of targeting additionality through a volume-based scheme, the recent Review of the R&D Tax Incentive sensibly recommended introducing an intensity requirement to better target larger companies' access to the scheme.[67] The AMGC will publicly support the recommendations related to additionality that were made in the Review.
- Governments could consider using the savings generated from tightened eligibility criteria to encourage investment by firms in R&D with different risk profiles and time horizons.
  - In order to encourage medium-risk or shorter-term business-led R&D, the Government could continue funding under the R&D Tax Incentive but simplify application processes to encourage take-up. The Review of the R&D Tax Incentive sensibly recommended a single application process rather than the current separation of registration and claims.[68]
  - In order to encourage higher-risk or longer-term business-led R&D, which often enjoys high spillover benefits, the Government should consider shifting the mix of government support for business-led R&D away from indirect channels (see Exhibit 35). As outlined in Section 2, Australia is an outlier in the proportion of government support for business-led R&D that is provided via indirect rather than direct channels. This affects the types of R&D that is encouraged. To ensure that higher-risk and longer-term R&D is incentivised, the Government could boost the mix of funding targeted at direct channels, such as by expanding the current pilot BRII or CRC programs.[69]

67 Finkel, Ferris, Fraser (2016), *Review of the R&D Tax Incentive*.
68 ibid.
69 See Footnote 28 in Section 2.3.3 for further information.

There are successful examples of direct R&D funding in many countries (see Exhibit 36). For example, the US SBIR program provides grants to small businesses in two phases, without matched funding requirements: small grants for feasibility and proof of concept work to 'establish the technical merit, feasibility and commercial potential of the proposed R&D effort', and larger R&D grants for projects shown to have high potential.[70] Other examples of direct funding organisations include Japan's NEDO, which provides targeted grants for translational research in areas that can 'enhance Japan's competitiveness'[71], and Singapore's NRF, with a grant portfolio including proof-of-concept grants for business.

Exhibit 34 – Government support for business-led R&D could be modified to better enable achievement of different R&D objectives



70 US Department of Health and Human Services, National Institutes of Health, Small Business Innovation Research. Available at: https://www.sbir.nih.gov

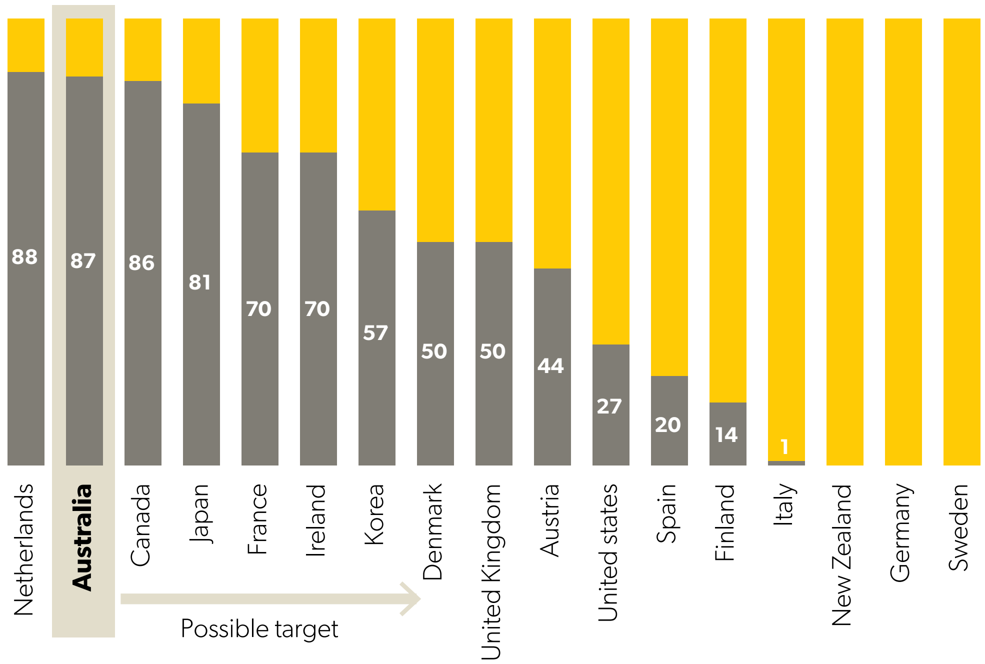
71 For example, investment by NEDO has facilitated the growth of the solar power industry in Japan: Yamashita, M. et al. (2013), *Impact evaluation of Japanese public investments to overcome market failure: Review of the Top 50 NEDO Inside Products*, Research Evaluation, Vol. 10, No. 13, Available at: http://www.nedo.go.jp/content/100799089.pdf

Exhibit 35 – Australia should shift to a higher proportion of direct R&D funding so as to improve policy impact and correct Australia as an outlier

Government support for business-led R&D, by channel

Percentage of support by direct versus indirect channel

Direct
Indirect



Direct R&D support
The OECD defines direct R&D support as the provision of research grants and payment for R&D services

Indirect R&D support
The OECD defines indirect R&D support as the provision of tax incentives, e.g. tax allowances, credits, deductions for R&D services

Note:
Sample of 17 of 35 countries shown here.
Source: OECD R&D Tax Incentives Indicators, based on 2013 OECD-NESTI data collection on tax incentives support for R&D expenditures and OECD, National Accounts and Main Science and Technology Indicators, 15 December 2014; AlphaBeta/McKinsey analysis

Exhibit 36 – Direct funding approaches are used around the world to drive innovative R&D

Example organisations	Overview	Key aspects of approach
US Advanced Research Projects Agency – Energy	The Advanced Research Projects Agency – Energy is the US Government's R&D investment agency for early-stage transformational technologies in energy	› Funds projects too early for investment from the public sector, through grants or cooperative agreements (greater scope for supervision/intervention), with tangible deliverables agreed for quarterly milestones › Focuses on a limited number of priority areas, with individual projects vetted by a panel including subject matter experts
Japan New Energy and Industry Technology Development Organisation	Japan's New Energy and Industrial Technology Development Organisation funds research in energy and industrial technology	› Explicit commitment to 'enhancing Japan's industrial competitiveness' › Focused on translational research (TRL4-6) in areas set through examination of trends and expert consultation, such as fuel cells, robot technology, power electronics and energy conservation
Singapore National Research Foundation	Singapore's National Research Foundation supports investments to create new industries and enable growth	› Focus on economic impact, with four priority areas 'where Singapore has competitive advantages and/or important national needs': advanced manufacturing, health and biomedicine, urban solutions and sustainability, and services and digital economy › Grant mechanisms include proof-of-concept grants for researchers to develop commercialisable prototypes and a technology incubation scheme (co-investment)
US Defense Advanced Research Projects Agency	The US Defense Advanced Research Projects Agency pursues breakthrough technologies for national security	› Invests across the spectrum of technological readiness from scientific investigation to integration in systems, explicitly pursuing high-risk, high-reward projects › Focus areas determined on an ongoing basis through a) program managers looking for areas with revolutionary potential, and b) requests from the military

Source: ARPA-E website; ARPA-E budget; DARPA website; BusinessWeek; NRF website and reports; NEDO website and report

4 ACTION PLAN FOR AUSTRALIAN MANUFACTURING

Proposed action:
Encourage greater collaboration between research and industry

As outlined in Section 2, Australia could improve its rate of collaboration between the research sector and industry to drive technical leadership among manufacturers and potentially improve alignment between public research and commercial opportunity.[72] There are a number of potential mechanisms for improving these rates including incentivising researchers who collaborate[73] and building collaboration requirements into existing government assistance for R&D, including business-led R&D.[74]

With regard to incentives and recognition, one approach is to ensure researchers who collaborate with industry are recognised professionally, with industry impact included in key metrics for performance evaluation. As highlighted by the Academy of Technological Sciences and Engineering, current incentives result in a focus on research excellence, 'often at the expense of [...] university collaborations with the private and public sectors, entrepreneurial behaviour and knowledge transfer'. As such, it is essential that 'research engagement is appropriately recognised and rewarded alongside research excellence'.[75] The new engagement and impact metric currently being developed by the Australian Research Council may help to promote collaboration under the Excellence in Research for Australia evaluation process[76], or explicitly recognise commercialisation outcomes in sector rankings.[77]

With regard to collaboration requirements, existing government support for R&D, including business-led R&D can be redesigned to require collaboration. For example, governments could increase sector-wide research funding that incentivises collaboration design, such as the Australian Government's investment in National ICT Australia (NICTA), now Data61 at CSIRO.[78] Or, as the recent Review of the R&D Tax Incentive by Finkel, Ferris and Fraser recommends, a collaboration premium could "provide additional support for the collaborative element of R&D expenditures undertaken with publically funded research organisations".[79] This recommendation is directed at lifting the current rate of collaboration under the Tax Incentive, with only 9.5% of projects registered under the R&D Tax Incentive in 2013–14 indicating collaboration with another organisation.[80]

"The new engagement and impact metric currently being developed by the Australian Research Council may help to promote collaboration.

72 Department of Industry (2016), 'R&D Tax Incentive Review Issues Paper', Canberra. Available at: https://www.business.gov.au/~/media/Business/RDTI/Review/Research-and-Development-Tax-Incentive-Issues-Paper-PDF.ashx?la=en

73 Bell, J. et al. (2015), 'Translating research for economic and social benefit: country comparisons', ACOLA, Melbourne. Available at: http://acola.org.au/PDF/SAF09/SAF09%20Full%20report.pdf

74 In addition to improving formal collaboration, the creation of informal spaces for 'integrative thinking' has been noted as a key ingredient for increased innovation. See, for example, Green, R. & Roos, G. (2012), 'Australia's Manufacturing Future: Discussion paper' prepared for the Prime Minister's Manufacturing Taskforce, Sydney. Available at: https://www.uts.edu.au/sites/default/files/Australia's_Manufacturing_Future.pdf

75 Bell, J. et al. (2015), 'Translating research for economic and social benefit: country comparisons', ACOLA, Melbourne. Available at: http://acola.org.au/PDF/SAF09/SAF09%20Full%20report.pdf

76 ATSE 2015, op. cit.

77 McKeon, S. et al. (2013), 'Strategic Review of Health and Medical Research', DCRC & CHeBA, University of New South Wales, NSW. Available at: https://cheba.unsw.edu.au/sites/default/files/presentations/McKeon%20SRHMR_130603%20(2).pdf

78 Stanford, J. (2016), 'Manufacturing (Still) Matters: Why the Decline of Australian Manufacturing is NOT inevitable, and What Government Can Do About It'. Australia Institute. Available at: http://www.tai.org.au/content/manufacturing-still-matters

79 Ferris, Finkel, Fraser (2016), *Review of the R&D Tax Incentive*.

80 Department of Industry (2016), 'R&D Tax Incentive Review Issues Paper', Canberra. Available at: https://www.business.gov.au/~/media/Business/RDTI/Review/Research-and-Development-Tax-Incentive-Issues-Paper-PDF.ashx?la=en

4.3.3 Use smarter procurement and smarter programs to drive advancement

Proposed action:
Use smarter civil and defence procurement to drive innovation, collaboration and export focus

Australian federal and state governments have the opportunity to leverage both their defence procurement and civil procurement to drive innovation and collaboration between firms, and to create opportunities for Australian firms in global supply chains. Australian governments can channel spending to provide greater domestic demand and craft the procurement requirements to enable firms to scale faster into niches where they can be globally competitive. To do this well, policy should be focused on:

- **Driving technical leadership:** Innovation requirements should be established to drive technical leadership and ensure that the technology or product will be a globally distinctive offering. This could be coupled with grants to help firms build capability and strengthen the domestic supply base, to make it easier for global contractors to include Australian firms in their supply chains. For example, the New Air Combat Capability – Industry Support Program of the Department of Defence enabled Australian firms to win work in the supply chain of the F-35 fighter plane by providing customised grants to Australian companies to upskill in key capability areas.[81]

  Procurement support should be focused on areas where Australia has comparative advantage, via either current capability or the ingredients for future capability, that could be developed to scale through guaranteed demand. Critically, support should not be provided to prop up industries that were once competitive but are no longer viable. This type of government support is not without risk, as government efforts to support industries without comparative advantage tend to fail. While it was delivered through a different mechanism, some of the support provided to the automotive industry highlights the risks involved in offering government support. In 2014, the Productivity Commission found that the costs of supporting the automotive industry outweighed the benefits.[82]

- **Ensuring export opportunities and global supply chain integration:** Government procurement can create opportunities to connect with global supply chains. As an example, Israeli defence procurement often requires a reasonable investment in building local capacity to engage with global supply chains, built on the principle that projects should be of mutual benefit and result in long-term strategic joint ventures or alliances. The Israeli Government has helped create partnerships and entry points to the global supply chains of leading aerospace companies, resulting in inbound investment in excess of the original mandate.[83] A clear pitfall here is escalating the cost of procurement and compromising capability through excessive focus on Australian content. Capability building should be focused on realistic opportunities on a case-by-case basis. Industry participation schemes that have focused on import substitution tend to make firms *less competitive* due to the explicit protection afforded.

