



# Advanced Manufacturing: Beyond the production line

April 2014

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# Advanced Manufacturing: Beyond the production line

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### **About this publication**

Advanced Manufacturing: Beyond the production line

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We achieve this through a rigorous and evidence-based research agenda, and forums and events that deliver lively debate and critical perspectives.

CEDA's expanding membership includes 700 of Australia's leading businesses and organisations, and leaders from a wide cross-section of industries and academia. It allows us to reach major decision makers across the private and public sectors.

CEDA is an independent not-for-profit organisation, founded in 1960 by leading Australian economist Sir Douglas Copland. Our funding comes from membership fees, events and sponsorship.

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## Foreword: Professor the Hon. Stephen Martin, Chief Executive, CEDA

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Despite the announced demise of several high profile multi-nationals in Australia, manufacturing is not a dying industry. Provided policymakers focus on the right type of manufacturing, it has the potential to continue to be a significant contributor to our economy.

However for this to occur, Australia's mindset about manufacturing must change. Australia cannot compete with low-cost, high-volume production. Our future is not in traditional assembly line production. It is in advanced manufacturing and opportunities in the global supply chain (GVC).

*Advanced Manufacturing: Beyond the production line* brings together leading thinkers to explore and analyse current practices and opportunities in this critical economic sector. It also broadens the discussion to embrace the full scope of what advanced manufacturing encapsulates and what policymakers and industry needs to do to transition to improving Australia's comparative advantage and international competitiveness.

Advanced manufacturing is often associated with niche products such as biopharmaceuticals or defence technology but that is only one part of the picture. Economies that have had the most success in advanced manufacturing are those that recognise it is not just about products – advanced manufacturing includes the full suite of activities from the concept, research and development (R&D) and design stages all the way through to post sales services. It is about adding value to the production line, and it is very much about securing a place in the GVC.

Knowledge-intensive manufacturing services such as R&D, after-sales maintenance for high tech products and the development of customised solutions for specific consumers are just some of the areas where Australia's future lies.

In reality this transition will most likely mean fewer overall jobs in what is described as traditional manufacturing. However, these new jobs will be higher skill, higher paying and make a bigger contribution to the economy.

CEDA has used the contributions in this publication to propose a reform agenda which outlines 14 key areas that should be addressed under the umbrella of an Advanced Manufacturing Industry Plan. The plan is not about handouts, it is about providing support to develop competitive and sustainable industries. For example through industry/government partnerships in R&D to ensure more of the innovations developed are commercialised, or through changing government public procurement tender processes to prioritise new-to-the-world technology solutions or products that offer improvements or innovations rather than off-the-shelf solutions.

I would like to thank the contributing authors and CEDA advisory group for their contribution to this very important publication. I would also like to extend a special thank you to our sponsor for this project, Siemens. Without this additional support from our members, projects such as this would not be possible.

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## Foreword: Jeff Connolly, Chief Executive Officer, Siemens Australia

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### Critical fork in the road to Industry 4.0

Manufacturing has a long history in Australia and is a vital part of our economy. Recently though, we have seen a downturn in the manufacturing sector; however Siemens believes there can be a positive future on the horizon but we have to act now.

Despite some current setbacks in manufacturing in Australia, we can and should have a successful and robust manufacturing sector. But don't expect it to look the same as it does today, because the rest of the world is rapidly changing and we need to adapt and find our place in what is now a globally competitive marketplace.

We're at an exciting point in time. As the world enters the fourth industrial revolution (Industry 4.0) we will witness significant advancements that will change the face of manufacturing.

With the digitisation of the product development process, we are seeing design, production planning, engineering, manufacturing and services merging into one unit, instead of being sequential. Production operations will be more efficient and flexible with rapid innovation cycles.

The result is improved economies of scale and faster speed to market. Wage costs become less important as the technological convergence is increasing productivity. This is making production in Western economies competitive again and is why we are seeing a manufacturing renaissance happening in countries such as Germany and the USA – but also tremendous manufacturing growth targets in countries such as India.

Advanced manufacturing also requires new and advanced skill sets, so educational institutions will need to work even more closely with industries and research bodies to ensure we have a capable and prepared workforce.

We are seeing that people all over the world are returning to the values of manufacturing, which day after day makes real products, secures jobs, and serves as a driver for growth, prosperity, and social peace.

Australia needs to embrace Industry 4.0, find our place in the global supply chain and have the right mechanisms, policies and levers to help Australian companies and industries compete globally.

We also need to encourage investment into advanced technologies which are available today because this is a journey and transition towards Industry 4.0 and we are at a critical fork in the road right now and we must become competitive.

# Executive summary

Rumours of the death of manufacturing in Australia are greatly exaggerated. However, today's successful manufacturers are enjoying a life very different to what has been known in the past. Rather than the mass production and assembly of final products (traditional manufacturing such as steel and automobiles), successful Australian manufacturers typically engage in advanced manufacturing, which is about variability, complexity and extensive customisation with high value-add. This usually involves low-volume, high-value manufacturing, with a customer and export focus and nimbleness in manufacturing that allows manufacturers to provide a customised and responsive solution to the market.

There are many successful Australian advanced manufacturers and they typically have similar characteristics of being export-focused, customer-driven, innovative and technologically-cognisant. They are also generally good managers of global value chains (GVCs or the complex and cross-border chain of activities from the conceptual stages to the post-sales stages of production), typically positioning themselves at the pre-production stage (for example research and development services) and engaging in high value-add activities. Further, they tend to be small and medium sized enterprises (SMEs) and also have the distinction of rarely being profiled or discussed in the media.

The perception of manufacturing in Australia is shaped by media reports about struggling manufacturers, who are more often than not subsidiaries of large multinational companies involved in high-volume manufacturing, and often poorly integrated within GVCs. The news continues to be dominated by an ongoing debate about traditional industry assistance, which is typically aimed at luring large multinationals to Australia to engage in traditional manufacturing, an area where Australian manufacturers struggle to compete. This approach essentially tries to pick winners regardless of their economic viability and compensate them for locating in Australia. Recent economic history shows that this is doomed to fail.

Instead, government can and should adopt policies that actively facilitate the emergence and success of competitive, viable and sustainable industries. This policy perspective recommends the implementation of an Advanced Manufacturing Industry Plan. It contains key elements of what government and industry need to pursue to facilitate the current transition of manufacturing into a new and vibrant sector that reflects Australia's comparative advantage.

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## Advanced Manufacturing Industry Plan

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Australia's high-cost economy means that our comparative advantage in GVCs lies in the pre and post stages of the production process (typically services), and low-volume/high-complexity/high-variability/high-value manufacturing. An Advanced Manufacturing Industry Plan involves enhancing the sources of comparative advantage for manufacturers and addressing structural weaknesses. This means government needs to take responsibility for ensuring the right macroeconomic and industry-specific conditions exist for manufacturers to take advantage of new and emerging opportunities to succeed. Industry must also play a pivotal role in enabling the transition, including sourcing capital for investment, rather than relying on government assistance in the form of subsidies or handouts.

There is much debate around any type of government assistance for manufacturing due to prevailing perceptions around the handout culture. Concern has been expressed around assistance simply being another form of protectionism or being seen as picking winners at random. Incentivising innovation, fostering collaboration and investing in education and technology have positive spill-overs for the entire economy, not just manufacturing. They address the market failure of externalities, thereby justifying a targeted form of government assistance. These issues underpin national prosperity and were detailed in CEDA's 2013 report *Australia Adjusting: Optimising national prosperity*.

## Incentivising innovation among manufacturing SMEs

Australia lags behind other advanced economies when it comes to innovation, particularly new-to-the-world innovations and collaboration. Innovation and collaboration are crucial for advanced manufacturing, as they underpin areas where manufacturers can add value and compete on a global scale, such as in knowledge-intensive services.

### Government's role

To enable advanced manufacturers to be globally relevant and take advantage of the growing role of knowledge-intensive services for manufacturing, government should:

- Ensure innovation policy includes services innovation and that as part of this, collaboration policy includes service firms operating within a manufacturing context as well as manufacturing firms that provide services.

To facilitate value-adding innovative activities, government should foster collaboration by:

- Facilitating closer links between technical training institutions, universities and industry which would help to overcome the cultural and other barriers that keep industry and research institutions from working effectively together. These measures could include tax incentives that foster research and development (R&D) and commercialisation of research; or the creation of research funds dedicated to applied research.

To enable advanced manufacturers to specialise in value adding R&D activities within GVCs and address the market failure in the uptake of innovation, government should:

- Introduce public procurement policies (consistent with our World Trade Organisation obligations) for manufacturing SMEs aimed at innovative new-to-the-world products or solutions that will have the ability to add value.

### Industry's role

Industry should foster value adding innovative activities by improving collaboration:

- Between industry and research institutions, including universities and CSIRO, with a view to increase applied research and innovation that can be commercialised; and
- Among industry participants by introducing a system of restricting the benefits of innovation to those who participate to create, stimulate and grow industry clusters that drive innovation.

## Enhancing the capabilities of the manufacturing workforce

Advanced manufacturing is a highly complex environment that requires a variety of highly capable staff with a diversity of skills and capabilities. Australia lags behind its global competitors on the human capital criterion.

To support a more complex manufacturing environment and address Australia's manufacturing skills weaknesses, government should:

- Through its education, immigration and workplace relations policies ensure Australians are equipped with the skills conducive to an advanced manufacturing career, such as science, technology, engineering and mathematics (STEM) skills as well as management and service industry skills.

## Addressing market failure in key enabling technologies (KET) uptake

Technology can play a significant role in equipping manufacturers and their workforce with the modern production systems and technology that will enable them to produce flexible, complex and responsive solutions to enhance their international competitiveness. However, despite these benefits, there is an identified market failure in the uptake of productivity-enhancing technology, particularly among SMEs. This is most often due to financial investment impediments and the inability of SMEs to recognise the benefits of applying such technology to their business environment.

To assist in the uptake of technologies that will enable manufacturers to compete globally, government should:

- Ensure innovation and technology policies include incentives to improve technology literacy within the manufacturing sector, particularly for SME employees, with a view to boosting rapid adoption of KET and modern production systems for high-cost economies.

On the supply side, government should:

- Ensure communications infrastructure is affordable and upgraded to provide the quality of service and security required by advanced manufacturers.

## Enhancing firms' participation in global value chains

It is vital for Australian manufacturers to successfully integrate in GVCs and take advantage of growing potential of knowledge-intensive services in manufacturing GVCs.

To facilitate this, industry should:

- Develop a roadmap that embraces a high degree of export focus as well as customer responsiveness and service (providing a customised solution), with knowledge-intensive, high-value services (for example R&D) being a core competency either through developing in-house expertise in those services or partnering with professional services firms; and

- Pursue cultural change within organisations through improved leadership of management teams.

Government should:

- Provide a clear indication of its support for new and emerging high-value manufacturing, specifically by prioritising its trade policy negotiations towards services and its export promotion mission away from the sale of finished products to the sale of manufacturing services and solutions.

## Rebranding manufacturing

The poor perception of manufacturing in Australia is a hurdle for successful industry participants. Advanced manufacturers struggle to attract and retain talent while potential customers and policymakers continue to sidestep the potential opportunities offered by advanced manufacturing.

Government and industry bodies should improve the perception of manufacturing by re-positioning the debate with the view to:

- Highlight the achievements of successful advanced manufacturers who have capitalised on Australia's comparative advantage and move the debate towards benchmarking Australia against the rest of the world;
- Promote Australian advanced manufacturers as increasingly successful players in GVCs; and
- Attract and retain workers to a manufacturing career, particularly highly-skilled workers and management.

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## Contributions

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This report brings together experts from the manufacturing field to provide evidence-based analysis of advanced manufacturing and its potential future in Australia.

In *The constantly changing manufacturing context*, Professor Göran Roos, Chair, Advanced Manufacturing Council, discusses the dynamism of manufacturing and how manufacturing will continue to change due to global trends such as technological and consumer behaviour changes. He examines the impact of these fluctuations on Australian manufacturers, identifies the challenges they face as they grapple with these changes, particularly in terms of Australia's weaknesses in a global context. Professor Roos also identifies opportunities for Australian manufacturers and recommends a modern approach to the manufacturing policy framework based on that of other successful advanced manufacturing countries.

In *Advanced manufacturing global value chains and policy implications*, Jane Drake-Brockman, Non-Executive Director, Australian Services Roundtable, examines global value chains (GVC) and how Australia lags behind other advanced economies in its participation in the GVC. She also discusses the growing importance of the role of services in the GVC and manufacturing, which she argues

has policy implications. She recommends that firms should aim to specialise in one task within the value chain and that policy makers should place more focus on innovation and trade policy for services for Australia to be ready to participate more efficiently in GVCs.

In *Advanced manufacturing: A smarter approach for Australia*, Innes Willox, Chief Executive, Australian Industry Group, proposes that advanced manufacturing is about the approach to creating value around any manufactured product. He argues that, even though sound macroeconomic policies such as taxation settings and regulatory reform underpin the growth of advanced manufacturing in Australia, skills, collaboration and innovation are also important. He recommends that improvements in the skills and knowledge of manufacturing employees, in the relationship between industry and research institutions and in the perception of manufacturing in Australia are crucial for the success of the industry.

In *META – Creating the engine for an advanced manufacturing industry in Australia*, Albert Goller, Chair, Manufacturing Excellence Taskforce of Australia (META), discusses the approach that META, a public funded membership organisation, takes to support the future of advanced manufacturing in Australia. He describes META's bottom-up approach to the transitioning task facing manufacturers, which involves identifying the top performing manufacturers and research institutions that collaborate with industry to create the META 500. The META 500 will showcase how success is possible through collaboration and participation in projects and will be a benchmark for the advanced manufacturing industry.

In *Key enabling technologies*, Dr Swee Mak, Director, Future Manufacturing Flagship, CSIRO, discusses the impact of key enabling technologies (KET) such as information and communication technology (ICT) and the Industrial Internet on advanced manufacturers in Australia. He argues that adoption of ICT and other KET will have a positive impact on firms' productivity, competitiveness, responsiveness and ability to customise products, factors which are crucial for a successful advanced manufacturing sector. Finally, Dr Mak demonstrates how technology can drive down costs for manufacturers and improve collaboration to create value.

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CEDA wishes to acknowledge the input and expert advice from the CEDA Advisory Group in the development of this policy perspective. The CEDA Advisory Group consisted of:

- Ian Satchwell, Director, International Mining for Development Centre
- Professor Göran Roos, Chair, Advanced Manufacturing Council
- Dr Swee Mak FIEAust, Director, Future Manufacturing Flagship, CSIRO

These distinguished experts provided guidance in the creation of the report and input into the final recommendations. However, the final report is entirely the responsibility of CEDA and of the individual authors.



# CEDA Overview

## Sarah-Jane Derby

CEDA Senior Economist

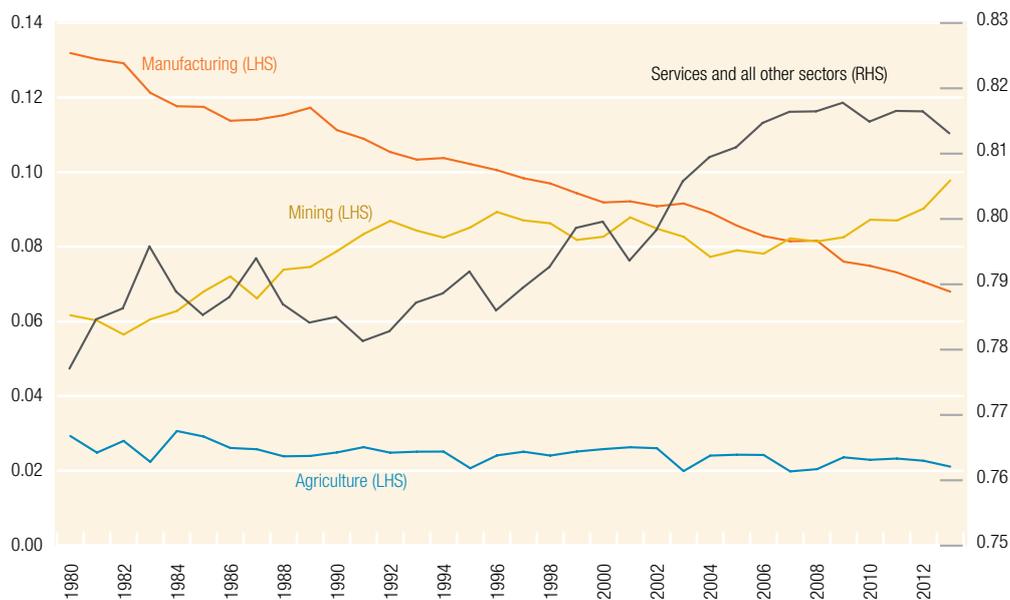
For most Australians, manufacturing is synonymous with a sense of doom and gloom, perpetuated by the media's constant reporting of factory closures, job losses, and large multinational companies exiting, or planning to exit, Australian manufacturing – notably (but not only) automobile manufacturing. As a result, the national policy debate rarely moves beyond industry assistance, with some sections of the community calling on the government to step in to save struggling manufacturers, and by extension, Australian jobs, while others are demanding an end of the so-called handout culture, arguing that it has a cost and does not create sustainable employment in any case.

The media reports do reflect real and major problems for firms and employees in parts of the sector and debate around assistance is healthy and should not be dismissed. However, the woes of some manufacturers are not unique to Australia, nor are they a new phenomenon. Traditional manufacturers in advanced economies across the globe, those aiming for (but struggling to achieve) low-cost, high-volume business models, have been suffering from a similar malaise since the rise of free trade and globalisation – forces which have driven rapid improvements in prosperity around the world, but which have also triggered significant adjustment problems, notably in manufacturing in advanced economies.

Over the past few decades, Australian manufacturers have grappled with economic and structural challenges that have left many of them at a comparative disadvantage in the global market, particularly in the face of strengthening low-cost competition from emerging nations, initially from Japan, before China dramatically surpassed it, but more recently also from South Asian and Southeast Asian nations, among others. The relatively strong Australian dollar, high labour costs, rising energy costs and a small domestic market have contributed to the sector's inexorable decline and inability to compete on a cost basis alone.

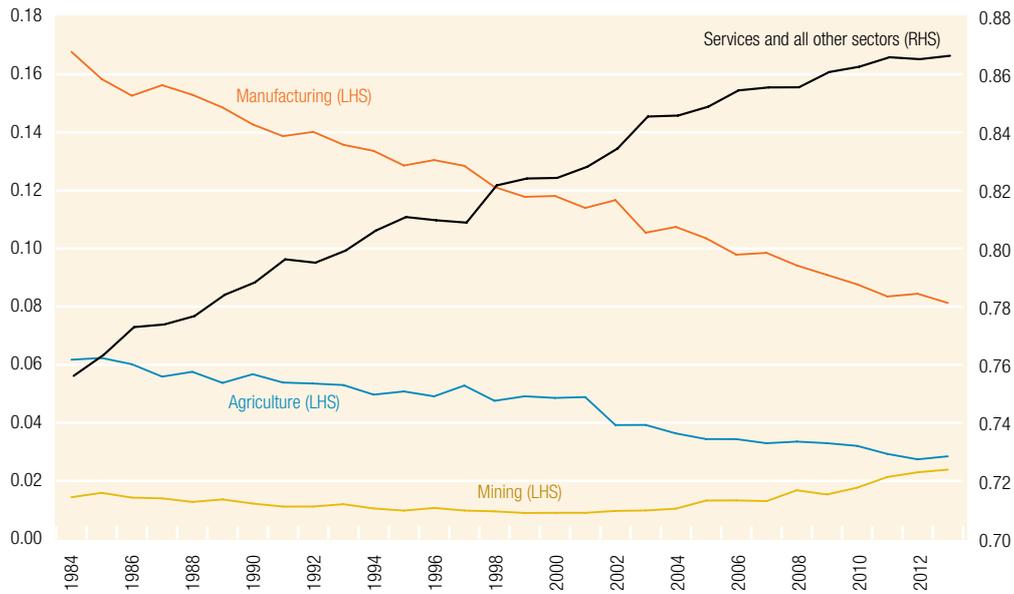
Between 1980 and 2013, the manufacturing sector's contribution to gross domestic product (GDP) has almost halved, from 13.2 per cent to 6.8 per cent last year, the lowest point over the period as shown in Figure 1.<sup>1</sup> To put this number in even more perspective, the sector peaked at 28 per cent in the 1960s.<sup>2</sup> Some industries, such as the textile, clothing and footwear (TCF) manufacturing and tyre manufacturing industries are now mostly defunct, with the car manufacturing set to follow suit by 2017. At the same time, other sectors (such as mining and the services sector) have been growing in importance in our economy, although the agricultural sector's contribution has remained fairly steady over the period.

**FIGURE 1**  
VALUE ADDED AS A PERCENTAGE OF GDP; SELECTED SECTORS



Source: ABS Cat 5206.0

**FIGURE 2**  
**SELECTED SECTORS' EMPLOYMENT AS A SHARE OF TOTAL EMPLOYMENT**



Source: ABS Cat 6291.0

In terms of employment, the story is very similar. Between 1984 and 2013, manufacturing's share of total employment has been steadily dropping from 16.8 per cent to a trough of 8.1 per cent last year as shown in Figure 2.<sup>3</sup> In absolute terms, this equates to about 155,160 jobs lost over close to 30 years and job losses are only set to grow in 2014. At the same time, the importance of the services and all other sectors (primarily made up of services) has been growing consistently. While declining employment in manufacturing is partly due to rising automation (i.e. capital equipment replacing labour) and some productivity gains, the sector's declining contribution to GDP suggests deeper structural changes are occurring in the sector.

Despite the gloomy figures about the state of the industry, particularly following the spate of bad news in the first quarter of 2014, it may be premature to be calling for the demise of the manufacturing sector as a whole. While manufacturers who compete in the low-cost, low-margin, high-volume market are doing it tough, the real manufacturing story is less straightforward than the numbers suggest. Examining the global trends behind manufacturing and identifying the opportunities they offer to Australian manufacturers is crucial as the industry transitions away from its current state, especially against the backdrop of retaining a mix in the economy that enables sufficient value creation for the country as a whole to maintain its present living standard.

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## Beyond the production line

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There are many Australian manufacturers who have been resilient in the face of challenging economic and structural conditions although they are rarely in the media spotlight. These ‘hidden champions’<sup>4</sup> exemplify the other side of the manufacturing story: There is such a thing as a successful Australian manufacturer and, in fact, there is scope for those manufacturers to contribute to and support the long-term continuation of a viable and strong manufacturing sector and its contribution to the growth of the Australian economy. These manufacturers exhibit characteristics that fall broadly within the category of advanced manufacturing.<sup>5</sup>

The distinctions drawn between a traditional and an advanced manufacturer vary in the literature. However, the Institute of Manufacturing provides a holistic definition of advanced manufacturing (or high-end manufacturing) as being “...*the full cycle of activities from research and development, through design, production, logistics and services, to end of life management...*”<sup>6</sup> This definition is distinct from what we would expect of a traditional manufacturer, where the focus would be primarily on the production side of things – just one link in the chain rather than the whole chain. In other words, advanced manufacturing goes beyond the production line to capture the more complex trends in manufacturing, seen within global value chains and including technological innovation.

Every Australian manufacturer has the chance to become an advanced manufacturer in theory. In practice, however, not everyone will succeed and those who do succeed at advanced manufacturing tend to have common characteristics, including:<sup>7</sup>

- Innovation: Successful advanced manufacturers innovate, constantly invest in research and development (R&D) and understand the role of technology as a competitive edge. They also innovate in non-technological areas and focus on simultaneously innovating to create value and innovating to appropriate value.
- Global value chain (GVC) cognisance: They manage their value chain and position themselves within it accordingly – for example, by including pre- and post-production activities.
- Export focus: They primarily serve export markets and often serve niche markets.
- Customer focus: They understand and are very responsive to the needs of their customers and the increasing trend to customer-responsive customisation.
- Value focus: They compete on value for money not on cost.
- Small and medium sized enterprises (SMEs): Many advanced manufacturers are small and medium rather than large scale enterprises.
- Highly skilled employees: They have highly competent employees and highly capable management frequently combined with a high performance workplace system. They continuously invest in education of their workforce.
- Collaboration: They are highly collaborative and understand how to manage competitive relationships.

Examples of successful Australian advanced manufacturers abound. This overview includes three case studies:

- **Codan** which developed its core competence around the R&D side of the value chain and manufactures high complexity, low volume products domestically while offshoring low-margin production;
- **NOJA Power** which shows that collaboration between industry and government can be profitable when it comes to innovation and advanced manufacturing; and
- **Liferaft Systems Australia** whose focus on innovation and technology has made it a world-leader in marine evacuation systems.

There are many other examples, including those who have successfully transitioned from traditional to advanced manufacturing. Textor Technologies, as an example, is a survivor of the now mostly-defunct TCF manufacturing industry, and used, among other things, innovation and collaboration with CSIRO to transition to being an advanced manufacturer.<sup>8</sup>

Advanced manufacturing is crucial in the Australian context. There is widespread evidence that Australia's comparative advantage lies in high-value, low-volume manufacturing,<sup>9</sup> with a strong focus on the design, R&D and innovation side of the production process. Specialising at the pre-production end of the value chain also turns some of the natural disadvantages Australians face into potential advantages (for example a skilled and costly labour force), while adding value to the production process is crucial to remain viable in a high-cost environment.<sup>10</sup> The world is seeing a resurgence of manufacturing in some advanced economies, including the US, meaning that Australian manufacturers will face competition not only from low-cost nations, but from countries with similar economic structures.<sup>11</sup>

Advanced manufacturing has a role to play in boosting Australia's competitiveness in the global manufacturing market. The next sections examine the trends behind advanced manufacturing and what needs to be done to ensure Australian manufacturers can benefit from these trends.

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## A value proposition

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Globalisation has radically changed the way that manufacturers operate. Since the rise of free trade, outsourcing production to nations where production costs are much cheaper has been a common strategy for manufacturers. Free trade, combined with the increasing use of technology and growing trend towards the export of services have led to the creation of complex supply chains, known as GVCs, as explored by Jane Drake-Brockman in Chapter 2. GVCs refer to the chain of activities from the concept end of manufacturing all the way through

to the after-sales customer support end, and feedback from customers. These activities often occur in separate firms in many different countries, albeit with links among them, hence the term global. For manufacturers, it means that they participate in GVCs and specialise in a core competence and comparative advantage (a specific activity or set of activities) while outsourcing the rest to a different firm or country. Participation in the GVC is crucial for integration into the global economy<sup>12</sup> – something that is even more important for Australians given our small domestic scale and market. As an example, Australia already participates in the aerospace GVC<sup>13</sup> and also the food processing (or agrifood) industry.<sup>14</sup>

The future of the Australian automotive component supply chain is in question following the imminent exodus of the remaining three car manufacturers from Australia. However, there is scope for some component manufacturers (about 25 per cent, according to an estimate by Professor Göran Roos) to find new markets and participate in the value chain, particularly those who were already innovative, diversifying, expanding globally and thinking about servicification.<sup>15</sup>

## Case study 1: Codan

*Codan is an example of a successful advanced manufacturer that manages the GVC to its advantage.*

Codan is a designer and manufacturer of high value added electronics products in three core areas: radio communications systems, metal detectors and mining technology solutions. The company was founded over 50 years ago by three South Australian friends and now operates a world class manufacturing facility in Adelaide with customers in over 150 countries across the globe.

Codan's business strategy focuses strongly on understanding and managing the GVC associated with each of its product segments in order to provide innovative solutions to its customers, in very carefully defined markets. In order to do this, Codan analyses and researches every aspect of the GVC to identify where it can play to its relative strengths, adopting a hybrid approach consisting of in-house design and manufacturing, commercial off-the-shelf solutions (COTSS) and outsourcing where practical to take advantage of factor cost environments overseas.

To optimise its position in the value chain, Codan's Australian manufacturing facility focuses on low volume, high complexity, high model-mix production, which Donald McGurk, Managing Director and CEO of Codan, sees as an area of core competence for Codan. Manufacturing these types of products locally ensures the company can maintain the skills and capabilities required to compete globally in high value-add product solutions and enables Codan to attract and retain the best engineers and other

research, design and development staff. Proximity between research, development and manufacturing capabilities is critical to ensure that product designs are commercialised rapidly and that the right environment is created for innovation.

However, manufacturing in Australia does present some challenges, including high labour costs, high payroll taxes, transport infrastructure costs and difficulty in finding skilled employees, particularly engineers. Despite these challenges, Codan's Adelaide manufacturing facility is up to the task of producing complex, high value-add products in a high-cost environment. The company does not produce high volume, low complexity products domestically; instead, production of these products is outsourced to Malaysia. This creates a cost-advantage for Codan which underpins the company's customer-focused strategy and positioning in the GVC.

Codan's customer-focused strategy involves understanding the needs of every client and developing innovative solutions that often incorporate third party products and technologies. This is a significant departure from some approaches to design and manufacturing that are based on a field of dreams analogy of 'if we build it they will come', where a standard product is produced, often without fully considering the customer's needs. Instead, Codan works closely with customers and focuses on innovative solutions that have the potential to disrupt the market and stay ahead of the competition.

The company's expansion approach looks at "carefully defining market spaces" according to Mr McGurk, with the aim of capturing significant share in each defined space. The company's customers range from defence forces to blue chip miners and consumers. Exports account for 90 per cent of Codan's revenue.

Using innovation and managing the GVC are not the only ingredients to the company's success. Mr McGurk believes Codan's continued success is also the result of implementing a strong culture of innovation based on the following core values: can-do, high performing, customer driven, and openness and integrity. He believes these core values are a crucial part of the company's success and ongoing drive to be globally competitive and to be a high performing company in the advanced manufacturing sector.

The servicification (also referred to as servitisation<sup>16</sup>) of manufacturing is also an important trend. It refers to the growing role of embodied services in manufacturing, in particular, pre-production activities such as R&D and post-production activities such as marketing and customer service, treated as highly valuable sources of information on customer needs. These and other services contribute the most value-add in the advanced manufacturing process, act as a point of differentiation<sup>17</sup>, and have the potential to be beneficial to manufacturers operating in high-cost economies, including Australia.

