



MAKE FOR ASIA

The emerging Asian middle
class and opportunities for
Australian manufacturing

King S, Hine D, Brea E, Cook H (2014) Make for Asia – The emerging Asian middle class and opportunities for Australian manufacturing, CSIRO, Australia.

Copyright and disclaimer

© 2014 CSIRO. To the extent permitted by law, all rights are reserved and no part of this publication covered by copyright may be reproduced or copied in any form or by any means except with the written permission of CSIRO.

Important disclaimer

CSIRO advises that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, CSIRO (including its employees and consultants), excludes all liability to any person for any consequences, including but not limited to, all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

FOREWORD

I am delighted to introduce Telstra's latest piece of research: "Make for Asia – The emerging Asian middle class and the opportunities for Australian manufacturing".

Telstra challenged CSIRO to explore what the future opportunities for Australian manufacturers might be, particularly in the context of the dramatic rise of the Asian middle class. Our research found that by 2030 the Asia Pacific will be home to two thirds of the world's middle class (up from 28% only a few years ago), an astonishing 3.2 billion people.

Our research shows that the emerging Asian middle class will demand what middle classes across the world demand – high-quality, safe, sustainable and reliable products.

Australia, geographically near to this "megamarket" and with first-world manufacturing processes, is well placed to capitalise on these enormous opportunities emerging.

Our research identified four broad areas of manufacturing opportunity for Australia: resource-efficient manufacturing, business model innovation, industry collaboration and connected manufacturing. We have explored what technologies underpin these manufacturing opportunities and how our manufacturing sector can leverage them to access this huge market.

This is where we believe Telstra can help the Australian manufacturing industry to recover, innovate and grow.

At the core of all future innovation will be fast, reliable and secure global networks through which manufacturers, suppliers, and customers will collaborate and create. Future manufacturing communities will use ICT collaboration platforms, fixed and wireless networks, the internet, social media and devices as the lathes and workbenches of the 21st century. Cloud-based services will support access to these new markets, as they are flexible, scalable and accessible across geographies.

We hope this research offers a valuable contribution to the conversation about how Australia can thrive as part of the globe's biggest and most exciting market opportunity.

Finally, I would like to thank the team at CSIRO – particularly the lead researchers, Sarah King, Damian Hine, Edgar Brea, and Hannah Cook – who have worked tirelessly over the past few months to produce this insightful piece of research.

Charlie Macdonald

ABOUT THE AUTHORS



Charlie Macdonald

Industry Executive Manufacturing
Transport and Logistics, Telstra

Charlie was born in Lagos, Nigeria and educated in the UK. He has spent over 20 years in a variety of leadership roles in the express logistics sector, based in Europe, Asia and, since 2004, Australia. In these roles, he has developed and deployed mobility, supply chain visibility and customs clearances solutions globally. In 2012, Charlie was appointed Manufacturing Transport and Logistics Industry Executive in Telstra's Industry Development team.

Charlie holds a Bachelor of Science in Fuel and Energy Engineering from the University of Leeds.



Dr Damian Hine

Associate Professor,
University of Queensland

Damian is currently the Strategy Cluster Leader at the University of Queensland (UQ) Business School, and Associate Professor in Innovation and Commercialisation in UQ Business School. Damian's expertise builds on his perspectives as an evolutionary economist and centres upon building intellectual assets in organisations and economic systems, including capability building and intellectual capital through interdisciplinary collaboration, all aimed at enhancing organisational growth through innovation. His focus is on employing novel quantitative modelling techniques using large data sets to offer new insights on innovation and knowledge. Damian has led a number of large projects, both nationally and internationally, in innovation and entrepreneurship.

Damian has also been commissioned to write papers in innovation and intangible assets for the OECD and UNESCO. He has published two books including one on Innovation and Entrepreneurship in Biotechnology, numerous book chapters and over 30 journal articles. He is currently the International Consultant on Vietnam's National Innovation Training Program, and is currently running Innovation and Commercialisation programs in Vietnam, Fiji, Chile, Ecuador and Colombia.