- **Collaboration opportunities:** One method to achieve scale used in many advanced economies is strategic procurement. Australia has few strategic procurement programs to help companies develop scale in niche areas, particularly compared to other developed countries.[84] When government organisations in Australia have used strategic procurement, they have tended to focus more on the perceived

81 Department of Defence, New Air Combat Capability – Industry Support Program, Canberra. Available at: http://www.defence.gov.au/dmo/DoingBusiness/Industry/IndustryPrograms/JSF-ISP/; AlphaBeta/McKinsey interviews with industry experts.

82 Productivity Commission, 'Australia's Automotive Manufacturing Industry – Inquiry report'. Available from: http://www.pc.gov.au/inquiries/completed/automotive/report

83 AIDN (2014), Industry Involvement for Defence in Australia, Melbourne. Available at: http://www.aidn.org.au/documents/aidn%20australian%20industry%20involvement%20paper%20-%20may%202014.pdf

84 ibid.

value of final assembly. As an example, during a recent defence aircraft procurement negotiation, the government initially pushed for final assembly to occur in Australia even though it would have been difficult to achieve efficiency at low volumes and would have provided little benefit in terms of capability transfer. This push was despite the manufacturer's offer to invest in building local capability to maintain advanced systems throughout the life of the aircraft, which could have helped to build competitive scale in a high-skill field.

- **Limited reliance on targets:** Many countries have decided to set a target for the amount of mandated foreign assistance that is tied to procurement contracts. If a government chooses do so, they would need to be confident the target was modest, initially realistic and wouldn't create unintended consequences such as those described above. A good example is Israel's modest targets of 35–50%, which are regularly exceeded by ensuring local firms participate meaningfully in global supply chains.[85] Australian levels are currently closer to 5–10% in F-35 acquisition[86]; targets would need to be initially set low and ratcheted up to enable time for industry to build capacity. This Plan outlines further actions by the AMGC to tailor civil and defence procurement opportunities (see sections 4.4.3 and 5).

> "The future submarine build offers a 'moon shot' opportunity for Australia, provided we play our cards right.

Proposed action:
Harness existing government assistance programs to drive advancement

Having uncovered the characteristics associated with successful and more advanced global manufacturing firms, federal and state government policy and programming can better target the promotion of these characteristics in Australian firms. A suite of federal government assistance programs is currently available to Australian manufacturers, including the Entrepreneurs' Programme, the Industry Skills Fund, the ARC Industry Transformation Research Programme, Austrade, the R&D Tax Incentive and CRCs. There are also numerous state-based industry assistance funds and capability-building or facilitation programs that provide assistance to manufacturers or are available to manufacturing firms. There is an opportunity for both federal and state governments to ensure that these programs are best aligned to advancing manufacturing:

- Where these programs are capability-building, the capabilities could be targeted towards building the types of characteristics associated with successful, more advanced firms. These include advanced knowledge (such as R&D intensity and wage levels), advanced process (such as capital intensity and automation levels) and advanced business models (such as share of services in revenue).
- Where these programs offer incentives or support, the evaluation criteria could be oriented towards ensuring higher prevalence of key characteristics – e.g. share of services, R&D intensity and capital intensity.

85 AIDN, *op. cit.*

86 As of December 2015, Australian industry had won US$554.5 million in production and development contracts (source: Department of Defence (2016) 'F-35 Program Key Facts & Milestones – March 2016'). With average costs of A$90 million per aircraft (source: ibid) and orders for 72 aircraft, the total order is worth ~US$6.5 billion for direct acquisition alone. Australian industry currently has an ~8.5% share.

4.3.4 Rethink how manufacturing and progress in manufacturing are measured

Measurement of progress in the sector should be designed to fulfil the dual objectives of measuring whether firms are advancing, and capturing the wider impact of manufacturing on the economy. These objectives of a revised measurement system will ensure that Australia is tracking what we desire to achieve in manufacturing. Are we transitioning to sustainable, high-value-added manufacturing and are we capturing the impact that manufacturing has on other industries? Accordingly, the Australian Government should make three changes to the way in which progress of the sector is currently measured (see Exhibit 37).

Proposed action:
Measure the prevalence of key 'advanced' characteristics

Currently, progress in manufacturing is primarily measured by whether value added, jobs and exports have increased for the subset of ANZSIC classes defined as 'advanced'. Rather than using these traditional metrics alone, we recommend measuring whether or not the sector is advancing by tracking the prevalence of key characteristics associated with 'advancement' across all manufacturing sub-industries. For example, advancement of manufacturing could be tracked by whether there have been changes in advanced knowledge, advanced processes or advanced business models. Specifically, this could involve measuring whether there have been changes in skill mix; average level of qualifications or proportion of high qualifications; research and development intensity; patent/trademark portfolio; wage levels; capital efficiency; automation rates; collaboration rates; the value density of products; and the share of revenue represented by services. Most of these metrics are currently used as part of the ABS's Expanded Analytical Business Longitudinal Database, except for the share of revenue represented by services, which we recommend be added to one of the existing survey formats such as the Business Characteristics Survey.

Proposed action:
Report modified versions of value-added and jobs growth

The department currently measures progress of the sector primarily against employment, value added and exports.[87] It reports progress against a number of characteristics-related metrics including innovation and business performance. These metrics are reported at the 1-digit level (e.g. manufacturing) and for the sub-industries currently classified as 'advanced'.

We recommend reporting modified versions of value-added and jobs growth at the 1-digit level of manufacturing. There are some challenges with traditional metrics like value added and employment, given the rate of servitisation and flexible sourcing of labour across the economy for services like design, accounting, marketing and cleaning. Where these jobs are directly linked to manufacturing activity, there is value in making the connection to manufacturing, albeit imprecisely. There are international examples of attempts to attribute value added and employment to different sectors. For example, in the US, the Bureau of Labor Statistics constructs annual employment tables for 168 sub-industries, which indicate the employment supported directly and indirectly per $1 million of sales of goods and services to final users. The BLS also provides input–output tables annually, which show sales generated in a range of sectors by demand from other sectors. This allows for reallocation of value added to upstream sectors to be observed.[88] Accordingly, we recommend reporting a modified version of value added and jobs that captures the direct and indirect impact of manufacturing (see Exhibit 38).

87 As per international documents from the Department of Industry, including the advanced manufacturing data pack.

88 US Bureau of Labor Statistics. Available at: http://www.bls.gov/emp/ep_data_emp_requirements.htm

89 For example, see https://d3n8a8pro7vhmx.cloudfront.net/theausinstitute/pages/536/attachments/original/1464819264/Manufacturing_Still_Matters___Centre_for_Future_Work.pdf?1464819264, pp. 4–6.

Even this modified reporting of employment is likely to understate the employment impact of manufacturing. The transitions occurring in the new economy mean that new economy manufacturing activity may not appear in either the manufacturing codes or in input–output tables related to manufacturing. For example, in an era of digitally delivered textbooks, jobs in printing and distribution might be lost but jobs in technology development, maintenance and support will emerge and not necessarily appear linked to the manufacturing industry.

Proposed action: Measure 'spillover' benefits

In addition to the common metrics outlined above, we recommend measuring the 'spillover' benefits of manufacturing, or its broader contribution in the economy. Specifically, given the important role of manufacturing in supporting innovation, productivity and exports[89], we recommend tracking the share of R&D, productivity growth and total exports represented by the manufacturing sector.

Exhibit 37 – We recommend three changes to how the sector is measured

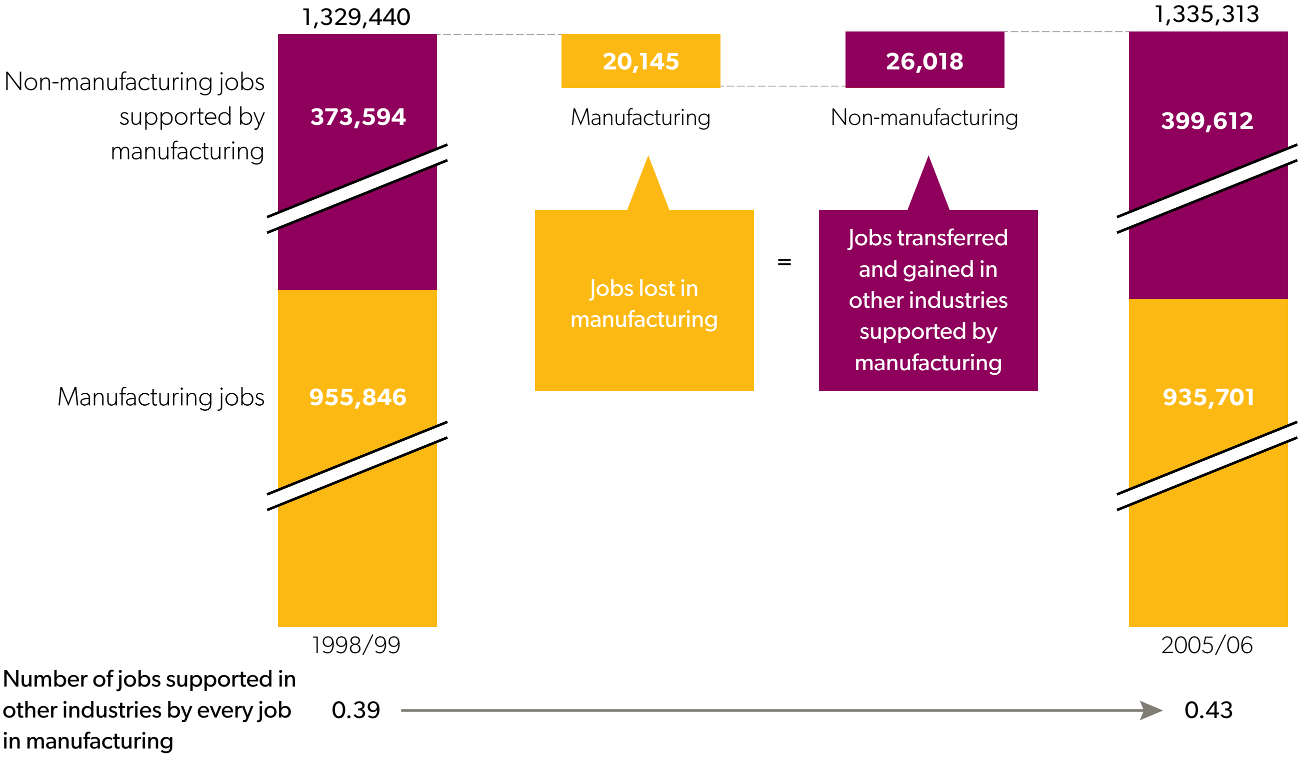
1. Measure the prevalence of key characteristics	2. Report modified versions of value-added and jobs growth	3. Measure 'spillover' benefits
Track 'advancement' of sector by the **prevalence of characteristics** associated with being more advanced such as: - Advanced knowledge: skills (by type); qualifications (by level); research and development intensity; patent/ trademark portfolio; wage levels; collaboration (by type) - Advanced processes: capital efficiency; automation - Advanced business models: value density; share of services	**Report modified version of key metrics of interest (e.g. value-added, jobs, exports) across the Growth Centres** including: - For 1-digit manufacturing - A modified version of value-added and jobs for 1-digit manufacturing, which captures the impact of manufacturing on other industries (see Slide 9) - For a set of firms found to be 'more advanced' according to prevalence of key characteristics - Establishing thresholds for characteristics in Year 1 that capture 50% of firms as 'more advanced' (e.g. overall advancement index of 1.2) - Aggregate incremental jobs growth of all firms in Year 2 that meet criteria (including new entrants and minus exits)	**Track 'spillover' benefits of manufacturing** or why manufacturing matters to wider economy such as: - Share of business expenditure on R&D - Share of total exports - Share of total productivity growth

89 For example, see https://d3n8a8pro7vhmx.cloudfront.net/theausinstitute/pages/536/attachments/original/1464819264/Manufacturing_Still_Matters___Centre_for_Future_Work.pdf?1464819264, pp. 4–6.