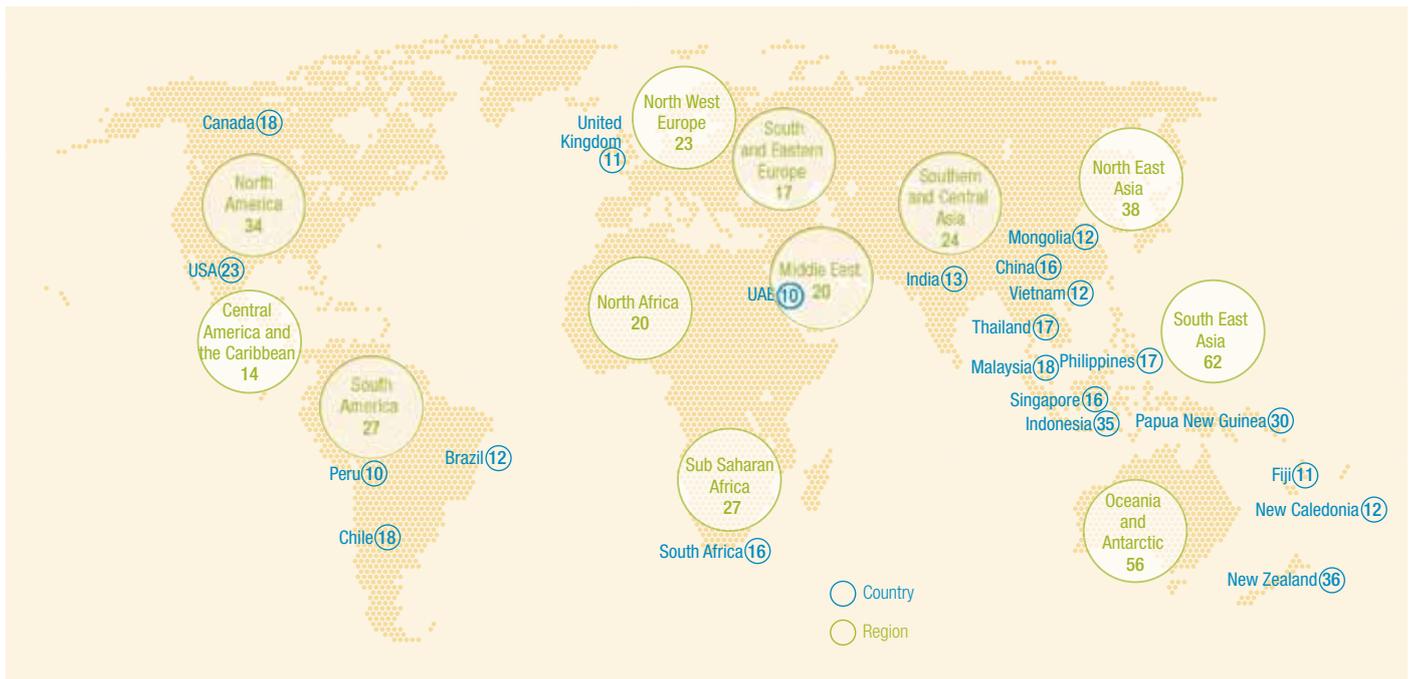
As an example, Swedish manufacturers have repositioned themselves to take advantage of the servicification trend, leading to a rise in manufacturing exports and in highly-skilled jobs, as discussed by Professor Göran Roos in Chapter 1.<sup>18</sup> In Australia, about 32 per cent of manufacturing exports is services value added, particularly business, distribution, transport, telecommunications and financial services.<sup>19</sup> Australia lags behind other advanced economies such as Germany, Sweden and New Zealand on this criterion. Services value added is most significant for transport equipment manufacturing at just under 40 per cent, closely followed by chemicals and minerals manufacturing, and food product manufacturing.<sup>20</sup>

The mining equipment, technology and services (METS) sector in Australia exemplifies the benefits of servicification – in this case, to the mining sector and to advanced manufacturers operating within the sector. METS companies provide specialised support and solutions to the mining and minerals sector and companies range from manufacturing, to engineering and professional services firms. According to Austmine, the METS industry association, the sector contributes 6.4 per cent to GDP, including through exports of \$27 billion, or about 30 per cent of its revenue. A high proportion of METS companies export to New Zealand, Indonesia and Papua New Guinea, with 62 per cent of businesses reporting they export to Southeast Asia, followed by 56 per cent of businesses exporting to Oceania and Antarctic as shown in Figure 3.<sup>21</sup>

These figures include manufacturing firms that provide equipment and related-services to the mining and minerals sector. Manufacturers account for 38 per cent of METS companies and 41 per cent of METS revenue, by far the most significant player in the sector.<sup>22</sup> The contribution of METS to the mining sector and to the economy as a whole highlights the importance of trade in services in the global supply chain, particularly in adding value, while simultaneously demonstrating the importance of embodied services in manufacturing. (i.e. the close link between business services and manufacturing).

Other advanced manufacturers also have the potential to gain from the servicification trend, just like manufacturers in the METS sector have. To benefit from servicification, companies must first be cognisant of GVCs and understand the implication of GVCs for their business. For manufacturers, there is scope for servicification at both sides of the manufacturing value chain – at the pre-production end, i.e. at the concept, design, R&D and innovation stage, which requires a highly-skilled workforce and strong intellectual property (IP) laws; and at the post-production stage, including logistics and after-sales service.

**FIGURE 3**  
**PROPORTION OF AUSTRALIAN METS COMPANIES THAT EXPORT SEGMENTED BY**  
**REGION AND SELECTED COUNTRIES**



Source: Austrmine. These percentages are based on a survey of METS companies. Most companies service more than one country and more than one region, hence percentages do not add up to 100 per cent.

Providing a standardised, high-volume product is the domain of traditional manufacturers. Advanced manufacturers are distinct in that they provide a customised solution or experience,<sup>23</sup> moving away from the tangible product towards providing an intangible service with a product embedded within in. Servicification can not only help companies participate in the value chain and add value to manufacturing, it also helps them to differentiate their products and support the trend towards extensive, customer-responsive customisation.<sup>24</sup>

## A highly complex environment

Advanced manufacturing requires a highly complex and competitive operating environment. According to the contributors to this policy perspective, there are a few key enabling factors that are conducive to advanced manufacturing where Australia lags behind other nations, namely, collaboration, innovation, skills and capabilities.

### Collaboration and innovation

Collaboration is critical to innovation – innovative activities have evolved from a closed process to being one where the sharing of ideas and knowledge has become part and parcel of the process.<sup>25</sup> Collaboration is poor in Australia by international standards. We lag behind when it comes to collaboration between industry and academia/scientists, but also score poorly at global collaboration,

despite evidence that collaboration is beneficial to businesses.<sup>26</sup> The relationship between the manufacturing industry and the education and training system and Australia's collaboration performance is further discussed by Innes Willox in Chapter 3.

It is critical to facilitate collaborative research between industry and academia/research organisations to ensure that R&D and innovation is targeted towards activities that can be translated and commercialised, and that can add value within the advanced manufacturing supply chain. This includes fostering an innovation environment that is more geared towards service activities, keeping in mind the close and necessary mutual relationships between business services and manufacturing.<sup>27</sup>

There is also scope for industry participants to work together to increase innovation within the sector.<sup>28</sup> Given that collaboration occurs between many parties and frequently in close geographical proximity, there is the additional benefit generated through the agglomeration economic effect, frequently known as the benefits of working within a cluster or in a hub.<sup>29</sup> Benefits include faster revenue growth, higher growth in profitability and higher growth in productivity, underpinned by an environment that is conducive to innovation provided through the many cooperative relationships in such a cluster.<sup>30</sup>

Collaboration aside, Australian businesses' innovation performance has been mixed – the proportion of innovation-active businesses fell from 44.9 per cent in 2007–08 to 39.1 per cent in 2010–11, and although the share has since risen, we still lag behind when it comes to new-to-the-world innovations.<sup>31</sup> There is a market failure in the uptake of innovation, particularly among manufacturing SMEs. Innovation and knowledge, once created, is often diffused to the entire economy; as a result, the firm that invests in innovation is often unable to internalise the investment benefits.<sup>32</sup> Furthermore, many SMEs find it challenging to obtain funding for innovation<sup>33</sup> further worsening the supply of and demand for innovation.

“There is scope for the government to incentivise and/or facilitate innovation, particularly for SMEs, and to foster collaboration. Collaboration and innovation have a net benefit for the country when directed towards a value adding activity, and towards improving the economic complexity and productivity of Australia.”

There is scope for the government to incentivise and/or facilitate innovation, particularly for SMEs, and to foster collaboration. Collaboration and innovation have a net benefit for the country when directed towards a value adding activity, and towards improving the economic complexity and productivity of Australia. This reflects the findings of CEDA's *Australia Adjusting: Optimising national prosperity*, which included recommendations on how to improve the nation's capacity for successful innovation. In the report, Professor Beth Webster recommends incentivising demand-driven research and collaboration through R&D corporations that are mostly industry-led and funded.<sup>34</sup> The model is particularly effective for SMEs – and would therefore suit advanced manufacturers – as each company is able to internalise the benefits of innovation.

The government working with industry to incentivise innovation (for example through R&D tax concessions) and fostering collaboration and innovation (for example setting up of the Manufacturing Excellence Taskforce of Australia – META – via the Industry Innovation Precincts Programme) have proven successful. META is a public funded membership organisation of manufacturing companies and universities in Australia operating as a channel to facilitate and accelerate changes required in the manufacturing sector. META's bottom-up, industry supporting industry approach, discussed by Albert Goller in Chapter 4, is aimed at developing an advanced manufacturing sector that is strongly focused on collaboration (through hubs and other projects) with a view to help industry participants, including SMEs, to achieve best practice and to support growth.<sup>35</sup>

The Grains Research and Development Corporation (GRDC) is an example of successful collaboration and innovation in the rural sector in Australia. The GRDC is a research institution that works closely with grain industry participants to improve grain quality and functionality and is mostly funded by industry. Its successes include transforming the grains industry of Western Australia's South West region into a leader through collaborating with farmers to develop grain varieties that are tolerant of variable weather conditions.<sup>36</sup>

## Case study 2: NOJA Power

*NOJA Power is an example of a successful advanced manufacturer that uses collaboration and innovation to stay ahead of the competition.*

NOJA Power is a researcher, developer, manufacturer and supplier of low and medium voltage switchgear products, specialising in auto reclosing circuit breakers for the industrial, infrastructure and electricity distribution utilities markets. Founded in 2002 in Brisbane, the company aims to offer its customers an integrated solution, superior customer service and reliable products through a culture of innovation.

The company delivers its commitment to innovation via ongoing investment in research and development (R&D). In fact, R&D is the root of the company's existence – NOJA Power was founded through a government R&D grant of \$750,000 that was matched dollar-for-dollar by the company. Since this initial grant, the company has successfully obtained two follow-up grants: the second grant being for \$2.5 million and the third grant worth \$5 million, also for R&D purposes. These grants were also matched by NOJA Power.

This partnership between the company and the government to incentivise innovation has enabled NOJA Power to create leading-edge new products that are more environmentally friendly, safer and with more functionality than that of competitors. As a result, the company has grown by doubling its revenue every year and is now a successful, competitive and large manufacturing organisation that employs more than 150 people in

Australia. According to Managing Director Neil O'Sullivan, the success of the company is an example of how government and industry can collaborate to create viable, competitive and global manufacturing organisations.

The company also attributes its success to its location. Because of NOJA Power's commitment to continued innovation with up to 10 per cent of revenue devoted to R&D annually, the company requires skilled staff such as engineers as well as production staff at its facilities. It therefore located itself within the trade coast precinct in Brisbane, an area that acts as an innovation hub thanks to its proximity to transport infrastructure and ability to attract workers.

According to Mr O'Sullivan, operating in Australia has many advantages, including access to wonderful universities, good capital equipment and skilled labour. NOJA Power undertakes all its R&D activities in Australia, with in-house research and development staff working on constantly making improvements to products and on developing next-generation products. The company specialises in R&D and developing intellectual property in Australia, rather than focusing on inputs. Instead, raw materials are sourced from low-cost countries, taking advantage of the global supply chain and giving the company a competitive edge in a high-cost environment.

Serving a global customer base is crucial for manufacturing companies given the unsustainable small size of the domestic market and the fact that we live in a global village. NOJA Power, which Mr O'Sullivan describes as having been born global, derives more than 90 per cent of its revenue from exports, with products in service in over 80 countries across the globe. Its products are aimed at a global market through, for example providing language support software, while it employs a multicultural workforce to foster the global culture needed to be successful today. The combination of NOJA Power's culture of innovation, global focus and precinct location ensures the company is a competitive advanced manufacturer on the world stage.

The government can also create demand for innovation through public procurement policies (ensuring that they are consistent with our trade obligations under World Trade Organisation [WTO] rules). Public procurement is particularly effective for SMEs, companies with limited resources and for advanced products.<sup>37</sup> It helps to lower the risk of innovation for these companies and has the potential to incentivise innovation with a net economic benefit. It also adds to economic complexity by building knowledge and capabilities that can then be spread throughout the economy. Public procurement of innovation is one of the policies of the EU's Europe 2020 initiative<sup>38</sup> and has also been successful in the US through, for example the Small Business Innovation Research (SBIR) program.<sup>39</sup> Under SBIR, about 2.5 per cent of the federal agencies' research spending is set aside for the

sole purpose of purchasing innovative, presently not existing, products and services from small existing firms or potential small firms. The program incentivises innovation, as opposed to procurement of off-the-shelf solutions that act as a hurdle to innovation in local industry.<sup>40</sup>

## Skills and capabilities

The skills and capabilities of the labour force are crucial foundations of collaboration and the economic complexity of a country. Even though Australia is generally known as a highly-skilled nation, the country lags behind Organisation for Economic Co-operation and Development (OECD) leaders when it comes to Programme for International Student Assessment (PISA) scores, with our mathematics and reading scores worsening in recent years.<sup>41</sup> As for the skills of manufacturing workers, Australia also tends to perform poorly, particularly when it comes to leadership and management quality, according to Innes Willox.<sup>42</sup>

Transitioning from traditional to advanced manufacturing will require a more skilled labour force and as a result, manufacturers increasingly face competition for labour from other sectors of the economy (for example mining and professional services). Manufacturers face difficulties in attracting workers to a manufacturing career in Australia, particularly experienced scientists, engineers and managers, as well as younger workers.<sup>43</sup>

From an overarching point of view, enhancing the overall skills and knowledge of the labour force, particularly in the STEM (science, technology, engineering and mathematics) field will help to address Australia's weak spots. Better STEM skills will be of benefit to manufacturers as well. However, the focus should also be on other types of capabilities that will be of benefit to advanced manufacturers, including service industry skills. Industry also has a role to play in attracting workers to the sector (for example through internships) and in placing more focus on the importance of improving the skills and capabilities of its workforce through, for example, employer-responsive technical training and strong programs for training and skills development within firms.

Developing better capabilities also involves strengthening the link between industry and research institutions (including universities) to overcome the cultural barriers to undertaking applied research. The barriers for university researchers are primarily incentive structures that reward publishing of theoretical research in peer-reviewed journals as opposed to applied research topics that would be of benefit to industry. There is a role for the government to play in fostering the relationship between industry and research institutions so as to optimise Australia's manufacturing capability.

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## Case study 3: Liferaft Systems Australia

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*Liferaft Systems Australia is an example of a successful advanced manufacturer that combines in-house skills and capabilities with innovation to its competitive advantage.*

Liferaft Systems Australia (LSA) is a privately-owned designer and manufacturer of high-quality marine evacuation systems and large capacity life rafts for use on different types of vessels including conventional ferries, cruise ships, military vessels and large private yachts. The company's head office and production centre are located in a purpose-built facility in Hobart, Tasmania.

LSA dates back to the early 1990s when LSA's founders identified a gap in the market following a request by shipbuilder Incat for a safe, light, reliable and good quality marine evacuation systems that also offer value for money. The company then designed and developed an internationally-approved inflatable life raft that was the first of its kind in terms of the number of passengers it could hold but also in terms of safety standards. According to Managing Director, Michael Grainger, LSA's innovative evacuation slides revolutionised global safety in the business of passenger ferries.

LSA's global success did not happen by chance or easily. For the first three years Incat was the only customer. However, the plan from inception was always to become an international exporter. When the company developed its pioneering evacuation slides in the early 1990s, Australia had no brand recognition when it came to marine evacuation systems and the company faced an uphill battle to build its brand overseas. Today, exports account for 95 per cent of LSA's business with the company operating service centres in 26 countries around the globe, particularly in Europe and North America.

LSA's business model has underpinned the company's success. Unlike many other traditional manufacturing companies of that era, LSA has always been a low-volume, high-margin manufacturer, an area of comparative advantage for Australia. This business model also enabled the company to enter niche markets such as the defence force. LSA also had the foresight of targeting export markets as an area of growth early on in the company's life, even though their primary market was domestic when the company was first created.

Even though most of LSA's customers are located overseas and in spite of the long-term manufacturing trend towards offshoring, Mr Grainger says that the company has no intention of moving its production centre overseas. He believes that given the unique product that LSA manufactures, safety and quality standards are crucial to the success of the company and Australia, and in particular Tasmania, provides the best environment

to manufacture such a product at a competitive cost, with a high enough quality standard to ensure international certification recognition.

The company's continued success lies in its strategy to stay ahead of its competitors by continually improving its products and using better manufacturing techniques. Further, when LSA was set up in the early 1990s, the company developed the skills required to design and manufacture its marine evacuation systems in-house, and it now operates its production centre with decades of expertise in the sector, which it is continually building on. Those factors, combined with a strong safety record which is a crucial criterion for success in producing a lifesaving product, have ensured that LSA remains a profitable and viable Australian manufacturing company even as traditional Australian manufacturers continue to downsize or exit the sector.

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## A technology opportunity

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The core role that technology and collaboration between industry and research organisations such as CSIRO play in underpinning innovation is one of the many ways in which technology can play a role in advanced manufacturing.

The rising digitisation of our economy and advances made in information and communication technologies (ICT) present potential opportunities for advanced manufacturers to enable them to respond to global competition.<sup>44</sup> While additive manufacturing (3D printing) immediately comes to mind when thinking of technology for manufacturers, the applications are much broader than disruptive technology. As an example, in Chapter 5, Dr Swee Mak discusses how ICT applications can improve the way that manufacturers operate their supply chain, thereby creating a cost advantage.<sup>45</sup>

CSIRO has identified the following four major groups of technologies as being key enablers for advanced manufacturing, namely: robotics, mobile devices, consumer devices and cloud services. Despite being primarily driven by consumer markets, when adopted by manufacturers, these ICT solutions will ensure that advanced manufacturers can be highly responsive to consumer demand, thereby enabling agility, flexibility and the ability to provide a customised service to customers. ICT technologies can also support manufacturers' excellence at low-volume, high-value manufacturing and underpin their competitiveness. Just like breakthroughs in automation technology supported mass production, ICT can support the trend towards extensive, customer-responsive customisation. Technology can also improve the way that factory floors work. The industrial Internet, for example, integrates different fields (including big data, machine-to-machine communication and the Internet of Things) to make physical factories smarter and enable the optimisation of the performance of factory floors.<sup>46</sup>

The importance of some technologies for manufacturing can be seen in the focus that the EU and the US put on ICT and other key enabling technologies (KET), such as nanotechnology, industrial biotechnology, photonics, advanced materials and advanced manufacturing technologies.<sup>47</sup> According to Professor Göran Roos, these KET underpin the development of modern production systems for high-cost economies, such as:

- Individualised production systems that permit a high degree of variability;
- Virtual production systems that have the objective of reducing time and resources use for planning activities;
- Hybrid production systems that integrate separate production processes into a single process; and
- Self-optimising production systems that flexibly and intelligently adapt themselves autonomously to changing conditions.

In other words, technology has a significant role to play in ensuring that manufacturers transition seamlessly from traditional manufacturers to low-volume, high-complexity, high-variability, high-value producers with successful integration in the GVC. However, there is a market failure in the provision of ICT and other KET within advanced manufacturing SMEs partly due to poor communications infrastructure and KET understanding and knowledge. There is a role for the government and industry to play in overcoming this hurdle, and ensure that manufacturers are equipped with the appropriate tools to be globally competitive.

“There is scope for industry to help re-position manufacturing in the mind of Australians. Part of the rebranding or positioning would include a shift away from the handout culture and the associated pitfalls (and community cost) of being dependent on government assistance.”

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## A perception shift

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The poor perception of manufacturing (and by extension, advanced manufacturers) in Australia is a major hurdle to the industry’s transition to advanced manufacturing, a view reinforced by Innes Willox in Chapter 3. Successful advanced manufacturers are rarely profiled in the media and many members of the public see any form of assistance as coddling bad behaviour and a waste of taxpayers’ money. This, in turn, does not inspire confidence in the workforce to consider a career in advanced manufacturing, exacerbating the skills and capabilities shortages that many manufacturers face.

There is scope for industry to help reposition manufacturing in the mind of Australians. Part of the rebranding or positioning would include a shift away from the handout culture and the associated pitfalls (and community cost) of being dependent on government assistance. Instead, it would pave the way to a more positive campaign to shift the debate towards constructive conversations around Australia’s actual and potential comparative advantages, where and how manufacturers can add value, including the implication of the growing services value

add potential in manufacturing. Changing the perception of manufacturing would also help to attract and retain skilled workers to the sector and promote Australia as an area of opportunity for advanced manufacturers,<sup>48</sup> a crucial step if manufacturers are to improve their participation in GVCs, and crucial if Australia is to maintain its present standard of living.

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## Conclusion

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The way we manufacture products in a modern world has changed. Manufacturing is no longer just about production and assembly. The value chain, from the conceptual stage all the way through to providing after-sales service, is becoming more complex and interlinked. The role of services is becoming more crucial for manufacturers in high-cost nations. As consumers continue to demand highly-customised products, nimbleness and the ability to respond quickly to dynamic demand conditions will be an important competitive advantage for manufacturers.

Manufacturers are not expected to be everything to everyone. Instead, manufacturers should specialise in areas along the value chain in which they have a comparative advantage (their core competence), outsourcing and/or offshoring the rest. For advanced manufacturers in Australia, this comparative advantage lies in low-volume, high-value manufacturing, with a strong focus on the pre- and post-production activities such as design, R&D, innovation and communications. This means that advanced manufacturers would be taking advantage of the servicification trend in order to add value to the sector.

There are a few hurdles in the way of Australian manufacturers transitioning to advanced manufacturing, including Australia lagging behind in collaboration, innovation and capabilities, a dearth of funding for innovation, ICT and other KET and poor public perception of the sector. While all these need to be addressed, the industry itself has a major role to play in changing the culture of its companies. To be a successful advanced manufacturer, an organisation must foster a culture of innovation, collaboration, globalisation and competitiveness. As further structural changes remain inevitable, Australian manufacturers must seize the opportunity to become part of a vibrant and globally competitive industry.

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# 1. The constantly changing manufacturing context

Professor Göran Roos

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This chapter examines the type of manufacturing that can prosper in Australia and outlines a policy framework for business and government to achieve the transition necessary.

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Göran is the founder or co-founder of several companies and has worked as a consultant in more than 50 countries.

He is one of the founders of modern intellectual capital science and a recognised world expert in this field.

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## Introduction

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Manufacturing is changing and will continue to do so, thanks to the dynamic interaction of constant developments in technology and consumer behaviour and value perceptions, as well as the shifting forces that encourage improvements in efficiency and effectiveness.

On the micro level (groups of individuals and organisations), these changes will necessitate investment in developing competencies, equipment, processes and production systems. This will in turn encourage innovations that add value, especially in service delivery. For manufacturers, this value-adding innovation will be essential as production activities become less profitable, and pre- and post-production activities create more value.

On the meso level (industries and clusters), highly complex offerings will be relatively more valuable in Australia's relatively high-cost operating environment, which suits low-volume, high-variability and high value adding activities. The emphasis should be on building and retaining sectors that help maintain diversity in the national economy; are export-oriented, either through being part of global supply chains or by a 'born global' approach; and are grounded in domains where Australia holds a comparative advantage or could create one.

Finally, on the macro level (nations and markets), employment is likely to decrease in the manufacturing sector because productivity improvements generally exceed growth in demand, and rapid digitisation means firms require fewer workers even as they become more service-oriented. As a result, existing and new manufacturing activities will have to grow more quickly to compensate. These factors combine with the increasing trend towards deindustrialisation, the need to improve productivity in the resources sector and increase global competition pressure on the domestic retail market. Failure to accelerate growth will dramatically increase unemployment in the next five to 10 years, and the close ties between employment and income in the service and manufacturing sectors will mean that even a growth in services won't offset the effects.

This chapter outlines a policy framework for business and government to respond to these challenges, so that Australia can maintain its present prosperity and high standard of living.

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## How we got here

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The fragmented global manufacturing chain grew out of three related developments, namely:

- Reduced trade barriers, offering consumers more choice and increasing market size and thereby laying the grounds for benefiting from economies of scale by growing the size of production facilities and thereby firm size;
- Increased use of offshore labour, which takes advantage of reduced barriers to trade and national differences in labour cost to cut costs; and
- Fragmentation and further global dispersal of value chain activities enabled by the developments in information and communication technologies (ICT).

As a result of these changes, the value chain has become global and fragmented both within firms and in sectors at large.

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## Employment in the manufacturing sector

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In the manufacturing sector, productivity improves rapidly due to the high pressure to focus on developing processes and equipment quickly at ever reducing cost, rather than increasing the range of product offerings.<sup>1</sup>

### The automotive industry

The automotive industry illustrates the extent of this rapid improvement. As one of the industries with the highest rate of continuous productivity improvement, it is also the source of many productivity improvement tools and techniques used across other industries and the public sector.

In the automotive industry between 1987 and 2002 in the US:

- 45 per cent of the productivity improvements originated in process improvements within existing plants, primarily in the adoption of 'lean production';
- 25 per cent originated in the market shift from low-value add models to high-value add models;
- 15 per cent came from increases in the value of existing models as a result of adopting new features, improved quality and higher performance; and
- 15 per cent originated in the market shift towards more efficient producers and changes in the production mix.<sup>2</sup>

In Japan, 70 per cent of productivity improvements in the automotive industry could be attributed to improvements in operations and management systems.<sup>3</sup>

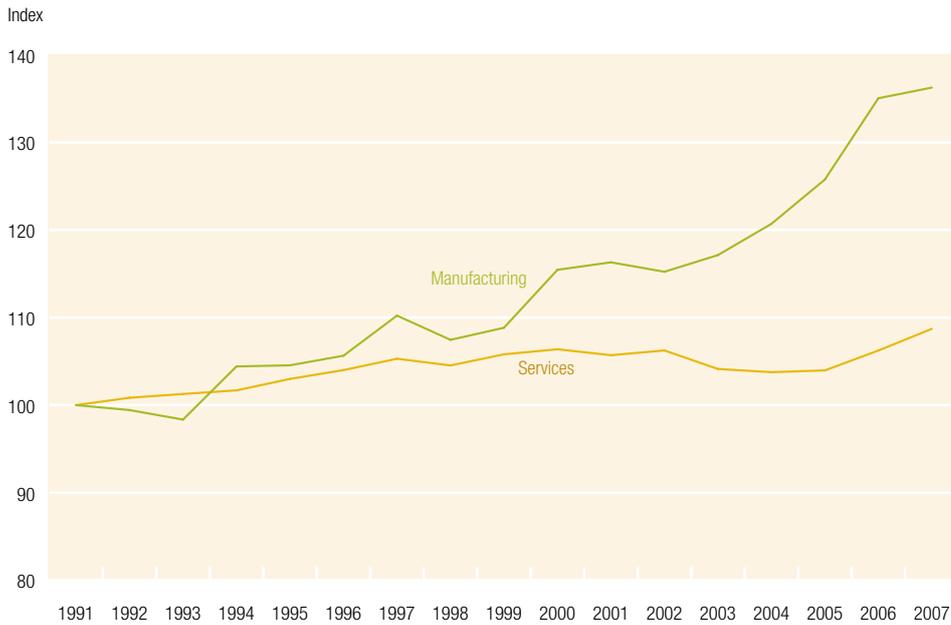
For mature industries like the automotive industry, sustained productivity improvement eventually exceeds growth in demand, so firms can satisfy growing demand while simultaneously reducing employment. This is one of the key factors behind the declining share of manufacturing employment in many countries in the Organisation for Economic Co-operation and Development (OECD).

### Manufacturing adds value by adding services

Productivity growth in manufacturing is generally substantially higher than productivity growth in most service industries, at the same time as manufacturing productivity growth exceeds demand growth in most manufacturing domains, while service productivity growth falls below demand growth in most service domains.<sup>4</sup> As a result, we may see a reallocation of employment from high-productivity domains like manufacturing to low-productivity domains like healthcare. This will take place more rapidly in de-industrialising, low-complexity economies like Australia, and poses a strategic threat to the country's ability to retain its current living standards.<sup>5</sup>

Figure 1 illustrates what the studies<sup>6</sup> show: that improved productivity in the manufacturing sector by far leads that of other areas in the economy.

**FIGURE 1**  
**PRODUCTIVITY CHANGES OVER TIME IN THE GERMAN MANUFACTURING AND SERVICES SECTORS**



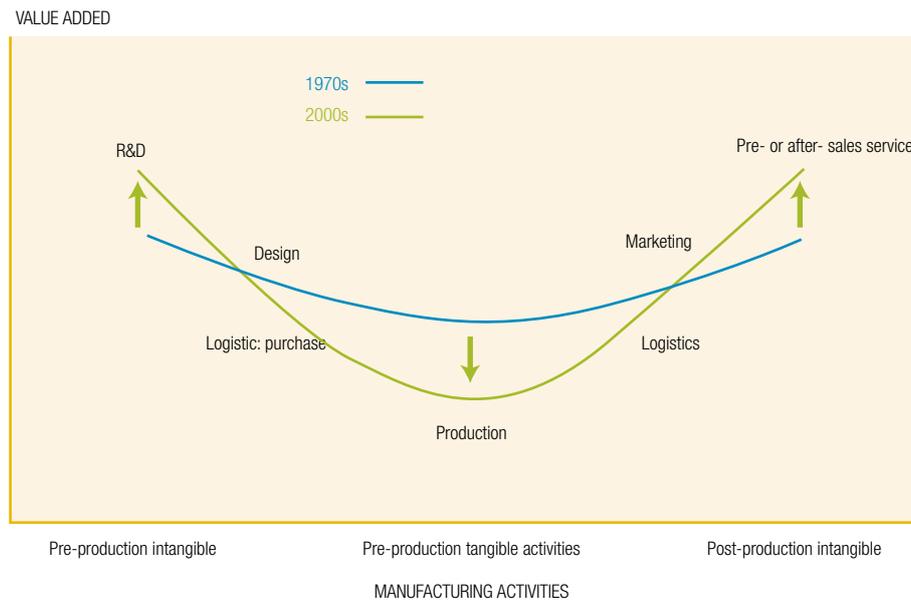
Source: www.euklems.net

A statistical illusion may explain why manufacturing seems to be becoming less important in terms of employment: manufacturing firms contract out numerous activities ranging from design to transport.<sup>7</sup> This illusion is also partially created by the blurring of traditional distinctions between services and manufacturing as the level of service in manufacturing increases, both as an output created by (or on behalf of) manufacturing firms and as an input feeding into them.<sup>8,9,10</sup> This makes it difficult to measure interactions between the manufacturing and services sectors.<sup>11</sup>

Using knowledge-intensive business services gives manufacturers an industry advantage when the depth of the market is taken into account<sup>12</sup>, and also contributes to competitive advantage at the firm level.<sup>13</sup> In-house service offerings have also expanded<sup>14,15</sup>; service exports in the manufacturing industry more than doubled between 1998 and 2006.<sup>16</sup> Manufacturing services have shifted from being an incomplete offering in a product-focused, transaction-based customer relationship to a complete service offering that bundles products and services to better meet defined customer needs in a long-term customer relationship.<sup>17,18,19</sup> This is underpinned by the increased value-adding potential when manufacturing migrates from production activities to pre- and post-production activities, as illustrated in Figure 2.