Sarah King

Leader, Sustainable Manufacturing, CSIRO
Future Manufacturing Flagship

Sarah King leads Sustainable Manufacturing and Innovation within the CSIRO Future Manufacturing Flagship. She spearheads cross-disciplinary projects which improve resource efficiency for the benefit of Australian manufacturers. Sarah's projects focus on resource efficient technologies, industrial ecology, life cycle assessment, and generating wealth from waste. Sarah recently co-authored two pivotal reports with the CSIRO Futures team which described megatrends and strategic directions for the Australian Chemicals and Plastics Industry.

Sarah holds a Bachelor of Forestry Science from Canterbury University and a Masters in Corporate Environmental and Sustainability Management from Monash University. Her knowledge and expertise is garnered from experience in the forestry, agriculture, IT, manufacturing and R&D sectors. Sarah is also an active member of the Australasian Industrial Ecology Network.

CONTENTS

Executive summary	6
1 Introduction	8
Part 1 – Setting the scene	9
2 Trends in Asian Demand	10
2.1 Economic trends behind the Asian middle class consumer	10
2.2 Demand in Asia – Five consumer trends	11
3 Megatrends Influencing Manufacturing	14
3.1 Emerging markets	14
3.2 Resource scarcity	15
3.3 Food for all	15
3.4 Responsible industry	16
3.5 Technological advances	17
Part 2 – What are the Manufacturing Opportunities for Australia?	18
4 Resource-efficient Manufacturing	20
4.1 Overview	20
4.2 Additive Manufacturing for the Asian health sector	20
4.3 Implications for manufacturers	23
5 Business Model Innovation	24
5.1 Overview	24
5.2 Adding value through innovation and servitisation	25
5.3 Implications for manufacturers	26
6 Industry Collaboration	28
6.1 Overview	28
6.2 Australian food and beverage goods to feed a growing and demanding Asia	30
6.3 Implications for manufacturers	31
7 Connected Manufacturing	32
7.1 Overview	32
7.2 Agility and market growth through automation in food processing	34
7.3 The potential for increased agility through digital connectivity	34
7.4 Implications for manufacturers	35
8 Conclusion	36
9 References	38

EXECUTIVE SUMMARY

This report explores the opportunities for Australian manufacturers in Asia by first addressing the characteristics of the emerging middle class: increased discretionary income, a desire for choice and convenience, and (in some cases), a preference for high quality, foreign products.

The central themes include agility, customisation for the mass market and the emergence of the “meganiche”. These meganiches are beyond our traditional idea of a niche, with markets of 50-300 million people who are seeking a better quality of life, and a reward for their risk and effort. These markets will provide opportunities for the astute, agile and sophisticated manufacturer who can offer a product from a well-regulated, clean, design-driven, high-technology environment with a focus on individualised service to create a “fit-for-specific-purpose” product. These massive markets are central to the emerging opportunities in Asia.

In 2009, the global middle class held 1.9 billion people with 28% of this total in the Asia Pacific region. This is forecast to grow to 4.9 billion people by 2030 with the Asia Pacific share growing to 66%, equating to around 3.2 billion people. This represents a huge market and opportunity for Australia, which has unequalled proximity to Asian markets.

This report identifies four opportunities:

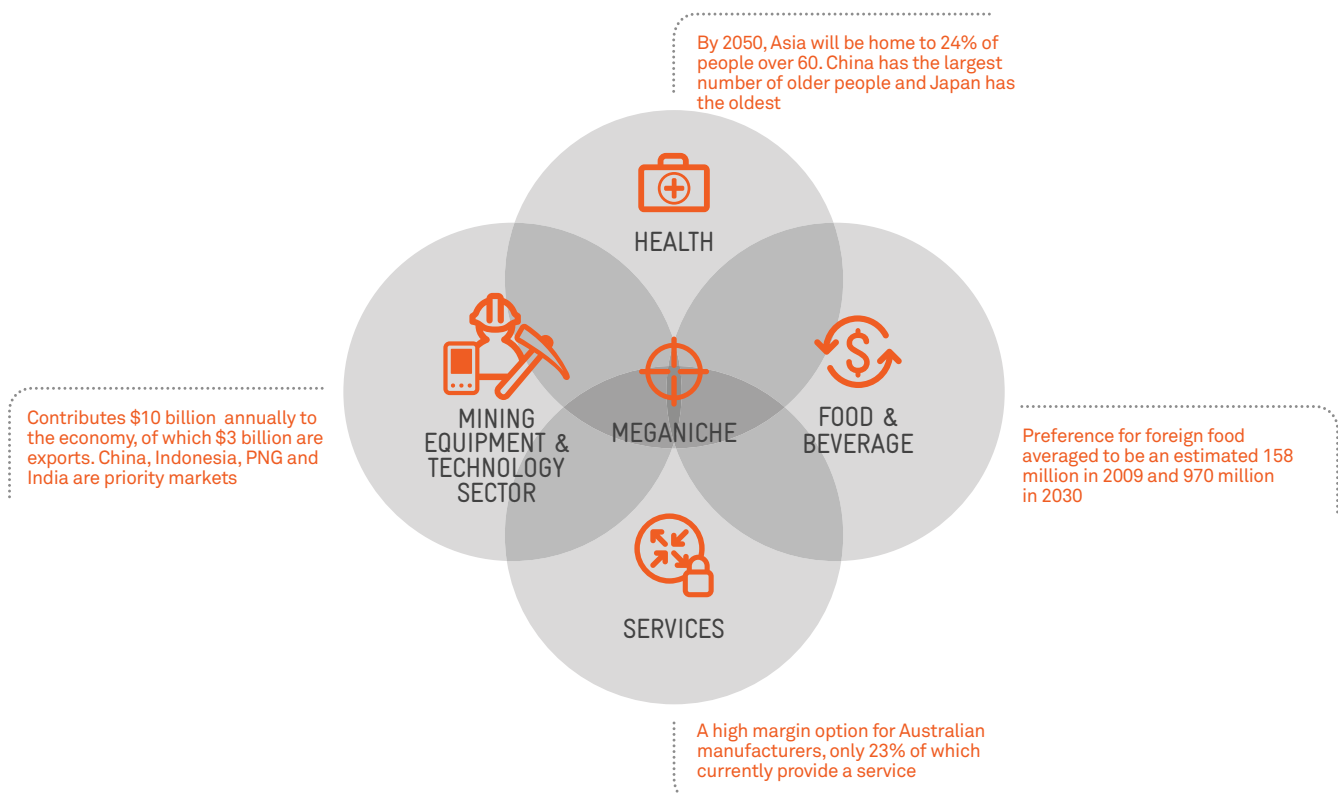
1. **Resource-efficient Manufacturing** – driven by new technologies such as additive manufacturing, combined with innovation and IP protection.
2. **Business Model Innovation** – developing new services, R&D driven solutions and novel manufacturing models to deliver to meganiches.

3. **Industry Collaboration** – working together to innovate, build competitiveness and take on export markets.

4. **Connected Manufacturing** – low-cost intelligent robotics, automation, sensors and data analytics across the factory and supply chain.

These four broad opportunity areas intentionally cut across business sectors. They aim to strike a balance between addressing business competitiveness and corresponding market sector opportunities in the Asian middle class. Figure 1 shows some more specific examples relating these opportunity areas to particular industries.

Figure 1: Example sectors relevant to the Asian middle class



Technology enablers have the capabilities to improve manufacturing sophistication and therefore have a role to play in building competitiveness, flexibility and the ability to customise for the meganiche. Examples discussed in this report include:

1. **ICT Collaboration platforms** – supporting a digital relationship with the customer as the gap between manufacturer and consumer closes.
2. **Data Security** – is paramount as value shifts from the physical to digital, and digital relationships are formed across the supply chain.

3. **Data Analytics** – are essential to building greater awareness and value from inside the factory walls and across the supply chain.
4. **ICT Fixed and Wireless networks** – fast and reliable networks for devices provide real or near real time access to decision-making tools and provide greater control.

Australia must also seek to leverage what might be seen as burdens domestically: regulated markets, high quality control and adherence to standards. We must make full use of our highly-educated, highly-skilled population, and our reputation in mining and food quality, to innovate our way to excellence. The combination of technologies referred to in this report will support Australian manufacturing opportunities created by the emerging middle class in Asia.