Exhibit 38 – Rethinking the way that manufacturing is measured will help to better understand progress and the broader impact of manufacturing

Direct and indirect employment from Australian manufacturing

Number of jobs



Note:
Non-manufacturing jobs supported by manufacturing are calculated from IO tables and employment/value added ratios. The period selected (1998/9 to 2005/6) deliberately excludes the global financial crisis and automotive industry decline.

4.4 KNOWLEDGE PRIORITIES

4.4.1 Overview of Knowledge Priorities

Industry's leadership in the transition to advanced manufacturing can be further guided and informed by investigating key Knowledge Priorities. Developing and disseminating knowledge is key to helping Australian manufacturing differentiate itself on value and technical leadership. The AMGC has identified two types of Knowledge Priorities that will need to be addressed in order to enhance the competitiveness of the Australian manufacturing sector:

- R&D priorities – these are technological and scientific gaps that can help to improve manufacturing processes or drive product innovation
- Business improvement priorities – these are analytical priorities aimed at better understanding business capability gaps and the best ways to overcome these gaps.

The Knowledge Priorities outlined in this section are the product of our competitiveness analysis, a review of the existing literature, and industry engagement including consultations and an industry-wide survey with more than 50 respondents from companies, industry associations, government bodies and research organisations.[90] Annex B provides further detail on the methodology used to identify the priorities.

90 Survey participants were asked to evaluate the relevance of the proposed priorities, identify additional priorities and offer further comment on the R&D and business improvement issues most affecting the industry. More than 50 organisations and companies responded to the survey.

4.4.2 Australian manufacturing's R&D priorities

Australian manufacturing businesses, industry associations and the research community have identified a number of R&D priorities to help Australian manufacturing become globally competitive. These will help by increasing technical leadership in products and expanding associated value-adding services.[91]

Robotics and automated production processes

Robotics and automated production processes refer to the design and operation of robots in manufacturing[92], enabling greater productivity, lower costs, improved workplace safety and higher product quality. Examples of knowledge gaps include:

- How can error detection and reduction rates be improved so that automated processes continue to provide a reliable output?
- How can advanced materials improve the functionality of robots and the enablement of 'soft robotics'?[93]
- How can robots better develop situational awareness (vision and sensors) to interact with workers and customers and in controlled environments?
- How can software be improved to enable robots to communicate with one another and other manufacturing equipment/processes?

> Australian manufacturing businesses, industry associations and the research community have identified a number of R&D priorities to help Australian manufacturing become globally competitive.

Advanced materials and composites

Advanced materials and composites refer to new materials developed to provide superior performance across a variety of dimensions (e.g. strength, weight and flexibility)[94], enabling greater product differentiation and customisation for manufacturers. Examples of knowledge gaps include:

- How can flow chemistry increase reproducibility, scale and safety?
- Are there new bonding techniques that can improve the speed of manufacturing and the resilience of existing materials and composites?
- What new materials exist at the molecular or nano scale that can herald new opportunities?
- How can self-healing or flexible materials better allow for remote repair?
- How can the development and application of wear resistant materials be enhanced?

Digital design and rapid prototyping

Digital design and rapid prototyping refer to the product development cycles enabled by ICT visualisation and analytic tools[95], providing lower product development costs and greater product customisation opportunities to manufacturers. Examples of knowledge gaps include:

- How can software platforms be improved to make it easier for Australian manufacturers to complete new product designs?
- What production processes or business services will allow increased rapid prototyping so as to enable manufacturers to create highly customised products?
- How can small-scale production be made more cost-effective so that smaller Australian manufacturers can viably engage in design-led production?

91 The following list is ranked in order of importance and impact as identified by the survey and sources listed in the previous section. For greater detail on a number of these priorities, we recommend referencing the CSIRO's Industry Roadmap for Advanced Manufacturing.

92 CSIRO (draft: October 2016), 'Future of the Australian Advanced Manufacturing Industry - An Industry Roadmap'.

93 'Soft robotics' refers to the use of soft or deformable materials in robotics systems, enabling safer interaction with their environment and improved performance (Source: IEEE Robotics & Automation Society, at http://softrobotics.org/basic-information/).

94 CSIRO (draft: October 2016), 'Future of the Australian Advanced Manufacturing Industry – An Industry Roadmap'.

95 CEDA (April 2014), 'Advanced Manufacturing: Beyond the Production Line', http://www.ceda.com.au/research-and-policy/research/2014/04/30/advancedmanufacturing; CSIRO (draft: October 2016), 'Future of the Australian Advanced Manufacturing Industry – An Industry Roadmap'.

Sustainable manufacturing and life cycle engineering

Sustainable manufacturing and life cycle engineering refer to the development of products with lower energy consumption, improved durability or maintenance costs, and higher potential for recycling or collaborative consumption.[96] Sustainable manufacturing presents an opportunity to reduce costs and greater ability to meet eco-conscious market demand. Examples of knowledge gaps include:

- How can we identify and take advantage of waste capture opportunities in the production cycle?
- How can new and existing recycling methods be expanded across more parts of the value chain and to more industries?
- How can products and production processes be designed to maximise recycling opportunities?

Additive manufacturing

Additive manufacturing refers to the use of digital 3D design data to make a component by successively depositing layers of material, enabling mass customisation and on-site printing. Examples of knowledge gaps include:

- How can uniformity be improved in mass manufacturing using 3D printing processes?
- How can composites and dissimilar materials be manufactured reliably using additive techniques?
- What are effective ways to combine additive and subtractive processes?

Sensors and data analytics

Sensors and data analysis refers to the use of devices to monitor, control and diagnose issues with production lines in real time, enabling increased production volumes and reduced downtime.[97] Examples of knowledge gaps include:

- Can relevant sensors be embedded into more parts of the production process and final product, especially where this involves exposure to harsh operating environments?
- What kinds of battery and data storage solutions will be needed to make the use of sensors more widespread and viable?
- How can the analysis of data gathered from sensors be made more user-friendly for manufacturers as well as clients?
- How can sensors be made more self-powering, biodegradable, bio-compatible and wirelessly connective?
- How can systems increase data storage and security to handle higher capture and security threats?

Materials resilience and repair

Materials resilience and repair refers to the ability of a material under stress to absorb energy and return to its original state[98], enabling product performance characteristics including strength, flexibility and durability. Examples of knowledge gaps include:

- How can material behaviour and complex processes such as flow chemistry be better modelled to increase material resilience?
- How can scanning or other methods be enhanced to better detect stress points and weaknesses in composite materials or assembled products?
- Are there new or substitute materials that can increase the resilience of a product line?

96 CSIRO (draft: October 2016), 'Future of the Australian Advanced Manufacturing Industry – An Industry Roadmap'.

97 ibid.

98 White, M. A. (2011), *Physical Properties of Materials*, 2nd Edn, CRC Press; Princeton University Press, *The Properties of Materials*, Ch 1, http://press.princeton.edu/chapters/s9638.pdf

Bio-manufacturing and biological integration

Bio-manufacturing and biological integration refer to the use of biological systems to produce molecules that cannot be extracted or synthesised directly[99], enabling the development of innovative products and materials. Examples of knowledge gaps include:

- Can more advanced resilient bio-degradable packaging solutions be found?
- What high-value compounds and new materials can be created by using biological instruments, e.g. algae?
- How can biological processes, including the breakdown of materials for easy recycling, be incorporated into the production processes of traditional products?

Nano-manufacturing, micro-manufacturing and precision manufacturing

Nano-manufacturing, micro-manufacturing and precision manufacturing refers to production that uses very small-scale components and materials or applies high-precision tools[100] to improve product performance characteristics, enabling a high degree of product differentiation and customisation opportunity for manufacturers. Examples of knowledge gaps include:

- How can the resilience and reliability of precision manufactured items be enhanced?
- What is required for the system-level integration of precision manufacturing innovations?
- What computational and modelling innovations will better enable precision manufacturing?

Augmented or virtual reality systems

Augmented or virtual reality systems refers to technology that engages workers with a computer-generated representation of the physical world, enabling remote control of machinery or guiding workers through operations on-site[101] and ultimately improving cost and safety outcomes. Examples of knowledge gaps in include:

- How can augmented reality be used to allow closer human–machine interaction in product design and manufacture, including through advanced sensors?
- How can improved processing power, download size, resolution, frame rates and depth sensors allow for more complex visualisations?
- What kinds of wearable virtual reality technologies are best suited to manufacturers in different contexts: on the factory floor, exhibiting to a client or in testing product use?
- How can the computability of software platforms be enhanced?

4.4.3 Australian manufacturing's business improvement Knowledge Priorities

The competitiveness analysis detailed in Section 2 and our industry survey identified a number of areas where further investigation is required to understand business capability gaps and how to correct these gaps.[102]

Drivers of the management capability gap

Recent studies have demonstrated that Australia has a long tail of manufacturing companies that perform poorly on management capability[103] and a shortage of managers with higher qualifications. Examples of knowledge gaps include:

- How do different manufacturing sub-industries perform on management capability?
- How does management capability vary by firm size?

99 White House (April 2016), 'Advanced Manufacturing: A Snapshot of Priority Technology Areas Across the Federal Government'; Industry Canada (2006), 'The Canadian Biopharmaceutical Industry Technology Roadmap', http://publications.gc.ca/collections/Collection/Iu44-31-2006E.pdf

100 US National Science Foundation (2002), 'Workshop on Nanomanufacturing and Processing: Summary Report', https://www.nsf.gov/mps/dmr/nsfec_workshop_report.pdf

101 CSIRO (draft: October 2016), 'Future of the Australian Advanced Manufacturing Industry – An Industry Roadmap'.

102 Proportion of survey respondents identifying each business improvement knowledge priority as having high impact or very high impact on their business: management (94%); workforce skills requirements (85%); international engagement (73%); industry 4.0 (63%); engaging in government procurement processes (52%).

103 Bloom, N. et al, (2007), 'Management Practice and Productivity: Why They Matter', *Management Matters*, available at: http://www.growingjobs.org/downloads/management_practice.pdf; and McKinsey & Company (2009), *Management Matters*.