The conclusion from this figure is that manufacturing firms need to increase or extend their pre- and post-production activities to maintain a stable potential for adding value – highlighting the importance of well-developed service offerings as a growth strategy for manufacturing firms.

**FIGURE 2**  
THE SHIFT IN VALUE ACROSS KEY STEPS IN THE VALUE CHAIN OVER TIME



Source: Veugelers, 2013, p.27, based on original concept by Shih, 1992<sup>20,21</sup>

### The effect on the national economy

A nation's economic prosperity is tied to the robustness of its manufacturing sector, so it is important to understand which characteristics of the sector generate its high employment effect locally, as opposed to globally.

First is the economic complexity of the region. Analysing the relationship between the level of overall economic development (as illustrated by gross domestic product [GDP] per capita) and the degree of industrialisation (as represented by manufacturing sector GDP per capita), reveals that<sup>22</sup>:

- Countries with the highest per capita GDP – the US, Japan, Germany, Switzerland, and northern European countries such as Sweden and Finland – have the highest manufacturing GDP levels. This group is followed by most of the remaining European countries, as well as Canada, Australia, and some Asian countries such as South Korea.<sup>23</sup>

### Knowledge and economic complexity

Other approaches, such as economic complexity, also identify the importance of manufacturing in the national economy.<sup>24</sup> This approach relates an economy's complexity to the multiplicity of useful knowledge embedded in it, since modern societies not only amass but also effectively use large amounts of productive knowledge. This knowledge is distributed among individuals<sup>25</sup>, enabling people to access knowledge they are not capable of holding individually. To be useful and shareable, modules of knowledge need to come together in diverse combinations on the micro, meso and macro levels. This creates networks of informed

individuals and groups, enabling increased specialisation and absorptive capacity development, and expanding the potential for deploying it in an economically productive way.

Much of this knowledge is tacit and non-tradable, so it can't be priced in the normal sense. In terms of manufacturing, this distributed system of knowledge is sometimes referred to as the industrial commons. It is hard to acquire and is a competitive strength for those who hold it, giving superior organisations a basis for competitive advantage beyond standard price-based competition.

Economic complexity embedded in industrial commons is evident in high-cost manufacturing economies that succeed regardless of low-cost competition.<sup>26</sup> It is vital to all countries, particularly those like Australia that have become high-cost economies and are in clear danger of losing significant manufacturing capabilities unless they quickly focus on developing advanced manufacturing activities.<sup>27</sup> The higher the economic complexity the easier this transition will be, since it requires combining the knowledge of a broad range of specialists – including designers, marketers, finance specialists, engineers, technology experts from various disciplines, human resource managers, legal experts, and environmental and social scientists.

If this information input is missing, the sector cannot create advanced, complex products. Making advanced products involves interdependencies and cooperation between individual actors, and the more these can be localised within a nation or region, the more that nation or region's economy can capture the benefits. Building these networks so they embody key capabilities, including leveraging demand along high-growth value chains, is a central task for policymakers.

The Economic Complexity Index (ECI) examines 128 national economies, measuring their sophistication, uniqueness, pervasiveness and diversity.<sup>28</sup> The more complex the economy and the faster it grows, the stronger its prospects of creating value. The top economies are<sup>29</sup> Japan (2.3), Germany (2.0), and Switzerland and Sweden (1.9). Australia is number 79 with an ECI of -0.3.

Areas like sophisticated manufacturing increase a country's ECI, while areas like agricultural production and mining bring it down.<sup>30</sup> From this, we understand that manufacturing is critical for a country to achieve high economic complexity and to capture value from the economic activities (including all entrepreneurial activities) that will underpin its ability to grow employment and GDP.

### **The role of the multiplier effect**

The second characteristic of high-employment manufacturing relates to the balance between the multiplier effects of different types of manufacturing, and the geographical structure of their supply chains. While nations must pursue highly advanced manufacturing if they are to prosper (hence the often very visible focus on high-tech activities), on a local scale, regions may be better served by medium-tech manufacturing that creates geographic clusters of similar companies and suppliers.

On the other hand, in terms of the dollar value it contributes to a region, low-tech manufacturing is easily superseded by medium- and high-tech manufacturing. In comparison higher-tech manufacturing requires higher levels of skill and higher wages, and typically leads to higher levels of business and public investment in the region.

Additionally, the multiplier effect of medium- and high-tech manufacturing can be greater because robust supplier networks often co-locate in the region to support just-in-time manufacturing, as in the automotive industry. As products become more sophisticated and detailed – requiring complex subsystems of unique or specialised suppliers that provide access to advanced global supply networks – the close proximity between the supplier's production activities and manufacturing or final assembly facility location often becomes less important. We can see this effect in the aerospace industry, and increasingly in the automotive industry. Access to specialised suppliers and unique global supply networks – not located in close geographic proximity – takes priority over the geographic co-location of stages in the manufacturing process. The value added to the region may actually be diminished if clusters of similar companies and their supply bases are not formed in the region, due to a locally unmet need to access highly specialised and advanced suppliers in other parts of the world. Figure 3 shows the resulting relationship between the level of complexity in manufacturing and the local economic benefit.

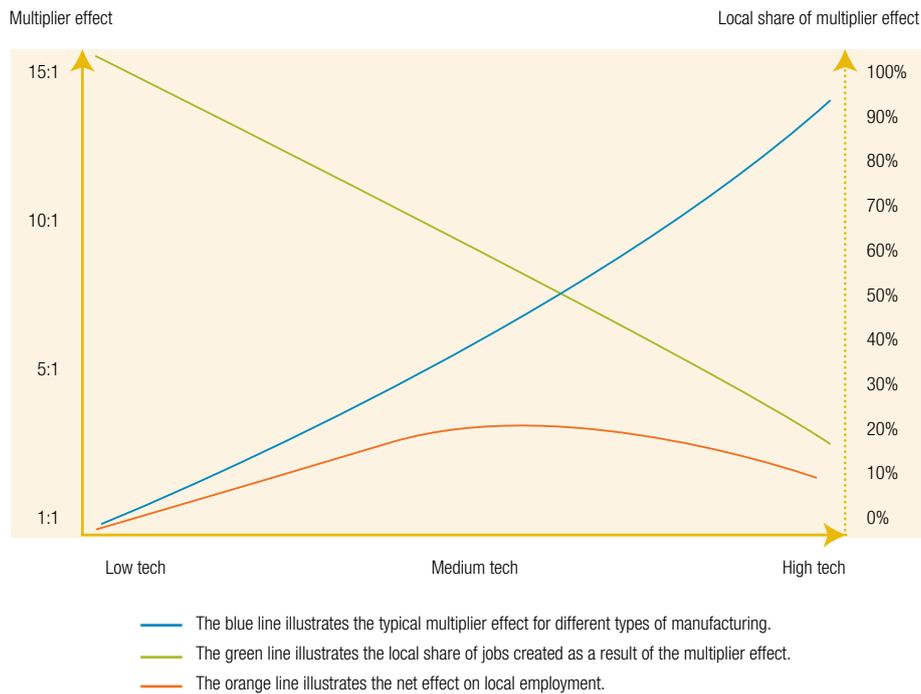
Figure 3 suggests that there is an optimum advanced manufacturing level for a region, after which the benefit diminishes. This point could vary considerably and depends on a number of factors, including:

- The maturity, vitality and competitiveness of the manufacturing supply network;
- The presence of similar manufacturing organisations and public infrastructure, such as research universities and technology centres;
- How quickly certain industries migrate towards more or less mature states, and more or less fragmented or consolidated value chains;
- The entrepreneurial activity level in the region; and
- Regional and local investment activities of economic agents.

The optimum level is directly related to economic complexity; in a region (or country) with high economic complexity the optimum would be very close to the right-hand side in the figure below, whereas in a region with a medium level of economic complexity the optimum would be to the right of but very close to the medium-tech results shown below.

In Australia, the optimum is likely to be to the left of the medium tech point in Figure 3. This is an unsustainable situation given the increasing competition from countries where their economic complexity is overtaking Australia. This will erode Australia's ability to create and appropriate value within the country. It is critical to create policies aimed at increasing Australia's economic complexity, and advanced manufacturing should be a key focus area.

**FIGURE 3**  
THE EFFECT OF ADVANCED MANUFACTURING ON LOCAL EMPLOYMENT



Manufacturing industries interact more strongly than any other with other industries as providers and users of intermediary inputs in the form of services and products.<sup>31,32,33,34,35</sup> In other words, the services sector's role as provider of intermediate input to other industries is more limited than the manufacturing sector's, so a country's capacity to develop its services sector depends on the structure of its manufacturing sector, something frequently missed in the debate around becoming a service economy.<sup>36</sup>

### Competition works to fragment value chains (GVCs)

Today's advanced goods are produced through complex interactions in fragmented value chains, with varying degrees of proximity between interdependent manufacturing and service activities performed by increasingly specialised organisational entities – either firms or parts of firms. This process can be seen in the rise of outsourcing and offshoring, the growing trade in intermediate goods and the increasing ratio of global imports to global exports.

Effectively managing this system requires continuous organisational restructuring and coordination at the architectural level of the GVC, which would not be possible without massive use of information and communications technologies (ICT) and the direct development of (or indirect access to) appropriate capabilities.<sup>37,38</sup> This is further complicated by the continuous commoditisation that occurs within any value chain<sup>39</sup>, as knowledge disseminates and barriers to entry are eliminated. In these situations, competition becomes primarily cost-driven, and manufacturers relocate to an activity-specific low-cost environment.

In high-cost environments, the best response is to develop new knowledge faster than it can be disseminated, in domains where barriers to entry and competitive advantage are more easily maintained – that is, in activities that rely heavily on intellectual capital.<sup>40,41,42</sup> This leads to a general shift to knowledge-based services and vertical specialisation, allowing firms to take advantage of cost savings or productivity enhancements gained from externally supplied components (outsourcing) or from abroad (offshoring). However, there is evidence that many companies have overestimated the advantages of outsourcing and offshoring while underestimating problems such as inventory management, obsolescence, organisational traumas, reaching quality standards and maintaining in-house technological capabilities.<sup>43</sup>

### Offshoring – and hosting relocated operations – consolidates global value chains (GVCs)

While the above forces are at work fragmenting GVCs there are also forces consolidating them. Leading firms tend to prefer larger, more capable, globally operating, first-tier suppliers.<sup>44</sup> This varies from industry to industry and within each industry, depending on the existing structure of production and trade. Another consolidating force is the trend towards servitisation – the trend towards offering services as well as manufactured goods.

As yet, there is little available discussion on the dynamic, interlocking effects of offshoring for countries that are losing manufacturing firms (or service providers) and those acquiring the same organisations.<sup>45</sup> The offshore relocation of these firms triggers two transformational processes that affect the productive and technological structures of their home countries.

“In countries that relocate a large share of their manufacturing activities outside the country, the industrial commons tend to deteriorate, production-related services are increasingly relocated and the level of technology development tends to stagnate.”

In countries that relocate a large share of their manufacturing activities outside the country, the industrial commons tend to deteriorate, production-related services are increasingly relocated and the level of technology development tends to stagnate.

In countries that receive these relocated production firms, the manufacturing sector expands and co-location increases for other manufacturing firms – and for production-related service providers. Relocation and co-location may be triggered by offshoring service providers as well as manufacturing firms. However, given the multiplying effects that characterise the expansion of manufacturing and the fact that certain services (in particular production-related services) must stay close to production, it seems that offshoring manufacturing activities is strategically more damaging than offshoring service providers.

These cumulative processes of relocation and co-location are responsible for transforming countries' productive and technological structures (that is, their specialised role in GVCs) and for driving the present and future prospects of innovation and specialisation within private companies. There is evidence that countries acquiring production and production-related services accumulate technological capabilities, and increasingly benefit from further relocation and co-location of companies at all stages in the GVC.

### **Co-location allows manufacturing and services to grow in tandem**

It is also obvious that the increase in manufacturers' service offerings leads to a shift in the demand for service-related occupations. Furthermore, countries with a highly functioning system of production-related service providers and firms anchored in GVCs also tend to benefit in the areas of net employment, net output, productivity growth and knowledge production. Examples include Sweden, Switzerland and Germany; Sweden, for example, has registered a simultaneous growth in its manufacturing and services industries.

Sweden's manufacturers have successfully repositioned themselves in the value chain<sup>46</sup>; in 2007, service-type jobs already made up 39 per cent of manufacturing employment in the country. In mature economies as a whole, the manufacturing share of total gross value added declined from 25 per cent in 1980 to 16 per cent in 2007. However, Sweden saw only a minimal decline from 21 to 20 per cent. Sweden's net manufacturing exports increased from 0.5 to 4.8 per cent of GDP over this period. The number of highly skilled workers increased by 1.7 per cent a year from 2001 to 2007, even as employment in assembly occupations declined by 2.6 per cent a year. Swedish companies invested, and continue to invest, double the average of the EU 15 in vocational training time. The imported content of manufacturing exports increased from 33 per cent in the mid-1990s to 39 per cent in the mid-2000s. The important telecom sector had an import content of more than 45 per cent by the early 2000s. Overall, Swedish manufacturing employment still declined by 85,000 positions from 1993 to 2007, but there was a compensating 120,000 increase in employment in manufacturing-related business services.

Product and process innovations are strongly intertwined in advanced manufacturing industries. Regular interaction between local manufacturing firms and other manufacturers and production-related service providers generates strong industrial commons and delivers a competitive advantage for all involved – as does the presence of demanding and competent customers.<sup>47</sup> No more sophisticated products will be produced than there are competent customers to demand them.

Outsourcing, especially offshoring, tends to delink manufacturing and services, hindering their ability to conduct research and experiment with new products and technologies. The deterioration of industrial commons caused by outsourcing can limit an economy's ability to introduce new products, as the suppliers, skills and services required to set up a new enterprise are no longer available locally. As Professors Pisano and Shih explain<sup>48</sup>:

*“In reality, there are relatively few high-tech industries where the manufacturing process is not a factor in developing new – especially radically new – products. That’s because in most of these industries product and process innovation are intertwined. So the decline of manufacturing in a region sets off a chain reaction. Once manufacturing is outsourced, process-engineering expertise can’t be maintained, since it depends on daily interactions with manufacturing. Without process-engineering capabilities, companies find it increasingly difficult to conduct advanced research on next-generation process technologies. Without the ability to develop such new processes, they find they can no longer develop new products. In the long term, then, an economy that lacks an infrastructure for advanced process engineering and manufacturing will lose its ability to innovate.”*

Those countries where manufacturing and services activities co-locate according to different patterns of complementarity develop strong industrial commons and benefit from the innovation opportunities that arise when manufacturing and services meet.<sup>49</sup>

Offshoring reduces incentives to innovate, leading to an erosion of technological competitiveness.<sup>50,51</sup> The adverse consequences of losing technology dynamics<sup>52</sup> and competitiveness in global industrial systems following the loss of production capacity<sup>53</sup> is attracting increasing interest from policymakers in innovation driven economies and advanced countries.<sup>54</sup>

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## Future development of the manufacturing sector

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This chapter discusses three key drivers of the future manufacturing industry:

- The national policy settings needed to maintain production sites in countries that have high labour costs;
- Future developments in key technology areas that will affect production processes and equipment, as well as the products themselves; and
- The shifting balance between the fragmenting and concentrating forces that act on firms and their supply chains, including both technology and policy settings.

Continuously changing consumer demand is a fourth key driver that underpins the operations of successful firms by allowing them to offer in-demand products and services at a market-acceptable price while remaining profitable. Although this is an important driver, it is not discussed in this chapter.

### Maintaining prosperity despite high operating costs

Since Australia is a high-cost operating environment, we need to look at some of its manufacturing industry challenges. Manufacturing companies operating in a low-cost operating environment tend to focus on economies of scale and imitation within simple, robust, value stream-oriented process chains. Manufacturing companies operating in a high-cost operating environment, on the other hand,

tend to focus on balancing economies of scale with economies of scope, while also balancing imitation and innovation in an environment of sophisticated and capital-intensive planning tools and production systems.<sup>55,56,57</sup>

High-cost operating economies can address the challenge of low unit costs by standardising business processes, technical systems, and manufacturing processes and systems – in turn benefiting from economies of scale. This frequently means having interconnected, highly automated production equipment. The price paid for this approach is reduced production flexibility, which in turn reduces firms' ability to adapt their production systems when conditions change.<sup>58</sup>

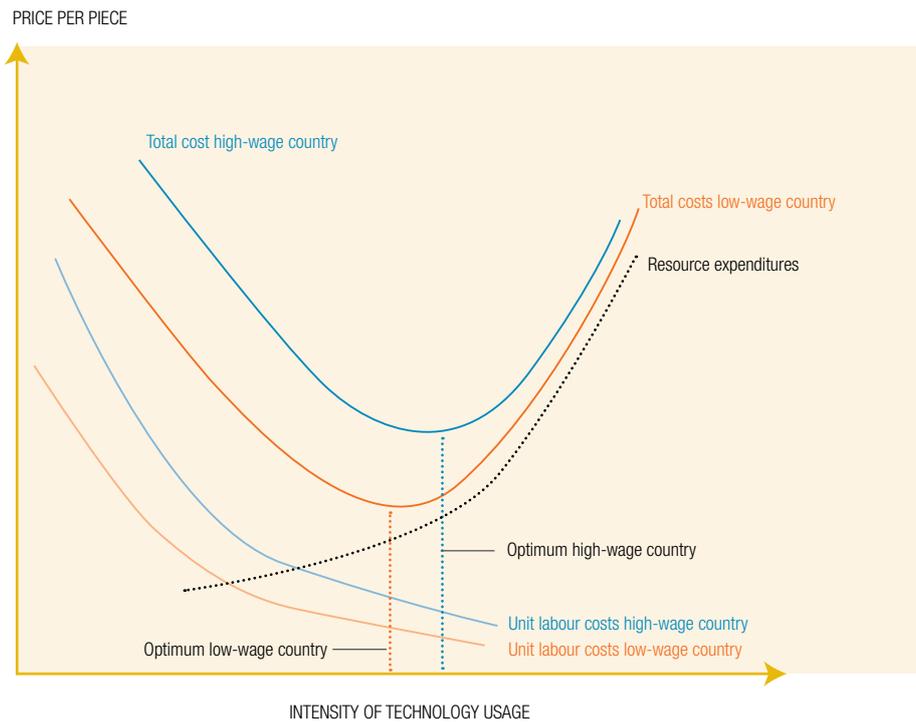
Given that Australia doesn't generally have the right boundary conditions to develop these economies of scale, this route is not feasible for most Australian manufacturing firms. Instead, Australia's opportunities lie in low-volume (meaning the ability to be profitable at low volumes), high-value adding, high-variability, medium- to high-complexity manufacturing – that is, in realising economies of scope above economies of scale.<sup>59</sup> This means having business processes, technical systems, and manufacturing processes and systems that allow high variability in what is produced. This approach requires additional investment as well as (presently) a higher proportion of manual work (such as at changeover times), resulting in higher unit costs than can be minimised by a production system designed for this environment.<sup>60</sup> This requires a high level of planning, and can lead to an extensive use of models, simulations, optimisation and, as a consequence, high personnel expenditure. From a lean perspective, this looks like the wrong approach since these kinds of planning activities do not immediately add value. The alternative is to focus on value-adding processes while standardising work processes, which minimises the effort required for planning, work preparation, handling, transport, storage and so on.<sup>61</sup> The challenge is that the latter is easier to imitate than the former and hence cannot normally form the basis for a competitive advantage.

“Australia's opportunities lie in low-volume, (meaning the ability to be profitable at low volumes) high-value adding, high-variability, medium- to high-complexity manufacturing – that is, in realising economies of scope above economies of scale.”

Succeeding in a high-cost operating environment means managing the different requirements that arise from balancing economies of scope with economies of scale. This includes managing various distribution channels, organisational structures and technologies – in short, simultaneously maintaining different business models.<sup>62,63,64</sup> The higher the operating costs the more this balance will focus on achieving economies of scope and, paradoxically, the less complex the balancing task will become.

Increased technology use leads to manufacturers replacing manual labour with capital equipment, which increases output and decreases labour costs. Since any given level of intensity in technology use will result in the same level of labour reduction, the cost reduction effect is higher in a high-cost operating environment than in a low-cost operating environment, and the optimal level of technology intensity is lower in a low-cost operating environment than in a high-cost one, as outlined in Figure 4.<sup>65</sup>

**FIGURE 4**  
OPTIMAL LEVEL OF TECHNOLOGY USE BASED ON RESOURCE AND UNIT LABOUR COST



The graph shows resource costs (including material, energy and cost of capital) and unit labour cost, which add up to the unit cost.

Source: Brecher et al. 2012, p. 25<sup>66</sup>

In Figure 4, we see that developing production systems – and our understanding of their implementation – will have dramatic effects on the manufacturing industry. We will see significant impacts as a result of developing key enabling technologies in the areas of<sup>67</sup>:

- Additive manufacturing, specifically metal-producing systems;
- Industrial biotechnology, with a specific focus on microbial consortia engineering and synthetic biology;
- The ‘Internet of Things’ (IoT) – an IoT can be conceptually defined as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual ‘things’ have identities, physical attributes, and virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network<sup>68</sup>; and
- Photonics, advanced materials, nanotechnology, nano- and micro-electronics, big data analytics and advanced manufacturing equipment, especially industrial robotics.

These developments will enable production systems targeted at high–operating cost environments, in particular:

- Individualised production, which involves designing and laying out all elements of a production system to permit a high degree of variability in the production program while maintaining production costs comparable to that of mass production;
- Virtual production systems that reduce the time and resources used for non-productive planning activities prior to value creation;
- Hybrid production systems, which build on a combination of production technologies, combining various physical principles or integrating separate production processes into a single, new production process; and
- Self-optimising production systems, which possess an inherent intelligence and can adapt autonomously to changing conditions to increase process flexibility.<sup>69</sup>

High-cost operating countries must enable their locally operating companies to retain economically significant parts of the GVC in their country.<sup>70</sup> This facilitates high-quality products and processes, while securing specific knowledge about products and processes – that is, protecting intellectual property.<sup>71</sup> This is consistent with a policy objective of increasing national economic complexity.

Such a policy must focus on the industry’s ability to develop leading-edge production systems – with capabilities as complete and comprehensive as possible – as offerings in their own right, as well as the ability to deploy these systems. If both these objectives are pursued, high-cost operating economies like Australia can maintain high-functioning manufacturing industries while also supporting a successful export industry. These industries could develop and sell a complete range of production systems – from simple to high-tech offerings – including all the key technologies involved, such as production equipment and processes.

In addition, the policy setting must provide boundary conditions that encourage development while also supporting firms that choose to move in this direction. This generally means emphasising demand-side policy tools rather than those on the supply side<sup>72</sup> – for example, supporting boundary-pushing, complex projects (frequently in the defence or advanced technology sectors) that use domestic firms, products and services to generate developments, thereby boosting market competition.<sup>73,74,75,76,77,78,79,80</sup>

“...policy must focus on the industry’s ability to develop leading-edge production systems – with capabilities as complete and comprehensive as possible – as offerings in their own right, as well as the ability to deploy these systems. If both these objectives are pursued, high-cost operating economies like Australia can maintain high-functioning manufacturing industries while also supporting a successful export industry. These industries could develop and sell a complete range of production systems – from simple to high-tech offerings – including all the key technologies involved, such as production equipment and processes.”

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## Conclusions around the future of manufacturing

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The pressures and opportunities provided by technological development, change in consumer preferences and as a consequence customer behaviour, and a changing policy environment will reshape the manufacturing industry even faster than they have done up until now. This reshaping will occur in the five key dimensions outlined below.<sup>81</sup>

### Capital intensity

Capital intensity will develop differently in different parts of each business. It will continue to increase at the front end around research, development and innovation (RD&I), and also in the digital aspects of all manufacturing activities, such as planning and simulation systems. Competence development and training will increase, given that firms will need to keep pace with the opportunities afforded by science and technology. Consequently, average spending on developing competencies will have to increase at the same pace as knowledge growth in the domains underpinning each firm, even while it is reduced by efficiency gains in training methods (such as massive open online courses [MOOCS] and cognitive science), and either reduced or increased by the salary difference between exiting staff and potentially more competent new staff.

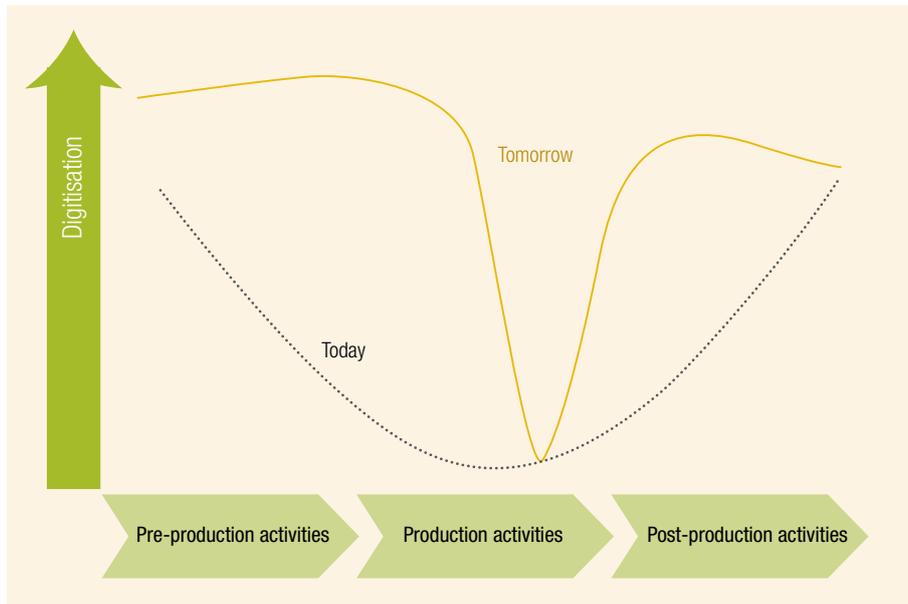
When it comes to production and the associated value and supply chain systems, it is likely that the capital intensity will initially continue to increase due to more expensive materials, more expensive production equipment, higher-complexity products, more expensive production systems, more complex global supply chains and so on. Capital intensity will then taper off as new production technologies, a higher share of operations in the digital space and new materials allow for less complex global supply chains and production systems. Eventually, all pre-production activities will take place in the digital space, resulting in a digital product that could then be sold as a data file to the customer, who decides when to convert it to a physical product using additive manufacturing for physical realisation and robotics for assembly. There will also be an opportunity for manufacturing firms to offer post-production activities (increasingly in the digital space, as outlined in Figure 5) using the product as a carrier, collector and transmitter of information – and even as receiver and user of information, such as in the case of directed self-repair.

### Plant and equipment

Plant and equipment will develop in five key areas – in parallel and with different dynamics over time. These areas involve:

- Movement into the digital space, which will initially be driven by developments in simulation tools, techniques and the Internet of Things, as well as big data analytics, linking production equipment and materials, and linking the product with its user environment and the producer;

**FIGURE 5**  
INCREASED DIGITISATION IN MANUFACTURING ACTIVITIES



- The development of increasingly digital production systems that can handle interlinked digital and physical spaces;
- Increasingly sophisticated production equipment, systems and processes, combined with developments in additive manufacturing and robotics;
- Developments in advanced materials, which will require customisation and new production equipment but will enable new functionalities; and
- The increasing need to reduce manufacturing's resource footprint in terms of energy and raw materials, which will drive the move towards advanced, digital-based manufacturing systems, and the deployment of advances in different technology domains such as industrial biotechnology, nanotechnology and photonics.

The conclusion is that investment in new production equipment will increase – in terms of cost and frequency – over the short and medium term, while decreasing in the long term due to the subsequent increase in digital manufacturing activities. Manufacturers will still need to invest in sophisticated software (although some of this will be available on a pay-per-use business model from the cloud) and hardware. At the same time, the physical production process will move to the customer's domain with the increasing sophistication of additive manufacturing and robotics.

The more materially homogenous the product and the simpler it is to assemble, the faster this transition will take place. On the other hand, for multi-material systems that require complex assembly, the impact will be slower and may only affect parts of the value and supply chains.

## Relationships and relationship systems

The manufacturing ecosystem will change as the digital domain takes precedence over the physical. This means that the importance of services as an input into manufacturing will increase – mirrored by the increased importance of manufacturing firms offering services – while the manufacturing value chain itself will become more complex (continuing the present fragmentation trend) and then simpler. To succeed amidst such change, manufacturing firms will need to develop and maintain new relationships, using relationship development skills and mechanisms, as well as an understanding of network economics.<sup>82</sup> These changes will also reduce the technical reliance on geographic proximity, while economic drivers are likely to strengthen as the front and back ends of the manufacturing value chain become more important relative to the physical production stages.

On the industry level, this will increase the concentration of manufacturers within precincts and clusters, with economic drivers determining where these hubs are located.

## Organisational resources

Strong branding will become increasingly important as a complement to the growth in customised offerings, as will real-time access to information that can underpin fast decisions. Here, big data and associated analytics will play an important role alongside the Internet of Things. Developing production systems and the associated processes will become critical, and manufacturers will need to be able to anticipate necessary changes in the production structure if they are to survive in this rapidly changing world. Furthermore, all of this will need to be supported by simultaneous and parallel business models that can change and develop more frequently and rapidly than ever before.

