Trends in manufacturing to 2020

A foresighting discussion paper

Future Manufacturing

Industry Innovation Council




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For more information, or to comment on the paper, please contact:

Manager
Future Manufacturing
Department of Innovation, Industry, Science and Research
GPO Box 9839
Canberra ACT 2601
Phone: (02) 6213 6000
Facsimile: (02) 6213 7000
Email: Futuremanufacturing@innovation.gov.au

Table of Contents

Future Manufacturing Industry Innovation Council
Discussion paper:
Trends in manufacturing to 2020

Executive summary

Australian manufacturing is a diverse and vibrant industry that plays a significant role in the economy. The industry employs close to one million people and its of total industry gross value-add was 10 per cent in 2010-11. In addition, manufactures accounted for one-third of Australian exports. Manufacturing is also an important driver of innovation in industry – being responsible for a quarter of research and development among businesses.

The industry is faced with both challenges and opportunities. Some of these are shorter term 'shocks', while others are longer term trends. Some, such as globalisation, ageing workforce and the small size of the Australian domestic market have been recognised for some time. Others are more recent, including requirements for low carbon production, the impact of terms of trade and the associated rise in the exchange rate of the Australian dollar. Global 'megatrends' resulting from population growth, economic growth, urbanisation, peak resources and societal changes are contributing both opportunities and threats over the medium term.

Technology, such as information and communication technologies and emerging technologies, is also driving 'disruptive' changes, providing major opportunities and challenges in product and production innovation which will enable the Australian manufacturing industry to respond positively to the challenges and opportunities.

A robust manufacturing sector of the future requires firms that are not only technologically sophisticated, but are also agile, adaptive, and efficient. This is only possible in firms that are knowledgeable, innovative and well managed, and which have access to skills as well as capital. Such assets provide the absorptive capacity needed by successful firms to embrace new knowledge, technology and innovative practices to increase productivity and competitiveness.

Thus, the resilience or robustness of Australian manufacturing lies in firms that:

- recognise that to succeed in the high value-add, low volume products in which they are likely to have a competitive advantage, they must bundle products and services to *sell solutions*, rather than simply tangible products;
- have the capability to identify, design, develop, make and sell products and services that *are in demand*;
- operate with high efficiency and productivity, allowing them to *optimise the use of their capital* – human, intellectual and material;
- have the ability to maximise leverage from *strong and sustainable partnerships* through local and global supply chains; and that
- *seek markets in emerging growth economies*, both by partnering in global supply chains, and by meeting demands from their growing middle classes for high value-add niche products, rather than low cost commodities.

Finally, there is often a tendency to view the innovation needs of an industry through a sectoral lens. A more system-wide approach to building an innovation system is required. Policies and programs that support the development of knowledge, skills, competencies and capabilities that can be effectively translated *across* industry sectors are likely to contribute to the future robustness of Australian manufacturing.

Background

The Future Manufacturing Industry Innovation Council (Future Manufacturing Council), in collaboration with the Department of Innovation, Industry, Science and Research, and the CSIRO Future Manufacturing Flagship, prepared this discussion paper on trends in manufacturing to 2020 at the request of the Enterprise Connect Manufacturing Advisory Committee.

The paper describes Australia's manufacturing industry as it is currently and discusses a number of emerging issues and trends that are affecting, and are expected to affect and influence, Australian manufacturers in the period leading up to 2020 and possibly beyond.

The paper collates informed views of a cross-section of stakeholders including industry, the R&D community, innovation advisory bodies, unions and the public sector.

The paper is intended to invite and provoke debate and discussion among relevant stakeholders on the implications of these, and potentially other, emerging issues on the future of innovation-driven, high value-add manufacturing in Australia.

Future Manufacturing Council

The Future Manufacturing Council is one of a number of Industry Innovation Councils established by the Australian Government.

The Council's focus is on innovation-intensive, high technology, high value-add, high-skill, export-orientated manufacturing. While its primary role is to advise the Minister for Innovation, Industry, Science, and Research, the Council is also championing innovation in manufacturing and helping to build connections between and collaboration with other innovation initiatives and organisations.

The Council has defined a vision for Australian future manufacturing:

> *A future manufacturing industry that provides innovative products and related service solutions to domestic and export markets in innovative ways, builds and retains its highly skilled workforce and is a vital enabler of highly productive and competitive Australian manufacturing.*

To that end, to establish priorities for its work, the Council has formulated a ***Strategic Roadmap for 2010 – 11***, which is at page 38.

Defining manufacturing

Manufacturing, for the purposes of the paper, is defined as including product development, innovation and commercialisation, design, production, manufacturing services and support. This is succinctly defined by the University of Cambridge's Institute for Manufacturing in its 2006 paper *Defining High Value Manufacturing*[1]:

> *…the full cycle of activities from research and development, through design, production, logistics and services, to end of life management…*

[1] http://www.ifm.eng.cam.ac.uk/cig/documents/DefiningHVM.pdf

Innovation, for the purposes of this paper, is defined as

> *… the implementation of new or significantly improved products, operational processes, marketing methods or organisational methods in business practice, workplace organisation or external relations. These innovations can be new to the firm/educational institution, new to the market/sector or new to the world.* [2]

The Council considers that Australia's manufacturing future lies in innovation-intensive, high technology, high value-add, high-skill, export-oriented manufacturing, rather than commodity products. These technologies also have the potential to benefit 'traditional' manufacturing.

Importance of 'low-tech' industries

It should be remembered that innovation-intensive processes are also a critical part of so-called low tech industries. For example, the development of a hard, wear-resistant coating for mining equipment that exhibits a longer life than the current weld overlays would be of enormous benefit. Increasing efficiencies by reducing down time for improved production is desirable and lucrative. … These low hanging fruit from what is perceived as low tech should not be ignored but actively encouraged. In fact it is proposed that successes in low tech ventures would have a more dramatic impact on the bottom line than a specialized, high-tech venture.[3]

Why is manufacturing important to the economy?

Recent experience with the Global Financial Crisis (GFC) highlighted the importance of maintaining the full spectrum of manufacturing capability in the broad economy. Evidence from Germany, Switzerland and other high value-add manufacturing countries in Europe demonstrates that business culture and economic policy settings have kept manufacturing a strong contributor to economic production, productivity and employment. This enabled Germany to survive the GFC much better than other leading developed economies. The US Chicago Manufacturing Renaissance[4] is advocating a similar approach of a manufacturing sector closely aligned with broader society, and especially education.

[2] OECD definition at: http://www.oecd.org/document/10/0,3746,en_2649_33723_40898954_1_1_1_1,00.html

[3] Professor Christopher Berndt of Swinburne University of Technology, comment on draft of the document

[4] http://www.chicagomanufacturing.org/

Importance of a diverse manufacturing industry

It is very difficult to establish and develop new and innovative industries in isolation from the rest of the industrial ecosystem. For example, in scaling up start-up businesses that will hopefully become future SMEs and ultimately successor industries, there is a need to cost effectively access many ancillary capabilities such as pressure vessel and furnace manufacture, fabrication, chemical analysis, electronics, drafting etc. These ancillary industries, while not necessarily 'high tech', can only exist where there is a deep and long term market for their services that will justify their establishment in a specific location. Their competitive advantage is through their relationship with customers, quality and agility.[5]

Profile of Australian manufacturing

Australia's manufacturing industry is diverse. It comprises industries ranging from those producing relatively low value-added commodity products such as some foods and beverages, and other simply transformed manufactures, to high precision, high value-add products including automotive and aerospace components, machine tools, medical devices, electronics, scientific instruments, advanced materials and pharmaceuticals.

Australia's manufacturing industry has grown steadily in absolute terms over the last decade, albeit at a slower rate than other sectors of the economy. The comparative growth of the industry sectors within manufacturing has not been uniform; Australia's manufacturing industry is characterised by change and diversity (see Table 1).

[5] Dr George Collins, Chief Executive Officer, CAST Cooperative Research Centre

Table 1: Industry gross value added of key industry sectors and manufacturing subsectors, and their growth rates.

	2000–01 ($b)	2009–10 ($b)	2010–11 ($b)	Year on year % change 2009–10 to 2010–11	Average annual compound growth rate (%) 2000–01 to 2010–11
Agriculture	**24.0**	**28.4**	**34.0**	**19.7**	**3.6**
Mining	**95.8**	**121.1**	**117.7**	**–2.8**	**2.1**
Services	**613.4**	**844.3**	**866.9**	**2.7**	**3.5**
Manufacturing consisting of:	**103.4**	**110.9**	**111.9**	**1.0**	**0.8**
Food, beverage and tobacco products	22.5	23.7	23.4	–1.2	0.4
Textile, clothing and other manufacturing	8.1	4.6	4.3	–6.8	–6.1
Wood and paper products	8.1	7.4	7.3	–2.3	–1.0
Printing and recorded media	5.4	4.5	4.5	0.2	–1.8
Petroleum, coal, chemical and rubber products	21.0	19.7	19.9	1.4	–0.5
Non-metallic mineral products	3.9	5.7	5.5	–3.1	3.6
Metal products	18.3	23.0	25.2	9.7	3.2
Machinery and equipment	18.2	22.3	21.9	–2.1	1.8

Source: ABS Cat. No. 5206.0.