- What are the key drivers of management capability gaps?
- What are the most effective ways for Australian manufacturers, especially SMEs, to drive improvement in management capability?

Understanding workforce skills requirements

Understanding the strengths and weaknesses of the current Australian manufacturing labour force, as well as future requirements, is key to developing an evidence-based skills plan. Examples of knowledge gaps include:

- Which parts of manufacturing are making the shift to higher skills and which are not?
- Is there a mismatch between the supplied and demanded labour skills in particular sub-industries? For example, companies have indicated a shortfall of device physics and composites engineering knowledge.
- What specific qualifications are manufacturers demanding and what common skills are manufacturers demanding across qualifications? What commercial skills are most complementary for graduates with technical qualifications who are headed for the manufacturing sector?
- What skills are most likely to be demanded in the jobs of the future?
- How can we match, transfer and transform skills in declining manufacturing sub-industries with skills in growing manufacturing sub-industries?
- How can education service providers be more responsive to future economic needs?

International linkages

As outlined in Section 2, some sub-industries in manufacturing currently under-serve key export markets, including for both intermediate and finished goods. Australia also has among the weakest backward linkages[104] of any major economy. Examples of knowledge gaps include:

- Which export markets are most under-served by each of the manufacturing sub-industries?
- What strategies should Australian manufacturing firms follow to identify and access international opportunities in these under-served markets?
- How can Australia improve its backward linkages in different sub-industries? What markets are most reputable and accessible for sourcing foreign components by sub-industry?

Driving Industry 4.0 uptake

Australian manufacturing has the opportunity to improve cost competitiveness and value differentiation by taking advantage of technologies transforming production processes and customer understanding. Many countries around the world are moving towards Industry 4.0 as a means of harnessing the opportunities afforded by cyber-physical production systems made up of smart machines, logistics systems and production facilities. Examples of knowledge gaps include:

- What opportunities does Industry 4.0 have to offer Australian manufacturers? How can current trends in automation and data analysis best be scaled and made relevant and accessible to the operations of Australian manufacturers, especially SMEs?
- What key actions can manufacturers pursue to ensure the successful take-up of Industry 4.0 methods and technologies?
- How can government initiatives, such as the Prime Minister's Taskforce on Industry 4.0, be made most relevant to the commercial opportunities and challenges facing manufacturers?

104 Backward linkages refer to the use of foreign inputs to produce goods and services for export.

Leveraging government procurement

Government procurement provides Australian manufacturers with a large market opportunity, especially in industries like defence, and in infrastructure investment such as rail. Similarly, Australian governments have the opportunity to leverage their procurement to drive innovation and collaboration between firms, and to create opportunities for Australian firms in global supply chains. Examples of knowledge gaps include:

- How can manufacturers be better appraised of upcoming procurement opportunities?
- How can Australia ensure a strong industry policy role in the forthcoming defence capability acquisition?
- What are the best ways to create spillover benefits through government procurement processes from industries with traditionally intensive procurement processes (e.g. defence) to other industries?
- How can value differentiation and integration into global supply chains be prioritised and incentivised through civil and defence procurement processes?

> Australian governments can leverage their procurement programs to create opportunities for Australian firms in global supply chains.

4.5 CHANGE CAN START IMMEDIATELY, BUT THE TIME TO PAYOFF WILL VARY

The transition can start immediately but the time to payoff for action will vary depending on the action (see Exhibit 39). In the short term, there are a number of quick wins that can be actioned by companies, governments, the AMGC and the wider community:

- The AMGC, governments and industry associations can communicate the benefits of optimising costs, differentiating value and improving market focus to manufacturers.
- Governments can redirect a higher proportion of funding to commercial R&D.
- The AMGC, industry and researchers can identify technology priorities for the sector and expand collaboration hubs.
- Governments can rethink how manufacturing is measured to gain a better understanding of whether the sector is advancing and its impact on other industries.

Australia has a real opportunity to advance its manufacturing sector. The analysis and actions contained in this report will help to take Australian manufacturing to another level. As we have observed, some firms have already made the transition to improve their differentiated value and shift focus to higher-value market segments. Actions by companies and governments, along with further investigation into key Knowledge Priorities, can help other companies to make this transition and high-performing companies to further advance. The AMGC will work with companies, governments and other stakeholders to implement this Plan and harness the full potential of Australian manufacturing.

Exhibit 39 – Change should start across all actions immediately, with a number of quick wins expected in the short term

Quick wins	Medium time-to-impact	Longer time-to-impact
Sell the ‘benefits of change’	Encourage smarter procurement	Industry 4.0 applications
Improve government support for business-led R&D	Increase commercial collaboration	Integrate into global value chains
Identify projects and collaboration hubs	Identify under-served markets and GVCs	Reach untapped markets
Accelerate the shift to servitisation	Collaborate to play bigger	Improve management capability
Change the measurement of manufacturing	Increase skill intensity, including STEM	Extend technology leadership

Time to payoff

KEY

Industry actions

Government support

Knowledge Priorities

Source: Competitiveness analysis

> The AMGC will advance manufacturing by setting direction, demonstrating the direction through projects and collaboration hubs, and generate impact by influencing companies and government.

5 THE ROLE OF THE AMGC AND NEXT STEPS

5 THE ROLE OF THE AMGC AND NEXT STEPS

5.1 OVERVIEW OF THE AMGC'S ROLE

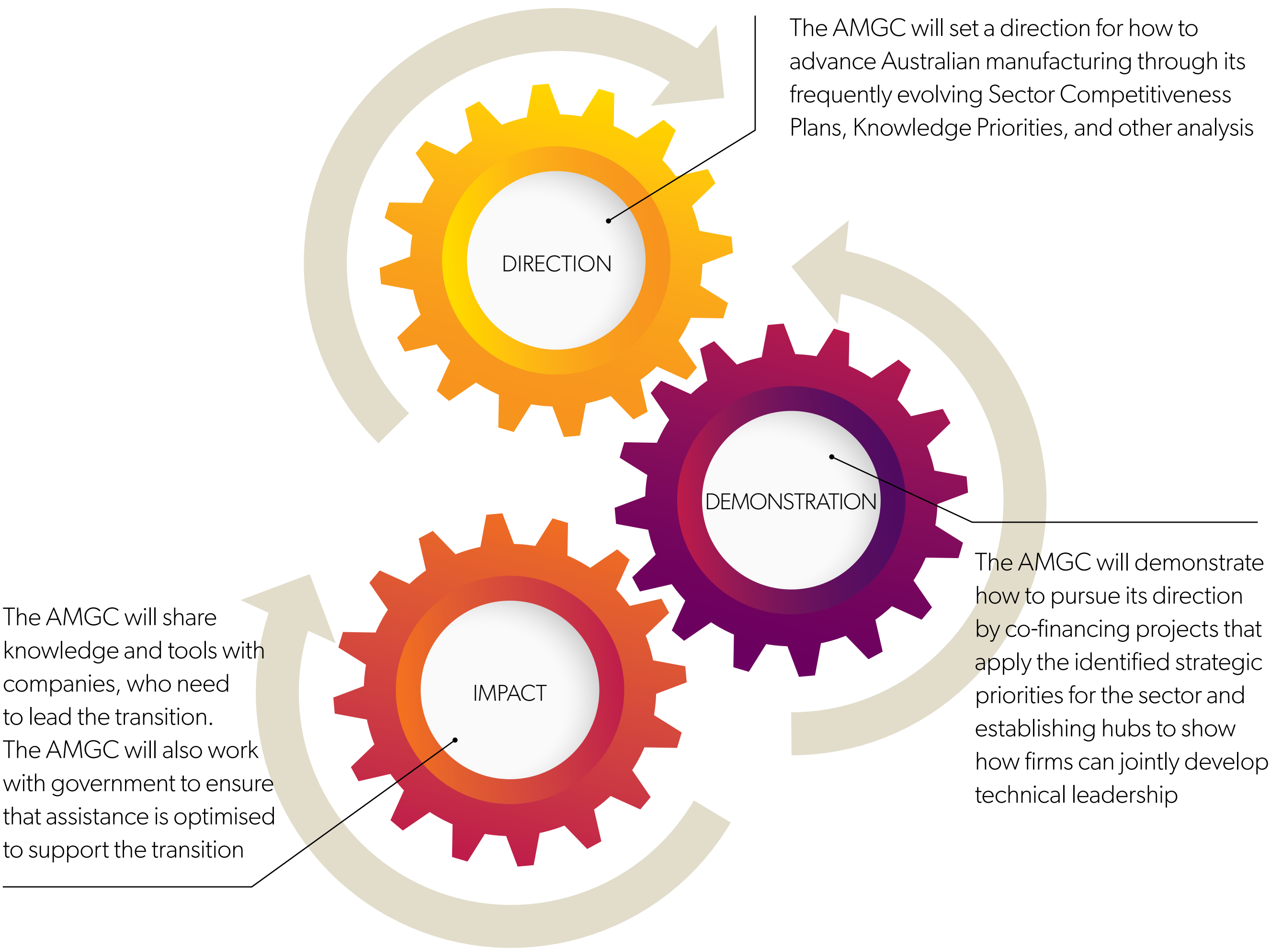
The role of the AMGC is to harness its unique capacity as an industry-led but government-supported Growth Centre to help advance Australian manufacturing. There are three key levers by which the AMGC will pursue this role (see Exhibit 40):

- **Direction:** Set the direction to advance manufacturing in Australia
- **Demonstration:** Demonstrate ways to achieve this direction through projects and hubs
- **Impact:** Work with companies and governments to help them play their key roles in pursuing the set direction.

To perform all three of these levers, the AMGC will maintain close engagement with industry associations, companies, governments and their agencies, and research institutions. AMGC members will stand to gain priority access to the AMGC's initiatives, including participation in demonstration projects and collaboration hubs. The AMGC acknowledges the important role of industry associations in assisting the AMGC in its consultation activities and looks forward to continuing to work with the existing bodies in the sector.

For further detail on the background of the Growth Centres Initiative, please see Annex A.

Exhibit 40 – AMGC will advance manufacturing by setting direction, demonstrating the direction through projects and hubs, and generate impact by influencing companies and government



5.2 SET DIRECTION FOR AUSTRALIAN MANUFACTURING

5.2.1 Overview of the role to set direction

The AMGC will set a direction for advancing Australian manufacturing through its annual Sector Competitiveness Plan, other complementary sub-annual analytical investigations and through material outlining the sector's Knowledge Priorities.

The Plan will outline actions for companies, governments and research institutions to help advance Australian manufacturing. It will be based on a detailed analysis of the competitiveness of the Australian manufacturing sector, including challenges and opportunities. The Plan will detail near-term activity that the AMGC will undertake.

The AMGC will also annually publish and refresh a list of Knowledge Priorities for the manufacturing sector to inform the research community and governments about R&D priorities and inform analytical activities designed to improve the sector's business capabilities.[105]

The Plan and Knowledge Priorities will be made available to the whole industry in order to set direction. Members will enjoy priority access to detailed insights and further analysis that is generated as a result of this work.

5.2.2 Near-term actions for the AMGC to set direction

Over the next 12 months, the AMGC will undertake a number of specific actions to set the direction for advancing the manufacturing sector.

- **Additional sub-industry analysis:** The AMGC will update its Sector Competitiveness Plan in 2017. Where possible, analysis will be conducted at the whole-of-manufacturing level, but the investigation of the barriers and opportunities facing manufacturers will often require analysis at the sub-industry level. In this Plan, some of the lessons were drawn from detailed analysis of the aerospace and medical technology manufacturing sub-industries. Over the next 12 months, the AMGC will undertake competitiveness analysis of additional sub-industries to build a more comprehensive view of the challenges and opportunities facing manufacturing.