## Competencies and work hours

As mentioned above, the half-life of technology-related competencies will become shorter, with a corresponding increase in the need for continuous professional development. The responsibility for this development will rest equally on the employee and employer, and organisational career paths will emerge when individuals change responsibilities to follow a product, service or system along its lifecycle. This path will be grounded in one generation or lifecycle of technology rather than in one responsibility that tries to keep pace with the ever-increasing development underpinning several sequential product generations, which for most individuals is an impossible undertaking.

There will also be a change in work-hour requirements: a reduction in absolute volume terms, and an increase in the relative distribution across activities outside production. That increase will be seen at the front end of the manufacturing lifecycle (RD&I, and the development of software tools and production processes) and at the back end of the manufacturing lifecycle, through increased service offerings to support physical outputs. This overall reduction will of course be driven by an increase in labour-saving advanced manufacturing systems and the migration to

increasingly digital workflows.

On the industry level, this means that the number of jobs in the economy created by one job in manufacturing will decrease from around 2.5 presently to about 0.7, which is more typical of the service industry. This is on top of the dramatic productivity improvements that new technological development and new industry structure will drive. Productivity growth will far outstrip growth in demand, which will in turn see a rapid decrease in production-related and production-driven employment in the manufacturing industry. What remains of the industry will also have a much lower multiplier effect, which will have severe implications for employment levels and the tax base, with associated social and economic challenges.

The countries likely to be least affected by this transformation are those with a high level of economic complexity and which:

- Produce much of the advanced manufacturing tools and systems used in the new industry, and also provide many of the services required to support them;
- Develop the necessary ‘smart’ materials that make up new, manufacturing processes (such as nanoparticles for additive manufacturing or microbial consortia engineering for cellular factories);
- Provide pre-production services like RD&I (from training to contract research) as well as post-production services; and
- Deploy advanced manufacturing tools and systems used to create highly complex equipment requiring sophisticated assembly methods, few of which will be produced using additive manufacturing in the foreseeable future.

The policy objective must be to end up as a country that can benefit as a consequence of this development rather than losing out.

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## The manufacturing policy framework

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Over the last few years, leading nations have undergone a clear change in manufacturing policy. For example, policy agendas in the US and the UK both reflect the need to reverse de-industrialisation.

The US is focusing on three traditional policy clusters – competitiveness conditions, export promotion and manufacturing RD&I – while the UK is focused on rebalancing the economy by supporting long-term growth in key industrial sectors.<sup>83</sup> Leading manufacturing nations like Germany and Japan emphasise the need to participate in the markets and industries that are expected to drive future growth. In Japan, the government has sought to actively promote the reorganisation of the domestic industrial structure, particularly to address the inward-looking orientation of small and medium sized enterprises (SMEs). In Germany, where SMEs have traditionally been able to participate in global markets, the emphasis has been on increasing RD&I expenditure and coordinating policy efforts around future markets, driven by socioeconomic challenges.<sup>84</sup>

**TABLE 1**  
COUNTRIES PERFORMING WELL ACROSS THE SIX AREAS OF THE RESOURCES VALUE CHAIN<sup>85</sup>

	Develop resources		Capture value		Transform value into long-term development	
	Institutions and governance	Infrastructure	Fiscal policy and competitiveness	Local content development	Spending the windfall	Economic development
Highest performer	Norway	Canada	Canada	Canada	Norway	Norway
Second performer	Canada	Norway	Norway	Norway	Australia	Australia
Third performer	Australia	Australia	Australia	Australia	Canada	Canada

In Australia there is the additional need to manage the long-term wealth-generating potential of natural resources. Table 1 compares Australia’s performance in the six steps necessary to achieving this, compared to two other developed, resource-dependent economies.

Domestic manufacturing is mostly linked to the local content development and economic development columns in Table 1. On the local content development side, there are several lessons to be extracted from Norway’s journey. Norway has become a successful producer of oil-field services and equipment; it is home to global companies that are part of significant domestic clusters of suppliers to oil and gas operators, employing 114,000 people domestically, with sales in 2010 of US\$52 billion.<sup>86</sup>

It is important for local content policy to be aimed at high-value added, high-complexity manufacturing opportunities (marked in bold blue in Table 2) and high-variability, low-volume opportunities (marked in bold green).

**TABLE 2**  
MINING AND OIL AND GAS EXPENDITURE<sup>87</sup>

Cost categories	Metals and mining	Oil and gas
Basic materials	8–17%	13–23%
Low- to medium-complexity equipment and parts	7–14%	5–10%
<b>High-complexity equipment and parts</b>	<b>4–10%</b>	<b>12–20%</b>
<b>Integrated plant equipment solutions</b>	<b>5–12%</b>	<b>15–25%</b>

On the economic development side, countries go through three phases, as summarised in Table 3.

**TABLE 3**  
**PHASES OF THE RESOURCES BOOM<sup>88</sup>**

Phase	Boom Resource exploration and extraction boom (increasing resource prices)	Return Resource exploration declines but extraction accelerates and stabilises (decreasing resource prices)	Post-boom Resource exploration is almost non-existent and extraction has stabilised on a new, higher level. (stable resource prices)
<p><b>Characteristics</b></p> <ul style="list-style-type: none"> <li>• National income growth driven by terms-of-trade improvements and increasing investments in the resources sector, enabled by resource prices or resource rent increases.</li> <li>• Low employment increase due to the capital intensity of the sector.</li> <li>• Productivity decrease due to large capital investment with long lead-times to production, combined with haste in resource extraction to capitalise on the high prices or rent conditions.</li> </ul>	<ul style="list-style-type: none"> <li>• Economic growth is supported by employment increases, normally in the public sector, since government windfall is used to pay higher government salaries and hire more employees. There is also growth in local services such as retail trade and financial services, as some of the resource wealth is recycled into the local economy.</li> <li>• Investments made by sectors benefiting from resource sector activities, like real estate and utilities, and by the government investing some of the windfall in infrastructure projects.</li> </ul>	<ul style="list-style-type: none"> <li>• A new focus on productivity reduces employment in the resources sector. This cannot be absorbed in other sectors since they have been reduced due to lack of competitiveness induced by currency appreciation in phase two – normally visible as deindustrialisation – unless a globally successful resource-related industry has been built during phase two as a result of policy intervention.</li> <li>• Capital for investment is scarce and salaries have reached an unsustainable level given productivity levels and international competition.</li> </ul>	<ul style="list-style-type: none"> <li>• Budget pressure if government has increased spending over the revenue increases or if it has spent the projected revenue before receiving it.</li> <li>• As government expenditure slows, overall economic growth can decline significantly.</li> </ul>
<p><b>Factors hampering growth</b></p>	<p>Not applicable</p>	<ul style="list-style-type: none"> <li>• Terms of trade decline as the resources boom slows.</li> <li>• Low emphasis on increasing competitiveness in the sector leads to reduced investment.</li> <li>• Private investment is limited by macroeconomic volatility and currency appreciation, which reduces the competitiveness of other sectors, and concerns about the business environment, all of which government fails to address properly because it is preoccupied with the resources boom.</li> <li>• Capital productivity declines further as supporting infrastructure, such as utilities, is ramped up quickly; governments fail to select and execute their major capital projects effectively; and private sector funds flow into non-productive areas such as real estate.</li> <li>• Labour productivity comes under pressure as the share of public sector employment rises and many of the bottlenecks that prevent improvements in private sector productivity go unaddressed.</li> </ul>	

As can be seen in Table 3, manufacturing sectors in resource-driven countries face challenges that reduce their global competitiveness, such as currency appreciation, talent scarcity and increased global competition for local opportunities. It is critical that governments enable improved productivity in the manufacturing industry. In energy- and resource-intensive manufacturing sectors, this includes addressing infrastructure bottlenecks to minimise transportation costs and ensuring sufficient access to cost-efficient energy. In high-value adding, high-complexity, low-volume, high-variability manufacturing (Australia's sweet spot), it means creating opportunities and enabling access. This is achieved through an interventionist approach that can taper off over time (as seen in Norway) and through applying demand-side policy tools.

The policy framework that emerges out of this modern approach to manufacturing in the big countries – combined with the policy approach in other successful manufacturing countries like Sweden, Switzerland, Austria, Korea and Singapore – can be expressed in a matrix as shown in Table 4. The column headers are extracted from the lens of intellectual capital as a driver of competitive advantage, and the row headers relate to the lens of economic scale and agglomeration. Examples of policies for the individual cells can be found in *Manufacturing Works*<sup>89</sup>.

The task for governments will be to enter the appropriate policy measures in each cell in Table 4, in a way that drives increased economic complexity in the manufacturing industry, by supporting a systemically integrated, high-value added system of firms. In Australia, this should be aimed at the Australian manufacturing sweet spot: low-volume, high-variability, medium- to high-complexity, high-value added manufacturing.

**TABLE 4**  
**POLICY FRAMEWORK MATRIX**

	<b>Monetary resources</b> Policies to ensure access to financial resources.	<b>Physical resources</b> Policies to ensure access to infrastructure and key production equipment, including utilities and other necessary inputs at the lowest possible cost.	<b>Relational resources</b> Policies to ensure access to lead customers and lead knowledge providers, as well as facilitating access to international markets.	<b>Organisational resources</b> Policies to ensure access to information, standards, IP protection, minimum red tape and other organisational resources-like systems (such as production systems), and processes that are conducive to high-performance workplaces.	<b>Competence and human resources</b> Policies to ensure access to competent potential employees and to support continuous competence development.	<b>Resource transformation systems</b> Policies to ensure the effective and efficient deployment of available resources.
<b>Policies aimed at the micro level</b> (for example individual firms)						
<b>Policies aimed at the vertical meso level</b> (key manufacturing industry sectors)						
<b>Policies aimed at the horizontal meso level</b> (key manufacturing clusters; cross-sectoral policies)						
<b>Policies aimed at the macro level</b> (to create a conducive macroeconomic environment for manufacturing)						

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## 2. Advanced manufacturing global value chains and policy implications

Jane Drake-Brockman

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This chapter examines global value chains (GVC), how Australia lags behind other advanced economies in its participation in GVCs and the growing importance of the role of services in manufacturing GVCs.

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Patterns of global production and trade have witnessed remarkable transformations in recent decades. Two of the biggest phenomena are the rise of global value chains (GVCs) and the rise of services.

It can be helpful background, in considering international trends in advanced manufacturing, and Australia's potential to compete, to look through the lens of the emerging 21st century paradigm of GVCs and the simultaneous 'servicification'<sup>1</sup> of the global economy. Before considering these two phenomena in turn, we first need a quick explanation of how they happen to be connected.

Just as transportation and logistics services enabled international trade in finished goods for the consumer market, information technology and telecommunications services now provide the interlinkages, the orchestration and the 'glue' which has enabled the manufacturing process to fragment across borders into value chains of intermediate 'tasks'. Services inputs such as financial and professional services, marketing and distribution, are, moreover, embodied in all goods, and indeed provide on average around 25 per cent of the total value added of an exported good<sup>2</sup>. Typically the more elaborately transformed the manufactured good, the higher the value added and the greater the embodied services content. Advanced manufacturing, which is especially services intensive (often well over 70 per cent of value added), is fundamentally dependent on services inputs such as research and development (R&D), engineering and design. It follows that in modern economies, manufacturing cannot function without the intermediate and enabling services inputs – whether local or foreign – that connect up and bring together all the individual aspects of cross-border production.

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## Global value chains

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International trade can no longer be understood in terms of export or import of finished goods or services produced by one firm, at one location, in one country and thereafter delivered to an unrelated party in another country. Production of goods and increasingly of services now involves a combination of business-to-business intermediate inputs including services activities, sourced globally, to make up a finished output for the final consumer market. This fragmentation of production into goods and services tasks has seen the emergence of a system of global supply or global value chains, referred to by the World Economic Forum as *“the world economy’s backbone and central nervous system”*.<sup>3</sup>

The process giving rise to GVCs is not new, but it has evolved through a number of complex phases<sup>4</sup>. Following the trend in the 1960s towards vertically integrated firms and industries, the 1970s witnessed a wave of global dispersion of industrial activity through investment in offshoring by multinational corporations. The 1980s saw the first evidence of both geographic and organisational fragmentation (deverticalisation or unbundling) of the firm by way of both outsourcing and offshoring into cross-border protection networks. The 1990s saw yet another evolution, with the rise of China and big new global suppliers. The 2000s brought the widespread application of digital technology, the beginning of services offshoring, global knowledge and innovation networks and the rise of India.

It is now well understood that any business function can become a core competence, or be outsourced (to another separate provider, for which the outsourced task becomes the core competence). Most can also be offshored, that is outsourced to an offshore location, leading to new competitive opportunities for both country and firm-level specialisation. Within this global context, supply chain activity has been most pronounced in geographically integrated regions, such as the European Union and East Asia. Remarkably, trade in intermediate goods is now twice as large as trade in consumption goods.<sup>5</sup>

Over a period of 20 years or so, firms everywhere, but especially in Asia-Pacific, have participated increasingly actively in the resulting regional production networks, enjoying increasing levels of inward direct investment as they did so. The benefits have been somewhat uneven; typically, small or remote manufacturers have had trouble capturing overseas goods markets generally due to difficulties achieving the necessary scale and volume.

Some commentators suggest that we are now in the midst, in a fast globalising world economy in which services play a much bigger role, of another major wave of GVC activity described as a second unbundling.<sup>6</sup> This is borne out by the long term trend in foreign direct investment flows towards services,<sup>7</sup> with the likely impact on small and medium sized enterprises (SMEs) potentially more positive, as scale tends to matter less in services markets than nimbleness and project by project flexibility.

With intermediates now accounting for more than half of merchandise imports by OECD economies and close to three-quarters of merchandise imports for large

developing economies, such as China and Brazil<sup>8</sup>, there has been a shift in the public policy interests and activities of companies. Both multinationals and SMEs have become interested not only in lowering trade barriers abroad in order to access export markets – but also in benefiting from lower barriers for imported intermediate inputs. Lower barriers for imports have become nearly as important as access to export markets in firms' quests to remain competitive. Development of know-how and intellectual property has also become more important.

Researchers, such as Gary Gereffi at Duke University have mapped a number of specific industry value chains, and shown where individual countries' firms are located on these maps.<sup>9</sup> The length of the chain, for any industry, is not static, especially as the second unbundling unfolds, but in general the chains are longer in the manufacturing sector than in agriculture, mining or services.<sup>10</sup> Microeconomic work of this nature is helpful in identifying chokepoints in cross-border production, but very little such work has yet been conducted for Australia. Work of this nature requires use of firm level data and input/output tables, rather than traditional balance of payments statistics.

In 2011, the World Trade Organization (WTO) and the Institute of Developing Economies-Japan External Trade Organization (IDE-JETRO) pioneered the way with a ground-breaking study on trade in tasks which showed how the emergence of GVCs radically challenges the concepts behind traditional measurement of trade flows.<sup>11</sup> The study highlighted the fact that as trade in intermediates becomes more important, traditional trade statistics become less meaningful, as they fail to reflect value added (i.e. the value of exports minus imported inputs). Understanding current patterns of production and trade, and the economic significance of Australia's own participation or lack of participation in GVCs, requires analysis using the new WTO/OECD Trade in Value-Added (TiVA) data released in 2012<sup>12</sup>. While the data is still very limited, this paper is a first attempt at such research. However, first we need to understand the second major phenomenon, the rise of services.

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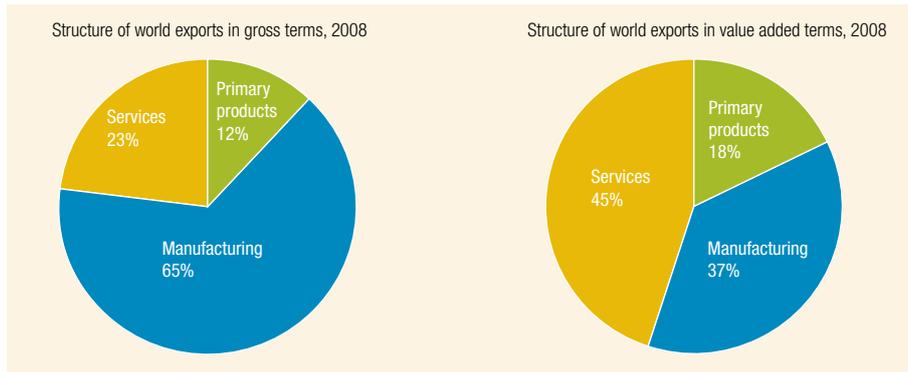
## Servicification

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It is a more recent phenomenon, but globalisation is bringing about a similar transformation in services as took place in manufacturing. Traditionally, services providers were constrained by their inability to capture, store and possess the value of the intangible. There were few opportunities to create step-by-step pathways to market as services tend to be delivered and consumed simultaneously. However, telecommunications reforms and the application of digital technology to a widening range of business services are now driving a rapid emergence of supply chains in services. The innovative business process transformation involved is affecting SMEs as well as creating globally integrated services firms.<sup>13</sup>

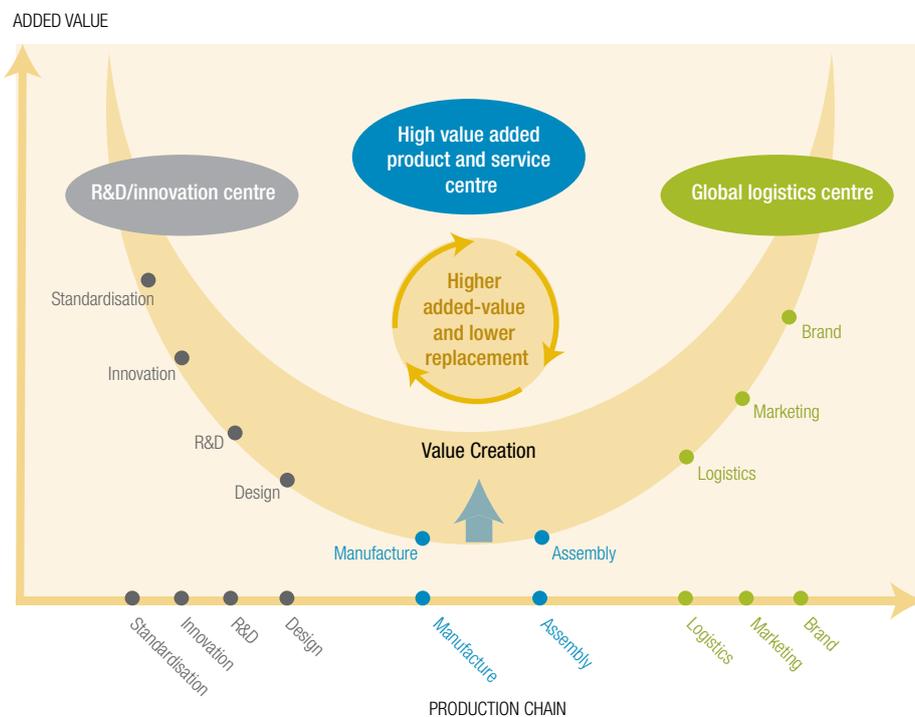
There is now a constant quest in the services sector to segment out any business function in which knowledge can be commoditised and packaged as a product, ownership can be established, production can be scaled up and trade can take

**FIGURE 1**  
THE IMPORTANCE OF TRADE IN SERVICES



Source: WTO Secretariat

**FIGURE 2**  
THE 'SMILEY FACE': ROLE OF SERVICES IN HIGH VALUE ADDED MANUFACTURING



Source: Business Week International (2005)

place separately from production. Services intermediates (generally described as knowledge-intensive business services) are now the fastest growing component of world trade and services have now been shown to be approaching half of world trade in value added.

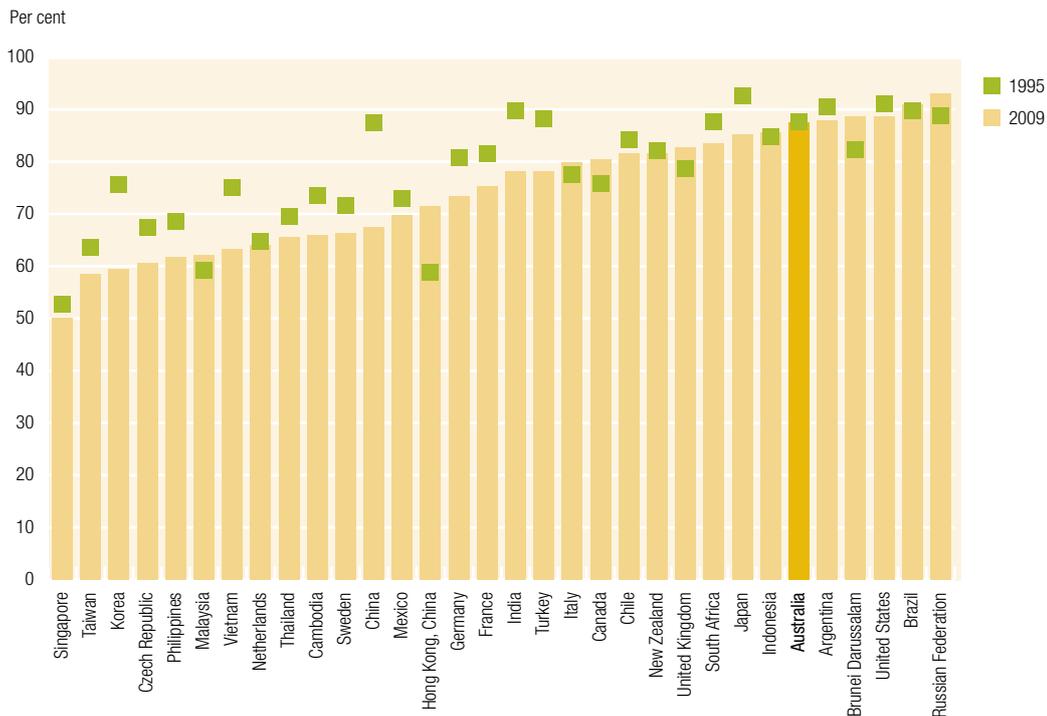
As Stanley Chih of ACER computers demonstrated in his famous Smiley Face<sup>14</sup>, for many advanced manufactures, the highest value added is now contributed by services inputs, often at the R&D and design phase, or at the logistics/distribution phase. More than 50 per cent of the iPod's value, for example, has nothing to do with merchandise components and everything to do with the services activities involved in conception, design, retail and distribution. The iPhone is an even stronger example where merchandise components represent less than one third of the total value of the final product.<sup>15</sup>

## Australia's role in manufacturing GVCs

The new OECD/WTO TiVA database covers, in its initial stages, 58 countries and 18 aggregated groups of industries (both goods and services) over the years 1995 to 2009. For any country, the percentage of domestic value added (DVA) in gross exports can be understood as a general reflection of the level of integration into GVCs: the lower the share of domestic content, the more integrated the country is. High percentages can be expected of course in large economies which can source inputs domestically. High percentages can also be expected in geographically isolated economies, in countries with high levels of trade barriers, in economies with exports dominated by upstream activities with little local value added such as mining and perhaps in economies with strong services export performance (export of pure services, as distinct from services embodied in goods). Figure 3 compares Australia with a range of other economies.<sup>16</sup>

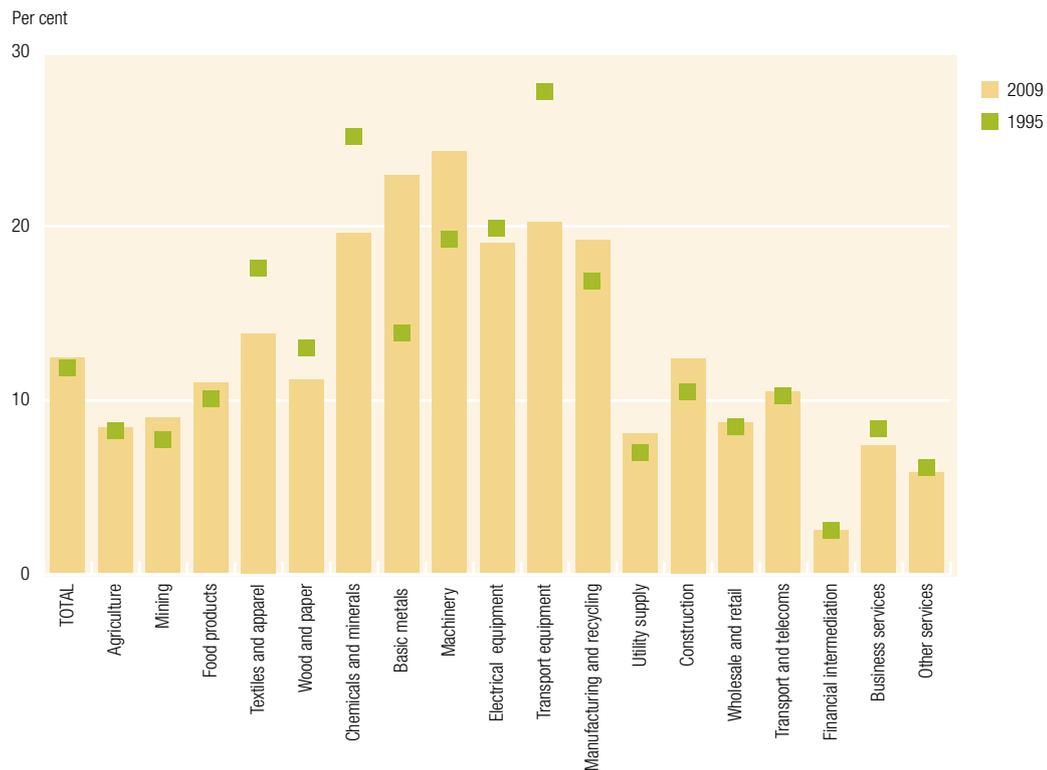
Perhaps unsurprisingly, given the geographic remoteness and the dominance of mining exports, the share of domestic content in Australian exports is over 87 per cent, well above the OECD average of 76 per cent, the Association of Southeast Asian Nations (ASEAN 8) average of 70 per cent and 67 per cent for China. This share has seen no more than a trivial drop over the last 15 years. The reality is that Australian industry has had persistent difficulty accessing and participating in global and regional value chains.

**FIGURE 3**  
DOMESTIC VALUE ADDED AS A PERCENTAGE OF GROSS EXPORTS, SELECTED COUNTRIES



Source: Authors calculations OECD/WTO TiVA data base

**FIGURE 4**  
**FOREIGN VALUE ADDED AS A PERCENTAGE OF GROSS EXPORTS BY SECTOR,**  
**AUSTRALIA**



Source: Author's calculations OECD/WTO TIVA database

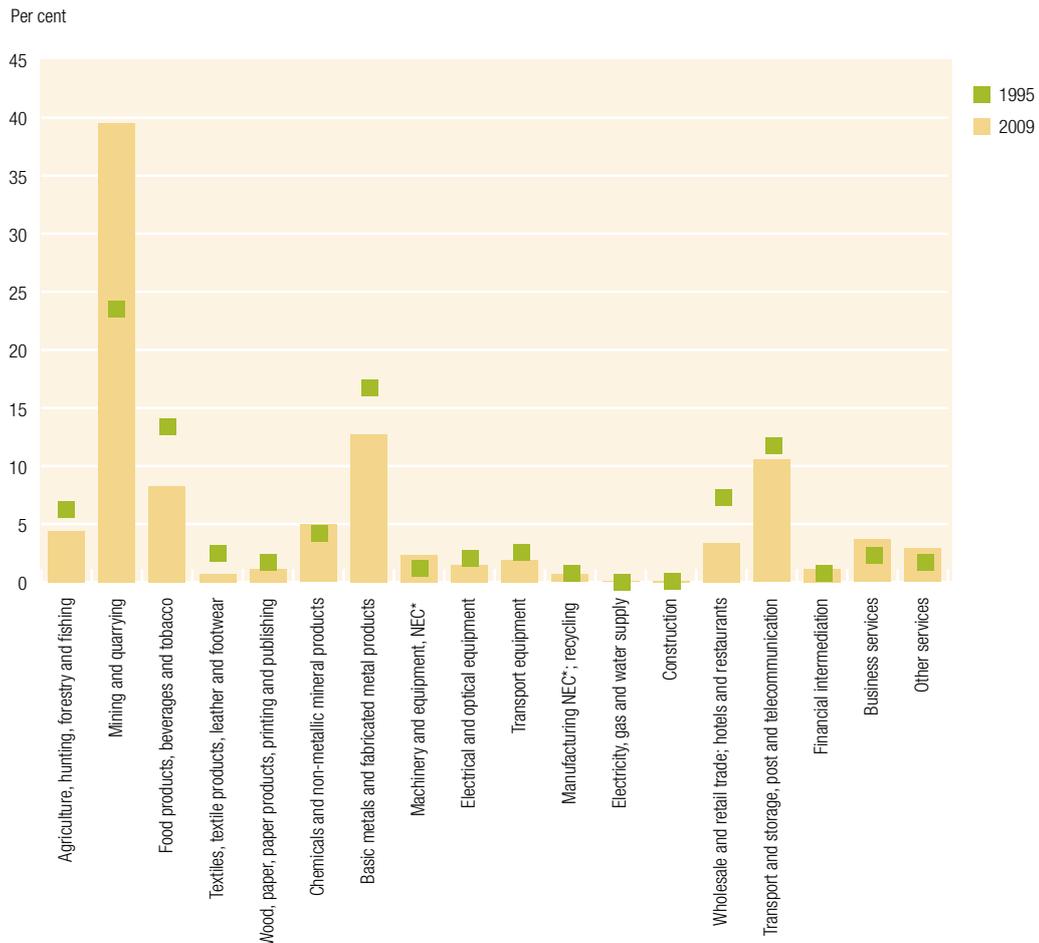
Figure 4 plots the foreign value added (FVA) share in gross exports by sector. For Australia the average foreign content is a mere 12.5 per cent, compared with a world average of 28 per cent and an average for developed economies of 31 per cent. Again this reflects very low engagement in GVC activity, again barely increasing since 1995.

Agriculture, mining and services exports drag this overall figure down, with average foreign content around eight per cent. Financial services have an especially low imported foreign content of less than 2.5 per cent. In the high value-added services sectors, these low figures can be good news, signalling a high degree of local competitiveness. But for the manufacturing sector, the relatively low figures run counter to global trends and signal potential red alerts.

