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1.4 Strategic innovation priorities for sustainable manufacturing in Australia

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Abstract
This paper presents a strategic perspective and 3 sustainable manufacturing innovation priorities for the Australian manufacturing sector. They are, improving resource efficiency, developing new business models and adopting new technology. These are not the only strategies by which to achieve sustainable manufacturing or improved competitiveness. However, they are a prioritised response to current global trends, government signals and challenges and opportunities for Australian manufacturers. Manufacturing in Australia has reached a crossroad. Tough economic conditions mean in order to survive manufacturers must adapt and respond to competitive pressures by innovating to remain productive and prosperous. This paper provides an overview of the drivers, enablers and an example for each innovation response. This clearly demonstrates the link between innovation and sustainable manufacturing and how innovation can provide a competitive advantage.

Keywords:
Australia, Innovation, R&D, Resource Efficiency, Sustainable Manufacturing

1 INTRODUCTION

The previous two years have seen a focus like never before on the future of manufacturing in Australia. An increasingly challenging economic environment is the consequence of many factors, including the high Australian dollar which has had near parity with the US dollar between December 2010 to June 2013. Rising resource costs have also placed pressure on manufacturers to remain competitive. In October 2011, the Australian Prime Minister convened a taskforce on manufacturing to map a vision for the future of manufacturing in Australia as it adjusts to economic pressures and competition from Asia[1]. In December 2011, the Commonwealth Scientific Industrial Research Organisation (CSIRO) held an industry workshop to discuss 'What sustainable manufacturing means to Australia'[2]. This paper takes into account the current global trends as well as government and industry signals to describe the innovation priorities for sustainable manufacturing in Australia. Innovation is a key lever by which to address the challenges of manufacturing while becoming more economically, socially and environmentally viable. This paper describes 3 sustainable manufacturing innovation priorities; resource efficiency, new technology and business model innovation. For each innovation priority, a driver, enabler and example are provided. The author proposes that the three innovation priorities described in this paper are critical in enabling a transition to sustainable manufacturing in Australia, and further, that they provide a competitive advantage in today's challenging times. These innovations are not the only source of competitive advantage for manufacturing firms. For example, improving skills, diversification and the ability to enter new supply chains are also sources of competitive advantage.

2 CONTEXT AND DEFINITIONS

2.1 The current state of manufacturing in Australia

Manufacturing makes a vital and significant contribution to Australia's economy. The sector's contribution to GDP has declined from 9.5% to 8.7% between 2005-06 and 2009-10. In 2010-11, the manufacturing sector employed 991,800 people; this is a decrease from the 1.05 million people employed the previous year, and sadly, over 100,000 jobs have been lost in manufacturing since 2008[3]. In 2010-11, manufacturing accounted for 34% of Australia's total export trade. This has declined steadily since 2006-07 when manufacturing's share of exports was 50%[4]. In 2010-11, the sector contributed to over 27% of total business in R&D expenditure, this is larger than any other sector and equates to a $4,760 million investment in R&D. Further, this increased by $499 million compared to the year prior[5]. Despite the general decline of many economic metrics over the previous few years, manufacturing remains an important part of the Australian economy. It contributes to a diverse economy with both direct and indirect contributions and it supports and enables other parts of the economy such as agriculture, mining, construction and services[3]. In 2006, the Australian Industry Group estimated for every $1 generated by the manufacturing sector this resulted in additional $1.25 expenditure in the rest of the economy[6].

In 2006, the OECD noted the declining contribution of manufacturing to GDP as an ongoing trend across many OECD countries. This reflects the shift of developed economies towards the services sector and an increasing blurring of the distinction between manufacturing and services[7]. As competition with low cost, developing economies continues, this trend may well continue for Australia. The pursuit of sustainable manufacturing innovation objectives will improve competitiveness and may well play a role in differentiating Australian manufacturing from low cost competitors. As such, these 3 sustainable manufacturing innovation priorities may be relevant to other developed nations.