  The AMGC is currently in discussion with other Growth Centres about opportunities to conduct sub-industry analysis involving relevant parts of their industries. Other sub-industries of particular strategic importance are also being considered for analysis.
- **Refresh Knowledge Priorities:** The AMGC recently consulted industry representatives and conducted a widely distributed survey to test its proposed Knowledge Priorities for the manufacturing sector. Over the next 12 months, the AMGC will continue to test these priorities in its meetings with companies and industry associations and will conduct an annual survey to refresh and update the priorities. The published list of priorities on the website will be updated following industry consultation and surveys, and a revised list will be included in each annual Sector Competitiveness Plan. These Knowledge Priorities will be used to inform the research community about the R&D priorities of industry; inform selection processes for government R&D assistance; direct the efforts of businesses, industry associations and policy makers; and inform the future work of the AMGC.
- **Map employer demand for workforce and skills to build an evidence-based, industry-led skills plan:** Section 2 outlined the need for the sector to lift its skill intensity to drive value differentiation and optimise Australia's labour cost advantage. To support this transition, the sector needs a thorough analysis of the workforce skills that will be required in manufacturing for the future, detailed analysis of whether Australian manufacturing firms are transitioning their workforces to incorporate these workforce and skills (compared with other countries), analysis of the size of the current skills gap in different parts of the industry and by geography, an understanding of the drivers of this workforce skills gap and barriers to progression, and a clear plan to provide these skills for the future. This analysis will also need to take into account how the existing skillset in the Australian workforce can be transferred to new opportunities as the Australian manufacturing sector undergoes structural change.

105 Knowledge Priorities will be used to inform the research community about the R&D priorities of industry; inform selection processes for government R&D assistance in manufacturing; direct the analytical and service delivery efforts of policy makers, industry associations and business support services that target improved business capabilities in manufacturing; advise manufacturing firms seeking direction on how best to invest in building knowledge; and inform the future work of the AMGC.

- **Assess Australian manufacturing against 'advanced' characteristics:** Section 3 described analysis of top global manufacturing firms to help understand the characteristics associated with advancement and successful manufacturers. Over the next 12 months, the AMGC will assess advances made by Australian manufacturers against the key characteristics associated with 'more advanced' global manufacturers. This will provide a picture of the performance of Australian manufacturing and distribution of manufacturing firms by the characteristics that we care about, including advanced knowledge, advanced processes and advanced business models. Specifically, the AMGC will use a detailed ABS database of companies (BLADE) to assess the historical and current performance of Australian manufacturing firms against R&D expenditure, patent portfolio, collaboration with research institutions, collaboration with other firms, wage levels, STEM skill intensity, ICT and technology asset intensity, capital intensity, level of plan automation, marketing spend, the introduction of new products or services, and trade intensity.[106] This will provide a clear picture of how Australian manufacturing is currently tracking against these key 'advanced' characteristics that we care about, as well as how these characteristics have trended over time.
- **Further investigate Australia's industry–research collaboration:** Encouraging greater industry–research collaboration is a key part of the AMGC's mandate as a Growth Centre and a key part of AMGC's identified actions to drive technical leadership in the sector. However, views within the sector vary on the extent of the challenge of industry–research collaboration. Prior to the release of the next Plan, the AMGC will used a detailed ABS database (BLADE) to further investigate the industry–research collaboration challenge and better understand the distribution of collaboration among companies.

5.3 DEMONSTRATE THE DIRECTION THROUGH PROJECTS AND HUBS

5.3.1 Overview of the role of demonstrating direction

The AMGC will use demonstration projects and hubs as examples of how to advance manufacturing. First, the AMGC will provide co-financing and management resources to support projects that apply the identified strategic priorities for the sector. The criteria for funding these projects will be based on the success factors for competitiveness outlined in the Plan, with a particular focus on value differentiation, and based on whether the projects will help to fill identified knowledge gaps. The projects will demonstrate best practice strategies to advance manufacturing in Australia and pave the way for other actors in the sector to model these practices with similar initiatives. These projects will also inform the evolving analysis of future Sector Competitiveness Plans. Projects could include:

- Investing in commercialised research collaboration between multiple actors (e.g. a global firm, Australian SMEs and domestic research institutions) and encouraging them to come together
- A partnership between Australian SMEs to build a more integrated product and/or service to deliver into global markets
- Enabling cross-industry technology transfer to capture export opportunities.

The AMGC recently announced project co-funding of $250,000 for the Advanced Fibre Cluster Geelong. This investment will kickstart projects among a consortium of advanced fibre and composite manufacturers located at the Carbon Nexus facility at Deakin University. The purpose of the project is to build on existing strength in carbon materials and encourage further innovation.

106 These metrics are available in the ABS's Expanded Analytical Business Longitudinal Database and other datasets.

Second, the AMGC will use hubs to support and demonstrate how firms can share resources and knowledge in pursuit of R&D priorities or shared technical leadership. The hubs will involve a mix of virtual and physical sites and institutions, and be located within different states and territories, and in different manufacturing sub-industries. The hubs will facilitate the sharing of resources, research outcomes, capabilities and skills between firms that have similar needs due to their location in the value chain, sub-industry or technology priority.

AMGC members will have priority access to these initiatives. Demonstration projects and collaboration hubs will be designed and selected with input from AMGC members. In addition, membership will be a requirement of participation in demonstration projects.

5.3.2 Near-term actions for the AMGC to demonstrate direction

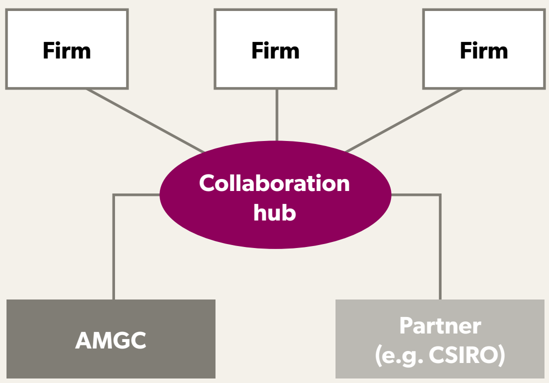
In addition to its current projects and hubs, the AMGC will identify further projects and hubs over the next 12 months in other states and content areas.

- The AMGC will keep an open dialogue with manufacturers, research institutions and industry associations and encourage strong prospects to apply and co-fund projects.
- The AMGC will work with leading research institutions and groups of companies to identify potential new hubs where there is an overlap with existing areas of comparative advantage, unmet technology needs for the sector or proximate companies that would like to collaborate further.

Exhibit 41 – The AMGC has begun identifying competitive technologies to accelerate through funding and as part of collaboration hubs

The AMGC will work to identify technology priorities and support these through collaboration hubs

- The AMGC has begun identifying technology priorities for research through its collaboration hubs. Further work is required to identify new areas where Australia has a distinctive competitive advantage, including existing world-leading industry or research strengths that can be leveraged.
- Collaboration hubs will facilitate the sharing of resources and research outcomes between firms that operate in the same geographical area and are part of comparable value chains.



Source: AMGC internal documents

Example: Advanced Fibre Cluster Geelong

- Announced in August 2016
- Joint initiatives with the CSIRO Manufacturing Division, Deakin University, Geelong Manufacturing Council and several firms
- Collaboration hub based in Geelong, where firms such as Carbon Revolution, Quickstep and Carbon Nexus are already established – this allows the AMGC to leverage pre-existing potential for collaborative gains
- $250,000 committed by the AMGC toward a Project Collaboration and Innovation Fund.

Source: CSIRO

5.4 PURSUING IMPACT BY WORKING WITH COMPANIES AND GOVERNMENTS

5.4.1 Overview of the role of pursuing impact

Australian manufacturing can only advance if companies lead the transition by focusing on competing on value. A comprehensive understanding of the requirements for shifting towards more advanced manufacturing is an essential enabler for progress. Accordingly, a key action area of the AMGC is to build this body of knowledge and share it among its constituency. The AMGC's members will have priority access to this body of knowledge, including consultations to provide more tailored insights from this knowledge.

Governments can accelerate businesses' transition to advanced manufacturing. As an industry-led but government-supported body, the AMGC is well positioned to ensure that government assistance is targeted to support the transition. Drawing on analysis and learnings, the AMGC will work with relevant government agencies to ensure that its policy, programs and regulations are better aligned to advance manufacturing.

5.4.2 Near-term actions for the AMGC to influence companies

Over the next 12 months, the AMGC will seek to influence companies by:

- Creating a tool for firms to benchmark themselves against key 'advanced' characteristics relating to such things as R&D intensity, capital intensity and wage levels. This will be delivered through an online tool created by the AMGC and distributed to constituents
- Communicating the characteristics associated with advancement among top-performing global manufacturing firms, the different 'ways to win' and the benefits of change to Australian manufacturers. This will be achieved through media outreach and the distribution of fact sheets via the AMGC website, major business organisations (e.g. CEDA), industry associations and the AMGC's mailing list
- Communicating the key findings of the Plan and the four key action areas that companies should pursue, via a series of roadshows and events. This will involve dissemination of both full and abridged versions of the Plan, a brochure, and targeted media and social media content
- Showcasing examples and case studies of firms that have successfully servitised, via the AMGC website, industry associations and the AMGC's mailing list. In the long run, the AMGC's projects will provide examples of companies that have successfully transitioned to 'more advanced' manufacturing
- Using online job ad data from manufacturers, demonstrating to manufacturers which parts of the sector are taking advantage of Australia's cost advantage in higher-skilled workers and which are not making the transition (including by sub-industry and geography); demonstrating which parts of manufacturing are making the shift to servitisation; and, identifying the skills of the future.

Over the next 12 months, the AMGC will evaluate which of these channels for impacting company behaviour are most effective, and will iterate accordingly.

5.4.3 Near-term actions for the AMGC to drive action within government

This Sector Competitiveness Plan identifies priorities for government action in R&D, smarter procurement, smarter programs and changes in sector measurement:

- **Change the lens on manufacturing:** This will involve encouraging governments to reframe the image of manufacturing and help shift public perception towards a 'more advanced' and less production-centric manufacturing industry.
- **Support business-led R&D:** The AMGC will publically support a number of the recommendations outlined in the recent Review of the R&D Tax Incentive by Finkel, Ferris and Fraser, and recommend that governments consider shifting the mix of support for business-led R&D towards more direct instruments. Further consideration of shifting the type of support for business-led R&D could form part of Innovation and Science Australia's 2030 strategic plan.
- **Encourage smarter civil procurement:** Working with the Department of Finance and communities of procurement practice across government, the AMGC will help to inform procurement officers about the key levers of competitiveness in manufacturing and help to shape how procurement opportunities can build firm capability in innovation, collaboration and links to global value chains.