Historical trends

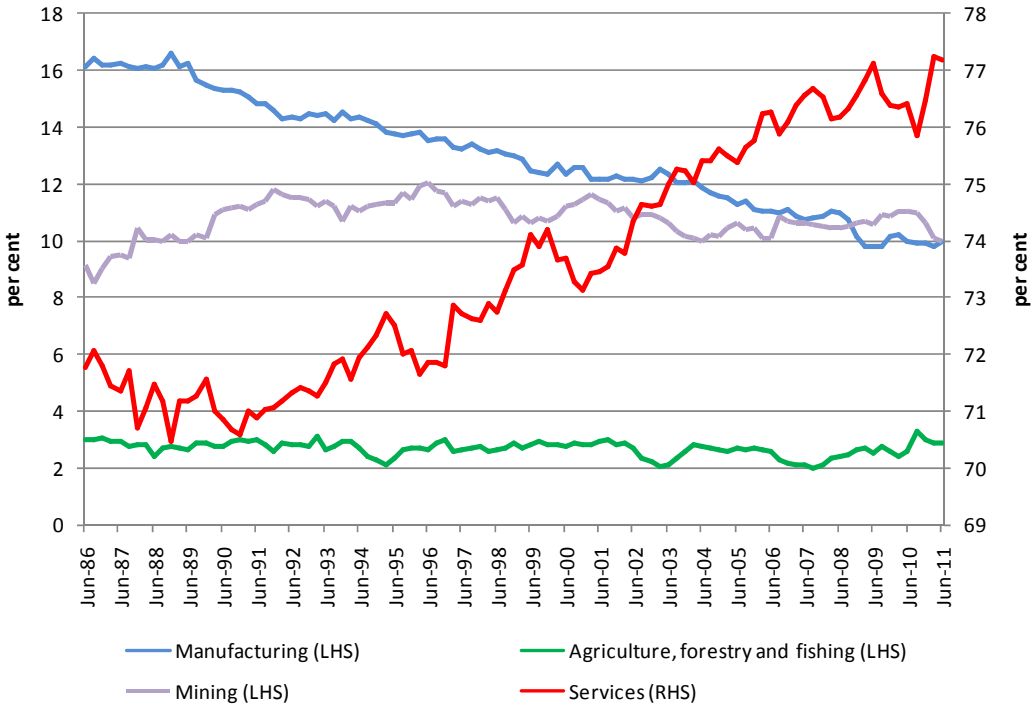
The Organisation of Economic Cooperation and Development (OECD)[6] notes that economic development in OECD economies has long been characterised by a gradual process of structural change. In the initial stage of economic development, agriculture typically accounts for the bulk of GDP and employment, as is still the case in many developing countries. In later stages of economic development, the share of agriculture in total industry value-added and employment typically declines, while the manufacturing sector grows more rapidly as economies industrialise. In recent years, many OECD economies (such as the United States, the United Kingdom, Japan, Germany and France) have experienced a decline in the share of manufacturing in overall employment and output, with a concurrent rise in the share of services.

[6] OECD 2006, *The changing nature of manufacturing in OECD economies*, OECD Directorate for Science, Technology and Industry working paper.

Australia's manufacturing sector, while growing in absolute terms over the past 25 years, has declined as a share of total industry gross value added (GVA)[7]. As can be seen in Chart 1 below, services sector GVA has increased rapidly over the past 25 years, outpacing all other sectors. Mining sector GVA has been increasing faster than manufacturing sector GVA, with both sectors now contributing a similar amount to the economy.

Over the past 25 years, the manufacturing sector's share of total industry GVA has declined from 16 per cent in the year to the June quarter 1986 to 10 per cent in the year to the June quarter 2011. In contrast, the mining sector's share of total industry GVA has increased from 9 per cent in the year to the June quarter 1986 to 10 per cent in the year to the June quarter 2011. The services sector remains the key contributor to the economy, with a percentage share of 77.3 per cent in the year to the June quarter 2011 (see Chart 1).

Chart 1: Industry gross value added, June quarter 1986 to June quarter 2011



Source: ABS Cat. No. 5206.0, quarterly data.

In absolute terms, the number of employed persons in the manufacturing sector has declined over the past 25 years, while employment in the services sector has increased rapidly over the same period. Since the onset of the mining boom, the number of persons employed in the mining sector has also increased rapidly, although off a low base. Despite the rapid increase in mining sector employment during the commodity boom, the manufacturing sector still contributes almost five times that of the mining sector to total employment. Manufacturing currently employs almost 1 million people (8.5 per cent of the workforce) and mining, over 200,000 people (1.9 per cent of the workforce).

[7] Total Industry GVA is equal to GDP minus *Taxes less subsidies on products*, *ownership of dwellings* and *Statistical discrepancy*

Manufacturing employment by subsector

As at the September 2011 quarter, manufacturing employment stood at 945,600 people, a net fall of -5.4 percent through the year from 999,400 people in the September 2010 quarter. Over the past 10 years, from September 2001 to September 2011, manufacturing employment has declined by 86,300 people or at an average annual rate of -0.9 per cent (see Table 2). The long-term decline in manufacturing employment reflects higher levels of labour productivity and capital deepening.

By industry subsector, trends in manufacturing employment vary. Through the year to September 2011, subsectors such as primary metal, and beverage and tobacco product have led the bulk of employment gains following the GFC. However, when employment growth is examined over the past 10 years, from September 2001 to September 2011, only food, beverage and tobacco product, and primary metal and metal product have experienced an increase in employment (see Table 2). All other manufacturing subsectors have experienced a decline in employment over the period. Once again, this trend in employment decline is consistent with higher productivity and capital deepening in the manufacturing sector.

Table 2: Manufacturing Employment by industry subsector (000's persons)

Industry	Sep-2001	Sep-2010	Sep-2011	Year on year % Change	Average annual growth from Sep-2001 to Sep-2011
Manufacturing, nfd	28.3	78.8	72.2	**-8.4%**	9.8%
Food Product	172.3	204.4	196.0	**-4.1%**	1.3%
Beverage and Tobacco Product	22.1	22.4	29.8	**32.8%**	3.0%
Textile, Leather, Clothing and Footwear	80.1	48.6	37.7	**-22.4%**	-7.3%
Wood Product	42.9	38.9	35.9	**-7.8%**	-1.8%
Pulp, Paper and Converted Paper Product	28.0	21.9	14.4	**-34.2%**	-6.4%
Printing (including the Reproduction of Recorded Media)	52.1	60.8	38.2	**-37.2%**	-3.0%
Petroleum and Coal Product	13.8	6.6	11.3	**70.7%**	-2.0%
Basic Chemical and Chemical Product	49.5	39.7	39.6	**-0.3%**	-2.2%
Polymer Product and Rubber Product	45.7	32.7	31.6	**-3.5%**	-3.6%
Non-Metallic Mineral Product	46.0	36.2	37.5	**3.8%**	-2.0%
Primary Metal and Metal Product	64.7	84.6	94.5	**11.6%**	3.9%
Fabricated Metal Product	82.5	56.6	54.9	**-3.2%**	-4.0%
Transport Equipment	104.8	86.1	80.7	**-6.2%**	-2.6%
Machinery and Equipment	121.7	122.5	110.1	**-10.1%**	-1.0%
Furniture and Other	77.4	58.4	61.2	**4.8%**	-2.3%
Total Manufacturing	1,031.9	999.4	945.6	**-5.4%**	-0.9%
Total- all industries	9,043.9	11,208.3	11,344.7	**1.2%**	2.3%
Manufacturing share	11.4%	8.9%	8.3%		

Source: ABS Cat. No. 6291.0.55.003 (original, detailed quarterly)

Manufacturing employment by state/territory

Victoria accounts for the largest share of manufacturing employees in Australia (31.8 per cent) followed by New South Wales (29.3 per cent) and Queensland (18.3 per cent) (see Table 3).

Table 3: Manufacturing employment by state, May 2011

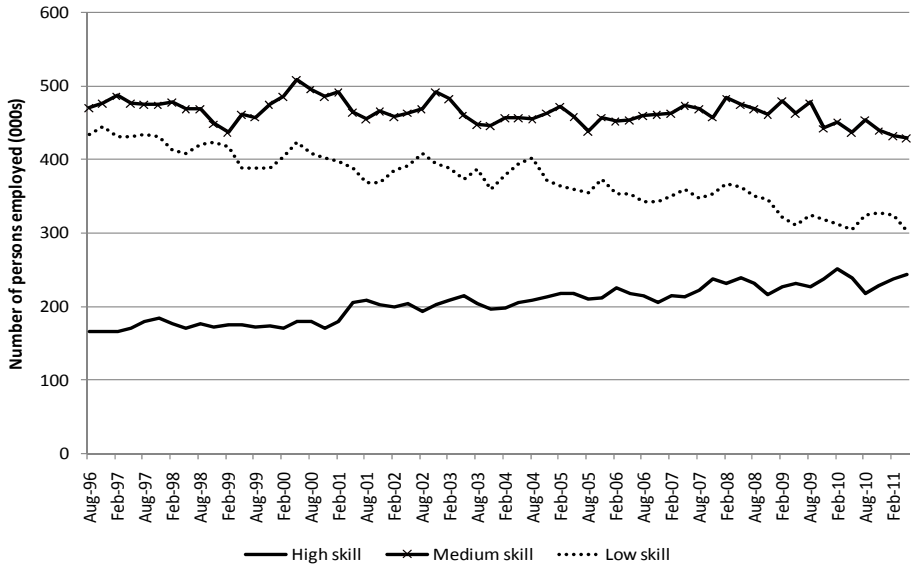
	000s persons	Manufacturing % share of total state/territory employment	State/territory % share of total manufacturing employment in Australia
New South Wales	285.9	8.0	29.3%
Victoria	310.0	10.8	31.8%
Queensland	178.6	7.6	18.3%
South Australia	82.2	10.0	8.4%
Western Australia	92.5	7.5	9.5%
Tasmania	21.0	8.9	2.2%
Northern Territory	3.1	2.7	0.3%
Australian Capital Territory	2.9	1.4	0.3%

Source: ABS Cat. No. 6291.0.55.003 (original, detailed quarterly)

Manufacturing employment by occupation

In May 2011, 25 per cent of employed persons in the manufacturing industry were classified as 'high skilled', up from 19 per cent in the corresponding period ten years earlier (see Chart 2). This general increase in high skilled workers is concurrent with a general decline in lower skilled workers in the manufacturing industry. Managerial knowhow, workforce skills and innovation capabilities are important for improving competitiveness in the face of structural change and cyclical and other short term shocks.

Chart 2: Manufacturing employment by occupation



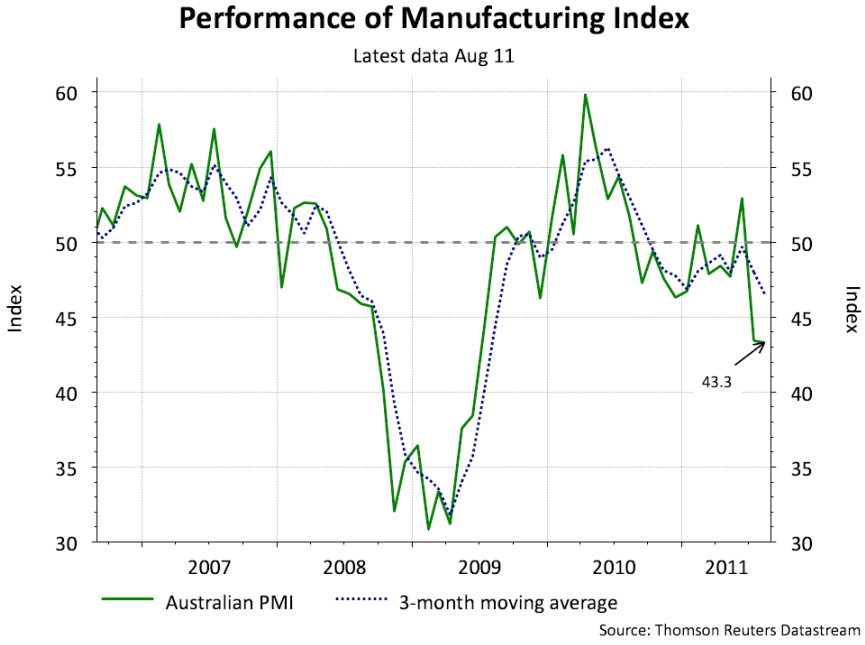
Source: ABS Cat. No. 6291.0.55.003

Note: High skill includes managers and professionals. Medium skill includes technicians and tradespersons, community and personal service workers, clerical and administrative workers and sales workers. Low skill includes machinery operators and drivers and labourers.