2.2 Definition of Sustainable Manufacturing

Manufacturing can be defined as 'the full cycle of activities from research and development, through design, production, logistics and services, to end of life management' [8]. However, similar to the definition of 'sustainability', there is no common definition for sustainable manufacturing. Most

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definitions generally adhere to the principles first outlined in the 1987 Bruntdland report, that is: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'[9]. Three useful definitions and descriptions for sustainable manufacturing are from the US Department of Commerce, Queensland State Government in Australia and the Organisation for Economic Co-operation and Development (OECD). The US Department of Commerce defines sustainable manufacturing as 'the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound[10].' The Queensland Government describes sustainable manufacturers as those who 'use world-class manufacturing and environmentally friendly practices to improve the profitability of their business and reduce their impact on the environment[11].' Lastly, the OECD defines the general principle of sustainable manufacturing 'to reduce the intensity of materials use, energy consumption, emissions, and the creation of unwanted by-products while maintaining, or improving, the value of products to society and to organizations[12].'

2.3 The nexus of sustainable manufacturing, innovation and competitiveness

There is a strong connection between sustainable manufacturing, innovation and increased competitiveness. It is important to note that the OECD also relates the term 'sustainable manufacturing' to 'eco-innovation'[13]. The latter is described as the trigger to developing a green economy and assist manufacturing to become sustainable. The connection between sustainable manufacturing and eco-innovation underscores the important role of innovation in transforming traditional manufacturing processes to a more sustainable paradigm.

Innovation can assist manufacturers through both the incremental evolution of current practice and the development and application of disruptive technologies which enable fundamental change to manufacturing and markets. Whilst research and development (R&D) plays a significant role in the process, innovation extends beyond R&D. Within Australia, a commonly used definition of innovation is: 'Innovation is the implementation of a new or significantly improved product (good or service), process, new marketing method or a new organisational method in business practices, workplace organisation or external relations[14]'

It has been proven that innovation is also connected with increased firm competitiveness and success. The 2012 Australian Innovation Systems report provides clear evidence that innovation active companies are more competitive as they are:

- 41 per cent more likely to report increased profitability,
- Twice as likely to report increased productivity,
- Twice as likely to export, and
- Up to four times more likely to increase employment and social contributions[15].

Innovation is needed for sustainable manufacturing, and in turn, the pursuit of both objectives have a high liklihood of influencing firm competitiveness. The following section describes the 3 strategically important innovation priorities for sustainable manufacturing.

3 RESOURCE EFFICIENCY

3.1 Driver - the global megatrend 'more from less' and environmental regulations

In 2010, CSIRO first published a report on Global Megatrends. This was well received by industry and of the 6 trends described, 'more from less' resonated greatest with manufacturers. It is testament to this persistent trend that when the CSIRO updated its global megatrends for 2012, 'more from less' remained and was simply updated with more recent data. This megatrend describes the depletion of our natural resources occurring at alarming rates while the impact of population growth and climate change will continue to increase pressure on resource demand[16]. Examples of data supporting this megatrend are; by 2043 our global population will reach 9 billion people, global food production needs to increase by 70% between now and 2050 in order to meet demand, global water demand will rise by 55% between 2000 and 2050 with manufacturing a key driver of this increased demand, global energy consumption will rise by 40% between 2009 and 2035, mineral ore grades are declining while ore production is increasing.

Manufacturing provides goods and services that support our quality of life and the economy. It has historically been based on the paradigm of unlimited resources [17]. The folly of this assumption, and the forces of the 'more from less' megatrend, make resource efficiency a priority for achieving sustainable manufacturing. Resource efficiency also provides Australian manufacturers with a competitive advantage by reducing costs and increased productivity.

Another driver of resource efficiency and increased manufacturer responsibility is product stewardship. This expands the responsibility of manufacturers to include responsible disposal of their products. Regulation has successfully been implemented in Europe and in 2011, Australia implemented the Product Stewardship Act which provides a framework for regulatory, co-regulatory and mandatory product stewardship. The aim of the Act is to reduce waste sent to landfill and increase recovery and recycling rates. Product stewardship now applies in Australia for televisions, computers, mercury containing lights and tyres[18].Future opportunities exist for manufacturers that reduce the environmental footprint of their products and processes and differentiate based on their whole of life impacts [8].