- **Encourage smarter defence procurement:** The planned defence procurement program over the next decade is an historic opportunity for Australian manufacturing. It is essential that Australia leverages this opportunity to accelerate the growth and transformation of Australian manufacturing, both as a source of national advancement and as an essential support for a robust defence industry for the future. The AMGC will work with the Department of Defence to ensure strong industry policy objectives are achieved as part of upcoming strategic capability acquisitions and procurement, including the recently announced strategic submarine acquisitions. The AMGC will support the Department of Defence by mapping capability among Australian manufacturers to support work in upcoming procurement activities and to understand best practice in designing defence procurement to maximise industry policy objectives such as building capability in innovation, collaboration and export-readiness.
- **Identify under-served export markets:** The AMGC will encourage Austrade to map under-served export markets (including for intermediate goods) by manufacturing sub-industry. This Plan provides examples for medical technology and aerospace of the first steps in potential analysis that could be conducted.
- **Optimise assistance:** In cooperation with the Department of Industry, Innovation and Science, the AMGC will advocate for evaluation criteria for relevant funding and incentive programs being aligned with the characteristics associated with 'more advanced' manufacturing, such as advanced knowledge, advanced processes and advanced business models. This could include informing the CRCs, CRC-Ps, ARC Industry Transformation Research Programme and R&D incentive programs.
- **Optimise capability-building:** In cooperation with the Department of Industry, Innovation and Science and relevant state government departments, the AMGC will advocate for programs that offer capability-building for SMEs and other manufacturing firms to target the development of characteristics associated with more advanced manufacturing, such as advanced knowledge, advanced processes and advanced business models (niche market targeting and service offering). For example, the AMGC is currently working with the Entrepreneurs' Programme to inform program leaders and business advisers about the ingredients required to advance the sector, including through the Committee, Programme Leadership meeting, Annual Forum and quarterly Advisers meetings.
- **Measure manufacturing:** More work will be done in collaboration with the Department of Industry, Innovation and Science to embed changes in the way manufacturing is measured. As outlined in Section 3, the AMGC has been working with the department to establish a new definition of 'manufacturing' that is not linked to a set of ANZSIC codes but relates more to a continuum of advancement against the key characteristics of advanced knowledge, advanced processes and advanced business models. The department is currently working through the implications of this redefinition for measurement and evaluation purposes. The AMGC will work further with the department to embed processes that will track sector advances by prevalence of characteristics associated with being more advanced. As a first step towards this, the AMGC is currently working with the department to test whether the characteristics associated with advancement among top-performing global manufacturing firms are present in successful Australian firms and how Australian firms currently perform against key 'advanced' characteristics.

The analysis and actions contained in this report will help advance the Australian manufacturing sector. The AMGC will work with companies, governments and other stakeholders to implement this Plan and harness the under-utilised potential of Australian manufacturing.

ANNEX A – GROWTH CENTRES INITIATIVE

BACKGROUND ON GROWTH CENTRE INITIATIVE

The Advanced Manufacturing Growth Centre (AMGC) is one of six bodies established by the Growth Centres Initiative, with each body corresponding to a key sector of the Australian economy[107] (Exhibit A.1). This industry-led initiative is designed to '*focus on areas of competitive strength and strategic priority to drive innovation, productivity and competitiveness*'.[108] Each Growth Centre is established as a not-for-profit company with a board comprised of industry experts. The initiative is a key part of the Australian Government's National Innovation and Science Agenda (NISA) but is not a delivery mechanism for other government programs.

The activities of each centre will be industry-led and structured around a mandate to:

- Improve access to international markets and participation in global supply chains
- Improve management capabilities and workforce skills
- Enhance industry–research collaboration and commercialisation
- Identify opportunities for regulatory reform.[109]

Exhibit A.1 – Industry Growth Centres have been established to drive industry-led activity in key sectors

The Industry Growth Centres Initiative is an industry-led approach driving innovation, productivity and competitiveness by focusing on areas of competitive strength and strategic priority. This will help Australia transition into smart, high-value and export-focused industries.

Six Centres have been established...

- **Advanced Manufacturing**
- **Medical Technologies and Pharmaceuticals**
- **Cyber Security**
- **Food and Agribusiness**
- **Mining Equipment, Technology and Services**
- **Oil, Gas and Energy Resources**

and have been broadly tasked with...

1. **Improve engagement with international markets and access to global supply chains**
2. **Improve managerial and workplace skills**
3. **Increase engagement between research and industry, and within industry, to achieve commercialisation outcomes**
4. **Remove unnecessary and over burdensome regulations**

107 The other five Growth Centres are Cyber Security; Food and Agribusiness; Medical Technologies and Pharmaceuticals; Mining Equipment Technology and Services; and Oil Gas and Energy Resources.

108 Department of Industry, Innovation and Science (2016), 'Industry Growth Centres Initiative Booklet', p 2.

109 Minister for Industry, Innovation and Science (21 April 2016), *Industry Growth Centres Initiative Programme Guidelines*, p 6. Available at: www.industry.gov.au/industry/Industry-Growth-Centres/Documents/Industry-growth-centres-initiative-programme-guidelines.pdf

CONSISTENCY WITH PROGRAM OUTLINES

As part of the Industry Growth Centres Initiative – and in identifying actions that will improve the sector's competitive strength, productivity and innovative capacity – the AMGC is tasked with addressing specific objectives. The following section maps the actions identified in this report against each of these objectives.

Objective: Improving the capability of the key sectors to engage with international markets and access global supply chains

This section outlines how the actions recommended in Section 4 map to the objective in the Growth Centre program.

- **Company action:** Collaborate to 'play bigger' – Reduce the cost disadvantage for small-scale companies by collaborating with other companies, allowing them to be more competitive in global supply chains (Section 4.2.5).
- **Company action:** Develop compelling service offerings – Accelerate the trend towards servitisation, which complements Australia's comparative advantages (Section 4.2.3).
- **Company action:** Reach untapped markets and segments – Grow exports in non-traditional markets, including by targeting niche or under-served export markets (Section 4.2.4).
- **Company action:** Increase business expenditure on R&D – Lift Australia's business-led R&D into the top half of OECD nations to drive technical leadership (Section 4.2.2).
- **Company action:** Collaborate with research institutions – Significantly improve Australia's weak record of industry–research collaboration to drive technical leadership (sections 4.2.2).
- **Company action:** Integrate into global value chains – Significantly improve on Australian manufacturing's current poor links into global value chains, with one of the lowest levels in the OECD on backward linkages (Section 4.2.4).
- **Knowledge Priority:** Understand the research and development Knowledge Priorities in areas of comparative advantage (Section 4.4.2).
- **Knowledge Priority:** Understand business improvement Knowledge Priorities (Section 4.4.3), including building better international linkages, leveraging government procurement and closing the management capability gap.

ANNEX A – GROWTH CENTRES INITIATIVE

Objective: Improving management and workforce skills

This section outlines how the actions recommended in Section 4 map to the objective for the Growth Centre program.

- **Company action:** Lift the skill intensity of the manufacturing workforce – Capitalise on Australia's c.40% cost advantage in high-skilled labour to drive technical leadership (Section 4.2.1).
- **Company action:** Lift management capabilities – Close the deficit in management quality to improve productivity and reduce costs (Section 4.2.4).
- **Company action:** Increase business expenditure on R&D – Lift Australia's business-led R&D into the top half of OECD nations to drive technical leadership (Section 4.2.1).
- **Company action:** Collaborate with research institutions – Significantly improve Australia's weak record of industry–research collaboration to drive technical leadership (sections 4.2.1 and 4.2.3).
- **Knowledge Priority:** Understand business improvement Knowledge Priorities (Section 4.4.3), including closing the management capability gap and understanding current and future workforce skills requirements.

Objective: Improve engagement between research and industry, and within industry, to achieve stronger research coordination and collaboration, and stronger commercialisation outcomes

This section outlines how the actions recommended in Section 4 map to the objective for the Growth Centre program.

- **Government action:** Encourage greater collaboration between research and industry (Section 4.3.1).
- **Government action:** Improve the design of government support for business-led R&D
- **Company action:** Increase business expenditure on R&D – Lift Australia's business-led R&D into the top half of OECD nations to drive technical leadership (Section 4.2.1).
- **Company action:** Collaborate with research institutions – Significantly improve Australia's weak record of industry–research collaboration to drive technical leadership (sections 4.2.1 and 4.2.3).
- **Knowledge Priority:** Understand the research and development Knowledge Priorities (Section 4.4.2) in the areas of robotics and production processes; advanced materials and composites; digital design and rapid prototyping; sustainable manufacturing; additive manufacturing; sensors and data analysis; materials resilience and repair; bio manufacturing; precision manufacturing; and augmented or virtual reality systems.
- **Knowledge Priority:** Understand business improvement Knowledge Priorities (Section 4.4.3).

Objective: Identify regulations that are unnecessary or over-burdensome for the manufacturing sector and its ability to grow, and suggest possible reforms

This section outlines how the actions recommended in Section 4 map to the objective for the Growth Centre program.

- **Government action:** Adopt an amended methodology to define and measure the success of the manufacturing sector and capture the wider impact of manufacturing (Section 4.3.1).
- **Government action:** Use smarter procurement programs that enable innovation, collaboration and links into global supply chains (Section 4.3.2).
- **Government action:** Improve government support for business-led R&D and encourage industry–research collaboration (Section 4.3.1).
- **Knowledge Priority:** Understand business improvement Knowledge Priorities (Section 4.4.3).

B ANNEX B – METHODOLOGY

DETAILED METHODOLOGY: PRODUCT COST

Method

This study modelled a hypothetical firm's profit and loss (P&L) statement and solved for price to generate a fixed return on invested capital.

The price solved to generate Earnings Before Interest and Taxes (EBIT) was equivalent to Return On Invested Capital (ROIC). This approach has the benefit of factoring in both cost/operating profit margin and differences in capital intensity.

The model assumes 10% cost of capital.

The relative weight of each cost category for aerospace and medical technology companies was estimated using detailed data from the 2014 US Census of Manufacturers (Table 1).

The US Census of Manufacturers contains detailed information on financial metrics for US industries at the 6-digit level (e.g., aircraft and aircraft engines are listed as separate industries). Metrics include figures such as the number of employees, employee costs, production labour costs, electricity costs, materials costs and capital expenditure.

This detailed sub-sector-level financial information was used to develop a reference P&L for a hypothetical manufacturing firm in each sector (aerospace or medical technology), as shown below.

Transport costs were calculated separately as product shipping data was not available in the Census of Manufacturers, and is detailed in the following section.

For each cost category, industry-specific benchmarks were used to identify the relative cost (higher or lower) for Australian firms, resulting in an overall product cost impact, which is detailed in the following section.

Table 1

Breakdown of costs	Aerospace (%)	Medical technology (%)
Employee costs	24.40	30.90
Energy costs	0.70	0.60
Materials costs	61.20	49.20
Capital costs (excluding rental/lease)	2.20	3.30
Overheads (including rental/lease)	11.20	16.03

Definitions

Productivity-adjusted labour: The total amount spent on labour as an input, factoring in both changes in wages (price per hour of labour) and labour productivity (hours of labour per unit of output).

Inputs: The total cost of materials, including both raw materials and sub-assemblies.

Energy: The cost of electricity and gas used in both production and general operations.

Transport: The cost of delivering a typical product to a major overseas market, including local transport, port fees and customs.

Tax: Corporate tax rates payable in the respective countries.

Capital: Capital employed in the business, inferred from depreciation spend at 10%.

Overheads: Sales and general and administrative expenses, including rent.

Relative cost estimates

The comparable Australian cost was calculated by estimating the differential in each component separately against an international benchmark.

Productivity-adjusted labour: Differences in industry hourly wages and differences in labour productivity were compared to compute the *total* cost difference of producing a similar product in different countries. Two methods for each component were averaged, given challenges with cross-country labour productivity comparisons. See Exhibit B.1.

For labour productivity, comparisons were made using: 1) ABS Series 8155.0 and US Census of Manufacturing 2014 data by dividing FY14 industry value added by employment, correcting for hours worked and typical number of weeks leave and using the FY14 exchange rate; and 2) the EU KLEMS data set, a cross-country data set designed for these types of comparisons; however, it is only available up to 2005. Values after 2005 were projected using productivity indices for each country (at sub-industry level for US productivity and at the 1-digit level for Australia).