1 INTRODUCTION

Manufacturing is a vital part of Australia's economy. It accounts for 34% of Australia's export trade, employs almost a million people and is the lead sector contributing the greatest investment to business expenditure in R&D, ahead of Australia's mining sector. As such, manufacturing is a driver of technological innovation.

Australia is also a good location for manufacturing, with its stable political environment, skilled and well-educated population, strong IP protection regime, and supportive infrastructure for innovation and research through leading universities and the CSIRO.

However, manufacturing in Australia is not without its challenges, as recent events will attest, arising from the current high dollar and global competition from low wage economies. To remain competitive in the face of emerging economies striving to advance their manufacturing capability, Australian manufacturing needs to navigate a new path.

To remain competitive, Australian manufacturing needs to navigate a new path.

One path Australian manufacturers can take is to deliver to emerging markets such as the Asian middle class. This is not simply a case of identifying sectors of importance, such as food and beverage. It is also about remaining competitive through innovation by exploiting technology enablers. This is why our report aims to strike a balance between defining manufacturing opportunities that can enhance Australian business competitiveness and identifying promising market opportunities in the emerging Asian middle class.

The report is divided into two sections. The first section sets the scene by describing the Asian consumer demand trends and the manufacturing megatrends. In the second section, we describe four major opportunity domains for Australian manufacturing arising from these trends (as illustrated in Figure 2).

Consider this report as a call to action. There are fantastic opportunities arising from the emerging Asian middle class literally on our doorstep.

Figure 2: Project methodology – manufacturing opportunities are underpinned by technology enablers and supported by megatrends and Asian consumer demand trends





PART 1: SETTING THE SCENE

2 TRENDS IN ASIAN DEMAND

2.1 Economic trends behind the Asian middle class consumer

As identified previously, Asia will host the world's largest middle class by 2030. This projected growth correlates with an intensification of the consumerist behaviour in the region. Figure 3a depicts OECD research forecasting that Asia's share of middle class consumption will grow more than 2.5 fold between 2009 and 2030 [2].

Indeed, by 2030, the Asia Pacific middle class will dwarf Europe and North America combined, see Figure 3b. As Asian economies struggle to keep pace with the internal demand this rampant growth brings, imports of value added product will inevitably grow [3].

One particularly noteworthy trend is Asian urbanisation. People are rapidly populating urban areas in Indonesia, Thailand and Vietnam in search of improved living conditions.

But the largest rate of urbanisation in the continent will be seen in China, where the percentage of the total population who live in urban areas will increase by nearly 20% between 2010 and 2030 [4]. China is, however, seeking to address this demographic flow to the east with coordinated policies to strengthen the economies of the central Chinese provinces – such as the National Development and Reform Commission's plan to set the region as a base for energy and machinery production [5].

Figure 3a: Total middle class consumption by region: 2009, 2020 and 2030 estimates [2]