Environmental regulations in Europe, such as the Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH) and the UK Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) demand increased transparency of product information and its impact on human health and the environment[19]. These types of environmental regulations support the development of global green supply chains and have the potential to restrict trade of noncompliant Australian products.

3.2 Enabler – investment to support resource efficient manufacturing

The Australian manufacturing sector was the third largest consumer of electricity in 2009-10[20]. Emissions intensity varies across the manufacturing subsectors and the plastics sector is ranked 9th. Despite this low rank, the Plastics and Chemicals Industry Association (PACIA) reported electricity costs for small to medium enterprises (SME) equates to

between 2-18% of input costs [21]. As a result, energy costs and energy efficiency are a key concern for Australian manufacturers.

Australia has historically benefitted from low energy prices. This is changing as resource costs rise and accounting for carbon emissions becomes part of the economy. The Australian government has committed to the long term target of reducing 2000 level emissions by 80% by 2050. This is consistent with targets announced by the United Kingdom and Germany. In the short term, Australia will reduce carbon pollution by 5% from 2000 levels, by 2020[22]. To achieve this, Australia implemented a carbon price on 1 July, 2012 as part of its Clean Energy Future policy. Under this program, support for the manufacturing sector includes $1.2 billion to improve energy efficiency and research and development for low carbon technologies. Government investment is enabling the transition towards more resource efficient and competitive manufacturing in Australia.

The increased constraints on resources, whether as a result of higher price or declined availability, will inevitably necessitate manufacturers becoming more efficient with their resources. In the future, manufacturers will continue to reduce waste of all types, through resource recovery, closed loop manufacturing, industrial symbiosis or industrial ecology.

The application of industrial ecology is embroyonic in Australia. The most well known example is the Kwinana Industrial Area in Western Australia. Industrial ecology has been noted as having the potential to improve sustainable manufacturing[23]. The 2013 New South Wales (NSW) Government Waste and Resource Recovery Initiative has recognised the potential of industrial ecology by prioritising the establishment of 4 industrial ecology networks as part of its Business Recycling Program[24]. The uptake of industrial ecology or symbiosis marks a turning point in strategic waste management as it supports both environmental goals to reduce waste to landfill and industry goals to improve resource efficiency. The NSW Government commitment is another example of investment that supports resource efficient manufacturing.

3.3 Innovation Example - Biofiba®

The CSIRO has many examples of applying R&D to develop resource efficient manufacturing processes. A recent example is the research collaboration with the company Biofiba® Ltd, a NSW based SME. A novel process takes fibres from commercially grown hemp and combines them with starches and binding agents to make a composite. This unique composite can be extruded into planks that are able to be drilled and nailed together into a bio-composite pallet[25]. The pallet is designed to decompose rapidly into a potentially valuable garden mulch product. The benefits of this pallet are:

- cost-effective process
- a strong, durable product
- sterile material removes the need for heat or chemical fumigation treatment
- minimal waste – planks manufactured to specific lengths
- bioderived, biodegradable end product[25].

If the technology is successfully scaled-up, Biofiba® will be ideally positioned to capture a portion of the USD$90 billion dollar export pallet market. In recognition of this novel process and product, Biofibre® was a finalist and runner up in the 2012 Australian Cleantech competition.

A second example is CSIRO's zero waste powder coating for plastic automotive components. This process replaces traditional wet paints, reduces waste, eliminates harmful chemical emissions and saves cost, energy and greenhouse gas emissions[26].

4 BUSINESS MODEL INNOVATION

4.1 Driver – The rise of the services economy

The provision of manufacturing services can be described as 'additional services to complement a tangible product offering in order to add value'[27]. This denotes a shift to a product-service relationship with customers, creating lengthier relationships, potentially excluding competitors and producing more reliable revenue streams[27, 28]. Globally, an average manufacturing services firm has around 30% of sales as services[29]. In Australia, the services economy delivers around 80% of GDP and employs 85% of the workforce[30]. Moreover, around 23% of Australian manufacturing companies already provide a service, and some companies that do so are already classified within the services sector[31]. The CSIRO megatrend 'Great Expectations' is consistent with the gradual shift towards service offering from manufacturers. It describes the rise in expectations for personalised services, the increase in demand for experiences over material consumption and the rise in moral and ethical expectations for consumer products[16].