The global experience suggests we should see a rise in foreign content since 1995. In Australia's case, the increase over 15 years has been marginal except in a couple of key sectors. Machinery has the highest foreign content at 24 per cent, up significantly from 19 per cent in 1995, followed closely by basic and fabricated metals at 23 per cent, accelerating up from 14 per cent in 1995. This makes sense, given that these industries are among those with the relatively longest production chains. Drops in foreign content have been experienced, however, in textiles and textile products, wood and paper and chemicals.

To understand and assess these sectoral developments, we need to look also at Figures 5A and 7. In general, if foreign content is dropping and global integration is therefore seemingly declining, we want to see a compensating rise in services

**FIGURE 5A**  
SECTOR SHARES OF EXPORTED DOMESTIC VALUE ADDED, AUSTRALIA

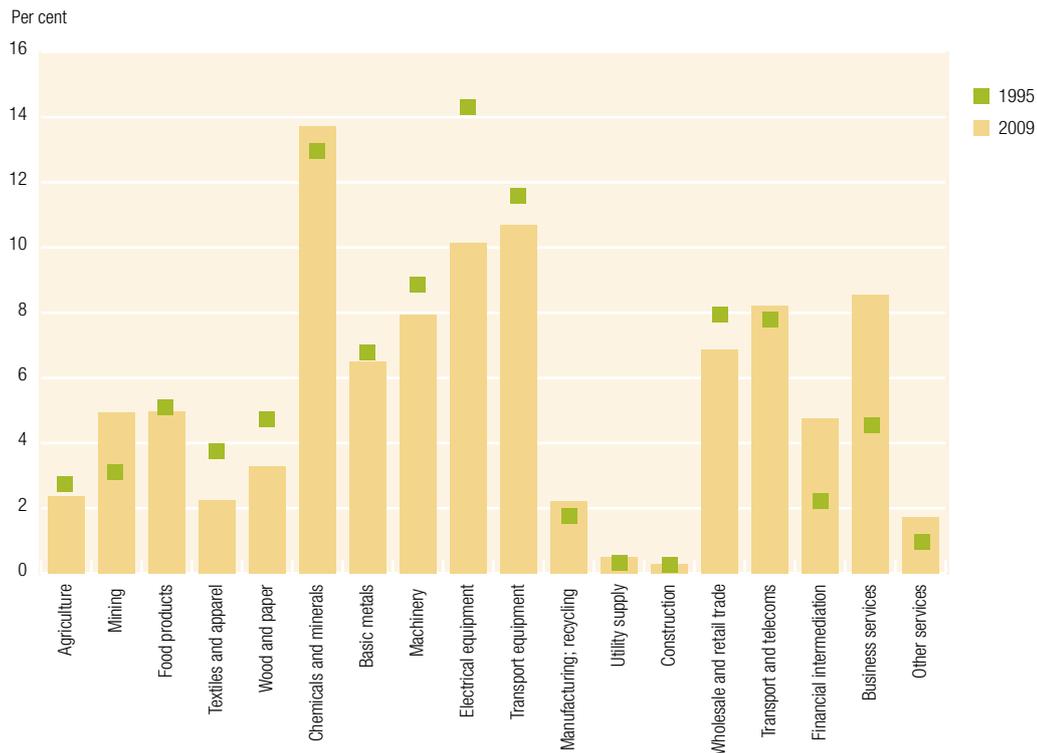


Source: Author's calculations OECD/WTO TIVA data base \*NEC – Not elsewhere classified

value added in that sector or a rise in the sector's share of exported DVA, indicating a movement to higher value added tasks or the attraction onshore of final assembly. In the case of textiles, wood and paper and also chemicals, while exports are not major contributors to gross domestic product (GDP), Figure 7 does show that the services content has indeed been increasing over the last 15 years and that most of this services content is domestic. These are healthy trends.

Figure 5A also shows of course that mining and quarrying contributes 40 per cent of Australia's exported DVA – and that this share has increased dramatically from 23 per cent in 1995. Metals contribute another 13 per cent, but this is a significant drop from 17 per cent in 1995. So while the foreign content in metals exports has increased, the local industry's overall contribution to export growth has declined. In other words, while the industry has become more integrated in global markets, it has also become less important to the economy – i.e. the economy itself is still not very geared toward GVC participation. The next most significant sector is the aggregation of transport and storage and post and telecommunications, which has also declined in importance but nevertheless still contributes 11 per cent of exported DVA. Agriculture has dropped in importance, as has food and beverages.

**FIGURE 5B**  
SECTOR SHARES OF EXPORTED DOMESTIC VALUE ADDED, OECD



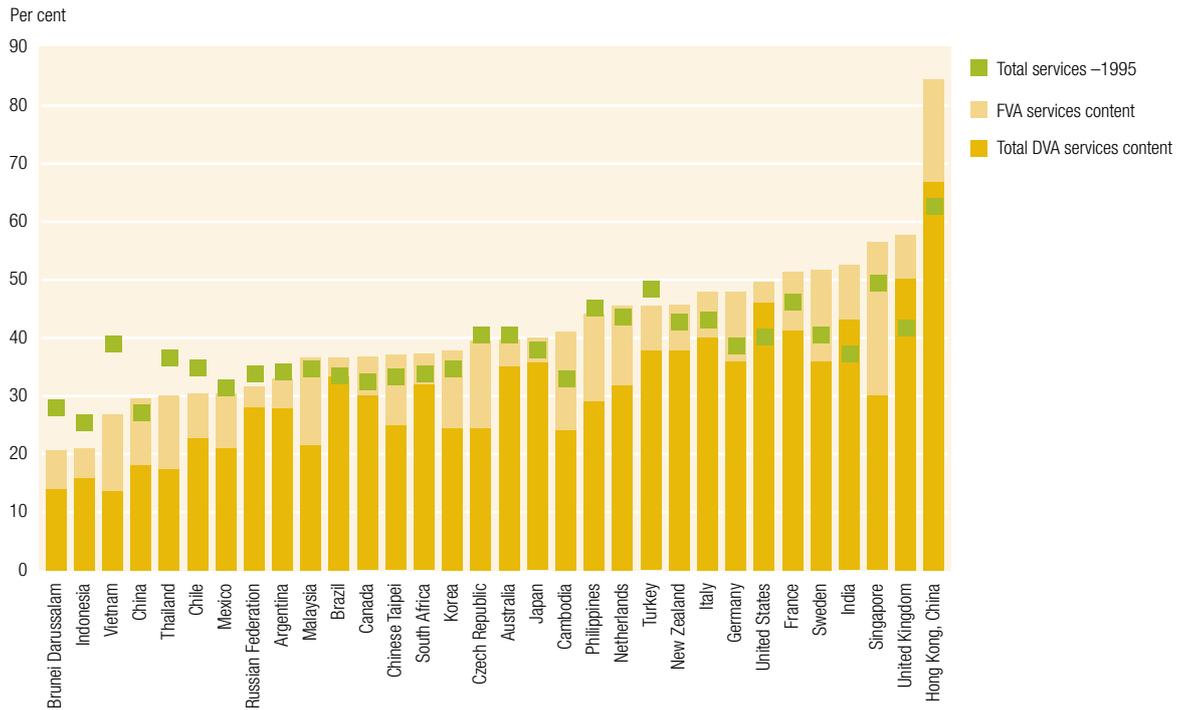
Source: Author's calculations OECD/WTO TiVA data base

For purposes of comparison, Figure 5B presents the OECD average, showing clearly that Australia is relatively under-integrated with the global economy, not only in the manufacturing sector, but also in the services sector, where competitive domestic content overwhelmingly prevails.

The TiVA data also identifies the services content of gross exports, measuring a composition of both pure services exports as well as services embodied in goods exports, and reflecting the general level of sophistication of a country's exports. In Australia's case, the services content of exports has actually declined marginally over the last 15 years to just under 40 per cent as shown in Figure 6. This is 10 percentage points below the OECD average. Australia's share is possibly artificially low, affected by the increased overall dominance of the mining sector. To decide how problematic the situation is, we need to drill down and examine the trend in services content embodied in exports of the other sectors.

Figure 7 confirms that embodied services content has actually increased since 1995 in most exported sectors other than mining, the exceptions being base and fabricated metals and electrical and optical equipment. For most sectors, then, we can infer an increase in the sophistication of production techniques (which have higher services intensity) or an increase in supporting services roles. However, for metals and electrical and optical equipment, the data raises another potential red alert. Importantly, moreover, the percentage of imported foreign services content is noticeably higher in the metals and electrical and optical sectors than is the case for other industries. So while these industries are more integrated into GVCs, as shown in Figure 4, it seems largely because of a higher level of

**FIGURE 6**  
SERVICES CONTENT AS A PERCENTAGE OF GROSS EXPORTS, BY COUNTRY



Source: Author's calculations OECD/WTO TiVA data base

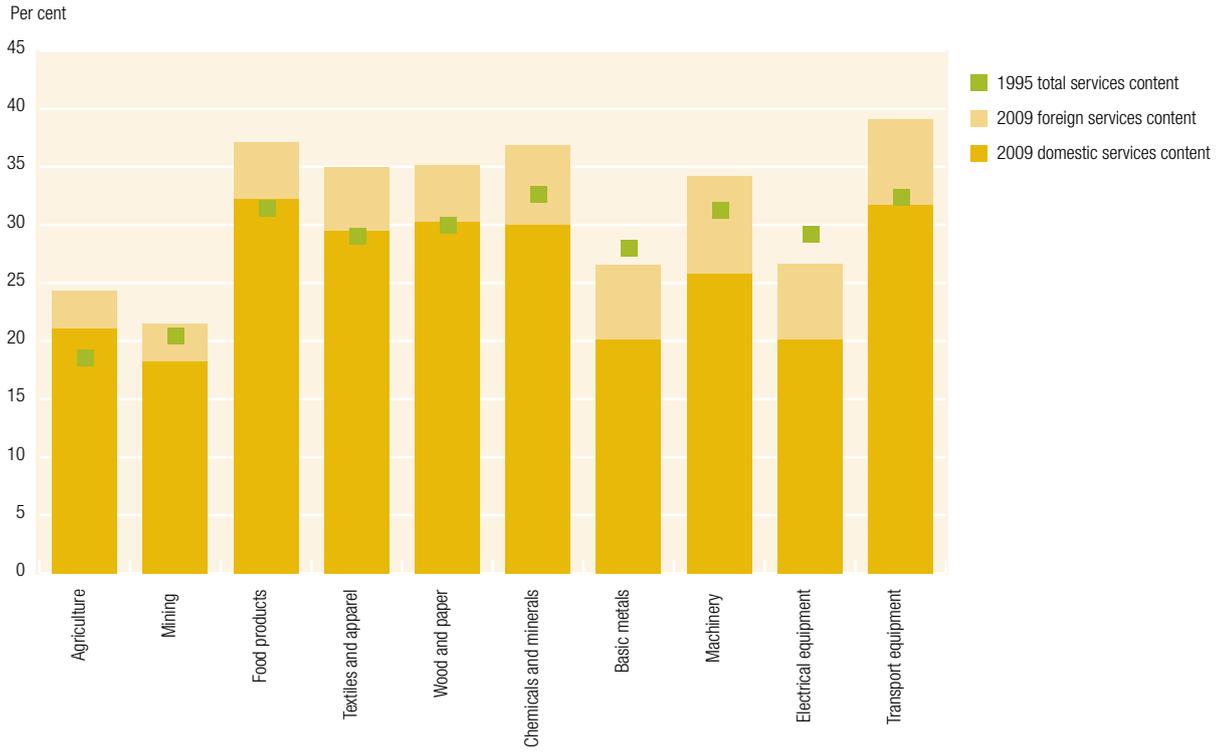
imported high value added services content. This is worrying, if the objective is both to increase Australia's access to GVCs and at a higher level of value added.

It is also possible, from the TiVA data, to compute revealed comparative advantage (RCA). The services sector data being relatively limited, the OECD recommends this only for the goods sectors at this stage. Both the balance of payments and the TiVA data show, in Figure 8, that in the goods sectors, Australia has comparative advantage only in basic and fabricated metals and in food products and beverages (RCA exceeding a measure of one on the vertical axis in Figure 6). Importantly, taking into account the imported foreign content, Australia's comparative advantage in metals is revealed to be lower than the balance of payments would suggest. This is an alert for both the metals industry – and the local services sector. More research needs to be undertaken to flesh out these initial insights.

The next step in the research process should be to map the metals industry value chains. Drawing up value chain maps which cover not only the core business but also all the complementary industries that add value upstream or downstream from the core competencies can be helpful to guiding both policy and business settings. Such mapping can help identify the critical inputs to competitiveness and possible choke-points in any distinct domestic services sub-sector. Value chain mapping should be an essential step in developing any advanced manufacturing industry roadmap for Australia.

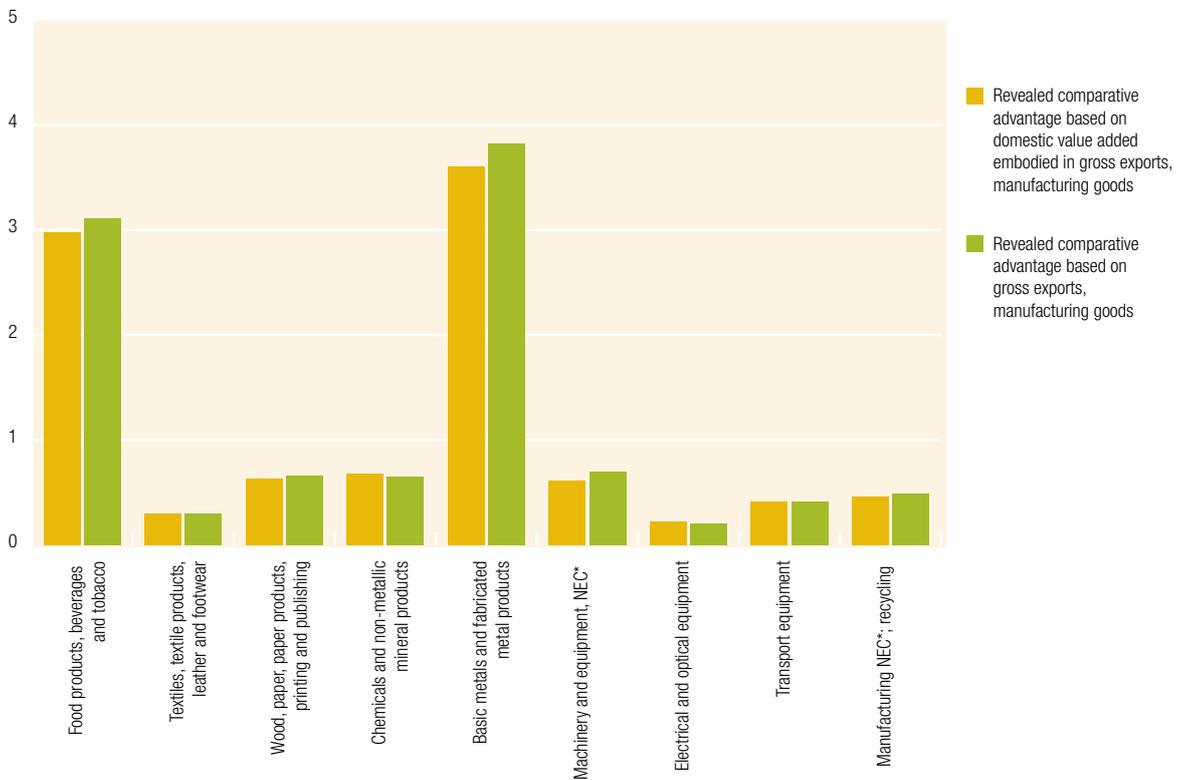
A final insight from the new TiVA data. The OECD computes an overall GVC Participation Index based on the percentage of a country's total exports which

**FIGURE 7**  
SERVICES CONTENT AS A PERCENTAGE OF GROSS EXPORTS, AUSTRALIA



Source: Author's calculations OECD/WTO TIVA data base

**FIGURE 8**  
AUSTRALIA'S REVEALED COMPARATIVE ADVANTAGE, GOODS



Source: Author's calculations OECD/WTO TIVA data base  
\*NEC – Not elsewhere classified

are engaged in GVC activity. The index is broken down into ‘backward participation’ i.e. imported inputs and ‘forward participation’ i.e. the exports that are destined as inputs into other countries’ exports. In Australia’s case, the index is relatively low, at just over 40 per cent, with two-thirds of exports of intermediates destined for further processing offshore. Korea, for the purposes of comparison, has a GVC participation rate of over 60 per cent, with roughly two-thirds of the activity being backward participation.

What does this all mean regarding the future prospects for Australian participation in advanced manufacturing chains? Clearly it means that Australia has a very long way yet to go – which raises the question of how to get there.

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## Policy implications

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There are several policy implications in this shift from traditional trade in finished products to trade in goods and services intermediates story.

In a world of GVCs, firms have increased opportunities to enter into international markets for intermediate activities by adding relatively small amounts of value added. GVCs therefore open up plentiful opportunities for new businesses, including for SMEs. Rather than having to be proficient in all aspects of production, firms can aim to capture a specialised task along the chain. This changes the way that policymakers can view competitive advantage as it can be much more fragmented internationally, than it was in the days of producing goods and services entirely at home. This also implies, in a nutshell, that a nation can rarely achieve export growth effectively, in any goods sector other than perhaps mining, if it doesn’t also import. It should also go without saying that services have become so important as intermediates in every sector, that efficiency in the local services sector has become paramount.

The servicification of manufacturing means industry policymakers need to pay greater attention to the factors that drive services competitiveness; development of human resources, research and innovation, provision of infrastructure, especially digital infrastructure as well as logistics and transport, regulatory efficiency to ensure an enabling environment for business, openness to trade, investment and cross-border people movement, adoption of global standards and quality assurance systems and the pursuit of mutual recognition for inter connectivity. Few of these factors are given or exogenous – most can be influenced by policy and regulatory settings – and will moreover impact positively on whole of economy productivity.

“Final assembly need not be the objective. Specialising in high value services tasks is the more appropriate way to go. The traditional tyranny of smallness, remoteness and distance from market is much less relevant to services tasks, including because transport costs for services are generally lower than for goods.”

What policy recommendations might follow in a quest to enhance Australia's readiness for engagement in advanced manufacturing GVCs?

At the simplest level, a strategy for Australian industry engagement in advanced manufacturing requires a focus on developing capacity in the intermediate services inputs. Final assembly need not be the objective. Specialising in high value services tasks is the more appropriate way to go. The traditional tyranny of smallness, remoteness and distance from market is much less relevant to services tasks<sup>17</sup>, including because transport costs for services are generally lower than for goods. Successful capture and financing of a task within an advanced manufacturing GVC may also require the attraction of foreign direct investment. Sustained innovation will be another essential key to attracting and retaining global business. This will require an innovation policy more closely geared to the needs of services innovation and focussed on facilitating collaborative links between services firms and the R&D community.

“From an Australian perspective, given the narrow range of comparative advantage in the goods arena and its consequent meagre participation in manufacturing GVCs, the trade policy focus needs to shift firmly to services.”

Promoting Australia as a location for advanced business tasks will require a dedicated focus on all of these elements. The export promotion mission will need to shift more radically from sales of finished products to international consumer markets, to sales of problem solving skill sets to international business clients looking to outsource intermediates.

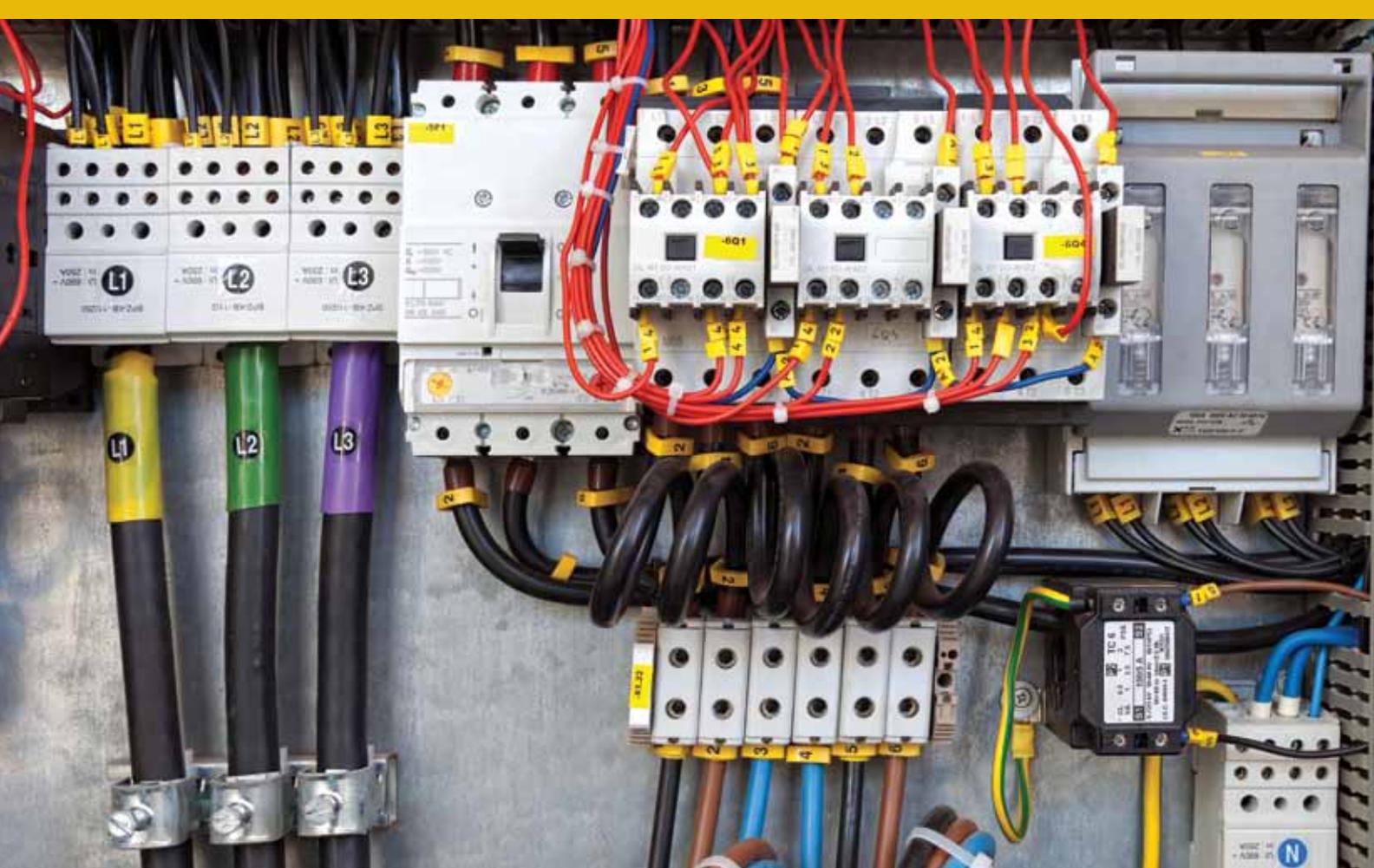
This will impact also on Australia's trade negotiating priorities. Some global commentators<sup>18</sup> describe the last 15 years of bilateral trade negotiation as essentially driven by business interests in facilitating integrated networks for GVC activity, given the WTO has lagged behind in negotiation of rules relevant to GVCs, for example with respect to investment and competition policy. From an Australian perspective, given the narrow range of comparative advantage in the goods arena and its consequent meagre participation in manufacturing GVCs, the trade policy focus needs to shift firmly to services. Australia is rightly playing a leadership role in the plurilateral negotiations for a Trade in Services Agreement. These negotiations present a long overdue opportunity to highlight Australian capacity and competitiveness in a very wide range of knowledge-intensive activities.

As pointed out by Michael Enright in a recent address on competitiveness to the regional business community<sup>19</sup>, countries in the Asian region have excelled at building global and more specifically regional supply chains for delivery of goods to western markets. As the data presented here confirms, Australia can hardly be described as having been a significant player in this manufacturing game. The task ahead for the region as a whole is to build global and especially regional value chains of both goods and services, but this time geared more, as Enright says, for the high growth emerging Asian markets. Australia's objective should be to ensure that this time around, Australia is a major player, bringing services expertise and infrastructure to bear, attracting investment financing and capturing business-to-business markets for high value added services tasks.

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## Endnotes

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- 8 WTO, International Trade Statistics 2011, "Trade in commercial services" accessed at 24 from [http://www.wto.org/english/res\\_e/statis\\_e/its2011\\_e/its11\\_trade\\_category\\_e.pdf](http://www.wto.org/english/res_e/statis_e/its2011_e/its11_trade_category_e.pdf) 24 February 2013.
- 9 Geferri, G 2011, *Global Value Chain Analysis and its Implications for Measuring Global Trade*, Presentation at the Global Forum on Trade Statistics: Measuring Global Trade-do we have the right numbers? WTO, Geneva, 2011.
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### 3. Advanced manufacturing: A smarter approach for Australia

## Innes Willox

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This chapter highlights the need for a more advanced approach to manufacturing in Australia. Centred on value creation, this approach will require further skills development, enhanced collaboration and changes to the perception of Australian manufacturing.

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## The need for a fresh manufacturing approach

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Manufacturers are having a tough time in most developed countries. In Australia, a variety of international and domestic factors are contributing to a prolonged period of especially difficult trading conditions for local manufacturers. These have been widely explored and include global challenges such as the disruption to trade markets wrought by China and other emerging economies and the economic downturn following the Global Financial Crisis, as well as more specifically Australian challenges – the high Australian dollar, unit labour costs and the sharp rise in energy prices.

Since its all-time peak in mid-2008, prior to the GFC, Australian manufacturing production has been heavily impacted by these challenges. Total output volumes, employment and aggregate corporate profits dropped by around 10 per cent, 14 per cent and 40 per cent respectively, over the five years to 2013.<sup>1,2,3</sup> After a partial recovery in 2009–10, the national Australian Bureau of Statistics (ABS) data and the Australian Industry Group’s Australian PMI®<sup>4</sup> have shown a steady contraction in manufacturing activity since mid-2010, relieved only sporadically

by temporary spikes in local orders (most recently for example, following the Federal Election in September 2013). A major cost squeeze and a consequent drop in aggregate profits and profitability across manufacturing have been apparent throughout these past five years, as the sector has experienced significant cost increases that are hard to pass on in a flat but ultra-competitive market. Combined with difficulties in raising capital for new investments, this has inhibited many businesses' ability to invest in new technologies or to generate sufficient productivity growth to remain competitive.

It is against this challenging backdrop that many people – in business, policy and other areas – are thinking about the direction that manufacturing might take in Australia. A focus on advanced manufacturing is often seen as the pathway to improving the security and prosperity of Australian industry. As discussed in this paper, Ai Group also believes that advanced manufacturing will generate many opportunities for Australia, although if we are to capture a share of these opportunities, the public and private sectors need not just to lift their game, but to change the game that they play. The human element will be critical to achieving this, including the skills and knowledge of individuals, the ways we combine and use our intellectual capital and the way we perceive the manufacturing industry.

To better explain this position we feel it is important to first define exactly what we mean by advanced manufacturing. For many people advanced manufacturing brings to mind thoughts of high-tech sectors and innovative technologies and is contrasted with old or traditional fields of manufacturing. However, a much deeper transformation is underway across a broad swathe of manufacturing sectors. This is changing how products are designed, produced, distributed and marketed in global supply chains; it is leading to new business structures; and it is altering business acquisition and use of information, knowledge and resources. Ai Group argues that the idea of advanced manufacturing is about much more than particular high-tech industries and their products. Rather the distinguishing feature of advanced manufacturing is more about the approach to creating value around any manufactured product.

“Defining advanced manufacturing as an approach does not restrict opportunities to specific sectors – any manufacturer in any sector can become an advanced manufacturer. It isn’t limited to particular technologies, and it isn’t even limited to production.”

Defining advanced manufacturing as an approach does not restrict opportunities to specific sectors – any manufacturer in any sector can become an advanced manufacturer. It isn’t limited to particular technologies, and it isn’t even limited to production. Further, it recognises that advanced manufacturing is not some sort of line in the sand, at least not a static one, but a smarter approach to manufacturing that constantly needs to be reviewed and revised. It embraces the inevitability that manufacturing as we know it will change almost beyond recognition in the future. Ongoing change has been and will remain a certainty for manufacturers. As such, the precise definition of advanced manufacturing is hard to pin down, but it can be helpfully illustrated by the examples in Table 1.