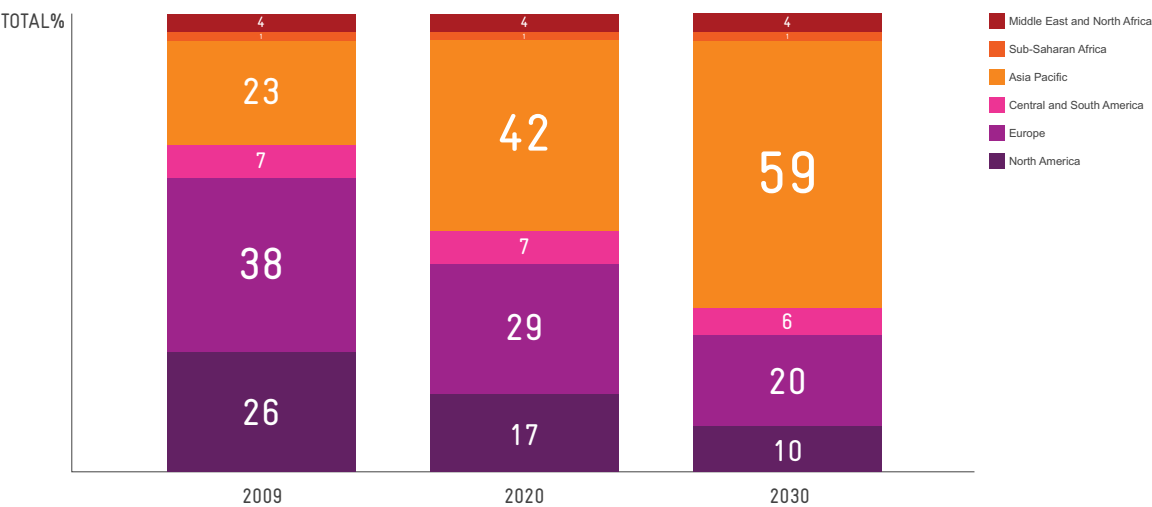
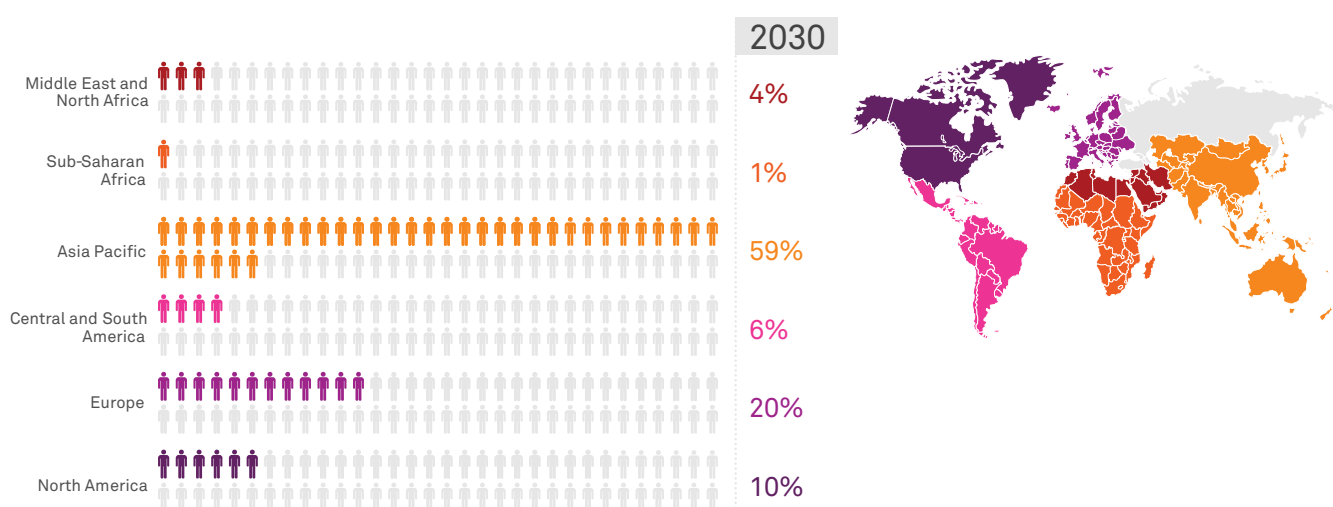


Figure 3b: Total middle class consumption by region: 2030 estimate [2]



2.2 Demand in Asia – Five consumer trends

With wealth, and an increasingly complex economy, comes choice. Asian economic and demographic trends are influencing consumers' purchasing behaviour, with trends showing similarities to industrialised nations in Europe and North America. An evaluation of the evidence behind this behaviour has resulted in the following list of five key emerging consumer trends:

1. Increased discretionary spending
2. Increased trading-up
3. More diversity in consumer preferences
4. A greater focus on personal and environmental health
5. Stronger demand for convenience.

There is a lot of overlap across these five consumer trends. Opportunities in niche markets are being created as a result of these interrelated trends; however, these will only be seized by those Australian manufacturers who can move swiftly before the void is filled by local manufacturers, or other astute international competitors.

2.2.1 Increased discretionary spending

As income rises, Asian consumers are shifting from essential spending on primary goods and services to more discretionary items [6]. Growth in non-essential categories such as imported cars, electronics and recreational equipment is surpassing those of primary goods in Asian economies [7]. In China, for example, discretionary spending is projected to grow almost twice as fast as expenditure on essentials.