Manufacturing performance

The Australian Industry Group/PricewaterhouseCoopers Performance of Manufacturing Index (PMI) fell marginally by 0.1 index points to 43.3 in August (see Chart 3). The index remains below the 50 level which separates expansion from contraction. Survey respondents cited reduced domestic demand, the strong Australian dollar, increased foreign competition, high interest rates, uncertainty surrounding proposed carbon pricing and renewed weakness in the global economy as factors affecting the sector.

Chart 3: PMI index for August 2011



Manufacturing's contribution and linkages in a diverse economy

Like all industries, the manufacturing sector has strong linkages to other sectors in the economy. ABS supply-use data show that re-inputs from the manufacturing sector account for 40.5 per cent of intermediate industry inputs to manufacturing. The services and mining sectors also provide significant inputs to manufacturing. The manufacturing sector provides $161.5 billion of inputs to other sectors in the economy (see Tables 4 and 5).

Table 4: Industry inputs to manufacturing ($ billion, current prices)

	2006–07	% share
Agriculture, forestry and fishing	23.8	9.6
Mining	50.7	20.4
Manufacturing	100.7	40.5
Services	73.5	29.6
Total industry inputs to manufacturing	248.7	100.0

Table 5: Manufacturing inputs to industry ($ billion, current prices)

	2006–07	% share
Agriculture, forestry and fishing	7.9	3.0
Mining	12.1	4.6
Manufacturing	100.7	38.4
Services	141.5	54.0
Total manufacturing inputs to industry	262.2	100.0

Source: ABS Cat. No. 5209.0.55.001, Final release 2006–07 tables

Accurate measurement of the manufacturing sector

Part of the difficulty in preparing this paper, and indeed, in analysing the manufacturing industry in general, is measuring its actual size and hence the economic and social impacts of the sector.

Successful, growing manufacturing firms do much more than make products. They offer both manufactured goods *and* services to provide a *solution* to the client's needs. The services provided in such cases can be either explicit, such as pre and after sales service of a product, or embedded in the solution – or both. Those manufacturing firms that bundle their services with product offerings are more sustainably successful than others that do not.

Business models these days are often bundles of services which package a manufactured product or range of products and these may not be counted as manufacturing in the ABS data. In other words the size of manufacturing and related skills is significantly understated.[8]

For statistical purposes, an industry is a grouping of business units that are mainly engaged in undertaking similar economic activities. With these points in mind, official statistical classifications and attendant data collections should be revised to reflect the spectrum of value-add provided by manufacturers.

[8] Professor Roy Green of the University of Technology Sydney, comment on draft of the document

Trends to 2020 ... and beyond: Issues and opportunities for Australian manufacturing

Since the 1980s, manufacturing in Australia has undergone substantial structural change influenced by a number of factors including trade liberalisation, removal of industry protectionist policies and economic regulation of markets, falling transportation costs and improved information and communications technology (ICT).

Moving towards 2020, Australia's manufacturing industry will be confronted with new opportunities and challenges resulting from the convergence of factors external and internal to Australia. Some are shorter term economic and/or environmental shocks, while others are longer term periodic trends.

The current strong global demand for Australia's resources, particularly from China and India, has driven the terms of trade to record levels with the consequential rising and volatile exchange rate. And, the effects of the GFC continue.

Australia's workforce demographic is changing, while Australia and other countries are experiencing the maturity of changes resulting from the widespread application of ICT. The impact of structural adjustments resulting from ICT will continue.

Emerging global megatrends will influence and shape the future of Australian manufacturing. These include increasing resource scarcity and climate change, urbanisation and increased affluence, people on the move, divergent demographics and the economic growth of developed and developing nations such as Brazil, Russia, China and India (BRIC) with consequential market demand and competition.

The scarcity of many natural resources (such as petroleum, rare earths, readily-accessible metals), calls for greater environmental sustainability and the growing importance of a low carbon economy are giving rise to the emergence of leading edge of 'Sixth Wave' innovations. The innovations include biomimicry, green chemistry and green nanotechnology, whole system design, industrial ecology, greater resource productivity, sustainable energy and satellite technologies.

Australia's manufacturing industry has responded positively to the challenges and opportunities that have faced it since the 1980s to now. It has transformed itself by adapting and repositioning itself to engage in higher value-added activities and become more outward focussed – increasing exports and reaching into global markets. The success and continued prominence of manufacturing in Australia's economy will depend on appropriate responses from business and government to the new and emerging challenges and opportunities. These responses will include leveraging innovation to drive increases in productivity, sustainability and global competitiveness, and integrating into increasingly complex global supply chain markets.

Terms of trade driving value and volatility of the Australian dollar and structural changes in the economy – an upside to manufacturing and associated downstream industries

The rising demand for Australia's resources is driving Australia's terms of trade higher. This and other global financial market movements are driving higher currency exchange rates and volatility. In turn, there are consequential structural changes in the economy.[9]

[9] Sydney Morning Herald. 4 May 2011. *$A staying high: ANZ* - http://www.smh.com.au/business/a-staying-high-anz-20110503-1e6tg.html#ixzz1R6tFElQM

Some economists predict this situation will continue for the foreseeable future, and this can be expected to will bring about altered usage patterns of inputs and consumption. For some time now, this has made Australian manufactured exports generally less competitive in the global marketplace. This is particularly so for those who compete on price rather than value for money.

In these conditions, trade-exposed manufacturers will be pressed to establish a competitive advantage in order to survive. Innovation provides solutions where it leads to reduced costs, increased productivity, and new or more appealing products and services. Conversely, a strong Australian dollar may support manufacturing industries with links to Australia's natural resource endowments.

However, an upside to the strength of the resources sector is the creation of high-wage jobs for Australians, and innovative, high value-add products and services to mining and associated firms both here and abroad.[10] Opportunities exist in exploiting downstream markets in the mining sector by supplying traditional goods and services or carving out niche markets. Examples include the manufacture and/or the provision of mining equipment and instrumentation, software, explosives, energy systems, transportation equipment and services, scientific research services through to personal protective technologies for miners.

Adding value to Australia's minerals

Australia has the world's largest reserves of titanium ore, as well as the technological know-how to turn ore into high value added manufactured metal products. There is a very wide range of high-end uses for titanium, including medical implants and aerospace components.

Today, most of our titanium ore is shipped overseas, and brought back after processing. Based on current mining and export volumes, it is estimated Australia has 90 years of this resource remaining. However, the value of titanium alloy metal in the world market is 100 times greater than that of titanium ore. CSIRO is developing technology to convert ore to titanium metal alloy. If Australia were to grow a local industry that converted its ore to alloy metal, it could maintain its current value of exports and effectively extend its natural ore resource by a factor of 100 (90 years to 9,000 years)[11].

As promising as these facts are, they raise the question of why commercial investment in such activities occurs elsewhere but not in Australia.

A strong exchange rate is likely to benefit industries naturally protected from import competition, especially by reducing import costs; although globalisation seems to reduce the range of what were once considered 'naturally protected' sectors.

In addition, a strong exchange rate may offset to some degree, the costs of imported capital and other items that are used by trade exposed manufacturing industries. This may

[10] Australasian Institute of Mining and Metallurgy, 2006. Submission to House of Representatives Inquiry into the state of Australia's manufactured export and import competing base now and beyond the resources boom. http://www.ausimm.com.au/content/docs/state_aust_manufactured_export.pdf

[11] http://minister.innovation.gov.au/Carr/Underthemicroscope/Pages/default.aspx

have a positive impact on capital deepening, productivity and the competitiveness of Australian manufacturing industries. A less positive possibility is for firms to rely on 'off-the-shelf' imported innovation, rather than developing proprietary intellectual property with the potential to provide a competitive advantage.

One response to a high-value, fluctuating currency is for Australian firms to draw on the opportunities presented by free trade agreements. These allow Australian industry to 'offshore' the low value adding, high labour content aspects of production, while keeping high value adding onshore. However, such strategies must be dealt with on a case-by-case basis. For example, the Scania Group considers that as long as the total cost of labour does not exceed 15 per cent of their cost base, the disadvantages of offshoring outweigh the advantages[12].

Other options for responding to currency fluctuations are for Australian firms to make use of financial instruments such as currency hedging and pricing their traded products and services in other foreign currencies. Financial innovation is therefore a valuable accompaniment to technology, management and organisational innovation.

Interdependency of manufacturing and associated services

To compete globally, firms need to provide innovative solutions and services that exploit revenue streams other than those arising from simple production.

Sell solutions – products bundled with value-adding services

The ability of manufacturing firms to provide solutions, rather than simple items of production, and the growing role of manufacturing services and support is of increasing importance.

Such behaviour is evidence of Australian firms transforming themselves from just a manufacturer or service provider to a total package problem-solver for their customers.

It is a smart move to add services to products because it is less risky to develop new services than new products. Services have ever-expanding boundaries and are not constrained by what the product can be first seen to do. A firm that provides services does not have to retool or invest in expensive and untried technologies.

The move made by Australian firms to 'selling solutions' is a competitive response so that they can succeed in an increasingly volatile and globalised business environment of cheaper products, shorter product cycles, faster business imitations and saturated markets.[13]

The capacity and willingness of firms to implement, manage and enforce appropriate intellectual property protection will also be vital to their success.

[12] Roos, Professor Göran. 14 July 2011. Presentation to the chairs of the Innovation, Industry, Science and Research portfolio's innovation bodies.

[13] Kennedy, Narelle. 22 August 2002. *Manufacturing New Competitive Strategies*. Australian Business Foundation

Technological advances

Research and development has underpinned the development of innovative and higher value-added products and services which have been a source of competitive advantage for many Australian manufacturing industries. It has also been vital to the development of new production processes that have lowered manufacturing costs, improved quality and driven economies of scale. Such developments also offer opportunities for Australian innovators to license their technology for both domestic and overseas use. Conversely, manufacturers may also choose to adopt and adapt existing technologies from domestic and overseas sources to introduce new production processes and/or products which add value, lower costs and raise productivity.