4.2 Enabler – NBN and service innovation

An enabler for business model innovation, such as developing manufacturing services, could be the upgrade of Australia's telecommunications infrastructure and implementation of National Broadband Network (NBN). At a CSIRO workshop in December 2011, industry participants expected the NBN to assist in supporting globally connected businesses, and new opportunities for services and exports[2].

Manufacturing services also support sustainable development, and the transition to sustainable manufacturing, through the dematerialisation of society[28]. The World Business Council for Sustainable Development identified service extension as a key aspect of eco-innovation, responsible for extending product life and reducing turnover[29]. Within traditional firms, the transition to services is enabled by business model or design led innovation. However, the transition to services does pose challenges to many manufacturers through lack of:

- senior management support,
- information technology,
- organisational design,
- appropriate capabilities,
- and culture[29].

4.3 Innovation Example – industry examples and the Australian Design Integration Network

There are opportunities to improve profitability through business model innovation by the application of design led innovation. An Australian example of business model innovation is from the mining sector. High value service provision occurs in exploration and customer solutions e.g. Orica Mining Services. Benefits include a higher margin business model[15]. Another example is the award winning plastic recycling scheme implemented by Tapex who manufacture plastic products for the Agriculture sector. Tapex created a market for recycled plastic by introducing a cost

effective program to capture all farm plastics, regardless of type or manufacturer. Recycled plastic is remanufactured into products, such as tiles and compost bins[32]. This closed loop solution provided improved customer service, developed a new brand, market and products. It is an example of business model innovation resulting in improved resource efficiency.

In March 2013, CSIRO participated in establishing the Australian Design Integration Network (ADIN). The network was launched with partners across the national innovation system to address 2 key gaps; the lack of a research base to support design led innovation in Australia and the lack of collaboration in design led innovation across Australia's innovation system[33]. The aim of the ADIN is to explore the role and value of design led innovation in Australia, particularly for the benefit of manufacturers. The ADIN will support business model innovation, creativity and innovation within the manufacturing sector.

5 NEW TECHNOLOGY

The imperatives for manufacturing in Australia range from a transition to high value, high tech manufacturing to more recently, smarter manufacturing for a smarter Australia[3]. Both are a recognition that Australia cannot compete with the low labour costs in developing countries in an increasingly high cost economic environment. The Australian government acknowledges that value adding through access to knowledge and technology is an important factor in the future of Australian manufacturing[34]. Value adding could be achieved by investment many types of technologies, for example clean technologies, lightweight robotics or additive manufacturing, and is dependent on firm needs.

Alongside the need to value add to manufactured products and transition to delivering sustainable, high tech manufacturing, is the gradual shift from mass production of goods to mass customisation. This was reported by CSIRO to the Prime Minister's taskforce on manufacturing as of increasing importance to Australia[3] and this is enabled by disruptive technology such as additive manufacturing.

5.1 Driver - Competing in the Asian Century

A major trend of direct importance to Australian manufacturing is the rise of Asia. The scale of growth and transformation in Asia was the driver behind the Australian Government's White Paper on Australia in the Asian Century. This paper will help position Australia through the recommendation of actions and policy initiatives to position Australia for the Asian Century[35].

Forecast Asian growth is referred to as 'The Silk Highway' in the CSIRO 2012 megatrends report. Data supporting this megatrend are: by 2025, Asia will account for over half of the world's economic output [35], over a billion people will transition from poverty to the middle class influencing global demand for goods and services, the 2012 five year economic outlook forecasts 8% per annum growth for Asia compared to 2-3% growth for advanced economies, China has strong economic links with Australia as its largest trading partner, China accounts for around 20% of the world's population[16].

Another driver is to add value to Australia's natural resources such as titanium ore. Australia has the world's greatest reserves of titanium ore, much of which is being exported without domestic processing. It is estimated that at current rates, Australia has 90 years of titanium resource remaining. The value of titanium alloy metal is 100 times the market value of ore. If Australia were to grow its domestic processing industry and convert ore to metal then it could theoretically extend the life of the ore and add significant value to exports [8]. New technology processes and additive manufacturing technologies will enable Australia to develop high tech, high value manufacturing opportunities in titanium products.