The intensity and focus of this trend may be affected by factors such as fluctuations in the price of essential goods, such as food and energy, and by the regulatory environment. One illustrative example of this is the move by the Beijing City Government to ban cars from central Beijing (where cars are well on the way to replacing bicycles and motorcycles as the transport mode of choice) and to limit the availability of vehicle registration [8, 9]. This regulation is in direct response to the rapid proliferation of private motor vehicles, which has stretched the city's infrastructure to breaking point.

As Asian economies successively develop – from the early lead of Japan to the most recent examples of Laos, Myanmar, Cambodia and Bangladesh – more people are becoming first-time consumers of manufactured goods such as televisions, mobile phones, motorcycles, air conditioners, and leisure equipment. In 2012, China became the world's leading PC market for the first time. During that year, shipments to China amounted to 69 million units, exceeding the 66 million total reached by the United States [10].

2 TRENDS IN ASIAN DEMAND (CONT.)

2.2.2 Trading-up is on the rise

The Asian story is one of increased trading-up: the purchase of more expensive products and services with improved features, as a sign of greater personal aspiration and affluence. This is fuelled by consumers' desire to improve themselves, the conditions in which they live and their perceived social status [11].

A perfect example is the consumption of improved versions of mobile phones. During the 2010-15 period, smartphone sales in Asia will total 0.83 billion units sold, equalling total sales in the Americas for the same period [12].

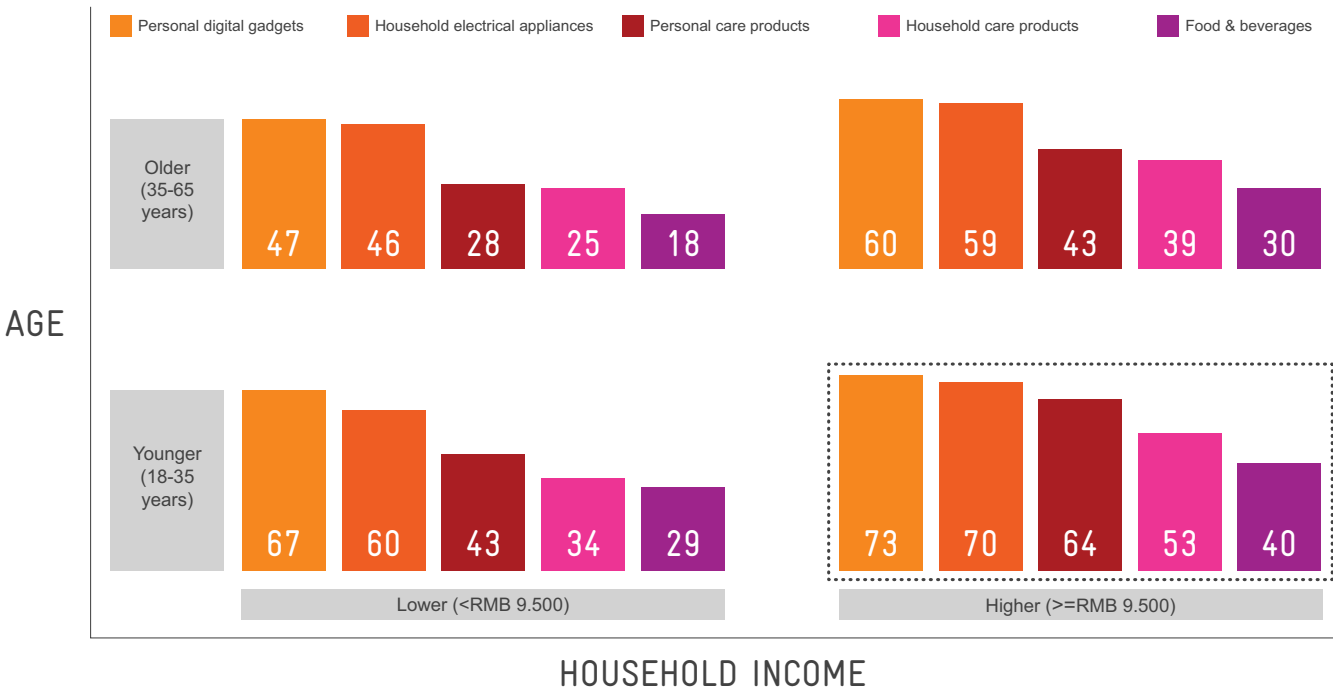
What makes the trading-up trend even more relevant for Australian manufacturing is the fact that many consumers in Asia, particular the younger generations, believe that foreign brands are more capable of supplying high quality goods that are increasingly in demand (see Figure 4).