The ability of firms to be aware of and exploit disruptive technology, technological advances and world's best innovation practices will be key to ongoing success.

Key enabling technologies such as nano technology and biotechnology, rapid prototyping and additive manufacturing are expected to support the development of new and improved manufacturing industries and higher value-added products, together with improved production processes. These are likely to increasingly play a prominent role in enabling such mass customisation. Such technologies also provide the opportunity for low volume manufacturing without relatively expensive set up costs, potentially allowing the localisation of manufacturing – as opposed to off-shoring to locations where economies of scale can be otherwise achieved.

Increasingly, ICT-enablement is allowing manufacturers to adapt and exploit new technological product and service offerings, opening new opportunities and pathways to competitiveness and wealth creation for Australian manufacturers[14] [15]. Over the last decades digital computing, communications and the ICT revolution have had a profound impact across manufacturing industries, shifting them towards more agile, just-in-time processing, high-performance manufacturing, and accelerated introduction of new products. As we head towards 2020, the convergence of nanotechnology, biotechnology, cognitive and neuroscience with ICT is expected to cause similar disruptive changes[16].

Increasingly manufacturers will need to leverage the power of knowledge networks and digitised manufacturing technologies such as computer integrated manufacturing (CIM) that allow flexible manufacturing of multiple product lines and do it without necessarily increasing their manufacturing footprint. While the need is recognised, there is currently a significant gap, and hence an opportunity to develop the design and production systems to address it.

Advances in CIM and the ability to move large amounts of information through broadband networks will in many cases enable manufacturing companies to operate remotely from the location of production or of markets. This potentially reduces the geographical constraints on manufacturing and allows Australian companies to operate more effectively through global supply chains.

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[14] Pricewaterhouse Coopers, 2009. The future of UK manufacturing: Reports of its death are greatly exaggerated, http://www.pwc.co.uk/eng/publications/the_future_of_ manufacturing.html

[15] Davies, A., Brady, T., et al, 2003. Delivering Integrated Solutions, University of Sussex, SPRU – Science and Technology Policy Research, Centre for Research in Innovation Management, Engineering and Physical Sciences Research Council, Imperial College.

[16] Australian Business Foundation. April 2011. Manufacturing Futures – A paper by the Australian Business Foundation for the NSW Business Chamber

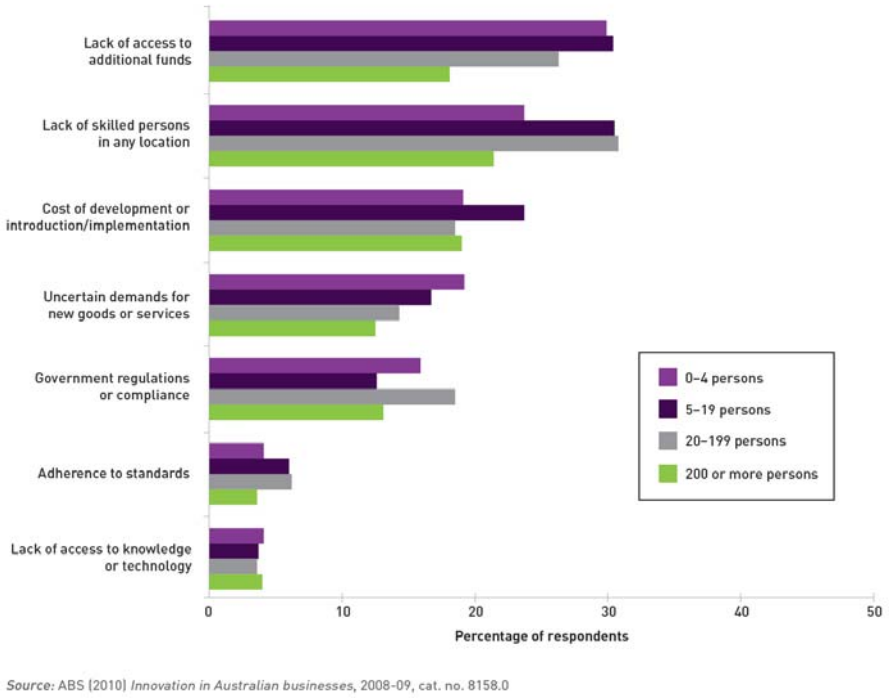
The National Broadband Network will be a key piece of infrastructure that will allow for process improvements within manufacturing firms. For example, it will facilitate the uptake and use of CIM across all aspects of the manufacturing process, resulting in productivity gains at the firm level. CIM will improve efficiencies across the supply chain, as well as enabling the rapid prototyping and product customisation mentioned elsewhere in this paper.

Related to CIM are other computer-enabled, networked technologies such as smart grids, mini-grids and building management systems which offer both increased efficiencies in their application, and opportunities for developers and manufacturers as the global economy adopts these technologies.

Increasing skills requirements for precision, high value-add manufacturing

A highly skilled, well managed workforce, combining an appropriate mix of leadership, professional, technical and trade skills is essential for Australian manufacturing industries to innovate, adopt improved technologies and remain globally competitive in the future. Chart 4 illustrates that the lack of access to skilled employees is a major barrier to innovation.

Chart 4: Barriers to innovation for innovation-active Australian businesses 2008-09



Source: Chart 3.5 from the *Australian Innovation System Report 2011*

Highly skilled jobs continue to be created as Australian manufacturing responds to the productivity and competitiveness challenges by investing in capital equipment that embodies ICT and enables computer-aided design, computer integrated manufacturing and

digital additive manufacturing. As firms package value-added services with their manufacturing solutions, highly skilled service jobs will be created. Many of these jobs will be office-type jobs. These types of jobs will be more attractive to the tertiary trained staff they require. That said, Australia's precision manufacturing jobs have attractive work environments.

An ageing Australian workforce could contribute to future declines in manufacturing employment due to natural attrition. The consequential loss of both formal and tacit knowledge held by those highly skilled employees will also pose problems for firms.

Competition in the labour market for skilled employees and trainees is intense. Many new entrants to the workforce are pursuing careers outside manufacturing industry. Consequently, the ability of firms and the industry as a whole to market manufacturing as a viable and rewarding career path will be vital to recruiting new generations of employees.

The lead time between action to increase levels of training and people actually taking up positions in industry is in the order of years. Education and training of the workforce at the firm level is therefore a strategic issue for the long term survival of the firm. This will require firm managers to fully appreciate human resource management issues and be aware of training assistance that is available.

Hence, recruiting or training employees with the necessary skills to embrace and implement technological advances and continuous innovation will be increasingly important for the success of manufacturing firms.

There is strong anecdotal evidence that Australia is not training sufficient people with necessary trade or professional skills, leading to the need to recruit skilled workers from overseas. At the more fundamental level, Skills Australia has indicated that 43 per cent of the Australian workforce has literacy problems and 47 per cent has numeracy problems[17]. While this might not be the case for high value-added manufacturers, it is important to note that approximately 50 per cent of workers in the manufacturing sector do not have a vocational qualification.[18]

To address this, firms need to consider appropriate in-house training, succession planning and mentoring so that skills are not lost. Industry involvement with the education system and a greater commitment to in-the-workplace training, including apprenticeships, will also be important in ensuring employees have relevant skills and experience.

Productivity growth

Productivity is a measure of the ratio of inputs, such as labour, materials and capital to the production of outputs in the form of goods and services. Growth in productivity is essential for the competitiveness and viability of Australian manufacturing industries in the domestic and global markets, and for sustaining long term increases in Australia's national income and standard of living. The OECD report, *Australia: Towards a Seamless National Economy, 2010* noted 'Australia needs to boost productivity to return to long-term sustained growth...'

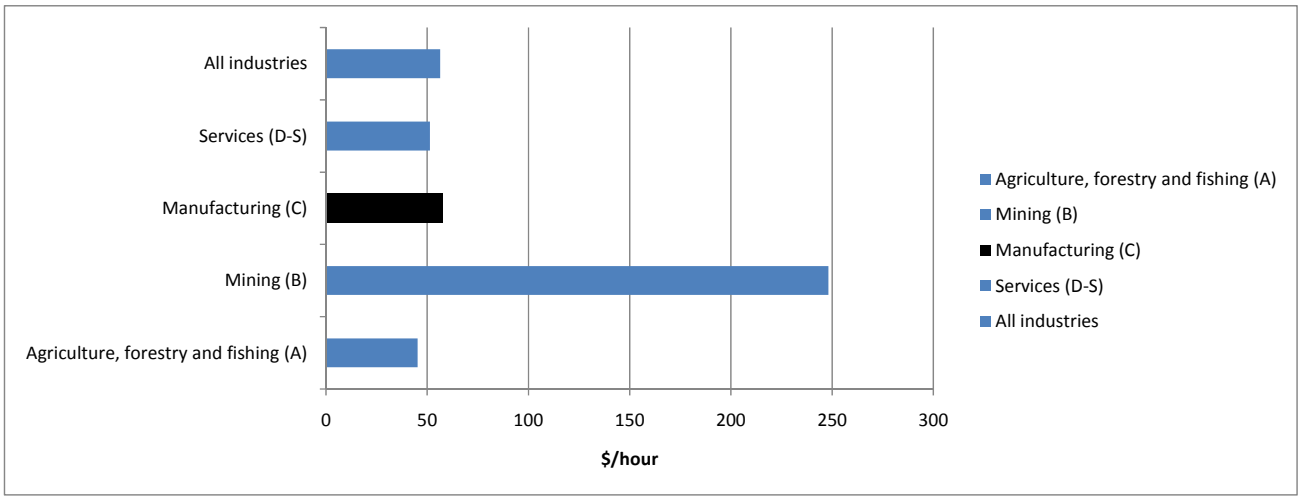
[17] Skills Australia .2010. Australian Workforce Futures - A National Workforce Development Strategy. http://www.skillsaustralia.gov.au/PDFs_RTFs/WWF_strategy.pdf

[18] David Pettigrew, QMI Solutions Ltd

As one measure of productivity, labour productivity is measured as industry gross value added per hour worked. Labour productivity in the manufacturing industry grew at an average annual rate of 1.8 per cent from FY 2000-01 to FY 2010-11. This compares to the labour productivity for all industries, which grew at an average annual rate of 1.2 per cent for the same period.