5.2 Enabler – additive manufacturing technology

Additive manufacturing (AM) is sometimes referred to as 3D printing and has evolved from rapid prototyping to become a disruptive technology with application for the manufacturing, aerospace, health and infrastructure sectors. It works by depositing material layer by layer onto a substrate. AM technologies differ in the type of material used and the bonding technique applied [36]. The general advantage of AM is it uses less energy, produces less waste and can create more complex products that are unable to be produced through traditional methods [37]. AM can also increase speed to market, time to manufacture and reduce costs [38]. These benefits are aligned with the earlier definitions of sustainable manufacturing.

AM is often referred to as a disruptive technology as it has the potential to create new markets and products, and realise a shift from mass production to mass customisation. It has been referred to as the next industrial revolution for manufacturing in advanced economies as it has the potential to provide competitive advantage that is not based on low labour costs. This may result in manufacturing returning to developed economies like Australia and the USA, with products produced close to markets. A key enabler to leveraging this technology for competitive advantage are capability strengths in designing and engineering fit for purpose parts and products[39].

Despite the attractiveness of the technology there are some challenges that remain to be overcome, for example;

- security of designs and intellectual property [38]
- parts are constrained by machine size [40]
- the high costs of technology, equipment and materials [37]
- product surface imperfections [37]

Some of these challenges create R&D opportunities to develop cost effective, fit for purpose products with additive manufacturing technology.

5.3 Innovation Example – Victorian Direct Manufacturing Centre

The CSIRO has identified additive manufacturing as a key opportunity for Australian manufacturers to leverage both competitive advantage and the comparative advantage of Australia's natural mineral endowment. An innovation example for AM technology is the CSIRO Victorian Direct Manufacturing Centre (VDMC). It was originally established in 2010 and in 2013, secured additional funding from the Victorian Government and industry partners to continue for another 3 years. The centre applies cold spray additive manufacturing technology to provide benefits for a number of industry partners across a number of applied research projects. The key benefits for the industry partners to date have been:

- reduced production costs
- increased design capability
- greener production processes

- more flexible production lines
- reduced material waste.

These benefits not only align with the definitions for sustainable manufacturing but provide the basis upon which to build a more competitive and sustainable Australian manufacturing industry. As such, AM technology is a strategically important innovation priority for Australia.

6 SUMMARY

The business case for innovation is clear; manufacturing firms cannot prosper based on a business as usual approach. They must respond to the competitive pressures brought about by globalisation and low cost competition. All 3 innovation strategies contribute towards greater sustainability for manufacturing in Australia by improving economic, environmental and social conditions. For example, improved resource efficiency can reduce input costs. Business model innovation can result in new market opportunities and value add to firms. New technologies can similarly create new product and market opportunities while also reducing business costs. These innovation strategies may also be relevant to other developed nations.

Each of the strategies are also interconnected, for example :

- New technology development can result in greater resource efficiency as in the case of Biofiba®.
- Business model innovation can be driven by new technologies as the case for Additive Manufacturing.
- Resource efficiency opportunities can be developed by applying business model innovation as demonstrated by the Tapex example.

Each strategy also contributes to the common elements in the definitions of sustainable manufacturing. These are; reducing environmental impact, conserving energy, applying world class manufacturing and improving the profitability and value of products to society and organisations.

7 CONCLUSION

Australian manufacturers are seeking opportunities to become more competitive. Innovation is a critical lever to achieving increased competitiveness and this is linked to sustainable manufacturing. The 3 examples described in this paper prioritise innovation strategies for industry. These are not the only strategies by which to achieve either sustainable manufacturing or increased competitiveness. However, they are the author's view of the most important innovation priorities for Australian manufacturers based on global trends, government signals, industry challenges and opportunities. These strategies are part of the solution to addressing the decline currently occurring in Australian manufacturing. Each strategy has the potential to improve competitiveness and supports the goals of sustainable manufacturing for Australia.

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