To put Figure 4 in context, according to the OECD, the middle class in 2009 included 1.9 billion people, with Europe (664 million), Asia (525 million) and North America (338 million) accounting for the highest number of people belonging to this group. The size of the "global middle class" is anticipated to increase from 1.8 billion in 2009 to 3.2 billion by 2020 and 4.9 billion by 2030.

The bulk of this growth will come from Asia: by 2030, Asia will represent 66% of the global middle-class population and 59% of middle-class consumption, compared with 28% and 23%, respectively in 2009 [14].

So while the percentages of the groups of respondents to the McKinsey survey in Figure 4 demanding foreign-branded, manufactured food products ranges from 18-40%, if we average this at 30%, this would equate to almost 158 million people in 2009 and around 970 million in 2030.

Figure 4: Percentage share of respondents who prefer foreign brands versus local brands (China), by segment [13]



2.2.3 Increased diversity of consumer preferences

The search for products tailored to individual consumers' explicit wants is also rising in the region. Asian customers value a firm's ability to customise its product to suit local preferences [15]. At the individual level, there is a growing focus on emotional considerations when shopping, as well as an increasing emphasis on self-expression. As this sense of individualism increases, expectations for a diverse set of offerings will also rise. This aligns with a progression from mass production to mass customisation, to servitisation.

In the manufacturing sector, the term servitisation describes a manufacturer who provides services that complement their product offering. Servitisation can provide a manufacturer with higher margin and new market opportunities, leverage the knowledge of workers, secure customer loyalty and promote ongoing exchanges with customers.

Additionally, an increasing wealth disparity causes a divergence of consumer segments across the region, which results in a diverse consumer base. China, in particular, is developing a strongly polarised consumer market with a growing base of consumers, hungry for discretionary goods and services and even luxury items, and a broad mass of consumers whose behaviour, and economic circumstance, has yet to convert from aspirational to actual.

Asian customers value a firm's ability to customise its product to local preferences

There is a lag in the response to these rapid developments in consumer demand by local manufacturers; however, the increasing capacity of local manufacturers to deliver sophisticated quality product will see the window of opportunity for international competitors narrow [16]. Thus, it is the agile sophisticated manufacturers who will most likely seize and maximise the opportunities presented by this growing diversity.

2.2.4 Personal and environmental health gains in importance

Good health is not just a sign of affluence; it is also essential to the earning capacity of many in Asian economies where health and welfare systems have not kept pace with economic development.

Increasingly, consumers in India, China and South East Asia are demanding attributes such as 'organic' and 'green' labels [17]. In Japan, an ageing population will boost the global health food segment in the medium term – Japan is already the world's second-largest market for that category after the United States [18].

Furthermore, there are indications that a substantial number of consumers in emerging markets are willing to pay a premium for eco-friendly products; one recent survey showed that Chinese consumers would agree to pay 10% more for 'green' products. (In contrast, consumers in developed markets, like France and Canada, would only pay 5% more for such products [19]). Consequently, the ability of Australian manufacturers to meet or surpass recognised standards for organic, 'green' and sustainable production will potentially be a key asset to Australian manufacturers.

A substantial number of consumers in emerging markets are willing to pay a premium for green and healthy products

2.2.5 Stronger demand for convenience

The most valued commodity for most in the emerging middle class is time. For example, as citizens move from isolated rural areas to densely populated urban centres, the faster pace drives them towards 'grab-and-go' outlets and products in convenient portable packaging [19]. Convenience also drives increasing consumption of pre-cooked and ready-to-eat meals. The expedience of home delivery and the convenience of being able to shop anywhere at any time are two of the factors driving the growth of online sales. By 2016, the Asia-Pacific region will account for nearly 40% of worldwide B2C e-commerce sales [20].