Chart 5 shows that in FY 2010-11, manufacturing labour productivity was above the average for all industries and was the second only to, and lagging behind, the mining sector.[19]

Chart 5: Labour productivity, FY 2010-11



A 2011 report from the Grattan Institute indicated that Japan and a collective of European nations experienced negative growth in labour productivity in manufacturing between 1990-2000 and 2000-07. [20]

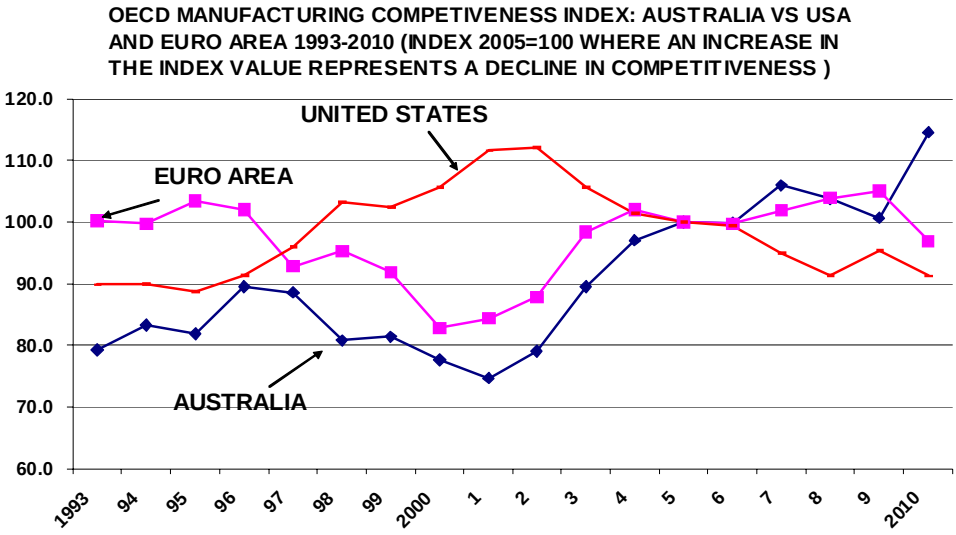
However, despite growth in labour productivity, the competitiveness of the Australian manufacturing sector declined compared to Europe and the USA as Chart 6 shows:

[19] Labour productivity values are DIISR estimates derived from ABS Cat no 5206.0 and ABS Cat no 6291.0.55.003, and expressed as financial year averages.

Note: Sectors grouped according to ANZSIC 2006 and services sector includes ANZSIC Divisions D-S.

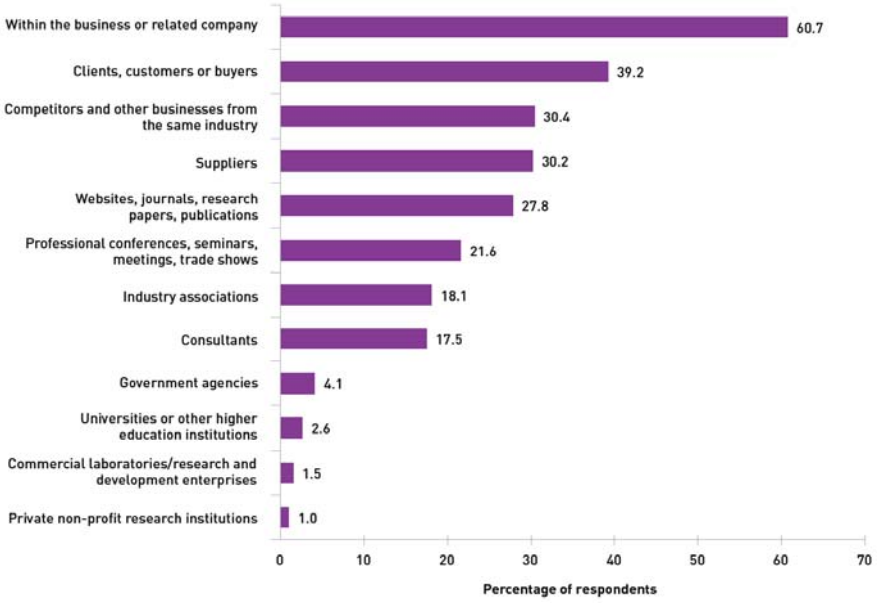
[20] Eslake, S. 2011. *Productivity*, paper presented to the annual policy conference of the Reserve Bank of Australia 15-16 August 2011.

Chart 6: OECD Manufacturing Competitiveness Index: Australia vs USA and Euro Area



Innovation is recognised as a driver of productivity and is an important factor in achieving the Australian Government's productivity agenda. Many studies on innovation have found that up to 40 per cent of innovation ideas come from customers. Chart 7 (source Chart 4.1 from the *Australian Innovation System Report 2011*[21]) illustrates sources of ideas or information for innovation-active Australian firms in 2008–09.

Chart 7: Sources of ideas or information for innovation-active Australian firms, 2008-09



Source: ABS (2010) *Innovation in Australian Business 2008–09* cat. no.8158.0

Innovation goes beyond the development and implementation of new or significantly improved products. It includes the implementation of new or improved operational

[21] Department of Innovation, Industry, Science and Research. 2011. *Australian Innovation System Report 2011*. http://www.innovation.gov.au/AISReport

processes, marketing methods or organisational methods in business practice, workplace organisation or external relations. These innovations can be new to the institution/firm, new to the market/sector or new to the world.[22]

Many firms, especially SMEs, view productivity and competitiveness as simply cost-reduction exercises, i.e. short-term actions. However, cost reduction and importantly the reduction of waste in all its forms is a strategic issue and needs to be integrated with technology, human capital and innovation in order for long-term productivity improvement to be sustained. For example, implementation of new systems and processes such as computer integrated manufacturing and lean manufacturing can significantly improve firm productivity.

Ensuring that firms identify and implement world's best practice in management, process and product innovation will be vital to success of manufacturing into the future. The leadership group in each firm is responsible for soundly judging their firm's business environment – the external challenges and opportunities – and their firm's strengths and weaknesses. With this information the leadership group must then make appropriate business decisions on what actions to take that will ensure the longer-term sustainable competitiveness of the firm. This has to be followed through with an implementation plan that achieves the firm's strategic objectives.

While new product and service innovation are seen as significant drivers of productivity, insufficient knowledge of human-capital management remains a major barrier to productivity gains for many companies. Human-capital management is necessary for firms to make appropriate, strategic decisions on the investment and best use their assets.[23]

The *Management Matters in Australia* report of 2009 by Professor Roy Green identified the contribution of management skills to firm productivity. It benchmarked Australian management practices against 15 other countries using 18 management criteria. Australia was ranked slightly above the average at 6th place, but behind other advanced economies. The report rated the management practices of Australian firms '…as only moderately above average when benchmarked globally'. In this respect, the report noted that many of our firms are being outperformed by the best of our competitors in China and India. The report noted that while Australian businesses do well in managing operations, there was significant scope for consistent and sustained improvement in key areas such as people and strategic management. The report's evidence indicates that while companies may offer innovative products, services or solutions, there is potential for improved productivity returns from investment in the people skills of managers and the associated culture change.

The lack of productivity growth in the wider economy has recently been highlighted as a barrier to success for many Australian firms. Given the challenges facing manufacturers described in this paper, the ability of Australian manufacturing to raise productivity sustainably will be vital to success in the medium to long term.

Ensuring that firms identify and implement world's best practice in process and product innovation will be vital. Management and organisational innovation will be necessary precursors to realising world's best practice. Furthermore, to be competitive, firms will need to ensure that any gains in productivity are made in line with the principles of 'green

[22] See also, the OECD definition at: http://www.oecd.org/document/10/0,3746,en_2649_33723_40898954_1_1_1_1,00.html

[23] *Gearing for growth – future drivers of corporate productivity.* A report from the Economist Intelligence unit (2011).

growth'. From this perspective, 'resource productivity', that is, how efficiently and sustainably manufacturers utilise materials, energy and water inputs, can be expected to become increasingly important.

Sustainable growth

Policy framework conditions in Australia and foreign markets

Government policy framework conditions and regulations will be an important driver in the competitive success of domestic firms through to 2020. In particular, policies that create an environment in which firms can grow are essential. In this respect, consistency of government policy settings is a recurring theme raised by industry in Australia and overseas. Investment is most likely to occur in an environment of reasonable certainty, and government must balance the conflicting challenges of providing a stable policy framework, while being flexible and responsive to changing economic and social conditions.

In this respect, initiatives such as the Government's *Industry Innovation Councils* are an important contribution to building an innovation culture in Australia. The Councils are charged with providing strategic advice on innovation priorities to the Minister for Innovation, Industry, Science and Research, championing innovation in industry, and building connections and collaboration across Councils and with other innovation initiatives. By increasing the flow of information and ideas across the various 'silos' in society, better policy, programs and regulation, and better use of these initiatives by industry and the research community can be expected.

A supportive regulatory environment is essential for the proper functioning of society and sustainable economic growth. The challenge for government is to deliver effective and efficient regulation that addresses an identified problem and benefits to the community, taking account of the costs.[24]

Such outcomes are a particular challenge in federal systems, with a tendency for regulation to be either duplicated across levels of government, or subtly inconsistent between jurisdictions – adding to business costs in both cases. Hence, regulation reform has been a focus of the Council of Australian Governments for some years.

Given these challenges, effective engagement between government and industry stakeholders can address the potential for problems created by regulation. It ensures mutual understanding of the problem, alternative options to address it, potential administrative and compliance mechanisms, and associated benefits, costs and risks. It also facilitates greater transparency in regulatory processes. This can improve accountability as well as address issues concerning regulatory failure, such as regulatory capture, rigidity, market uncertainty and inability to understand policy risk. [25]

Hence, firms' understanding of the regulatory environment in which they operate is an important factor in maintaining and improving their competitiveness. This extends to their awareness of the regulations – tariff and non-tariff barriers – applying in potential export markets.

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[24] Office of Best Practice Regulation. Accessed 5 Sep 2011.
http://www.finance.gov.au/obpr/proposal/handbook/1-productivity-and-regulation.html

[25] Office of Best Practice Regulation. Accessed 5 Sep 2011.
http://www.finance.gov.au/obpr/proposal/handbook/1-productivity-and-regulation.html

Environmental regulations – securing a social licence to operate and compete in increasingly greener markets

The recognition of a changing climate, the increasing scarcity of some key natural resources, and the need to adapt to a carbon-constrained future, has resulted in increased demand by consumers and governments for sustainable products and services. Some national governments, such as in Europe and South Korea, are responding to these emerging trends with growth and innovation policy frameworks and strategies.