**TABLE 1**  
**CHARACTERISTICS OF TRADITIONAL AND ADVANCED MANUFACTURING**

Traditional manufacturing	Advanced manufacturing
<p>Focused on the production of goods</p>	<p>Value creation is extended, so manufacturing is no longer just about production – services and manufacturing are inextricably linked, so that production is now the core of a much wider set of activities – the ‘virtual’ part of the total business – geared towards creating a tailored experience for individual consumers</p> <ul style="list-style-type: none"> <li>• In 2011, only 28 per cent of Australian manufacturers with more than 100 employees derived value from services related to their products, compared with the United States and Finland, where the figure was closer to 55 per cent of manufacturers.</li> <li>• Newcastle-based <b>Banlaw</b> decided some years ago that it needed to move away from just being a manufacturer of fuel management systems to a company that helps unify its clients’ fuel supply with products, systems and ongoing support. Service provision now accounts for about 30 per cent of Banlaw’s revenue and has enabled the company to diversify its offering and revenue from existing clients, as well as providing a ‘way in’ for new clients.</li> </ul>
<p>Much of the workforce is employed in low skilled, blue collar or production roles. Technical competencies are much more common than commercial competencies</p>	<p>High skilled operations that harness a wider skill base, including both technical and commercial competencies, and employ fewer people on the factory floor</p> <ul style="list-style-type: none"> <li>• <b>ResMed</b> designs, manufactures and distributes devices to assist those with sleep-related respiratory disorders. The company’s highly qualified employees, including medical and engineering researchers, clinicians and technicians, have been awarded numerous scientific and research accolades. The company’s founder was named the US 2005 Entrepreneur of the Year in Health Sciences, the 2001 Australian Entrepreneur of the Year, and is Chair of the Executive Council of the Harvard Medical School Division of Sleep Medicine (2010).</li> </ul>
<p>Firms compete on the basis of their own strengths. Competitiveness is based on stocks of knowledge, mostly developed and retained in house. Strategies focus on the company: cost control, ‘total quality’ and continuous productivity improvement</p>	<p>A solely internal focus is no longer sufficient to be competitive. Competitiveness is based on the ability to identify and harness globalised knowledge flows – the production, diffusion and use of knowledge. Individual firms cannot access all the information required to be competitive, so the depth and quality of a company’s networks and interactions is critical to its competitiveness.</p> <ul style="list-style-type: none"> <li>• Knowledge production has shifted from individuals to groups, and includes interactions between organisations across sectors, fields and borders.</li> <li>• Businesses are connected to ‘global webs of activity’ and value chains compete against each other to deliver value to customers.</li> <li>• <b>Landis+Gyr</b> is a global leader in total metering solutions for electricity and gas. The company’s Sydney research and development (R&amp;D) centre is viewed as an important innovation hub. Staff at the Sydney office have seized opportunities in Asia by identifying and partnering with best-in-class companies across the industry value chain and investing in R&amp;D capabilities to provide customised products for local customers in the region. More recently, the company has partnered with utility companies in China and India to install smart metering solutions that will enable businesses and consumers to manage energy better.</li> </ul>

Traditional manufacturing	Advanced manufacturing
<p>Mass manufacturing of commodity goods – “Any colour, so long as it’s black” approach – with manufacturing functions typically bound to localities and conducted in large capital and labour intensive factories</p>	<p>Firms rapidly and economically adapt physical and intellectual capital to exploit changes in technology, markets and customer demand.</p> <ul style="list-style-type: none"> <li>• A strong customer orientation, including mass customisation or short runs.</li> <li>• The changing workplace – greater flexibility in how and where people are employed.</li> <li>• Global firms operating across national boundaries and in close proximity to cheap manufacturing inputs, and large sources of demand and innovation.</li> <li>• <b>Centor</b> is a multi-award winning designer and manufacturer of architectural hardware systems and an example of a truly Australian global company. Headquartered in Brisbane, they also have production facilities in Birmingham (UK), Chicago (USA) and Nanjing (China), and distribution centres and branches across Australia and the rest of the world. As such, the company has a comprehensive distribution supply system, which automatically re-supplies Centor’s 6000 items worldwide, while managing three languages; staff in over 10 time zones; complying with 42 statutory authorities; and a lead-time of up to 211 days.</li> </ul>
<p>Energy intensive with large waste streams</p>	<p>Manufacturing processes and products are more sustainable, including a move towards low-emissions, zero waste and zero carbon manufacturing.</p> <ul style="list-style-type: none"> <li>• Manufacturing practices include built-in reuse; remanufacturing and recycling for products reaching the ends of their useful lives; turning waste streams into sources of value creation; and additive, rather than subtractive manufacturing techniques.</li> <li>• By applying innovative and cost effective ‘whole of life’ approaches to everything it does, NSW company <b>Ontera Modular Carpets</b> has nearly halved the amount of energy and water used in the manufacture of its carpet tiles; reduced waste to landfill by over 25 per cent; and increased the recycled content of its carpets by over 50 per cent. In addition to being designed for longevity, Ontera’s carpets are purposely designed for disassembly, so that individual components can be efficiently separated for reuse and recycling. The company’s EarthPlus® reuse program takes product back at the end of its useful life, and has diverted 175,000m<sup>2</sup> of carpet tile from landfill, thereby retaining the energy embodied in it.</li> </ul>

A focus on advanced approaches to manufacturing is a good fit for Australian manufacturers on a number of levels:

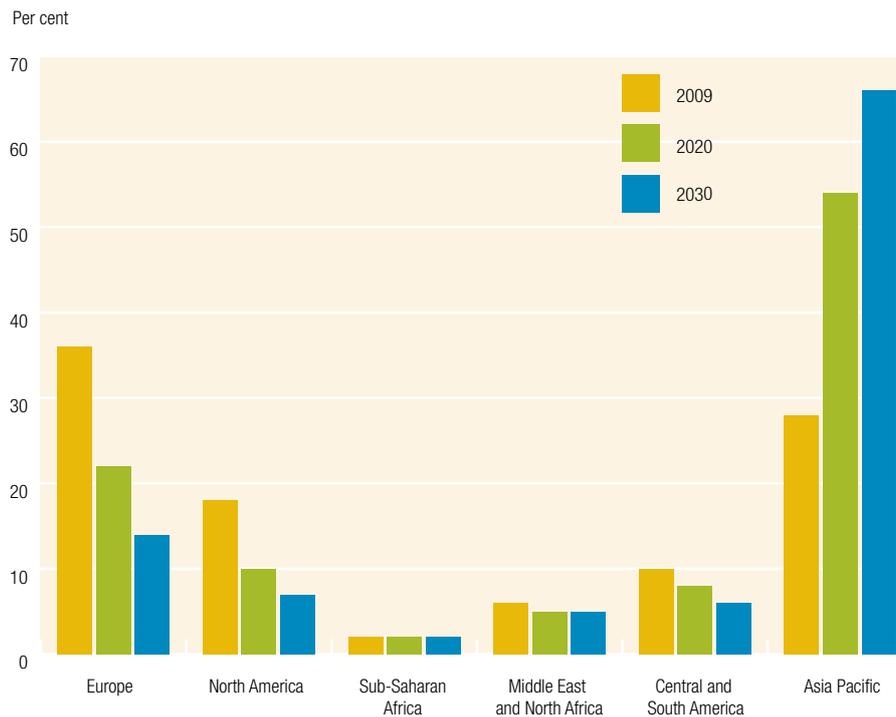
- Most advanced manufacturing production methods are more nimble and flexible and allow for better, faster customisation for individual clients. These characteristics can give Australian manufacturers a distinct edge over mass-production in local and global markets, neutralising labour cost disadvantages and turning small scale into an advantage instead of a liability. Given the relatively high proportion of Australian manufacturing businesses in the small category relative to our global peers (46 per cent of Australian manufacturing businesses employ less than 20 people and 43 per cent employee no staff<sup>6</sup>), this is particularly important.
- Advanced manufacturing is suited to the production of higher-value goods (including those requiring rapid turn-around times and/or customisation), so the high-cost base of many Australian manufacturers is not as much of a barrier as it is for mass production.
- The increasingly globalised nature of advanced manufacturing design and production reduces the disadvantage for Australian manufacturers of being located a long way from major markets or from major global innovation hubs.
- Australians tend to be early and enthusiastic adopters of enabling technologies, particularly with regard to communications such as the Internet, mobile devices and multi-platform services. This helps to globalise the workforce and to create a culture of openness to new technologies.
- Australia is well-placed to capitalise on global knowledge flows, with a large share of well-established immigrants in its workforce, as well as a sizeable diaspora of its own citizens around the world.
- Australia's strong research capabilities; ready access to a skilled workforce; and advanced education and training system, including a number of world class universities<sup>7,8</sup>, provide an existing comparative advantage in advanced manufacturing. However, as later sections of this chapter highlight, there is scope for improvement on this front, and our talents in this area could be better leveraged and orientated towards lifting commercial outcomes.

Estimates of the potential gain to be made by enhancing the adoption of advanced approaches to manufacturing in Australia are fraught. The skills and knowledge of Australia's workforce and the perception of Australian manufacturing will be critical to realising any gain, and are discussed in greater detail in this paper. How much we stand to gain depends on how far you think Australian manufacturing has

come and how much further you think it can go. If we truly want to be advanced we shouldn't be placing any upper bound on the latter. Ultimately, it will come down to the extent to which the adoption of smarter or more advanced manufacturing practices is able to boost the demand for Australian manufactured goods and associated services.

“How much we stand to gain depends on how far you think Australian manufacturing has come and how much further you think it can go. If we truly want to be advanced we shouldn't be placing any upper bound on the latter.”

**FIGURE 1**  
**GLOBAL SHARE OF THE WORLD'S MIDDLE CLASS, BY REGION.**



Source: Kharag, H. & Gertz, G. (2010), "The New Global Middle Class: A Cross-Over from West to East" in C. Li (ed), *China's Emerging Middle Class: Beyond Economic Transformation*, 2 Washington DC, Brookings.

In this respect, it is worth making a special mention of Asia. New demand is being generated out of Asia at a rapid pace and, as a result, Asia represents an extremely lucrative opportunity for Australia. As incomes in Asia have grown, an increasingly wealthy middle class has emerged, and Asia is soon expected to be home to the majority of the world's middle class (Figure 1). This has resulted in a shift in the balance of consumer markets towards Asia, which is expected to soon become the world's largest consumer of goods and services.<sup>9</sup> By 2025, Asia is likely to account for about half of the world's economic output, and four of the 10 largest economies in the world will be in the region – China (first), India (third), Japan (fourth) and Indonesia (tenth).<sup>10</sup>

Although Asia represents a sizeable opportunity, a lot is riding on Australia's ability to capture this opportunity. Australia's proximity to Asian demand and innovation will be crucial and, as a result, the rate and extent to which we develop capabilities and connections in Asia. Australia has a strong foundation to work from, and has steadily deepened its financial, political and cultural ties with Asia,<sup>11</sup> but these foundations need to be reinforced. Australia needs to better capture Asian consumer insights and develop capabilities to innovate and commercialise these insights. In addition, Australia needs to establish linkages with innovative Asian companies and institutions, as Asia is developing new knowledge at a rapid rate and is fast emerging as a world centre of innovation and technological development.<sup>12,13</sup>

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## The importance of people to the advanced manufacturing approach

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Sound policies that effectively and efficiently promote investment and productivity growth are essential to supporting the growth of advanced manufacturing in Australia. Innovation, technology, taxation settings, regulatory reform, infrastructure investment, procurement and energy policies all play their part in creating an environment that supports industry through the necessary transformation. However, ultimately it is people that create the competitive edge. People create new, disruptive processes, technologies and other innovations that drive transformative change; people identify and invest in innovation and technology; and people determine how effectively labour and capital are utilised.

In assessing the potential for Australian manufacturers to transform themselves into advanced manufacturers, it is useful to consider the concept of economic complexity and its implications for business skills and processes. Countries (or industries) with high economic complexity have both a high diversity of embedded knowledge and a sophisticated array of capabilities – the ability to do many things well – and the ability to combine and use their intellectual capital to create more sophisticated, unique and valuable products, processes and services. In advanced manufacturing, businesses will increasingly require a sophisticated mix of capabilities and skills in order to implement and manage this kind of complexity. Higher skill levels and genuine interaction across a range of disciplines and specialisations (within and between businesses) will become a necessary pre-condition to achieving global growth and maintaining a competitive advantage.

“Higher skill levels and genuine interaction across a range of disciplines and specialisations (within and between businesses) will become a necessary pre-condition to achieving global growth and maintaining a competitive advantage.”

Data indicates plenty of scope for improvement in Australia’s economic complexity. By measuring the diversity and ubiquity of manufactured goods made in 128 countries, Hidalgo and Hausmann et al. (2011)<sup>14</sup> developed a proxy for comparing the economic complexity of manufacturing in different countries. A broader range of less commoditised goods equates to higher complexity in their analysis. Using their index, Australia’s economic complexity ranked 79th in 2008, well behind other advanced manufacturing nations, including Japan, Germany and the US in first, second and 13th rank, respectively. Australia also ranked behind nations with rapidly developing manufacturing industries, including Singapore, China, Thailand and Malaysia at seventh, 29th, 31st and 34th rank, respectively. Furthermore, a longer term decline in Australia’s economic complexity accelerated between 1998 and 2008 as the range of manufactured goods being produced locally reduced.

Moving to an advanced manufacturing model is likely to require an increase in local economic complexity, probably focussing on a smaller range of distinctive manufactured goods. This in turn, will require changes in the skills and knowledge of individuals within the manufacturing sector and the ways in which their skills are combined.

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## Skills and knowledge in Australian manufacturing

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The skills and knowledge of those working in manufacturing are important to the creation and commercialisation of new innovations.<sup>15</sup> Technical skills or skills in science, technology, engineering and mathematics – so-called STEM skills – are critical to innovation and Australia’s ability to operate higher up the value chain. Technological developments are transforming the workforce, giving rise to new occupations and changing the nature of existing ones, and this is increasing demand for STEM skills. Furthermore, the extension of the value chain and enhanced customer focus is changing manufacturing from a step-by-step process to one of concurrency where design, manufacturing and market development occur simultaneously. As such, employees must be able to interpret and use information from outside their immediate discipline and increasingly need non-technical skills including leadership, management and entrepreneurial skills and the ability to be adaptable, network, communicate and negotiate.

“Hands on skills remain hugely important to the sector, but will increasingly be in the form of skilled trade roles rather than low skill professions, which are progressively becoming the domain of other sectors of the economy.”

Hands on skills remain hugely important to the sector, but will increasingly be in the form of skilled trade roles rather than low skill professions, which are progressively becoming the domain of other sectors of the economy. This transition to a higher skills base is heightening both the need and opportunity to boost foundation skills, including basic numeracy and literacy, to create pathways to higher skill employment. In fact, the opportunity for potential productivity improvement by boosting foundation skills is probably greater in the manufacturing sector than any other sector. However, for Australian manufacturing to become advanced, policies are also needed at the other end of the scale – to promote excellence in STEM skills, as well as leadership, management and other non-technical skills. Policies to both boost foundational skills and promote skills excellence would ensure a seamless transition towards the higher skill levels required for Australian manufacturing to be globally competitive.

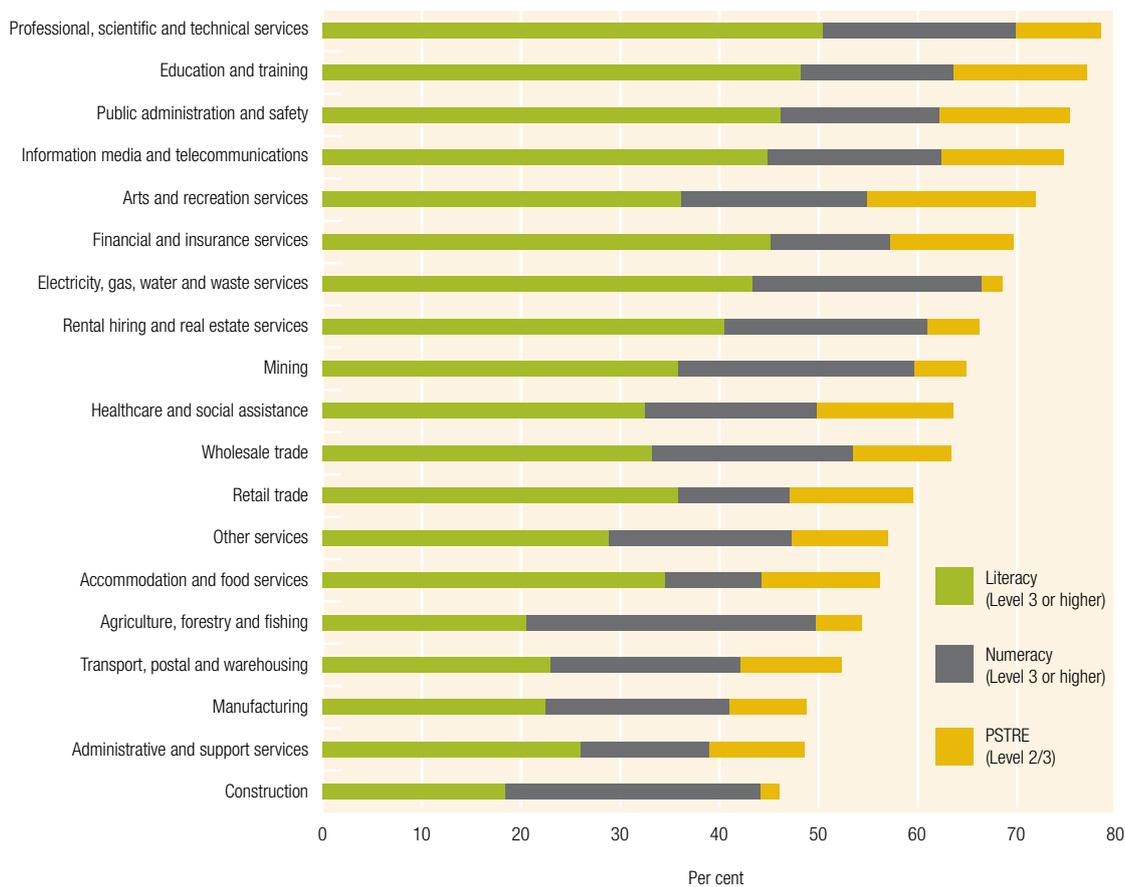
There is much to do to achieve this goal. Australian manufacturing employees perform poorly on technical, non-technical and foundation skills relative to employees in other Australian sectors. On average, manufacturing employees are more likely than employees in other sectors of Australia to have no tertiary qualifications and are less likely to have higher level tertiary qualifications (Table 2). Levels of numeracy, literacy and problem solving skills in a technology rich environment (PSTRE) in manufacturing are also lower than in most other sectors, according to a recent Programme for the International Assessment of Adult Competencies (PIAAC) study<sup>16</sup> (Figure 2). When compared to other occupations, technicians and trade workers, machinery operators and labourers had the lowest levels of numeracy, literacy and PSTRE skills.<sup>17</sup> In addition, at the other end of the skills scale, 22 per cent of manufacturing employers report that graduates with higher level qualifications in STEM subjects have a lack of workplace experience and difficulties applying their skills.<sup>18</sup>

**TABLE 2**  
**COMPARISON OF THE QUALIFICATIONS OF EMPLOYEES IN DIFFERENT SECTORS IN AUSTRALIA**

	Manufacturing	All industries average
Percentage of the workforce without post-school qualifications	45	39
Percentage of the workforce with higher level qualifications, including:		
• Diplomas and advanced diplomas; and	8	10.5
• Degrees or higher	14.5	27

Source: Australian Government (2013), Manufacturing Workforce Issues Paper, October 2013, Australian Workforce and Productivity Agency, p26.

**FIGURE 2**  
**COMPARISON OF LITERACY, NUMERACY AND PROBLEM SOLVING SKILLS IN A TECHNOLOGY-RICH ENVIRONMENT IN DIFFERENT SECTORS IN AUSTRALIA, 2011–12.**



Source: Australian Bureau of Statistics. Catalogue Number 4228.0, Programme for the International Assessment of Adult Competencies, Australia, 2013.

## How Australia's workforce compares internationally

At face value, the skills and knowledge of Australia's workforce appear to compare favourably to those of other countries (Table 3). Compared to the Organisation for Economic Co-operation and Development (OECD) average, Australia has more skilled professionals and research and development personnel in the workplace and more tertiary educated people in the working-age population, including more PhD graduates. Moreover, Australia's Programme for International Student Assessment (PISA) scores – which test the mathematical, reading and scientific literacy of 15-year-old students from 64 different countries at a time when they are nearing the end of the compulsory years of schooling – indicate that Australian students, on average, perform better than students in other OECD countries. This knowledge will be important to boosting advanced manufacturing in Australia. However, as Table 3 reveals, there is still a considerable gap between Australia's performance in these indicators and the top performers in the OECD. Outside of the OECD, Australia is also outperformed by a number of Asian countries and regions, including Shanghai, Singapore, Hong Kong, Taiwan and Macau, when PISA scores for reading, mathematics and science are considered.<sup>19</sup> In fact, students in Shanghai performed so well in mathematics that the OECD report compares their scoring to the equivalent of nearly three years of schooling above most OECD countries.

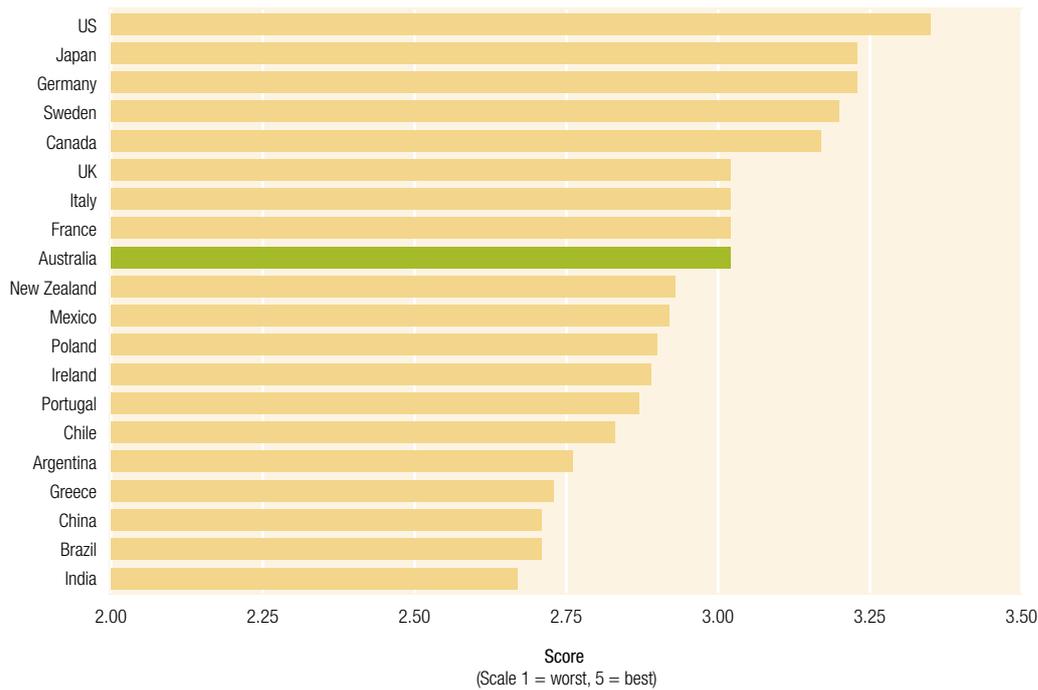
**TABLE 3**  
COMPARISON OF AUSTRALIA'S PERFORMANCE AGAINST A NUMBER OF HUMAN RESOURCE INDICATORS WITH THE PERFORMANCE OF OTHER OECD COUNTRIES\*

	Australia's score	OECD average score	OECD top 5 average score
R&D personnel as a per cent of total employment <sup>1</sup>	1.26	1.16	1.84
Share of professionals and technicians in total employment ( per cent) <sup>2</sup>	36.1	31.8	42.4
Total researchers in industry as a per cent of the national total <sup>3</sup>	29.92	59.49	74.42
Total expenditure on educational institutions as a percentage of GDP (per cent) <sup>3</sup>	6.13	6.26	7.68
PhD graduation rate (per cent) <sup>3</sup>	1.89	1.59	2.74
Percentage of 25–34 year olds with a bachelor degree or higher <sup>3</sup>	35	29.5	40.2
Proportion of population aged 25-64 attaining tertiary education (per cent) <sup>3</sup>	38.3	31.5	45.4
– aged 25–34	44.6	38.6	54.7
Proportion of population aged 25-64 attaining upper secondary or post-secondary non-tertiary education (per cent) <sup>3</sup>	35.7	44.0	67.2
Proportion of population aged 25-64 attaining below upper secondary school education (per cent) <sup>3</sup>	25.9	25.2	9.8
Program for International Student Assessment (PISA) mean scores on reading <sup>4</sup>	512	496	529
Program for International Student Assessment (PISA) mean scores on mathematics <sup>4</sup>	504	494	533
Program for International Student Assessment (PISA) mean scores on science <sup>4</sup>	521	501	539

Sources: [1] OECD, Main Science and Technology Indicators database, 2013/1. [2] OECD (various), Science, Technology and Industry Scoreboard. [3] OECD (various), Education at a Glance. [4] OECD, PISA 2012 Results.

\*Data for 2010–11 or the latest available year

**FIGURE 3**  
**AVERAGE MANAGEMENT PERFORMANCE IN MANUFACTURING**



Source: Bloom, N.; Genakos, C.; Sadun, R. & Van Reenen, J. (2012), Management Practices Across Firms and Countries, NBER Working Papers 17850, National Bureau of Economic Research, Inc.

A time series analysis of Australia’s performance in PISA tests indicates that, although still above the OECD average, Australian students’ performance in mathematics and reading has deteriorated over the last decade, while our performance in science has been relatively stagnant. Only 12 other countries experienced deterioration in their mathematics performance between 2003–2012, while only five countries experienced deterioration in their reading literacy between 2000–2012.<sup>20</sup> The deterioration in Australia’s reading and mathematics performance means that students today are about half a year behind where they were a decade ago.<sup>21</sup> And while Australia’s declining achievement has been fuelled by both a fall in the number of students achieving at higher levels and a rise in the number of students achieving at lower levels, our PISA scores remain among the most diverse in the world. In Australia, approximately two-and-a-half years of schooling separate the mathematics, reading and science scores of students in the highest socioeconomic group and students in the lowest socioeconomic group.<sup>22</sup> OECD statistics for 2010–11 indicate that just over one quarter of the working age population has not obtained a basic (below upper secondary school) secondary school education.<sup>23</sup>

Given the strong relationship between educational attainment and literacy, numeracy and PSTRE proficiency in the workforce,<sup>24</sup> the deterioration and inequity in the performance of Australia’s students is particularly concerning. As our expenditure on educational institutions as a percentage of GDP is also slightly below the OECD average,<sup>25</sup> it could be expected that this trend may continue and will impact our ability to compete with other advanced manufacturing nations in world markets.

In addition, the leadership and management skills of employees in the Australian manufacturing industry, while significant, fall short of the leading advanced economies (Figure 3), and have been identified by Manufacturing Skills Australia as a priority area for skills development:

*“Manufacturing needs strong leadership to help realise and capitalise on opportunities...Leaders must be able to effectively manage change and transition their organisations into high performing workplaces...Small and medium sized enterprises (SMEs) need to be specifically targeted for leadership and management development.”*<sup>26</sup>

Internationally Australia has among the lowest education levels in manufacturing and is ranked 13 out of 15 participant countries for the proportion of managers with university qualifications.<sup>27</sup>

### Attracting talent to the manufacturing industry

To a large extent, the skills and knowledge of Australia’s manufacturing workforce will be determined by the availability of skilled labour and the ability of the sector to compete for this labour. Skills and knowledge can also be developed through on-the-job training, or study while working; however, this type of up-skilling is both more likely to happen and more likely to be successful if people have a solid base of foundational skills to start with.

The previous section highlighted that, although still strong relative to other countries, the availability of skilled labour in the Australian workforce could become a limiting factor if we do not turn around our declining performance in reading, mathematics and science literacy. These skills provide critical pathways to the development of further technical and commercial competencies that will be essential for advanced manufacturing. This could be particularly problematic for the manufacturing sector because evidence suggests that the sector is a weak competitor for skilled employees.

Manufacturing firms were five per cent more likely than firms in the services sector to report information technology (IT) skills shortages, and eight per cent more likely than firms in the construction sector.<sup>28</sup> Businesses in the manufacturing industry, including innovation-active and – inactive businesses<sup>29</sup>, were also more likely than businesses in any other sector to report lack of skills as a barrier to innovation.<sup>30</sup> Moreover, the ageing profile of the manufacturing workforce – with 19 per cent of the workforce aged over 55 years and just 13 per cent aged under 25 years, compared to figures of 17 per cent and 16 per cent, respectively, for the whole workforce<sup>31</sup> – suggests that the sector may be struggling a little more than other sectors to attract younger workers. The inability of the manufacturing sector to attract skilled professionals may, in part, explain the lower qualification level of people in the manufacturing workforce. The following findings point to a continuing trend for tightness in the labour market for STEM skills, including:

- Reports of a decline in the number of Australian secondary school students electing to study mathematics or science subjects.<sup>32,33,34,35</sup>

- Findings that, despite high university enrolments in science subjects, a high proportion of students studying enabling sciences such as chemistry, mathematics and physics, discontinue their study after the first year.<sup>36</sup>
- Research indicating that by 2020 the demand for people with higher degree research (HDR) qualifications is projected to outstrip supply, despite the projected annual rate of growth in the number of people devoted to R&D (3.2 per cent) far outstripping growth in total employment (1.5 per cent).<sup>37</sup>
- PISA 2012 results which indicate that approximately one-third of Australian girls and one-fifth of Australian boys did not think that mathematics was important for later study.<sup>38</sup>
- Sharp reductions in the automotive sector, which has traditionally incubated skilled workers for the broader manufacturing sector.

It is clear that a multi-pronged approach is needed to boost the skills level of the Australian workforce in general and the manufacturing workforce more specifically, including initiatives to up-skill the existing workforce, attract skilled professionals to the sector and ensure the retention of existing skilled professionals. These initiatives need to consider the level of technical, non-technical and foundation skills. Ai Group's submission to the manufacturing workforce issues paper (2013)<sup>39</sup> provides a detailed account of the policy options we believe are important to enhance skills and knowledge in the manufacturing industry. There also needs to be greater recognition within industry of the importance of professional development and up-skilling, along with a work environment that rewards and stimulates skilled workers. As discussed in the remainder of this paper, Ai Group believes two additional factors will be important to the success of policies in this space, the relationship between the manufacturing industry and the education and training system and the perception of manufacturing in Australia.

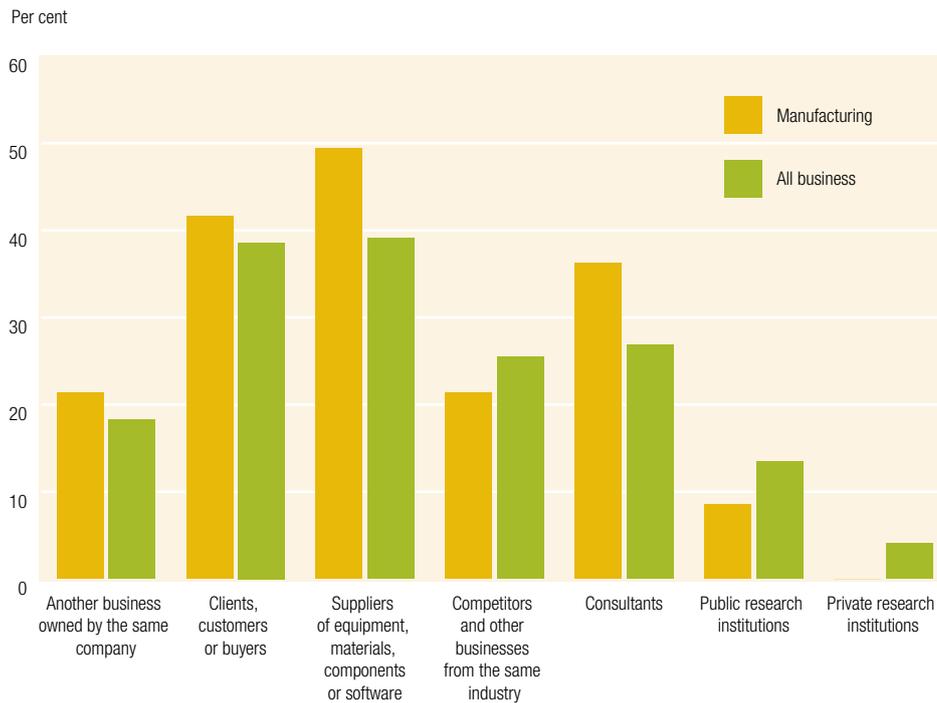
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## Collaboration and innovation in Australian manufacturing

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The production, diffusion and use of knowledge is critical to innovation. In today's fast-paced and competitive environment it is becoming increasingly difficult for individual businesses to access the level of skills and knowledge required to be competitive. Accordingly, a business's ability to collaborate and network is crucial. Collaboration helps a business access ideas, information and capabilities well beyond what it could obtain if operating independently. Through collaboration a business can utilise tacit knowledge and 'learning by doing' to embed unique advantages that cannot be traded and are difficult to replicate. The *2012 Australian Innovation Systems Report*<sup>40</sup> demonstrates the higher performance of firms that collaborate with other firms and public sector organisations when compared to firms that are less connected. Compared to businesses that don't innovate, innovative Australian businesses are 78 per cent more likely to report increases in productivity over the previous year, and collaborative innovation with research organisations triples the likelihood of business productivity growth.