For wages, comparisons were made using: 1) ABS and US census data; and 2) KMPG/Mercer data on wages from the 2016 *Competitive Alternatives* report. The ABS/census data was corrected for typical hours worked and average number of weeks leave. Method one involved the following calculations:

- Occupation data from Australia (ABS Census) for both medical technology and aerospace manufacturing was used to estimate the mix of occupations in each industry.
- Wages data by occupation was obtained for Australia (Employee Earnings and Hours, ABS 6306.0) and matched to the industry occupation mix to estimate average wages for high-skill (defined as 'professional' and 'managerial') and lower-skill workers in each industry.
- Wages data by worker skill level, defined by production versus non-production workers, was calculated directly for each industry in the US (Census of Manufacturing data).

Inputs: The share of imported inputs was calculated for each sub-industry using the ABS's input–output tables (aerospace was 44% and medical technology was 55%). A markup due to transport costs was assumed for the imported input components, and was based on the calculated figure for transport as a percentage of costs overall.

Energy: A direct comparison of electricity unit costs were drawn from the BCG Global Manufacturing Cost-Competitiveness Index.

Transport: Differences in transport costs to end users were calculated using two approaches. The first involved using comparison values by country from a KPMG *Competitive Alternatives* report, which infers a typical demand distribution for each industry. The second approach was to build up freight costs from unit estimates, considering the proportion of air freight versus sea freight, and using estimates of cost from factory to port, cost to export (World Bank data), cost to ship (per container for sea freight and per kilogram for airmail) and, finally, tariffs in destination markets. In each case, this was based on shipping from Australia or the US to Western Europe (Germany) as the second-largest market for medical technology and aerospace components.

Tax: The corporate tax rates payable in the respective countries were compared with the OECD average.

Overheads: The model assumes a scale-efficiency function with a power of 0.75. This is applied to an inferred measure of average firm size, based on OECD STAN firm size data by sub-industry.

Capital: The model assumes a fixed capital to labour ratio (K/L).

B ANNEX B – METHODOLOGY

Exhibit B.1 – Appendix: Labour cost was calculated using averages of different methods for assessing both wage and labour productivity

Labour cost differential

Contribution in percentage points

Method		Aero	Med
A	1	10.4	9.0
A	2	1.7	9.7
B	1	6.5	-2.2
B	2	5.0	-1.5
Average values:		9.1	3.0

Labour productivity

AUS as % of US

Method		Aero	Med
A	ABS/ Census	64	53
B	KLEMS	55	77
Average:		60	65

Method notes:

- FY14 data, $0.92 AUD/USD, sub-industry average
- $VA/hr (37 vs 41.2hrs, 47 vs 48 weeks)[1]
- Consistent PPP US/Aus data, 2005, projected
- BLS index for aerospace, ABS for mfg overall

Wages

AUS as % of US

Method		Aero	Med
A	ABS/ Census	108	71
B	KPMG	69	73
Average:		89	72

Method notes:

- FY14 data, $0.92 AUD/USD, sub-industry average
- $Wages/hr (37 vs 41.2hrs, 46 vs 47 weeks)
- 2016 data on 42 roles by country
- Assumed role distribution for theoretical firm

■ Values used in model

Source: Product cost competitiveness model; ABS; BLS; KPMG Competitiveness Database; RBA; EU KLEMS

DETAILED METHODOLOGY: SIZE OF THE PRIZE

Method

The potential impact of different improvement measures was triangulated using top-down and bottom-up estimates. This is framed in terms of the difference in value between a base case and a growth scenario in full year 2026, where value is defined as the total value added from advanced manufacturing sub-industries. For the purposes of this estimate, advanced manufacturing was defined according to the current ABS method, with ANZSIC sub-divisions 18 (basic chemical and chemical product manufacturing), 23 (transport equipment manufacturing) and 24 (machinery and equipment manufacturing).[110]

Top down, the overall size of the prize was estimated as a 33% uplift by projecting forward at historic high growth rates. Bottom up, a series of estimates were made for each area of improvement (reduce costs, improve differential value and shift market focus) and averaged to produce a total estimate of 34%.

110 ABS series 8170.0 (2015), 'Characteristics of businesses in selected growth sectors, Australia, 2013–14'.

Top-down estimate

Base case growth for the sector was calculated to be -0.9% (real) and +1% (nominal) and projected to 2026 as follows:

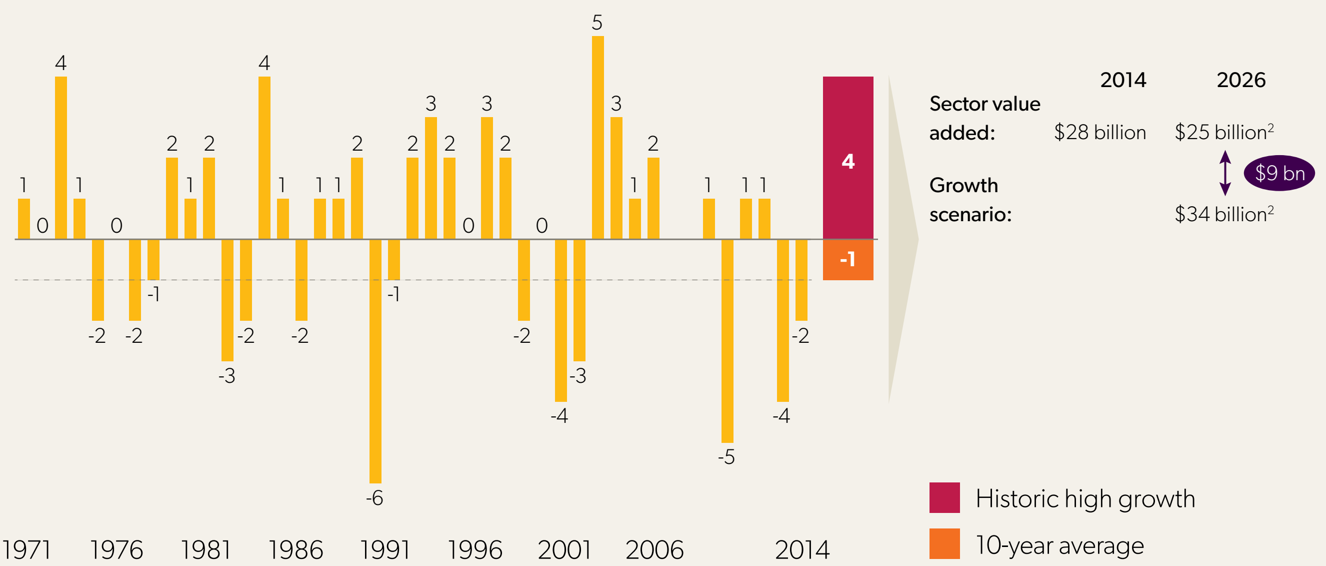
- Value added data for advanced manufacturing sub-divisions was drawn from 2006–14 ABS series 8155.0. Historic data (1970–2005) was drawn from the OECD STAN database.[111]
- The annual values were converted to real (inflation-adjusted) dollars using the RBA's inflation calculator tool.[112]
- The year-on-year growth rates were calculated as a percentage change in value from the prior year.
- The base case growth was projected using 2006–14 CAGR as the average annual growth rate through to 2026. The growth scenario was projected by ramping growth (in current dollars) to historic highs of 4% per annum and projecting growth to 2026 accordingly.
- Growth (in current dollars) was ramped from -0.9% to historic highs of 4% per annum over the 10-year period, in linear increments.

We calculate the difference between base-case projections (projections at 2006–14 CAGR) and estimates (a historic high rate of 4% p.a.). The net result of this is a top-down estimate of A$9.3 billion in increased value added in 2026 (with a base case of A$25.3 billion and an upside case of A$34.6 billion, both in 2016 dollars), as shown in Exhibit B.2.

Exhibit B.2 – Top-down estimate: Restoring growth from 10-year average of –1% to historic highs of 4% p.a. could be worth $9 billion in value add by 2026

Restoring growth from 10-year average of –1% to historic highs of 4% p.a. …
YOY growth of VA in 'advanced manufacturing' sectors[1], %, 2014 dollars[2]

… could be worth $9 billion by 2026
Value added, forecast



1 For 2007 onwards, ANASIC sub-divisions 18, 23 and 24 as per ABS definition of advanced manufacturing sector; for 1970–2006, ISIC rev 3 C23T25 Chemical, rubber, plastics and fuel products, C29T33 Machinery and equipment and C34T35 transport equipment

2 2014 real dollars; deflated using RBA calculator

3 Base case projects – 1% growth compounding over 10 years, growth scenario projects linear ramp up to 4% growth rate over period

Source: ABS Series 815540 'Australian Industry'; OECD STAN database; RBA calculator; AlphaBeta/McKinsey analysis

111 OECD STAN Database for Structural Analysis

112 RBA Inflation Calculator. Available at: www.rba.gov.au/calculator/annualDecimal.html

B ANNEX B – METHODOLOGY

Detailed bottom-up analysis

To calculate the bottom-up methodology, a series of estimates were made for each of the three areas of improvement (reduce costs, improve differential value and shift market focus) and averaged to produce a total estimate of 34%. For each area, three to five different measures were used to estimate the potential value at stake, as shown in Exhibit B.3.

For direct product cost, the first two estimates calculated the profit uplift for firms if they banked savings from closing the labour productivity gap by 50%. This was calculated as a total percentage uplift for both aerospace and medical technology, and then projected across the entire advanced manufacturing cost base. The third and fourth scenarios took the average uplift value and assumed that it was instead passed on as cost reduction to customers. Assuming demand elasticities of between 2 and 4 (the high and low range used for these two estimates), price reductions were translated into uplifts in value added.

For differential value, the first two estimates were based on lifting performance in export categories in each sub-industry (across the advanced manufacturing segments defined by the ABS) to either the highest level of Revealed Comparative Advantage (RCA) for aerospace or the average level for Medical Technology (a stronger performing export sector overall). The third approach looked at a sample of Australian medical technology firms for differences in profitability between the most innovative export successes and the average of the entire set, and projected this uplift across the entire sector. To estimate the value of shifting to the more service-based parts of the value chain, we lifted the proportion of high-skill research and design workers to US comparable levels. This was treated as an increase in employment, from which additional value added was calculated as the product of new roles and wages for high-skill roles. The total uplift was calculated for aerospace and medical technology separately and then projected as an average percentage uplift across the industry.

Finally, for market focus, each section was estimated separately.

To calculate the value of increased export market access, we based our estimates on average uplift for aerospace or medical technology in markets where Australia is underweight. For each, estimates were based on closing the gap between Australian exports for the category and Australia's average share of that category in each of the top 10 world import markets. This was done using 4-digit HS code data from UN Comtrade, which provides detailed breakdowns of Australian exports by country, and data on total imports by country for each category.

To estimate the value of drawing greater value added from higher-skill intense industries, we lifted Australia's proportion of value added derived from high-skill industries. The first method was based on lifting in sub-industries where Australian manufacturing has a skill deficiency relative to the US; the second approach focused on sub-industries that were the most skill-intense in the US. In each case, these sub-industries were lifted to the US share of the economy. However, sub-industries with poor definitional matches between Australia and the US (at the level of data available, given full concordance requires more detailed industry breakdowns to enable matching) were excluded, as were those where Australia had a small starting position (<$100 million in value added).

Detailed methodology: Defining advanced manufacturing

In developing the definition of advanced manufacturing, we followed a three-step process, seeking to identify 'more advanced' firms by both the characteristics they display and outcomes they achieve (see Exhibit B.3). First, we identified 'advanced characteristics', developing a long list based on expert interviews, workshops with the Department of Industry, Innovation and Science, and a literature review. This list was narrowed down based on measurability, including the use of proxies or inference. The shortlist of advanced characteristics comprised:

- **Advanced knowledge**, including R&D expenditure, ICT intensity, patent portfolio, collaboration with research institutions, collaboration with other firms, wage levels, employee qualifications and STEM skill intensity
- **Advanced processes**, including capital intensity, equipment age, level of automation, inventory management, energy intensity, water consumption and recycling rate

- **Advanced business models**, including product-value density, marketing spend, trade intensity, degree of backward linkages, geographical reach and share of services in total revenues.