Green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To do this, it must catalyse investment and innovation which will underpin sustained growth and give rise to new economic opportunities.

Environmental regulations and their enforcement are becoming increasingly stringent in both Australian and global export markets. For example, in all parts of Australia, governments are increasing landfill levies. These levies will continue to put pressure on both manufacturers and retailers to make and sell products with less packaging or with greater recyclability.

Product stewardship in Australia

Australia consumes over 1.5m tonnes of largely hydrocarbon-based plastics annually, of which less than 20 per cent is recycled. Product stewardship regulation has been successfully implemented in various parts of Europe, while the Australian Government launched product stewardship programs for rubber tyres and computer screens under its *National Waste Management Policy* of 2010. In June 2011 landmark product stewardship legislation was passed in the Australian Senate. The scheme aims to increase television and computer recycling rates from the current 10 per cent to 80 per cent by 2020-21. It is likely that in the future, other product classes will be included and a regulatory impact statement is currently being prepared on a range of measures to address packaging waste and litter, including container deposits, with public consultation expected to begin later this year.

This growing trend in environmental regulations, both in Australia and overseas markets expands the traditional role of the manufacturer to include the responsible disposal of products at the end of their service life.[26]

High-value market opportunities will exist for those proactive manufacturers that understand and reduce their environmental footprint of their products and production processes. High value products and services will be differentiated from their competitors on the basis of whole-of-life – that is the innovation, design, production and end-of-life management.

The recent release of the *Building Products Life Cycle Inventory* developed by the Building Products Innovation Council (a private sector body) provides an example of how

[26] http://www.environment.gov.au/minister/farrell/2011/mr20110615.html

manufacturers can develop the necessary knowledge to reduce the life cycle impacts of their products.[27]

Sustainable products and services cover the entire spectrum from low to high value-added outputs. The 'green jobs' created by these emerging markets will require a workforce with an increased understanding of and training in sustainability principles and competitiveness.

Operating in a resource constrained world – 'doing more with less'

There is mounting evidence that many natural resources are reaching their peak in terms of availability at either reasonable cost or quality. This includes non-renewable minerals and fossil fuels. Many of the high-grade ore deposits that underpin the success of the Australian minerals industry are now depleting or experiencing declining grades and quality.[28] There is scarcity of fresh water resources relative to demand[29] and energy demand is forecast to rise throughout the world in the coming decades.

In the book *The Sixth Wave - how to succeed in a resource limited world*[30], the authors suggest economic growth will eventually be decoupled from resource consumption and waste production. Resources will be valued and priced on the basis of a shift in assumptions from 'resources are cheap and plentiful' to 'resources being seen as scarce and valuable'.

Competition for materials will put pressure on manufacturers to make the best use of available resources and to respond by improving the efficiency of production. From a manufacturing perspective there will be a need to closely examine the effective use of virgin feedstock, the selection and availability of substitute or alternative feedstock, the re-use of waste or unused material and the need to give due consideration to energy and water efficiency during the manufacture of products. 'Cradle to cradle' will become the norm.

A report produced by the UK manufacturers' organisation, EEF Limited, in conjunction with Barclays Commercial Bank suggests that businesses spend around 5 per cent of turnover on waste, including unused materials, defects, energy and water, and points out that 90 per cent of materials used in production do not find their way into the final product.[31]

Resource efficiency can and should occur at both product and processing levels in the manufacture of commodities such as chemical or feedstock material and the production of both simple and elaborate manufactures. For example:

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[27] http://www.bpic.asn.au/LCI

[28] Mudd, G M, 2009, The Sustainability of Mining in Australia: Key Production Trends and Their Environmental Implications for the Future. Research Report No RR5, Department of Civil Engineering, Monash University and Mineral Policy Institute, Revised - April 2009.

[29] UN, 2006. Coping with water scarcity: A strategic issue and priority for system-wide action. United Nations Thematic Water Initiatives, New York.

[30] Moody, James Bradfield and Nogrady, Bianca. 2010. The Sixth Wave - How to Succeed in a Resource Limited World

[31] http://www.greenwisebusiness.co.uk/news/report-calls-on-manufacturers-to-increase-resource-efficiency-320.aspx

- Improved chemistry technology, enabling manufacturers to carry out simple and complex chemical transformations faster, more efficiently, with fewer processing steps, while offering reduced cost and lower environmental impact.
- Additive and direct manufacturing processes that convert raw materials (such as metal, ceramic or plastic) more directly to finished products without many intermediate steps, using less materials and minimising waste.
- The use of advanced materials that provide high performance and multi-functionality allowing manufacturers to make products with less materials and lower overall weight without sacrificing performance.
- Materials can be designed or treated to impart desired properties such as being biodegradable, recyclable or re-engineered after the product's end-of-life phase.
- Sophisticated packaging methods extend the shelf life of products; notably foodstuffs.

While manufacturers can innovate to achieve resource efficiency at factory or company level, most businesses operate within complex supply chains. The interdependency of manufacturers and their supply chains creates opportunities to take a more systems approach to achieving sustainable manufacturing.

Industrial ecology (IE) is an evolving field where industrial systems are viewed as part of the environmental system. There is potential to apply IE concepts more broadly to the manufacturing sector, including cradle-to-cradle, closed-loop production, zero waste manufacturing processes, design for environment/disassembly and industrial symbiosis. Specifically, IE includes the analysis of the social and industrial metabolism of industry, including tools such as life cycle assessment, material flow analysis, substance flow analysis and input-output analysis[32].

[32] Chris Davis, Igor Nikolic, and Gerard P.J. Dijkema. 2010. Industrial Ecology 2.0, The Journal of Industrial Ecology, Vol 14. No5

Industrial ecology precinct

One of the best-known examples of industrial ecology can be found in Kalundborg, a small industrial zone near Copenhagen in Denmark. Over time, this unplanned industrial park has evolved from a single power station into a cluster of companies that rely on each other for material inputs. In 1995, material and energy exchanges were about 3 million tonnes a year, providing estimated savings of US$10 million a year and an average pay-back time of six years[33].

In 2005, the UK Government launched the National Industrial Symbiosis Programme (NISP). NISP has delivered substantial benefits for the UK economy and businesses, and has boosted the UK economy by £1.5 billion – £2.4 billion.[34]

In Australia, the Kwinana Industrial Area, south of Perth is our best example of industrial symbiosis. As reported in the CSIRO's Ecos magazine in 2006 'There are 47 industrial synergies in place now – 32 by-product synergies, involving the reuse of solids, liquids or gasses, and 15 involving the shared use of utility infrastructure' [35]

By 2020, it is likely that manufacturers will have begun to make significant inroads to being more resource efficient – 'doing more with less' – through cleaner, leaner and 'greener' processing, smarter design using advanced and high performance materials as well as maximising efficiency within their supply chains.

Transitioning towards a low carbon economy

The Government has committed to a long-term carbon emissions reduction target of at least 80 per cent below 2000 levels by 2050. As a first step, Australia will reduce its emissions by between 5 and 15 per cent below 2000 levels by 2020.

In 2005, manufacturing accounted for over 25 per cent of Australia's energy use and over 28 per cent of greenhouse gas emissions. Australia's gradual transition towards a low carbon, cleaner energy future with the planned implementation of a carbon price and thereafter, an emissions trading scheme will challenge energy-intensive and trade exposed manufacturers in the near term, but conceivably provides a wide range of incentives and opportunities for manufacturers to adopt cleaner and less emissions-intensive technologies in the longer term.

To assist with the transition to a price on carbon, on 10 July 2011 Prime Minister Gillard launched the Australian Government's *Clean Energy Future*. The program provides a range of initiatives to assist industry to reduce its carbon footprint. Together with existing government programs, this provides an opportunity for the manufacturing sector to take the initiative and engage across sectors and with all levels of government to provide an advisory mechanism on green issues and ensure Australia remains competitive.

Improving energy efficiency will appear to be a fundamental first step for many manufacturers making the adjustment towards a lower carbon economy. Improved energy awareness, monitoring of energy efficiency through the entire production and supply chain

[33] http://www.iisd.org/business/viewcasestudy.aspx?id=77

[34] http://www.nisp.org.uk/Publications/Pathway.pdf

[35] ECOS, 2006 p22-26

and upgrading of production technologies to improve energy usage will likely become the norm by 2020 as many industries and companies strive to lower their carbon footprint. Accompanying such energy efficiency measures will be the increased use of a wider range of 'cleaner' energy from renewable sources or improved plant or building energy efficiency through the use of co-generation or tri-generation plants[36].

Manufacturers that are able to adapt their processes and products to the needs of a low carbon economy will have a competitive advantage over domestic and international competitors. Opportunities extend to include:

- Developing and/or manufacturing products and systems that support the growth of a low/no carbon energy future, such as components and energy management systems for solar and wind.
- Developing and/or manufacturing products that support the construction of a more sustainable built environment and infrastructure, including energy efficient building systems and materials with inherently lower embodied energy/carbon.
- Developing manufacturing techniques and technologies that are low carbon (and indeed, low net resource) and exporting those developments.[37]
- Target high value-add, high intellectual property manufactured products with relatively low carbon transport and hence, low shipping costs. Examples of these products generally come from the science and biotechnology areas such as medical devices and diagnostic equipment.

Global 'megatrends' – population demographics, people on the move and increasingly demanding, technological advances – opportunities abound!

Enormous market opportunities accompany a growing, ageing and increasingly urbanised global population. The need to house increasingly urbanised populations in a sustainable fashion will create demand for products and technologies that enable greener buildings and infrastructure. The rise in global urbanism is accompanied by an increased demand for greener mobility and transportation solutions, which again will be underpinned by innovative, cleaner, greener products, equipment and systems.

Population growth drives changes in, and usually increases, consumerism. Similarly a growing number of environmentally conscious consumers are reducing their environmental footprint, avoiding brands with poor environmental reputations and are often willing to pay a price premium for green products – all of which are opening up new markets for businesses.

Ageing populations will require improved healthcare products and services. Products of the future need to be designed so that older, less technically savvy people find them easy to use.

The increasing role that consumers play in setting expectations for sustainable and personalised products will require manufacturers to customise their products to meet

[36] The Australian. 23 March 2010. http://www.theaustralian.com.au/australian-it/tri-generation-plant-to-cut-banks-energy-bill/story-e6frgakx-1225844000091

[37] Prof. John Beynon, Dean of Engineering and Industrial Sciences, Swinburne University and Centre Leader, Australian Advanced Manufacturing Research Centre.

individual tastes and preferences. In addition to consumer sentiment on the environmental credentials of products discussed earlier, mass customisation is likely to be increasingly the norm. This is in contrast to the past, where mass production was the focus of manufacturers seeking to drive unit costs down through economies of scale and off-shoring of production to relatively lower labour cost economies.