**FIGURE 4**  
COLLABORATION WITHIN AUSTRALIA BY TYPE OF ORGANISATION COLLABORATED WITH,  
2010–11.



Source: Australian Bureau of Statistics (2012), Cat. No. 8158.0, Innovation in Australian Business, 2010–11.

Collaborative innovation is significantly correlated with the introduction of new-to-Australia or world-first innovations.<sup>41</sup>

There is considerable scope to enhance the flow of knowledge and ideas in Australian manufacturing by deepening collaboration. In fact, a 2011 Government report found that networking and collaboration remain the most significant flaws in Australia’s innovation system.<sup>42</sup> In 2010–11, 27 per cent of Australian R&D active firms collaborated on innovation<sup>43</sup>, which is low compared to the OECD average of 44 per cent.<sup>44</sup> Of this, only six per cent of Australian firms were collaborating internationally on innovation, compared to the OECD average for international collaboration of 17 per cent. Particularly stark was the contrast between the level of collaboration on innovation between industry and public sector research organisations in Australia and other OECD countries. On average 24 per cent of all firms and 34 per cent of large firms in the OECD<sup>45</sup> were engaged in this type of collaboration, compared to just 3.8 per cent of all firms and 3.5 per cent of large firms in Australia.<sup>46,47</sup> This is despite the significant investment Australia makes in its public sector research organisations and attempts over many years to increase collaboration between industry and public sector researchers.<sup>48</sup>

Looking more specifically at manufacturing in Australia, only 20 per cent of manufacturing businesses and 24 per cent of all businesses collaborated for the purpose of innovation in 2010–11.<sup>49</sup> However, of those businesses that did collaborate, only 8.5 per cent of manufacturing businesses collaborated with a

public research institution, compared to 13.5 per cent for all businesses (Figure 4). These results are consistent with those in Ai Group's *Business Investment in New Technologies* report (2012),<sup>50</sup> which found that only six per cent of manufacturing businesses collaborated with government or research institutions in order to develop new technologies. This is particularly concerning when you consider that only 30 per cent of Australia's research personnel work in industry, approximately half the OECD average (see Table 3).

The low level of collaboration between business and public sector research organisations in Australia has undoubtedly impeded the realisation and ultimate success of commercial outcomes from research in Australia. Collaboration between industry and education and training providers, such as universities, is also important to ensure that Australia's education system is producing graduates with the skills and competencies required by industry. Reasons for this lack of collaboration are numerous and may relate to the incompatible objectives of these organisations, with universities being more interested in the creation and publication of new knowledge and developing their reputation as academic organisations, while businesses are more interested in the commercial implications of research, or the creation of new innovations.<sup>51</sup> In addition, discussions with businesses reveal difficulties in finding research partners, inflexibilities in negotiations over intellectual property and a lack of understanding within public research organisations of business cultures and practices and the importance of meeting commercial timeframes.

Australian manufacturers also need to embrace collaboration among themselves and their overseas counterparts to boost innovation and lift competitiveness. The priority for focus here is collaboration beyond the supply chain, as business to business collaboration at this level is limited when compared to collaboration between businesses within the same supply chain or sector.<sup>52</sup> Data shows that Australia still relies heavily on the US and Europe as a source of ideas, investment, innovation and technology and this relationship should continue to be strong, but Australia also needs to build on existing linkages and collaboration to embrace new opportunities in Asian markets.<sup>53</sup> Unfortunately, investing in language, cultural understanding and business experience in Asia seems more important to others than it does to Australian businesses.<sup>54</sup>

In summary, there is a clear opportunity to increase innovation and the realisation of successful commercial outcomes through greater collaboration. Boosting advanced manufacturing in Australia will require greater action to ensure that Australia's manufacturers are well connected to global knowledge flows. They will also need to effectively collaborate with a diverse mix of people, including public researchers and offshore organisations and businesses, to maximise the flow and exchange of resources and ideas.

**“Australian manufacturers also need to embrace collaboration among themselves and their overseas counterparts to boost innovation and lift competitiveness. The priority for focus here is collaboration beyond the supply chain, as business to business collaboration at this level is limited when compared to collaboration between businesses within the same supply chain or sector.”**

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## What needs to be done?

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Advanced manufacturing, defined by innovation and agility, presents a tremendous opportunity for Australian manufacturers, regardless of their size or sector. However, while this approach may help neutralise disadvantages and level the international playing field for Australian firms, there will remain many players on that field. Competition to capture a share of the opportunities associated with advanced manufacturing will be fierce. A business as usual process will not deliver prosperity in this new environment, and success will be delivered, not by a silver bullet, but by a concerted and sustained effort over time. Capturing the opportunities advanced manufacturing presents will require action on multiple fronts and the collaborative efforts of the public and private sectors if it is to be effective.

Notwithstanding the importance of government's role in creating an environment that encourages the widespread adoption of more advanced approaches to manufacturing, there is an enormous amount that industry can do to facilitate change. Ai Group strongly believes that any agenda to boost the performance of Australian manufacturing must be led and owned by industry.

Defining advanced manufacturing as an approach leads to recognition that all industry sectors, technologies and products can potentially adopt and benefit from more advanced manufacturing practices. Governments can help by encouraging and supporting this broader transformation, rather than by concentrating efforts on a basket of notionally advanced activities. But it is industry, and indeed individual manufacturers, that can do the most to drive and direct these changes.

There are numerous examples of world class Australian manufacturing businesses that are adapting and are well-placed to prosper in the future. The challenge is determining how these success stories can be replicated to accelerate innovation in and heighten the competitiveness of Australian manufacturing. As this chapter has outlined, the human element will be critical to this challenge. But how best to attract and retain talent in the sector?

**“Defining advanced manufacturing as an approach leads to recognition that all industry sectors, technologies and products can potentially adopt and benefit from more advanced manufacturing practices. Governments can help by encouraging and supporting this broader transformation, rather than by concentrating efforts on a basket of notionally advanced activities.”**

Ai Group believes the perception of manufacturing in Australia needs to change if Australia is to attract and retain the volume of high-level talent required and encourage the necessary collaboration with other sectors and countries. While there are good news stories about manufacturing in the media, they are overshadowed by stories of demise – closures, job losses, cutbacks, uncertainty and vulnerability – all painting a very bleak picture of manufacturing's future in Australia. These perceptions matter to young students contemplating their future study and career pathway; to entrepreneurs, engineers and scientists looking for career development or investment opportunities; and to those already working

in the sector and contemplating their future. Nearly 65 per cent of the Australian public anticipate that manufacturing will further decline in the future; only 35 per cent view manufacturing jobs as stable and secure; and only 29 per cent would recommend manufacturing as a career for young people.<sup>55</sup> Manufacturing was rated as the second least attractive sector in which to work, from a list of eight major employing industries.<sup>56</sup>

The most important factor in improving perceptions is not necessarily more good news stories, but a change to the framework through which media, policymakers and the public interpret manufacturing news. The change is from a defensive, backward-looking vision – manufacturing as something to be preserved in the face of deep problems and a bleak future – to an active, challenging vision – manufacturing as a future opportunity, to be seized through reform and transformation. A broad-based conception of advanced manufacturing is an excellent fit for this task.

This positive agenda should be increasingly emphasised by a variety of public and private initiatives to bolster advanced manufacturing in Australia. The sense of opportunity should also guide government; resources no longer deployed to shrinking subsectors could be gainfully employed in underpinning new industrial opportunity, whether through skilling; support for innovation; provision of industry infrastructure; or otherwise.

It is also important that the sector works more collectively to capture a share of the opportunities available to it. At the moment action is largely taken at the company level – each company trying individually to secure opportunities and tackle challenges that exist at a national level – or consists of disparate state or national-level initiatives, often with little engagement of SMEs and the risk of competing agendas. While inspiration can and should come from many quarters and influence at many levels, for big leaps to be made collective action will be required. Industry leadership will be critical to this challenge, and in particular adroit leadership by people who are open to change and have the skills to drive and manage it. These people need both a strong understanding of the sector and a strong customer or external focus, combining technical and commercial acumen to seek out, pursue and create opportunities and build on positive momentum generated by the sector.

There is wealth to be found in a future of transformed manufacturing. If industry and the public sector can articulate this positive vision and back it up – especially through skills development and enhanced collaboration – Australia could be well placed to reap the rewards.

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## 4. META – creating the engine for an advanced manufacturing industry in Australia

Albert Goller

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This chapter discusses the approach META is taking to support advanced manufacturing in Australia including through the identification of top performing manufacturers and research institutions.

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**Albert Goller** is the former Chairman and Managing Director of Siemens in Australia and New Zealand from 2002 to 2012.

Commencing his career as an electronics engineer with Siemens in Germany in 1973, Albert has held a number of senior executive positions throughout the world including President and Chief Executive Officer of Siemens Canada and Head of the Corporate

Office for E-business in Munich, Germany.

He has a Masters Degree in Information and Telecommunications from Paderborn University in Germany and has been nominated as one of Australia's most influential engineers by Engineers Australia magazine consecutively from 2004–2010.

Albert took up the position of Chair of META last year. META – the Manufacturing Excellence Taskforce Australia – is a membership organisation of manufacturing companies and universities in Australia.

Albert is a passionate advocate of manufacturing and is convinced a national approach to Australian manufacturing, through the establishment of META, can generate new thinking and action within the sector.

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## 1. Introduction

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We work in one of the most diverse and challenging business environments possible but it's also one of the most rewarding and resilient industries in Australia. Here at META<sup>1</sup> we have the privilege of listening to CEOs from every type of manufacturing company across the country. In fact we've spoken to more than 400 business leaders to get a realistic view of the current landscape. What we've seen is inspiring and uplifting. We are seeing advanced manufacturing at its finest.

There has been a lot of talk that our industry is being hit hard but once you scratch below the surface you can see it's a time of evolution. Yes there's been a pull-back in some areas as the resource boom resides and car manufacturers pull out of Australia, but companies who are adapting quickly and have solid strategies in place, are succeeding.

Manufacturers have had to contend with a fast narrowing of the gap in labour and infrastructure costs. In addition, there are other issues to consider such as workforce protection and environmental impacts. The regulatory standards that manufacturing businesses need to adhere to in global supply chains have definitely increased.

Consumers can now access information in an instant and news travels at break-neck speed around the globe. This access has prompted people to be more aware of how and where products are made and companies are being held responsible for the materials they use more than ever. In turn that means investors are looking into the sustainability and risk profile of global supply chains.

More than one third of the service industry is created directly or indirectly by the manufacturing sector and countries enjoy a more resilient economy when the manufacturing industry is healthy. Developed countries like ours are looking for new ways to help their manufacturing industries thrive to help weather the storm of economic ups and downs.

The traditional way of thinking for manufacturers is being challenged. There have been huge changes on the demand side as well as mass customisation and extreme global price competition. New technologies and new materials have also changed the landscape of many sectors such as mining and defence, but also sports, to name just a few.

Another very interesting observation is that the specifics of certain industries are becoming much smaller and the thinking, the processes, the challenges and the opportunities are becoming very similar. Human behaviour between private (business to consumer) and business (business to business) transactions are getting closer.

There is no doubt our industry is changing again – and we need to work together and share ideas if we want to position Australia at the forefront.

At META we believe taking a bottom-up approach to these changes will help us implement practices that are already being successfully used by ‘hidden champions’ in the industry. These companies have created successful business models that many other CEOs and leadership teams across the industry can learn from. We are creating a hub where the manufacturing industry can exchange ideas and global best practices.

We believe it’s vital that best practice standards are shared across the industry and that collaborative models are set up to help facilitate new partnerships and help companies better utilise the assets available to them. We also see this as a way to strengthen our export markets and improve our already strong reputation in the manufacturing space.

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## 2. What is META?

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META was created on 1 July 2013 as a public funded membership organisation of manufacturing companies and universities in Australia. It means the manufacturing industry and government now have a vehicle to facilitate and accelerate the necessary changes. We want to ensure the manufacturing sector is a viable major contributor to Australian wealth.

The idea behind META was simple. Allow the industry to articulate what it needs – and then let the industry implement it. This will ensure that everyone, particularly small and medium businesses, have the opportunity to become involved. Small and medium enterprises (SMEs) are the backbone of most economies and have an important voice within META.

Universities are also involved to help open up partnerships and ensure that opportunities go back to Australian businesses via the flow of innovation. META works in a collaborative framework, across different industries and geographies. The Australian manufacturing industry should view the global changes in manufacturing as opportunities.

META is committed to rebuilding a solid, growing, future oriented agile industry that ensures ‘Australian made’ is a trusted, innovative and well known globally recognised brand. META will address challenges and opportunities from the bottom-up, starting within the industry and we hope it will become a trusted partner and advisor to governments at both a federal and state level.

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### 3. Australia’s tipping point

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Current debate over the state of the country’s manufacturing sector often focuses on issues such as wages, high-cost and the availability of government aid. These are important issues but Australia is a very expensive country even outside the production line. There is no doubt that we are a high-cost country.

The recent change in government could be seen as another trigger for the much-needed ‘tipping point’. Not everyone will like the policies of the new government but to reset and reconsider what was done and what has not worked in the past makes sense in every situation.

The government aid received by some manufacturing sectors in Australia was quite generous but in reality it did not lead to a significant turnaround. Money alone can’t replace the absence of a nationwide industry policy that enables prosperity and growth. The Federal Government has stated it is keen to reduce red tape and regulations to an extent that enables us to have a level playing field with other countries.

There are some natural disadvantages that are referred to repeatedly in debates over the industry. Australia has a diverse culture which results in high fragmentation of customer needs and expectations. There is a low population density which limits growth opportunities and we also have to overcome Australia’s long distances from many substantial markets.

These factors have led to high costs and in some cases a loss of competitiveness and an old fashioned culture. That in turn has seen some companies forced to downsize and permanently scramble for direct support from the government. Unfortunately some of those companies have been highlighted in the media, particularly those at the forefront of downsizing, restructuring or closing.

It's important to remember it has not been all bleak. There are other companies with the same natural disadvantages that have created a growing and sustainable business. They have adapted from a low cost country business towards a high-cost country business. These companies have done it quietly and proactively and these hidden champions are testament to the fact that manufacturing, as one of the largest employers in Australia, can still have a future.

These companies are still affected by disadvantages when you compare them to their often global competitors – but they don't make it the focal point of their thoughts and actions. There has been a lot of negative news about the state of manufacturing in our country but this could be the trigger for our tipping point. Often an initial wakeup call is needed to provide a solid ground for positive change. One can feel a lot of sympathy with the individuals in the middle of such a storm but these individuals can be the base seed for a new and better future.

“There has been a lot of negative news about the state of manufacturing in our country but this could be the trigger for our tipping point. Often an initial wakeup call is needed to provide a solid ground for positive change.”

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## 4. The future of advanced manufacturing

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At META we see advanced manufacturing as business excellence across the entire value chain not just innovation. This is the future for our industry. Many companies are already doing this and they are our hidden champions.<sup>2</sup> It is about taking full responsibility for not only what is manufactured but the process from beginning to end. It looks at how the product or material is produced, considering all regulations and communities impacted and how profits are then returned to the business or investors.

Manufacturing is an art form, challenges and opportunities are translated into research and development. Each piece has to be carefully considered during each process from designing and engineering, to laying out the production line and involving the right suppliers and service providers. And it doesn't end there; selling and servicing must be carefully considered and that process needs to be constantly refined to further optimise it on a continuing basis.

Often we see manufacturing viewed as the single process of producing but it is much more than that. It is not a simple task to understand or even fix challenges within the manufacturing process. Closing down a manufacturing site is only the latest act of a business in trouble. The root cause might be in other parts of the value chain and sometimes it might lead back to changes in the markets that were missed by the leader or owner of the business years before.

What successful long-term leaders of manufacturing companies and their employees deserve are our respect and the acknowledgment of the importance of a healthy manufacturing industry for our society, our wellbeing and our future.

## 5. Hidden champions

During our many company visits over the last six months, we have been impressed by both the quality and quantity of excellent companies across the country. We have seen a leadership mindset that does not accept defeat. They have found ways to overcome barriers and grow their business. They focus on growth and market leadership.

Surprisingly, although these are highly successful companies, they are largely unknown. They do not have a voice and often operate in the background as hidden champions. Our approach is to identify these companies and create the META 500. It will also include university faculties that excel in their collaboration with industry.

We want to enable these hidden champions to come forward and work with each other. By operating in a more structured way it can help improve everyone's capabilities and ensure sustainable growth. META will capture and transfer these successful models to all Australian manufacturing companies through the META projects, collaboration hubs and service activities. While the lessons learnt will be made available for all Australian manufacturers as scalable practical solutions – company specific intellectual property (IP) will stay with that company.

The META 500 will demonstrate what is possible through collaboration and participation in cross industry projects and will become the basis for future local and international showcases to highlight the vibrant Australian advanced manufacturing industry.

Advanced manufacturing is much more than technology or new materials, it is innovation and collaboration interwoven into the entire value chain and includes key suppliers and customers. We have seen these companies in Australia and they are operating very closely to what we have seen in a 20 year study in Germany on 1200 hidden champions.<sup>3</sup>

**TABLE 1**  
KEY ATTRIBUTES

1. Extremely ambitious targets	Want to be a market leader
2. Focus and depth	> 50% vertical integration
3. Globalisation	Direct customer relationship
4. Innovation	Research and developemnt (R&D) spending twice the industry average
5. Closeness to customers	> 25% of employees contact customers
6. Loyalty and highly qualified staff	> 50% less turnover rate than average
7. Strong leadership	Complete identification with the company, >10 years at the top, apply common sense to business

Source: Simon, Kucher & Partners 2013.

META wants to become the centre of excellence for the advanced manufacturing industry in Australia. With the help of the META 500 we want to demonstrate what's already possible today and how we can take advantage of the anticipated major changes in the global world of manufacturing.

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## 6. META – creating the engine for an Australian advanced manufacturing industry

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META is taking a completely new approach towards the Australian advanced manufacturing industry. This includes:

- A bottom-up approach (industry supports industry – the most trusted relationship);
- A cross-industry and national approach, with global connectivity;
- Collaboration and sharing between like-minded CEOs (leadership mindset); and
- Success models identified through practical projects and collaboration hubs.

META's portfolio is designed to target four discrete areas:

1. Collaboration hubs on subjects of high interest (industry defined);
2. Small collaboration projects as proof of concept and scalability;
3. Lighthouse projects to demonstrate breakthrough capabilities of industry and universities combined; and
4. Service activities for the transfer of local/global best practices.

It is expected that the results of these activities will lead to a structured transfer of knowledge and success across the entire manufacturing industry.

META will introduce a range of projects and collaboration hubs designed to help Australian manufacturers achieve best practice and create new opportunities for growth. These initiatives will be created with the help of the META 500 and will encompass a broad range of sectors within the manufacturing industry. Here is a cross section of some of the projects already in the planning stage.

### Collaboration hubs:

- **Business excellence** – an IT based continuous collaboration hub where members can share business excellence knowledge and experience.
- **Soft materials for additive manufacturing** – significant advances have been made in the field of additive manufacturing or 3D printing. However, applications are largely limited by the range of suitable (especially soft polymeric) materials available. This hub will bring applied research expertise to industry that could benefit from this leading research.

### Collaboration projects:

- **Continuous flow chemistry technology** – transformational manufacturing

technology in the fine chemicals sector. This new technology will help the Australian chemical manufacturing sector compete against traditional international batch manufacturing processes.

- **Best practices in biopharmaceutical manufacturing** – trial of a novel model to identify and deliver continuous improvement and best practice projects through business to business interactions in the pharmaceuticals industry supported by academic business staff.
- **Supply chain optimisation (armoured vehicles)** – to optimise domestic export potential by developing collaborative capabilities of domestic manufacturers around enhancing productivity while improving vehicle functionality and transforming the supply chain from the provision of lower value-add to higher value-add componentry.
- **Computer integrated manufacturing (CIM)** – transacting data between organisations involved in a common delivery/program is a hidden cost to manufacturing. CIM development will help Australian manufacturing companies develop interoperable manufacturing data systems.

Companies have welcomed META's innovative bottom-up, industry supporting industry approach rather than the traditional top down approach. As part of this approach, META wants to actively engage with other organisations such as industry associations to complement its industry reach. One of the guiding principles of META is not to duplicate existing activities.

META does not charge a membership fee at this stage. This has provided three very important benefits:

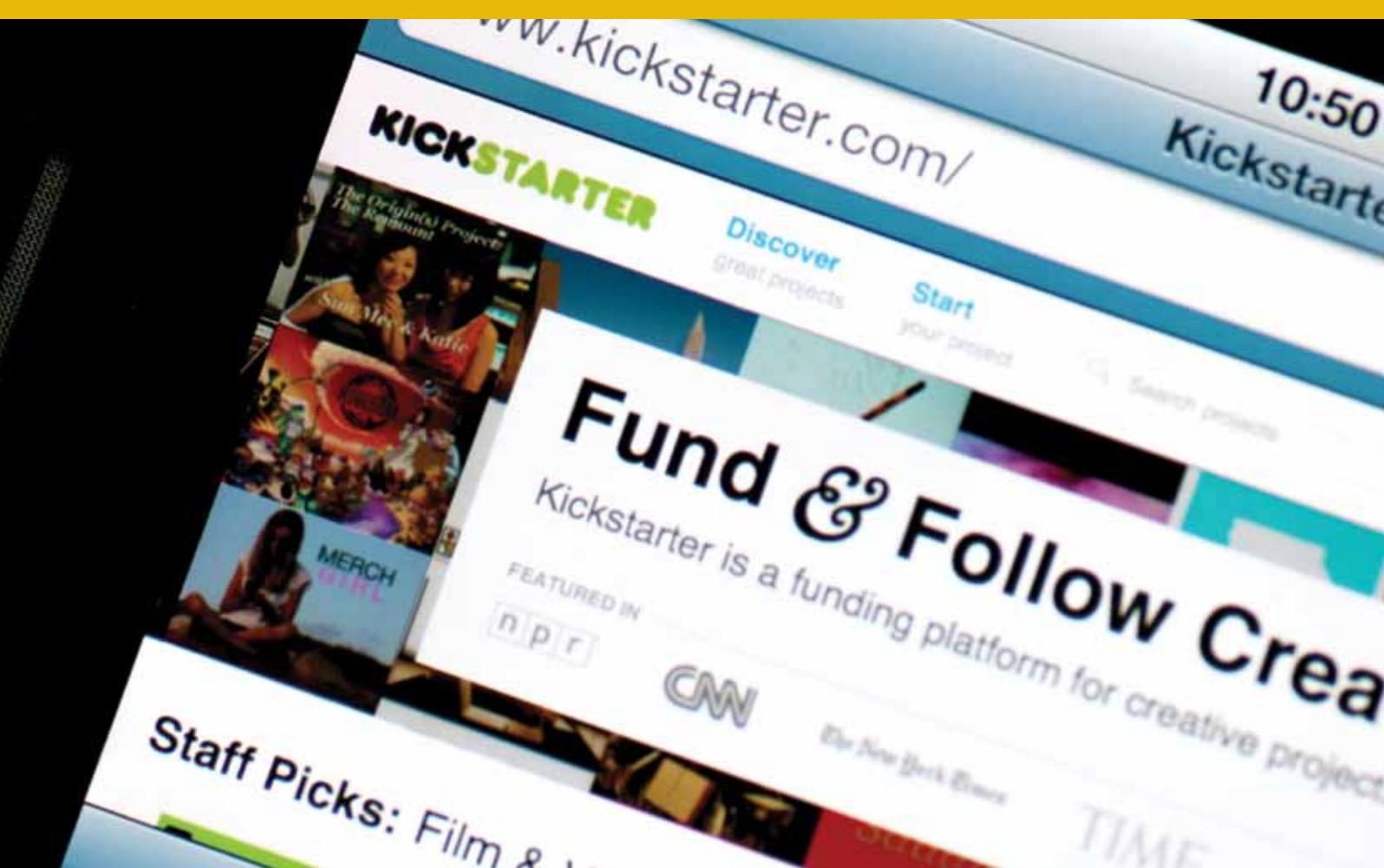
- SMEs will be involved as equal partners;
- META's financial independence from industry/universities has enabled an open and frank discussion based on honest self evaluation of their strengths and weaknesses; and
- Active involvement from members will be encouraged in lieu of a financial contribution.

The underlying principle behind META is to provide a launch pad for innovation and growth by bringing the industry together to share knowledge. We believe the future of manufacturing is bright and by combining the expertise and leadership skills we have seen across the industry we can uncover a wealth of untapped possibilities. We want to ensure the industry is given a full runway to deliver our shared passion: establishing the global competitiveness of Australian manufacturing.

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#### Endnotes

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## 5. Key enabling technologies

Dr Swee Mak

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This chapter discusses the impact of key enabling technologies (KET) such as information and communication technology (ICT) and the Industrial Internet on advanced manufacturers in Australia and the positive impact these can have on a firm's productivity, competitiveness, responsiveness and ability to customise products, factors which are crucial for a successful advanced manufacturing sector.

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**Dr Swee Mak** is Director of the Future Manufacturing National Research Flagship. The Flagship was established to help secure a competitive and sustainable future for manufacturing. In this role, Swee provides strategic leadership for a large portfolio of research and development activities that address technological innovation needs across various sectors including aerospace, automotive, building and infrastructure, CleanTech, defence, energy and health. Every year, the Flagship partners with and provides R&D services to over 1000 companies and organisations both in Australia and overseas.

Swee is a highly experienced innovation leader with an established track record in research, technology development and transfer, commercialisation, management of complex portfolios, international business development and strategic leadership. Swee is also a key thought leader and advisor to government and industry. He was a member of the Technical Working Group of the Prime Minister's Manufacturing Task Force and the Manufacturing Leader's Technical Working Group. Swee has played a major role in identifying the potential to create value and improve competitiveness of manufacturing firms by better integration of informatics and design with materials and processing technologies.

Swee's international research reputation was built on his work on sustainable materials and manufacturing processes. Swee obtained both his undergraduate and PhD degrees in Engineering from Monash University, an MBA (Exec) from the Australian Graduate School of Management and is a member of the Australian Institute of Company Directors. Swee is a Senior Fellow at the University of Melbourne and a Fellow of the Institution of Engineers, Australia.

The modern advanced manufacturing workplace is a complex environment, which requires a number of interoperable and seamless information and communication technology (ICT) solutions for:

- The improvement in operational processes through ICT driven mechatronics, control and analytics, robotics, laser based manufacturing etc.;
- Supply network productivity/management through full scale 'Internet of Things' exploitation, distributed enterprise software, mobile/cloud-enabled enterprise connectivity (including customer relationship management software). This is

further enabled through standardised information sharing and related infrastructure. Additionally, increased supply network productivity enables market penetration of new business models and technologies through new sales channels;

- Rapid innovation of products and services through ICT enabled digital design, product lifecycle management, simulation, visualisation and analytics of large amounts of data. This allows for rapid and less costly delivery of truly differentiated products and services and therefore provides competitive advantage;
- Optimal factory/worker interaction leading to a reduction of labour hours required for the same output (increased labour productivity) as well as increased worker safety; and
- Management of data and interoperability of assets throughout the design, build and user phases of an asset, product or service.

This chapter will explore the impact of emerging ICT enabling technologies, on Australian advanced manufacturing. Specifically,

- Robotics (assistive technology and real-time perception for unstructured environments);
- Mobile devices (ubiquitous connectivity and intuitive and portable interfaces);
- Consumer devices (cheap sensing, processing, and actuation; wearable computing); and
- Cloud services (big data, collective intelligence, semantic web and interoperability).

Even though the development of these enabling technologies is driven by markets other than manufacturing, namely consumer, finance and automotive, value will be realised for the Australian advanced manufacturing sector by ushering in flexible and agile ICT solutions to respond to global economic drivers.

Adoption of these technologies will have profound impacts on:

- Productivity – improvements through the use of various ICT technologies ranging from lightweight assistive technologies to big data, which will provide in situ training, quality control and physical assistance to the workforce.
- Competitiveness – improvements through a more cooperative and connected supply chain, and the formation of ephemeral virtual enterprises.
- Responsiveness – improving the speed to market, by assisting with the flow of information that allows the manufacturer to respond to unpredictable change in supply and demand.
- Customisation – the ability to personalise goods and services to capture added value.

Implementation of a number of these technologies within the advanced manufacturing sector is possible today. However, true optimisation of the value of these ICT technologies will require implementation across the supply chain – for this, disruptive solutions will be required not only in the technologies utilised but the business models developed<sup>1</sup>.

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## The Australian context

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The ongoing pressure faced by Australian manufacturing is largely due to the relatively high-cost base, lack of scale (production and market) and currency fluctuations. These externalities predicate a market outlook that is more globally connected, niche, high-value and low-volume. But, just as Shell did in the 1970s<sup>2</sup>, the outlook for Australian advanced manufacturing must be within the context of foreseeable global megatrends<sup>3</sup> such as:

- Great expectation – the expectation people have for personalised products and services that meet their unique needs and wants while being delivered en masse.
- Virtually here – a world of increased connectivity where individuals, communities, governments and businesses are immersed into the virtual world to a much greater extent than ever before.