Second, we ranked all firms by their success, defining 'success' by a number of outcome metrics including total factor productivity, gross margin, return on investment, EBIT margin and labour productivity.

Third, we determined the prevalence of these characteristics in more successful versus less successful firms to establish a shortlist of the most effective advanced characteristics.

To define success, we selected total factor productivity[113] as the primary measure and checked this against four other success metrics to observe whether similar firms demonstrated success on the other metrics. We selected total factor productivity as the primary metric as it is more comprehensive than labour productivity (including capital productivity) and represents a key driver of competitiveness in Australian firms. To analyse successful firms, we used a global database, Compustat, of 3,040 manufacturing firms with firm-level indicators.[114] For each of the success metrics, missing values and outliers were removed and the top quartile of performers were identified (Exhibit B.3).[115]

We found that firms that were top performers in gross margin, EBIT, ROI or labour productivity were also more likely to be top performers in total factor productivity (Exhibit B.4). This confirmed the utility of using total factor productivity as a primary success metric.

Exhibit B.3 – Success was defined by five metrics – total factor productivity, gross margin, ROI, EBIT and labour productivity

Total number of firms **3,040**[1]	**Total factor productivity metrics**	**Gross margin metrics**	**ROI metrics**	**EBIT% metrics**	**Labour productivity metrics**
1 Removing missing values	1,965	2,695	2,263	2,324	2,628
2 Removing outliers[2]	1,893	2,380	2,113	2,037	2,411
3 Identifying top quartile	**474** (A)	**474** (B)	**529**	**510**	**603**

(3): Total factor productivity, gross margin, ROI and EBIT% metrics

3 approaches as to how we determine 'successful firms'

- A Assessing 'success' as top quartile TFP will give **474** firms
- A Assessing 'success' as top quartile gross margin will give **595** firms
- A Assessing 'success' as top quartile in at least two of TFP, GM, ROI or EBIT will give **574** firm

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

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

Source: Compustat, AlphaBeta/McKinsey analysis

113 Total factor productivity measures the joint productivity of capital and labour. It is not directly observable or measurable, and so was derived using the residual of the regression of gross value added against capital and labour.

114 We included all firms in the Compustat database that are primarily classified as manufacturers.

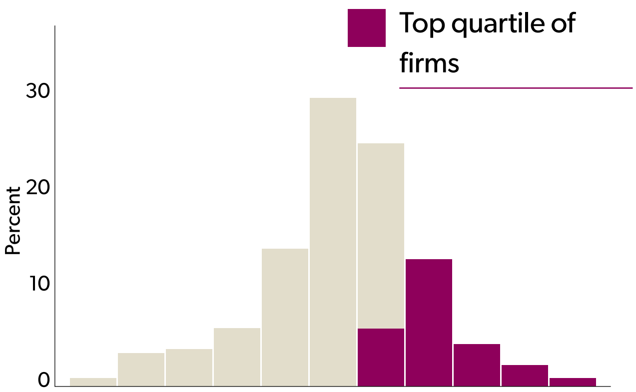
115 Outliers were selected and removed based on the criteria of being 3.5 times the absolute deviation away from the median.

Exhibit B.4 – Top-performing firms for gross margin, EBIT, ROI or labour productivity are also more likely to be a top performers in total factor productivity

Primary success metric

Total factor productivity (TFP)[1]

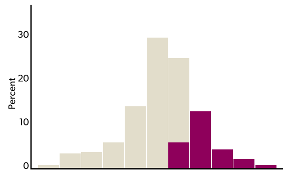
Total factor productivity was selected as the primary success metric as it is the key driver of competitiveness for Australian firms. It is more comprehensive than labour productivity, considering both labour and capital.



Secondary success metrics

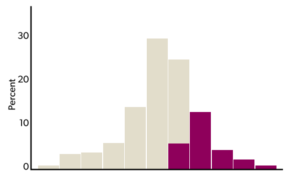
Gross margin

Firms in top quartile are **2 times** more likely to be in top quartile of TFP.



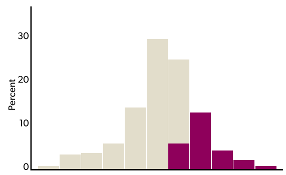
EBIT% (EBIT/total sales)

Firms in top quartile are **3.2 times** more likely to be in top quartile of TFP.



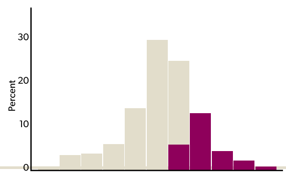
ROI (EBIT/average total investment)[2]

Firms in top quartile are **3.4 times** more likely to be in top quartile of TFP.



Labour productivity

Firms in top quartile are **3.7 times** more likely to be in top quartile of TFP.



1 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.

2 Average total investment calculated by average capital expenditure over 2013–15.

Note:

All data has been adjusted to account for industry effects by calculating the mean at the 3-digit sub-industry level and subtracting it from the individual firm outcome.

Source: Compustat, AlphaBeta/McKinsey analysis

Cluster analysis demonstrates there are different strategies for advancement

Research and expert interviews conducted to support the revised definition and the AMGC's Sector Competitiveness Plan revealed multiple formulas for advancement. Thus, in revising the definition, we wanted to ensure it would reflect that firms pursue a number of different strategies to achieve success and advancement in manufacturing. We then used cluster analysis to quantitatively test this hypothesis.[116] Specifically, we performed a cluster analysis of five characteristics – R&D intensity, capital efficiency, automation, share of services and value density – to determine whether firms 'clustered' around particular intensities of characteristics (Exhibit B.5). We saw evidence of manufacturers pursuing different strategies for success and advancement.

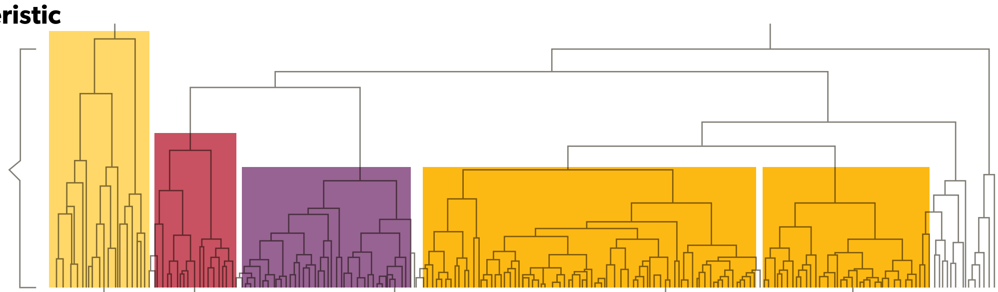
116 We developed hierarchical clustering by constructing a dissimilarity matrix, which contains dissimilarity scores for any pair of firms. The dissimilarity scores are based on the distances among the set of variables (R&D intensity, value density, share of services, and automation and labour productivity). For any pair of firms, the further these metrics are from each other the more dissimilar each firm is. We then created a dendrogram, where firms at the bottom have a smaller distance from each other (hence, they are less dissimilar), and firms further up have a greater distance (hence, they are more dissimilar). The different clusters were selected by cutting the dendrogram at select points.

- Firms exhibit different combinations of advanced characteristics to be successful, which are:
  - Knowledge differentiation: firms that use a high product value density (52% versus 25% in the median), capital efficiency and R&D intensity could be differentiating through product. Higher product value density would indicate superior product value or performance differentiation.
  - Process differentiation: firms that have high R&D intensity (26% versus 7% in the median), capital efficiency and high levels of automation could have sophisticated firm processes.
  - Business model differentiation: firms that differentiate based on a share of services that is significantly above the median (42% versus 6% in the median) could be winning by driving revenue uplift through service offering.
- Firms that appear to be successful using non-advanced factors (thus, less relevant to the definition), which are:
  - Low value density products: given that these firms are successful without ranking highly on any of the characteristics – and they hold a very low product value density – it is likely they represent industries that have an advantage through proximity of production to demand. For example, cement and bricks are usually locally produced due to their low value-to-weight ratio.
  - Non-advanced: a clear group is yet to emerge for these firms; however, it is possible this group represents a second set of less advanced firms that have an advantage through market regulation or other structural features.

Exhibit B.5 – Initial cluster analysis confirms that there are different strategies for successfully deploying more advanced characteristics

Median value by characteristic

Performing a cluster analysis of key characteristics, some clear groupings of firms formed[1]



	Overall					
R&D intensity	7.2%	14.7%	8.7%	26.4%	1.2%	7.3%
Capital efficiency	3.54	2.76	3.99	3.73	2.76	3.41
Automation	27%	25%	33%	37%	20%	26%
Share of services	5.7%	42%	1.5%	1.1%	0.2%	0.6%
Value density	25	31	52	23	6	21
Defining attribute/s		Business model	Knowledge	Process	Low value density	Unclear – less advanced?

There appears to be a number of successful firms exhibiting differing combinations of advanced characteristics

Likely firms that are **successful but through non-advanced factors** such as market structure or trade-protected industries

Below overall median

Above overall median

1 Hierarchical clustering 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. We then created a dendrogram, where firms at the bottom have a smaller distance from each other (hence less dissimilar), and firms further up have a greater distance (hence more dissimilar). The different clusters were selected by cutting the dendrogram at select points.

Source: Compustat, AlphaBeta/McKinsey analysis

B ANNEX B – METHODOLOGY

DETAILED METHODOLOGY: IDENTIFYING KNOWLEDGE PRIORITIES

The Knowledge Priorities outlined below are the result of our competitiveness analysis of the Australian manufacturing sector, a review of the existing literature and industry engagement, including consultations and a Knowledge Priorities survey.

The priorities will be routinely updated according to industry need. The AMGC will conduct an annual literature review and survey to update the priorities.

Analysis of manufacturing sector

The AMGC carried out competitiveness analysis of Australian manufacturing to help identify challenges and opportunities for the sector. The AMGC's Sector Competitiveness Plan identified the importance of firms increasing technical excellence in their products and expanding their value-adding services. The Knowledge Priorities for both R&D and business improvement are targeted towards helping firms compete on value.

Literature review

We added to our original analysis by consulting a wide variety of existing literature on the future of advanced manufacturing here and in international markets. Studies by the CSIRO, industry associations, universities and private firms were all consulted.[117] We also looked to the National Science and Research Priorities and Practical Research Challenges endorsed by the Commonwealth Science Council. Key international sources, including foreign governments, industry associations and organisations such as the OECD, supplemented the domestic analysis.

Industry engagement and survey

The AMGC has regularly consulted industry associations, manufacturing firms, and government and research organisations over the past year.

We also carried out an industry survey across firms, industry associations, research institutions and government agencies, which sought input on our proposed list of Knowledge Priorities. Participants were asked to evaluate the relevance of the proposed priorities, identify additional priorities and offer further comment on R&D and business improvement issues most affecting the industry. More than 50 organisations and companies responded to the survey.

117 CSIRO (draft, October 2016), 'Future of the Australian Advanced Manufacturing Industry – An Industry Roadmap'; CEDA (April 2014), 'Advanced Manufacturing: Beyond the Production Line'; White House (April 2016), 'Advanced Manufacturing: A Snapshot of Priority Technology Areas Across the Federal Government'; US National Science Foundation (2002), 'Workshop on Nanomanufacturing & Processing: Summary Report'; M. A. White (2011), 'Physical Properties of Materials'; Princeton University Press, 'The Properties of Materials'; Industry Canada (2006), 'The Canadian Biopharmaceutical Industry Technology Roadmap'.

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