The expected drive towards mass customisation is likely to create an increasing need for manufacturers to innovate in design, production and service delivery. From the design and production perspectives, manufacturers will need to respond very quickly to a much wider variety of product specifications.

Globalisation, the rise of emerging economies and global supply chains

Industries operate in an increasingly globalised world. To achieve success in this environment and achieve scale, Australian firms must seek to integrate into the global supply chain markets of multinational companies. Such markets for intermediate manufactured goods are estimated to comprise some two-thirds of world trade. A similar proportion is controlled by the top 500 multinational companies. The ability of firms to identify and exploit new and emerging markets, avoiding over-reliance on one or a few economic partners, will also be essential.

One grouping of emerging economies includes Brazil, Russia, India and China (colloquially called 'BRIC' countries). Whilst their collective relevance to Australia may be debatable, they nonetheless account for almost three billion people, or just under half of the world population. The middle classes in these countries are growing. With this, the disposable incomes of these middle class people are increasing. This represents a major opportunity for Australian manufacturers to export high value-added bespoke products and services into niche markets.

Australian manufacturers are practised in profitably manufacturing low volume, niche products due presumably to lessons learned from servicing the small domestic market. In contrast, firms in high volume economies like China and the USA tend to set up for high volume production rather than for the flexible and responsive demands from low volume/high mix customers. This competitive advantage for Australia can be exploited in these emerging markets, as well as the prosperous traditional markets in Europe and North America.

Recognising our competitive strengths

The size of Australia's domestic market is often seen as a disadvantage for local manufacturers but it can offer a competitive edge for those companies with the ability to design and manufacture products with small production volumes. Often this will be in niche markets where customisation is required. If a manufacturer is reliant on exports, then it will always have to struggle with labour cost and exchange rates. The alternative is to identify and commercialise manufacturing technologies that are cost competitive at a much smaller scale. Aside from maintaining local industrial bases and capabilities, there will be an increasing sustainability benefit and competitive advantage as transport costs, which are currently relatively low, increase due to energy and emissions constraints.[38]

As the BRIC economies play an increasingly important role in global trade, both in terms of the volume and increasing sophistication of their output, they will also play a significant role both as competitors and suppliers.

Chinese/Taiwanese mega manufacturers are emerging as dominant players in the global economy. For example, the Taiwan-based Hon Hai Group with its Chinese subsidiary Foxconn, is the world's largest contract maker of electronics. Foxconn is reputed to produce 50 per cent of the world's electronic products.

Integration into global supply chains and forming partnerships with firms in these countries, and in particular the large manufacturing base in China, will be vital to the success of Australian manufacturers. However, the scope for innovation is limited when product design and specifications are determined globally. This can restrict the ability of Australian manufacturers to differentiate their products, forcing them to compete on cost and absorb freight costs and exchange risks.

[38] Dr George Collins of the CAST CRC, comment on draft of the document

Opportunities created by innovation – industry examples

With these influencing factors and megatrends in mind, there are identifiable opportunities for Australian manufacturing. Rather than an exhaustive list, the following four opportunities should be seen as examples for high value manufacturing.

Medical devices

According to Access Economics[39], Australia contributes 1.1 per cent of the global expenditure on health R&D, yet 3.04 per cent of the benefits from global medical research can be attributed to Australian research. This defines our challenge and our opportunity – to successfully transform Australian research into commercial returns for local manufacturers.

Australia has developed a strong and vibrant medical device manufacturing industry encompassing the elements of specialist manufacturing, regulatory approvals and compliance, quality systems, design control, intellectual property protection and commercialisation. This industry is growing globally and expected to do so for the foreseeable future. It relies on access to new technology and valuing innovation.

IBISWorld recently published figures and analysis for Medical and Surgical Equipment Manufacturing in 2010[40]:

- Revenue of $3.2b
- Profit of $353.9m
- Exports valued at $1.7b (53 per cent of revenues)
- 3,785 businesses are involved
- Annual growth from 2006-11 was 4.8 per cent
- Anticipated growth from 2011-16 is 5.4 per cent

Future demand for new technologies and products is expected to grow strongly with low volatility due to increasing community expectations of healthcare (particularly from the 'baby boomers'), the pressures of an ageing population, income growth and price competition.

Access to global markets and strong demand is expected to drive employment growth in the sector at 3.5 per cent pa and wages growth by 4.3 per cent pa. Wages in this industry tend to be high due not only to the skills required, but also to the high costs of turnover incurred in training new staff in strict accordance with regulatory approvals (compliance) – therefore there is incentive for firms to retain trained staff.

[39] Access Economics. June 2008. *Exceptional Returns - The Value of Investing in Health R&D in Australia II* - http://www.asmr.org.au/ExceptII08.pdf

[40] IBISWorld Industry Report C2832. Nov 2010. *Medical and Surgical Equipment Manufacturing in Australia*

Australian automotive manufacturing industry

Changes in the global automotive industry are being driven by broader globalisation, environmental and resource factors. Both markets and production are experiencing major structural changes as evidenced by China emerging as both the largest automotive market and largest producer.

The rise in production in China, Korea and ASEAN economies, together with a demand for smaller vehicles have resulted in a downward trend in the volume of domestically produced vehicles sold in Australia. Vehicle builders, suppliers to the local vehicle builders and original equipment manufacturers have been forced to seek global markets for their products. The recent rise in the value of the Australian dollar in comparison to other major currencies has also accelerated this trend.

The choice for Australian automotive suppliers is to move to higher value added products and/or to focus on design and development of products which are then manufactured in lower cost economies. In this regard, both General Motors Holden and Ford Australia have produced designs for global platforms for their parent company.

Other opportunities for local manufacturers arise from the use of new materials for key components. The imperative to reduce fuel consumption and emissions from vehicles has created new opportunities for the use of lightweight materials for components and structures. Furthermore there are significant opportunities for software design for systems such as control strategies for electric vehicles, vehicle telematics, and smart vehicle-power grid interfaces for electric vehicles.

Transitioning textile manufacturing in Australia

Traditionally textile, clothing and footwear products are considered low-tech manufactures. However, technology and global challenges are opening up a vast array of new applications for textiles including smart protective textiles for the military and emergency services markets, textile composites for aerospace, automotive and marine applications, medical textiles including tissue engineering scaffolds, filtration textiles for water and energy applications, fibrous materials as components of mobile phones and batteries and large scale applications in mining, agriculture, aquaculture and horticulture. The future of textile manufacturing in Australia must increasingly be focussed on technical textiles and the development of products for demanding end-users and applications.

Although there is some scepticism about the future of textile manufacturing in a high wage economy such as Australia it should be noted that although commodity textile manufacturing has moved to low labour cost countries, technical textile manufacturing is still dominated by high wage economies such as Germany. The production of technical textiles in Germany has grown by 40 per cent in real terms since the mid-1990s; in part due to close collaboration with research institutes. As a result, German companies now have a 45 per cent share of the global market.

The Australian textile industry currently has a manufacturing base which can be transitioned to a successful knowledge-intensive technical textiles sector based on incorporating innovations in material science into fibrous structures. Australia has particular opportunities in fields such as:

- Healthcare - fibrous tissue engineering scaffolds, sensing wound dressings and bandages and sophisticated incontinence products.
- Defence – lightweight ballistic and blast protection, low multi-spectral materials and integration of power and sensing into textiles.
- Water, energy and environment – improved filtration media for the removal of toxic substances from air and water, selective recovery of valuable materials from waste streams and technical textile products for coastal protection.
- Mining – stronger and smarter geotextiles for the heavy roads, railways and tailings dams used in the mining industry.

Biomaterials

Biomaterials, which cover products as diverse as hip implants, cell therapy technologies and innovative drug delivery systems, was a global market of $25.6b in 2008. This is expected to reach US$65b in 2015 with a compound annual growth rate of 15 per cent from 2010-2015.[41] The orthopaedic and cardio-vascular areas are the dominant areas, and currently comprise 75 per cent of all revenues.

In the Australian manufacturing context the fledgling biomaterials industry has the potential to provide highly skilled Australian jobs and revenue as well as providing longer term benefit through improved quality of life and reduced healthcare costs.

The expansion of the biomaterials market is being driven by:

- An ageing population. Over 20 per cent of the world's population will be over 60 in 2050;
- An increasingly wealthy developing world (in particular China and India); and
- The expectation of improved quality of life.

Significant opportunities are available for new and improved products – although this is an area with significant regulatory hurdles, uncertain reimbursement pathways, increased pressure on government health spending and a relatively long path to market.

A range of small but innovative companies built on Australian generated R&D has appeared in recent years including AorTech Biomaterials[42] and Polynovo Biomaterials. AorTech Biomaterials has materials implanted in more than 3 million patients.

In addition, Australia has a number of companies developing biologically-based materials, such as collagens, for use in biomaterials applications. These companies are in part dependent on Australia's animal disease-free status and include, Holista Colltech, BioNova, Elastagen, Maverick, Devro and Allied Medical.

In contrast to the earlier more prominent role for synthetic biomaterials, the focus of regenerative medicine lies with human cells. However, regenerative medicine will still require a new generation of instructive, advanced materials able to coordinate local cellular processes or to act as materials for the in vitro production of stem cells for the 'cell therapies' treatment of human disease. The cell therapies market is estimated to be $2.3b by 2025[43].

Opportunities also exist for the production of blood cells and products and there is a requirement for facilities and materials that will allow this scale-up in a commercially viable way. Australian company Invetech is the world leader in the development and engineering of cell therapy scale-up equipment. Other opportunities exist for example in the development of materials for the delivery of small molecule drugs and biologics; bioactive coatings and surgical materials, for example, tissue sealants. All have the potential for manufacture in Australia.

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[41] Global Biomaterials Market (2010-2015) marketsandmarkets.com May 2011

[42] AorTech announced on 16 June 2011 that it had completed the relocation of its primary manufacturing operations from Melbourne to the Minneapolis/St. Paul area in the USA. Reasons given for the move included access to a larger pool of skilled staff in the US medical devices cluster, closeness to major markets, and currency stability.