Through this foresight, this new world will require Australian manufacturers to have the ability to customise on mass, and to adapt to and benefit from changing business models. This is important to Australia because through its broad based small and medium sized enterprises (SME) manufacturing sector, contributing over 50 per cent of the national manufacturing gross domestic product (GDP), Australia has a unique position within the global manufacturing market<sup>4</sup>. However, this position is being challenged as the industry's competitiveness has declined over the last five years, as a result of internal factors such as increasing operational costs, as well as global changes, which requires a higher level of adaptability that is difficult to reach by domestic SME manufacturers.

Key issues limiting the competitiveness of the Australian manufacturing sector were reported in the recent Prime Minister's Manufacturing Taskforce<sup>5</sup> 2012 report that identified:

“...this new world will require Australian manufacturers to have the ability to customise on mass, and to adapt to and benefit from changing business models. This is important to Australia because through its broad based SME manufacturing sector, contributing over 50 per cent of the national manufacturing GDP, Australia has a unique position within the global manufacturing market.”

- An uneven number of small firms: Australia's manufacturing industry is formed by a disproportionate number of small firms (86 per cent), many of which operate in small markets, restricting its ability to lift competitiveness, productivity, job generation and technology adoption among the sector;
- Skills shortage: The manufacturing industry is experiencing a shortage of skilled workers, especially in the heavy fabrication and engineering industry, caused by an ageing workforce (the median age of workers is 41 years). On average, fewer than two applicants are suitable to fill vacancies in the industry for each job application;
- High costs: Rising living and energy costs and weak productivity growth have made Australia a high-cost economy by international standards. Meanwhile,

low-cost competitors are emerging, while manufacturing centres in Europe and the USA are growing stronger;

- Decrease in demand: Manufacturing activity has shrunk for the ninth consecutive month as of May 2012, as it has been adversely affected by a slowdown in related areas of domestic demand such as residential and commercial construction; and
- Strong emerging competition: China has now emerged to compete against the USA as the world's largest manufacturer and, in doing so, it has reduced margins and radically disrupted global supply chains. Consequently, some Australian exports have become entirely unprofitable and some domestic markets are facing import competition for the first time.

In associated industrial sectors<sup>6</sup>, ICT solutions and systems were developed, piloted and implemented to address similar key challenges and in many cases were able to provide productivity increases through the more efficient transformation of labour, information and resources<sup>7</sup>.

ICT has turned the globe into an increasingly interconnected network of individuals, firms, schools and governments communicating and interacting with each other through a variety of channels and providing economic opportunities transcending borders, languages and cultures. ICT has opened new channels for service delivery in areas such as e-government, education, e-health and information dissemination.

However, orders are still received and manually entered into business systems, bills of materials prepared and then re-entered into production systems: this of course invites errors. This lack of supply chain interoperability is a significant and largely unrecognised cost for Australian SMEs. However, the problem is internationally well recognised and larger original equipment manufacturers (OEMs) have typically put in place product lifecycle management (PLM) systems. Suppliers to these OEMs typically adopt the same solutions to ensure data exchange or use alternative systems with data translation at their own cost. Such de facto standardisation makes sense in Europe and the United States, as OEMs tend to be (a) much larger than their Australian counterparts and (b) have much higher customer specific revenue.

These two factors jointly drive the adoption of common Australian SME centric, PLM systems as they derive a small part of their turnover from many different customers in many different sectors in addition to often being at the end of a very long supply chain.

For example, within the Australian aerospace sector, manually entered engineering data of a received purchase order into an in-house enterprise resource planning (ERP) system costs roughly A\$120 per order. With approximately 200 orders per month, a total cost of A\$288,000 per year is incurred and if an error is made and an order has to be re-processed or fabricated, the data handling costs for this alone can be up to A\$1200 for a typical order, not to mention the actual production cost and any penalties the company might incur for potentially missing customer on-doc.

Based on an approximate annual turnover of A\$20 million and a margin of approximately 10 per cent, the cost of initial engineering data entry is therefore approximately 1.4 per cent of turnover or 14 per cent of profit for what is essentially a non-value adding data exchange activity.

This is where ICT comes in, by providing ways to facilitate and manage the complexity of these information-intensive processes, as well as to achieve integration of manufacturing activities within and among manufacturing enterprises.

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## Fit-for-purpose

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The sale of a single product may now mean that a commercial relationship with a customer continues into the future through an ongoing ICT enabled, service business model. This link can enable product and process improvements by capturing information about product performance. Information links also allow firms to bundle products with services and lock customers into product enhancements and purchase of value added services – including project management and consultancy. These services may be more profitable than original product offerings. There are, however, wide disparities in the productivity growth rates of different manufacturing industries, and it appears that the less technology oriented and lower capital industries are recording lower productivity growth rates<sup>8</sup>.

Process related ICT investments will not of themselves deliver an economic return. If nothing changes about the way work is done then the role of ICT is simply to automate an existing process, and the economic benefits are likely to be minimal<sup>9</sup>. Successful introduction of ICT enabled production technologies has been accompanied by a fundamental redesign of business processes and business models.

The rise of Kickstarter<sup>10</sup> being a case in point of innovative models for not only capital raising but for the identification of lead and influential user cohorts. Further, given competitive pressures, novel ways of attracting ideas and responding to customer needs that will stimulate innovation will also play a part, with Gartner identifying that by 2017, over half of consumer goods manufacturers will achieve 75 per cent of their consumer innovation and research and development (R&D) capabilities from crowd sourced solutions<sup>11</sup>.

There is a latent need for affordable, fit-for-purpose, ICT solutions for Australian SMEs, to address productivity issues, facilitate fabrication of small runs of customised products as efficiently as possible, enable creation of safe high-performance workplaces in which human capacity to do their jobs are maximised, economically viable, easy to use, and adaptable to operational processes already in place.

“Conventional automation, such as that used in automotive manufacturing, is driven by the need to automate specific mass manufacturing tasks. However, economic drivers for Australia demands less focus on large volume production, and more concentration on mass personalisation of products.”

Conventional automation, such as that used in automotive manufacturing, is driven by the need to automate specific mass manufacturing tasks. However, economic drivers for Australia demands less focus on large volume production, and more concentration on mass personalisation of products. This macroeconomic environment therefore predicated a national quest for affordable assistive automation solutions that support high variety/low volume production runs that are easy to implement, highly flexible, and adaptable to operational processes, equipment and human resources already in place.

*Fit-for-purpose* for Australian advanced manufacturing specifically relates to the ability to:

- Be highly responsive with great customer insights and connections;
- Deliver customised solutions rapidly – flexibility in scope; and
- Excel at low volume manufacturing – high scalability – adjust easily to different volumes.

According to the US's National Institute of Standards and Technology<sup>12</sup>, there are key elements that define and, therefore, enable flexible advanced manufacturing environments from the factory floor to the communications across the supply chain, namely;

- Mobility across dynamic and unstructured environments;
- Autonomous (or semi-autonomous) operation in uncertain or unstructured environments;
- Ability to manipulate and interact with a changing external environment;
- Capable of achieving desired outcomes without the need of a fully pre-programmed script;
- Ability to perform tasks in close operation with humans; and
- Ability to augment the reality or the physical capabilities of a human user.

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## Addressing the ICT market failure

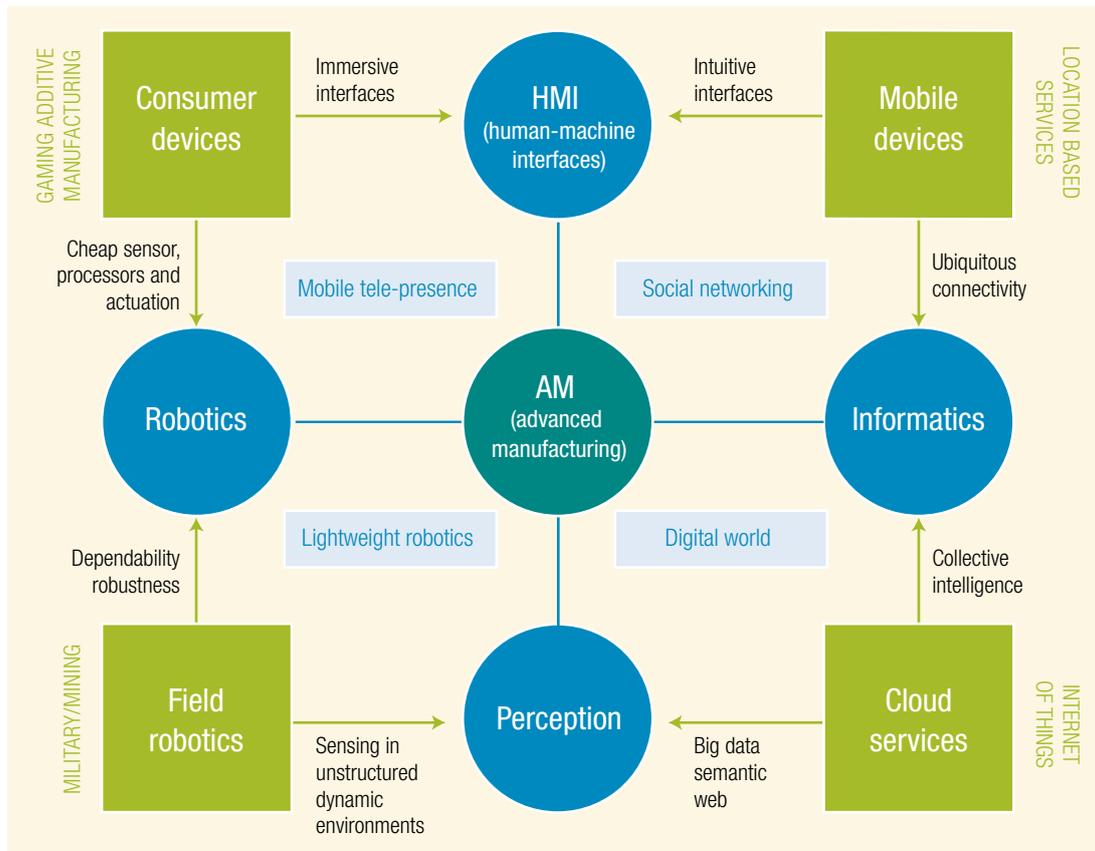
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There is currently market failure in the provision of ICT technologies for advanced manufacturing SMEs to support the responsiveness of Australia's industrial sector through fit-for-purpose information technology (IT) service innovations that improve the transformation of labour, knowledge and resources to address Australia's industrial competitiveness.

From the supply side perspective, key issues include the mediocre communications infrastructure resulting in lower quality of service, security, interoperability and disproportionate costs through to ICT products being designed for larger industrial firms and not SMEs.

On the demand side, key issues include the limited ICT literacy of SME owners and employees (and the associated capital, on-going maintenance, and adoption training costs both in terms of time and money) through to the risk in taking a firm through a learning curve that may be difficult and costly<sup>13</sup>.

**FIGURE 1**  
 A WORLD WHERE THE WORKFORCE AND AUTONOMOUS SYSTEMS ARE ABLE TO SEAMLESSLY, RELIABLY AND SAFELY COLLABORATE



Practically, the future enabling ICT technologies will need to transition from:

- Expensive to affordable in terms of capital and operational cost;
- Static to flexible and mobile in terms of ability to do many tasks and interoperable and compatible with a raft of technologies;
- Requiring expert, competent technical operators, to a system that anyone can use and configure; and
- Bulky to lightweight in terms of size, weight and power requirements.

Four key technology capabilities have been identified to enable this translation – human machine interfaces (HMI), robotics, informatics and perception. However, to maximise the return on investment, the four capabilities must be implemented in a seamless and cooperative manner such that:

- HMI and robotics leads to advances in mobile tele-presence. *The ability to go anywhere;*
- HMI and informatics leads to advances in social networking and therefore to *collaboration;*
- Robotics and perception leads to the development of lightweight robotics – *solutions that are low-cost and easy to deploy;* and
- Informatics and perception leads to advances in digital worlds – *where the virtual worlds available on the Internet will ‘mirror’ what is happening in the real world.*

Noting the Booz and Co 2013<sup>14</sup> survey, that identified that “companies (that) made significant use of these digital enablers were 77 per cent more likely to report that they outperformed competitors than were those with low or moderate usage rates”, our vision is an advanced manufacturing environment in which ICT systems and services, the workforce and autonomous systems are able to seamlessly, reliably and safely collaborate. Value will be realised in combining these techniques to produce novel fit-for-purpose solutions for advanced manufacturing as described in Figure 1.

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## High performance workplaces

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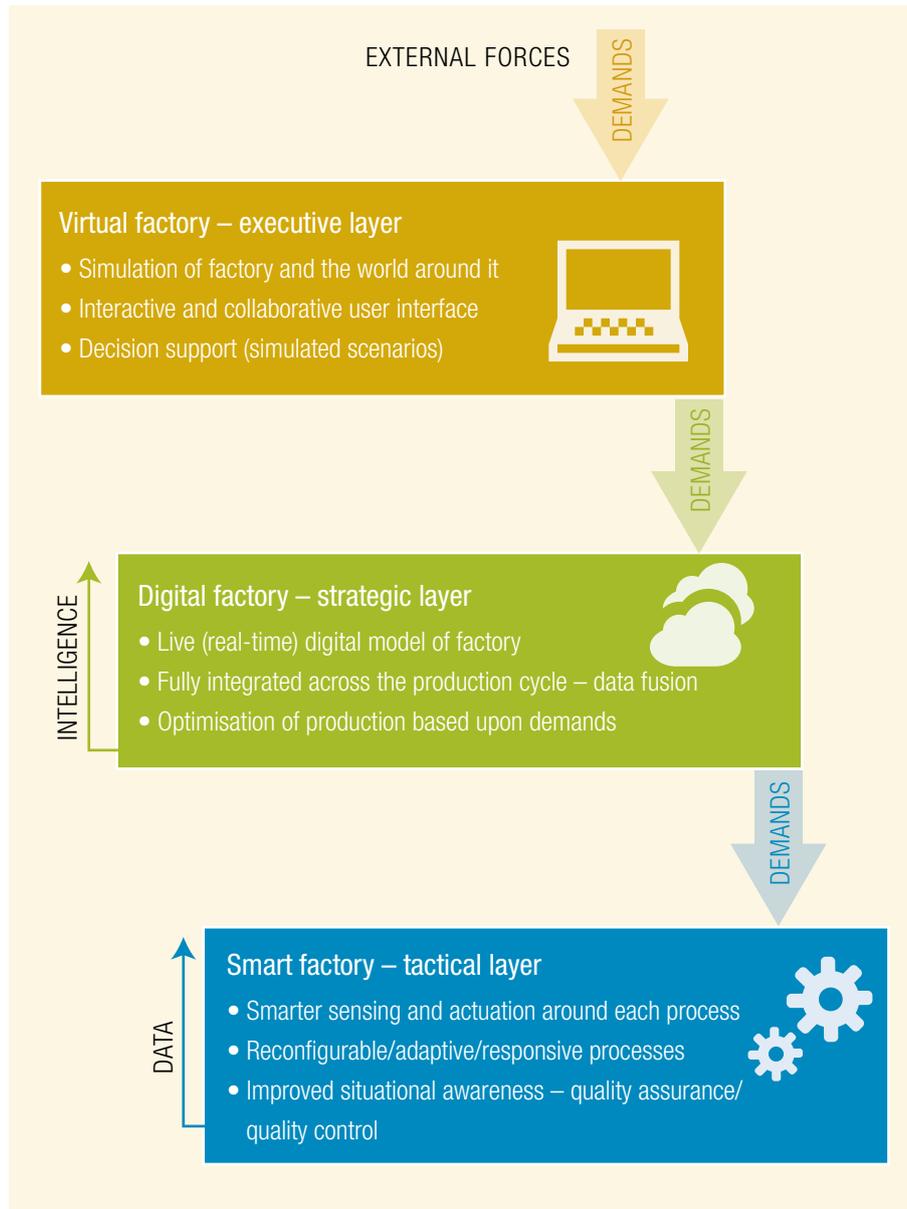
The competitive advantage provided by ICT intensive products is not the ICT per se, but the attributes, properties and customised service offerings that the ICT enables and which are embedded in the product. It is the clever use and incorporation of ICT that becomes a differentiator. This re-affirms the contemporary view in business strategy and marketing that customers do not purchase products: they purchase the stream of valued added services/experiences that products provide.

ICT differs from other infrastructure assets in that it supports the generation of knowledge that can be adopted, applied and used for innovation in business and manufacturing processes and in enhancing the functionality of products and services. It involves distributed and delocalised processes both within a factory as well as across factories, from source to factory, and across networked enterprises. Consequently, data associated with the manufacturing process is also often delocalised and distributed.

However, a crucial component of the factory of the future will be just the opposite: information will flow across all boundaries within a factory, across multiple processing systems and multiple enterprises. In this proposal we focus on developing systems, based on modern semantic web and knowledge representation technologies, to show how processing information barriers within the factory – and by extension outside the factory and across factories – can be broken down.

Within a factory, barriers exist between the ‘tactical’, ‘strategic’ and ‘executive’ layers – as described in Figure 2. The tactical layer of a factory incorporates its physical day-to-day operation: here processing takes place and sensors generate and deliver data to actuation systems, which regulate the production process. The strategic layer of the factory contains mainly digital objects (for example models) required to keep the factory operating on a day-to-day basis and is responsible for the optimisation of production depending on, for example, demand. The executive layer also contains digital objects, but at a higher level of granularity: here the factory is modelled in the context of the world around it (for example how do raw materials availability and market conditions affect the operations of the factory) and therefore provides decision-support and management capability.

**FIGURE 2**  
**FACTORIES OF THE FUTURE: INFORMATION FLOW**



As external demands impact upon the virtual factory (customer demand, supply chain availability and cost), executive decisions are made. In particular what type of product is to be manufactured – today we make widget X, tomorrow we make Y. This requirement is fed down to the digital factory, which look at the current situation and make a strategic decision as to what and how something will be manufactured. This is then passed down to the smart factory (the factory floor) where tactical decisions are made.

Connecting these layers together is the motivation behind the industrial Internet. The industrial Internet is a term coined by GE and refers to the integration of complex physical machinery with networked sensors and software<sup>15</sup>. The industrial Internet draws together fields such as machine learning, big data, the Internet of Things (IoT) and machine-to-machine communication to ingest data from machines, analyse it (often in real-time), and use it to adjust operations.

The industrial Internet is enabling this change to be more productive by making the physical world of industry more intelligent. By connecting machines to the Internet via software, data is produced and insight into the manufacturing process is gained. These machines become part of an intelligent network that can automate information and action to optimise plant floor performance<sup>16</sup>. This voice of industry is further reflected in the Economist Intelligence Unit<sup>17</sup> analysis that with falling technology costs and developments in IoT technologies will go beyond just a nice technology to have to being an essential way of doing business.

The factory floor is the nucleus of a company and when properly optimised, it is a competitive advantage. With a greater level of visibility at the plant level, manufacturers can achieve greater predictability in output, cost and quality.

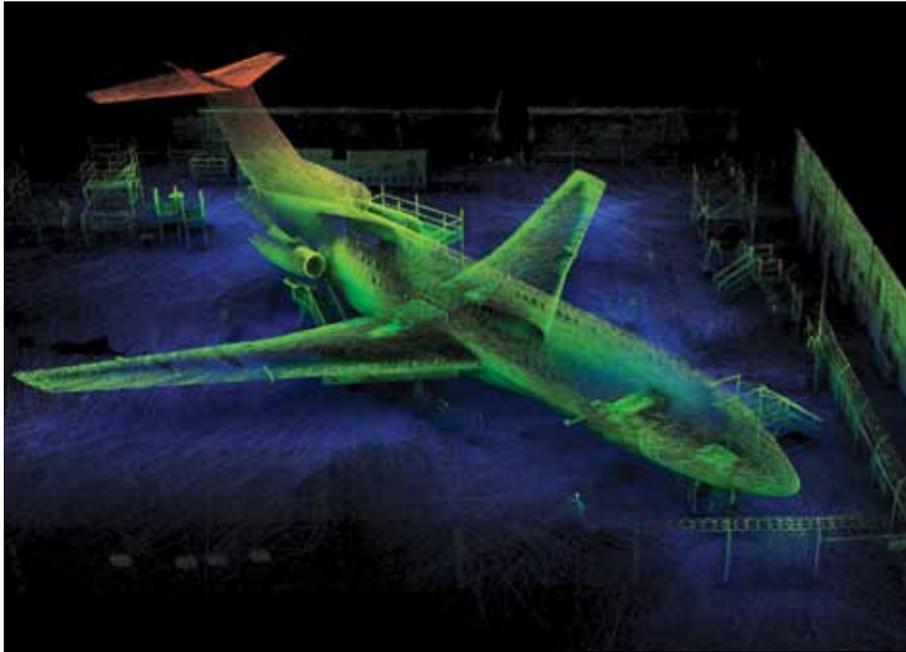
One of the key requirements of the industrial Internet is perception: knowing where you are (localisation) and knowing where everything else is (mapping). Perception can pose significant challenges to both man and machine. Sensors in the traditional manufacturing environment have been vision, proximity detection and Radio Frequency (RF) tags. Unfortunately these sensors are not suitable in dynamic and unstructured environments, such as those found in the mining and military industries, where there is little control over the environmental conditions (for example lighting). In this domain, GPS (Global Positioning System) and LIDAR (Laser Detection and Ranging) have been the sensors of choice.

CSIRO has been using 2D scanning LIDARs (lasers that scan in a 2D plane) for more than 15 years: first to track the location of ropes supporting a dragline bucket, and later for navigation of an underground loader. More than 10 years ago, LIDARs were used to map the terrain beneath mobile mining equipment (such as draglines, shovels and haul trucks). In these scenarios, the motion of the equipment is used to provide the third dimension of scanning by ‘painting’ the LIDAR footprint across the environment. This same technique is presently employed in commercial mobile mapping systems used primarily for street mapping. However, in such systems, an accurate knowledge of the scanner position and orientation is required at all times, and in environments that are GPS-deprived this creates a challenge. To address this problem, very sophisticated software algorithms were developed to use the environment itself to calculate the location and orientation of the sensor while it is continuously in motion. The challenge of building a map and estimating motion in an unknown environment without an external reference system is a well-known problem in the robotics community called Simultaneous Localisation and Mapping (SLAM), and CSIRO has been at the forefront of this development.

What is particularly significant about this development, is that these techniques have application to the more ‘casual’ manufacturing environment that is familiar to SMEs and other advanced manufacturing industries, where it is not always possible to control what is happening on the factory floor. Once again the

“Before we get too excited about the opportunities for ICT enabling technologies for the manufacturing industry, it is critical to acknowledge that adoption is a significant barrier to securing the latent competitive advantage. While 96 per cent of SMEs reported that they were online, only 19 per cent of those said that they had some form of digital business strategy.”

**FIGURE 3**  
ZEBEDEE LIDAR SCAN OF AIRCRAFT



environments are quite dynamic and unstructured, and it is necessary to achieve perception without control over every aspect of the environment. The software is now smart enough to cope with uncertainty and change. This dramatically lowers the cost and installation time to deploy a system. This is shown in Figure 3 above, where an aircraft factory was mapped with a small hand held mobile mapping system, Zebedee<sup>18</sup>, without the need for additional infrastructure.

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## Conclusion

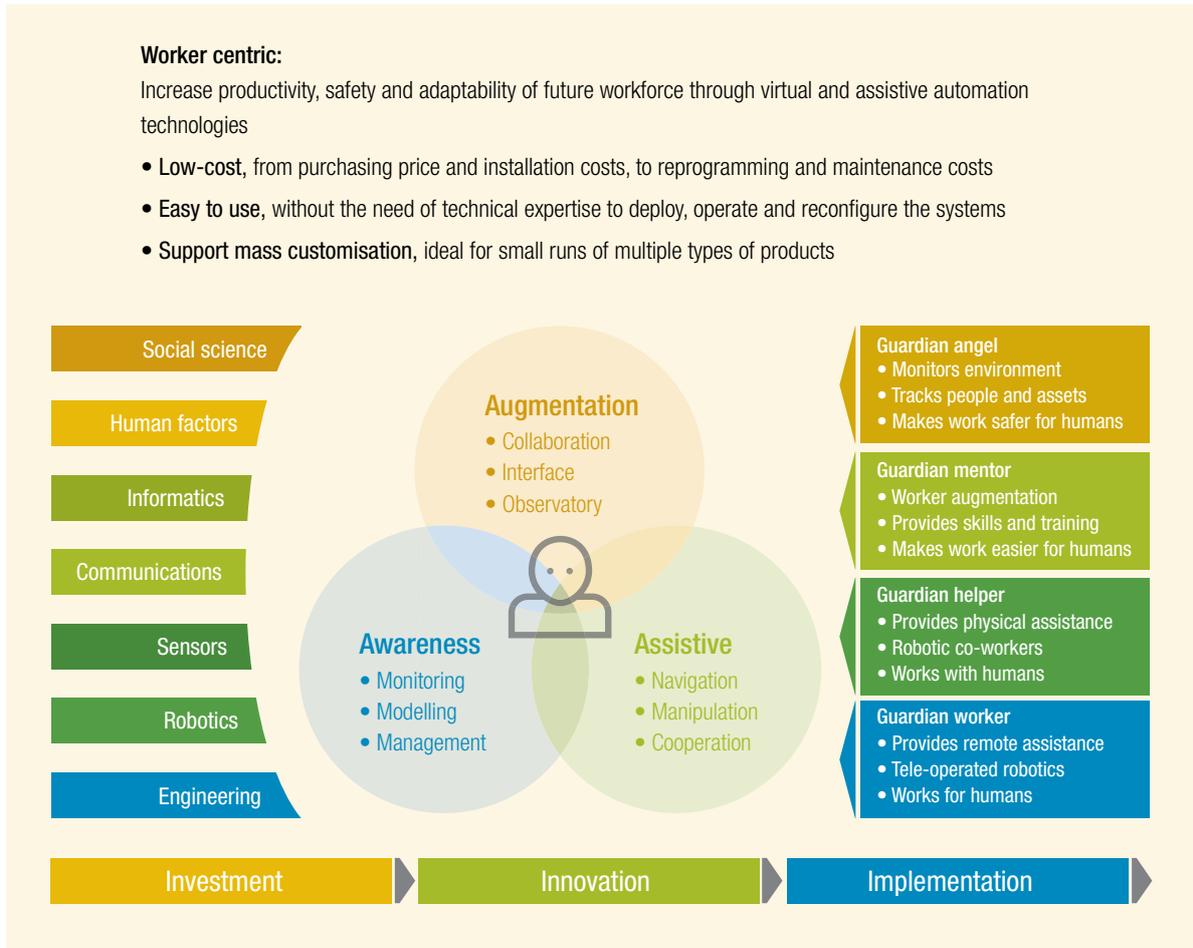
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How do we increase productivity, safety and adaptability of the future workplace? The most important step is to place the worker at the centre (worker centric) and then deploy ICT technologies in the workplace to provide the worker with:

- Skills through expert, remote tele-assistance guidance<sup>19</sup>;
- Perception with augmented reality goggles, virtual reality systems, distributed sensing systems;
- Strength and dexterity through cooperation with assistive robotic systems;
- Reach through tele-supervision to address safety issues (such as operations in confirmed and hazardous environments) and the tyranny of distance; and
- Creativity through initiative design systems.

There is no doubt that the prospects of companies adopting IT-based enabling technologies and services will become more prominent and given the ubiquitous nature of ICT technologies and services, it will be the business models and innovative approaches that are developed in concert with these technologies that will also make a great deal of difference.

**FIGURE 4**  
**GUARDIAN: RATE AND SAFETY FOCUSED HIGH PERFORMANCE WORKPLACES**



Business is supporting this proposition and in response, CSIRO envisages that such a guardian system (see Figure 4 above), with the workers' interest at the core, will increase rate (productivity), yield and safety, lower costs through avoidance and reduction pathways, allow the reincorporation of retired workers in the productive process, increase worker retention and satisfaction in the manufacturing sector and generate new market opportunities for Australian technology companies.

Before we get too excited about the opportunities for ICT enabling technologies for the manufacturing industry, it is critical to acknowledge that adoption is a significant barrier to securing the latent competitive advantage. While 96 per cent of SMEs reported that they were online, only 19 per cent of those said that they had some form of digital business strategy<sup>20</sup>. For those that did, it was most likely to be focused on the Internet and website development. This statistic is contrast with the public's insatiable appetite for mobile technology – at 65 per cent Australia has one of the highest smartphone penetrations in the world, with more than four in 10 SME CEOs reporting owning a tablet.

New technologies must be intuitive, simple and easy to use. This is a considerable challenge for the adoption of emerging technologies and clearly highlights the profound impact the right combination of design, social factors and smarts can have.

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## Endnotes

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- 20 Sensis Report 2013 Yellow™ Social Media Report

# Acknowledgements

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CEDA undertakes research with the objective of delivering independent, evidence-based policy to address critical economic issues and drive public debate and discussion. It could not complete its research agenda without the support of these contributions.

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The Bank of Tokyo-Mitsubishi  
The Future Fund  
The Myer Foundation  
Thiess  
Toyota Motor Corporation Australia  
Transdev  
Treasury Corporation of Victoria  
United Energy and Multinet Gas  
Urbis  
Victorian Department of Human Services  
Victorian Department of Premier and  
Cabinet  
Victorian Department of Transport,  
Planning and Local Infrastructure  
Victorian Department of Treasury and  
Finance

VicTrack  
Western Water  
Wilson Transformer Company  
WorkSafe Victoria

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**WA**  
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AGI Australia  
ATCO Australia  
Australian Bureau of Statistics  
Bankwest  
Brookfield Rail  
Chevron Australia  
CITIC Pacific Mining Management  
City of Greater Geraldton  
City of Perth  
Clifford Chance  
ConocoPhillips  
Dampier Bunbury Natural Gas Pipeline  
Nominees  
Edith Cowan University  
Fortescue Metals Group  
Georgiou Group  
Gerard Daniels  
GFR  
Grose International  
HASSELL  
Horizon Power  
K&L Gates  
LandCorp  
Lavan Legal  
Leighton Contractors  
Main Roads, Western Australia

Murdoch University  
OptaMAX  
Pilbara Development Commission  
Public Sector Commission  
Synergy  
The Chamber of Minerals and Energy of  
Western Australia  
The University of Western Australia  
Toro Energy  
UnitingCare West  
WA Department of Agriculture and Food  
WA Department of Regional Development  
WA Department of Treasury  
WA Department of Water  
WA Water Corporation  
WA Treasury Corporation  
Wesfarmers  
Woodside Energy

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committee for economic development of australia