[43] Market Research Report: *The Stem Cell Market Outlook. Pipelines, regulations, business models, and forecasts to 2025.* Business Insights Ltd., June 2011

Mining technology services

The mining technology services industry is an example of Australian manufacturing and related services firms leveraging Australia's mining and minerals industry, research strengths and global supply chain markets of multinational companies. This includes exploration, mine development and minerals processing.

In 2009, *HighGrade* surveyed 80 Australian owned and based mining technology and service sector. The revenue generated by these companies was $27.5 billion and they employed some 83,000 people.

The companies had grown by 19 per cent in the previous year despite the GFC.

The public/private ownership split was 45% / 35%. Western Australia was home to 34 of the 80 companies, 20 were from Queensland, 11 from New South Wales, 7 from Victoria and 4 from South Australia. Privately owned firms included Pybar Mining, UME Australia, Hofmann Engineering, Minepower, SBD Drilling, Metzke Engineering and Nepean Group.

A recent ABARE report identified the sector at $8 billion for technology companies' component only. Essentially, this sector is achieving:

- Excellent research infrastructure
- High levels of collaboration
- Cutting edge, world leading technologies
- Strong clusters and networks
- High exports
- Strong representation of large multinational enterprises and a large number of SMEs operating in domestic and international markets.

An excellent example of market development is the growth and specifically of Australian engineering firms designing and building gold plants in west and east Africa. This service has enabled the sale and export of locally produced goods into an international market.[44]

[44] Innovation Australia Board, communication of 26 September 2011

Summary

Australian manufacturers operate in an increasingly competitive global environment that is constantly changing, where many factors that affect the future of manufacturing are out of the direct control of firms. A good example of this is the impact of currency exchange rates that are putting pressure on Australian manufacturers now, in terms of export competitiveness. Furthermore, a range of mega-trends appears to be increasingly important and may remain in effect over the medium to long term.

Achieving a robust Australian manufacturing sector in the future will require ambitious vision, sound strategy and development of capabilities for manufacturing companies to stay competitive, profitable and sustainable over the long term.

A robust manufacturing sector of the future requires firms that are not only technologically savvy, but are also agile, flexible, adaptive, and efficient. This is only possible in firms that are knowledgeable, innovative and well managed, and which have access to information, technology and innovative practices as well as capital. More importantly, firms need to have the absorptive capacity to embrace new knowledge, technology and innovative practices.

Thus, the resilience or robustness of an industry sector will depend on the ability of its firms to adapt quickly to meet challenges and capture emerging opportunities. This requires that firms:

- Recognise that to succeed in the high value-add, low volume products in which Australian manufacturing is likely to have a competitive advantage, they must bundle products and services to sell solutions, rather than simply tangible products.
- Have the absorptive capacity to embrace the latest technological and business process innovations that provide competitive advantage.
- Have ready access to knowledge and world class capabilities that allow innovation and rapid adaption to changing market needs, tapping into innovative practices and building sustainable and profitable partnerships both domestically and globally.
- Have the capability to design, develop, make and sell products and services that are in demand.
- Operate with high efficiency and productivity, allowing them to optimise the use of their capital – human, intellectual and material.
- Have resilience in a low carbon and resource-constrained economy through resource efficiency.
- Have the ability to maximise leverage from strong and sustainable partnerships through local and global supply chains.
- Secure supply of resource inputs and skills, by direct acquisition, partnering or engaging in global supply chains.
- Harness technology and business process innovation that provides differentiation and competitive advantage. The continued evolution of ICTs, such as cloud computing, provides opportunities for enhancing firm productivity, marketing and product and service delivery.
- Possess the organisational flexibility to rapidly adapt to changing market needs – including changing their mix of skills and production technologies.

- Seek markets in the growing BRIC countries, both by partnering with them in global supply chains, and by meeting demands from their growing middle classes for niche and bespoke consumer products.

Global competitiveness requires world class capabilities that are effectively utilised. A key imperative is to ensure capabilities in supply chains for those sectors that are important to achieve a robust future for Australian manufacturing.

There is a broad consensus that Australia is not deriving the full benefits of our research investment; especially from publicly funded research. Hence it is imperative to improve the strategic alignment between the output from research organisations and industry/market demands. This will only come about through greater engagement and linkage between providers and users (and potential users) of research to ensure that there is an appropriate balance between 'push' from research organisations and 'pull' from firms that can benefit from research. Understanding trends and potential opportunities in the future will also be crucial in establishing a globally competitive manufacturing sector.

There is often a tendency to view the innovation needs of an industry through a sectoral lens. This needs to shift to a more system-wide approach to building an innovation system that supports a robust future for the entire Australian manufacturing sector. It would appear that policies and programs that support the development of knowledge, skills, competencies and capabilities that can be effectively translated *across* industry sectors are likely to contribute to the future robustness of manufacturing.

The future robustness of Australian manufacturing is also dependent on how well firms operate across complex global supply chains. This requires not only comprehensive knowledge of emerging market needs but also localised knowledge to facilitate adaptability to changing environmental and legislative landscapes in export markets. In particular, Australian firms need to be aware of environmental legislation that is increasingly becoming operational. This presents both a challenge as well as an opportunity to tap into an emerging greener global economy.

Having access to world class capabilities and knowledge is important for a firm’s future competitive advantage. However, it is equally important that a firm has the ability to absorb new knowledge and translate it into practice. Industry, the research community and government need to develop policies and initiatives that raise the capabilities and capacity of firms to absorb innovation in all its forms, to ensure that manufacturing firms of the future are adaptive, agile and innovative.

The strengths, weaknesses, opportunities and threats facing Australian manufacturing can be summarised as follows:

Strengths	***Weaknesses***
R&D Capacity Education system Capacity for low volume manufacturing Positive image of Australia Water technology Sustainable energy resources Sustainable energy technology development Financial and political stability Growing awareness of products-services nexus	Management skills Levels of trade and technical skills Commercialising R&D Image of Australian manufacturing vis a vis competitors Workforce retention and development
Price on carbon Ageing population Increasing health requirements Emerging technologies Urbanisation Computer Integrated Manufacturing Additive manufacturing Demand for customised products Expanding middle class in BRIC countries	Increasing energy prices* Price on carbon Water supply* Ageing workforce Increasing sophistication of BRIC countries Terms of trade and level and volatility of the Australian dollar 'Peak' resources*
Opportunities	***Threats***

*** Factors impacting on many/most economies**

Next steps - ensuring a robust Australian manufacturing sector in 2020

It has been suggested by some stakeholders that there would be value in further work to develop a likely scenario for 2020, and a further scenario to 2040.

Such scenarios would need to address both a description of the situation at those dates, and the initiatives needed to achieve these outcomes and avoid pitfalls.

Initiatives could involve coordinated implementation by government, industry (manufacturing, finance, professional and business services), researchers and commercialisation intermediaries to select and implement different strategies in the period to 2020. These could include:

- Initiatives by industry to advance the cause – especially in terms of collaboration and cooperation and skills building at all levels.
- Improving the strategic alignment between the priorities, work and output of research organisations and industry/market demands
- Means to raise the innovation absorptive capabilities of firms to grow businesses and generate highly skilled, attractive employment opportunities.
- Practical strategies for industry and government to improve skills in the key areas of management and technical and professional services, to grow Australian firms.
- Other initiatives from government could include technology roadmaps, technology and management advisory services, and influencing the education sector's course offerings.
- What other Australian Government agencies must do to achieve the desired outcomes.
- What other levels of government must do to achieve the desired outcomes.

Future Manufacturing Industry Innovation Council Strategic Roadmap 2010 - 11

Vision: A future manufacturing industry that provides innovative products and related service solutions to domestic and export markets in innovative ways, builds and retains its highly skilled workforce and is a vital enabler of highly productive and competitive Australian manufacturing.

2010 / 11 milestones		2014 outcomes
Supported the creation and growth of Australian multinational enterprises.		More companies with global leadership positions
Collaborated with stakeholders to identify and exploit domestic and export opportunities to provide innovative manufacturing solutions for the global mega-challenges of sustainable energy and water and health, including: ➢ Assisted, supported and leveraged the government's Supplier Advocates for Clean Technologies and Water.		Robust and aligned investment environment Effective commercialisation of new products
Influenced taxation reform, including government response to 2009 Taxation Review, to enable national wealth creation.		
Influenced the formation and development of skills to support Australian future manufacturing and related services, including leadership and management training.		Adaptive and diverse pool of skilled people New positive image
Provided the Minister with strategic advice on priority issues affecting Australian future manufacturing and related services, including innovation policy, government coordination and policy certainty.		Conducive and continuous government support National, globally competitive regulatory environment

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Innovation is customer and productivity focused (revised pathway)	Globally-competitive investment environment (new pathway)	Reduce cost of doing business (existing pathway)	Taxation supports national wealth creation (existing pathway)	Train and educate workforce to equip it for current and future needs (revised pathway)	Create a positive image for Australian manufacturing, its products and services (revised pathway)	Provide policy certainty and consistency (revised pathway)

← **Pathways (actions)** →

Contributors to this paper

The Future Manufacturing Council acknowledges and thanks the following people and organisations who contributed to the preparation of this document:

Professor Suzanne Benn, Professor of Sustainable Enterprise, UTS Business School, University of Technology, Sydney.

Professor John Beynon, Dean of Engineering and Industrial Sciences, Swinburne University and Centre Leader, Australian Advanced Manufacturing Research Centre.

Professor Chris Berndt, Professor of Surface Science and Interface Engineering, Swinburne University of Technology.

Mr George Collins, CEO, CAST CRC.

Professor Roy Green, Dean of the Faculty of Business, University of Technology, Sydney.

Mr Duncan Jones, Executive Director, Science Industry Australia Inc.

Ms Narelle Kennedy, Chief Executive, Australian Business Foundation.

Dr Swee Mak, Director, CSIRO Future Manufacturing Flagship.

Mr David Pettigrew, General Manager - Strategy and Growth, QMI Solutions Ltd.

Mr Matthew Rait, Project lead, Siemens Ltd.

Professor Graeme Sheather, Visiting Professor, Faculty of Business, University of Technology, Sydney.

Ms Michelle Tabet, Consultant, Informatics, Integrated Environments Group, Arup.

Mr David Miles AM, Chair, Innovation Australia Board.

Mr Dave Oliver, National Secretary, Australian Manufacturing Workers Union.

Mr Paul Howes, National Secretary, The Australian Workers' Union.

CSIRO Manufacturing Sector Advisory Council: Professor Roy Green (Chair); Phillip Butler, John Crapper, Jan Dekker, Anne Donnellan, John Duddy, Ben Waters and Mike Lawson (ex-officio),

Information Technology Industry Innovation Council.