3 MEGATRENDS INFLUENCING MANUFACTURING

The second part of setting the scene is to understand the megatrends influencing manufacturing. A megatrend is defined as a substantial shift in conditions – the social, economic, environmental, technological and political conditions – that may reshape the way an industry operates in coming decades. Each of the megatrends detailed below will influence Australian manufacturing and opportunities in Asia. In this section we describe these megatrends quite broadly and we will draw out the connection with specific manufacturing opportunities later in the report.

3.1 Emerging markets

Rapid income growth and technological advancement in Asia, and the developing world, will see the emerging middle class demand new goods and services as their newfound consumer wealth changes their preferences and enhances their buying power. This will open up new markets for Australian manufacturing products, but competitors in Australia and abroad are likely to be aware, and in hot pursuit of, the very same opportunities.

Rapid growth in Asian markets, including China, Hong Kong, Indonesia, Malaysia, Singapore, South Korea, Taiwan, Thailand and Vietnam, will see GDP collectively growing at 6.4% per year between 2011 and 2020. This is compared with growth in the US and Europe of 2.5 and 1.3 respectively [21].

Incomes in these countries will increase accordingly, contributing to the growing middle class. The OECD defines the global middle class as those households with daily expenditure between US\$10 and US\$100 per person. In 2009, 1.9 billion people fell in this bracket, with 28% in the Asia Pacific region. By 2030, the middle class is expected to grow to 4.9 billion people, with the Asia Pacific share growing to 66% [22]. Global expenditure from the middle class is expected to grow from US\$21 trillion in 2009 to US\$56 trillion in 2030, with 80% of that growth coming from Asia [22].

Figure 5: The five manufacturing megatrends



1 Expressed in purchasing power parity terms in order to account for the difference in the relative value of currencies.

3.2 Resource scarcity

Energy, mineral and water resources are essential inputs into the manufacturing industry. These resources have limited supply in the natural world. In contrast, domestic and global resource demand is rising. Global water demand is forecast to increase 55% between 2000 and 2050, with the largest increases coming from manufacturing, electricity and domestic uses [23]. Global energy demand is forecast to increase by 40% between the years 2009 and 2035 [24]. Previous decades have seen prices rise and become more volatile. A shrinking supply will lead to increased development of, and investment in, more efficient production techniques. For example, the gradual decline in ore grades from exploitable reserves of major mineral commodities [25] is likely to contribute to increased interest in recycling of existing resources.

Manufacturing industries which best adapt to an increasingly resource-constrained world will be able to derive significant competitive advantage.

3.3 Food for all

Global population growth and economic growth will fuel increased demand for food in coming decades. It is forecast that food production must increase by 60% by the year 2050 to meet the expected rise in food demand [26]. Food prices are high and most forecasts suggest they will remain high, or increase even further in the coming decades [27]. Between 25 to 50% of the household budget in many developing countries is already allocated to food expenditure [27, 28]. Higher food prices will have significant impacts on the distribution of household expenditure.

The quantity of food traded across borders is also rising sharply. Combined with increased spending power, increased food trade is changing dietary preferences [29]. In developing countries the most popular source of protein, for example, is from plants, whereas in developed countries it is mainly derived from animal protein [30].

However, people in developing countries are, on average, increasing meat consumption at the rate of 5% per year with expectations of further growth ahead [31]. Such interactions between demand and supply factors in the food sector may create opportunities for the manufacturing industry in food processing.

The interaction between demand and supply factors in the food sector may create opportunities for the Australian manufacturing industry

Based on predictions of population growth, changing diets and changes to agricultural systems, the United Nations Food and Agriculture Organization (FAO) forecast that food production must increase by 60% by the year 2050 [26]. At the same time, every year the world loses around 12 million hectares of productive agricultural land which, if kept in production, would have produced around 20 million tonnes of grain [32]. Thus gains in production must predominantly come from yield and efficiency gains and not through the expansion of agricultural land [28]. This reinforces the need for Australia to continually improve its agricultural productivity.



3 MEGATRENDS INFLUENCING MANUFACTURING (CONT.)

3.4 Responsible industry

Coming decades will see an increased emphasis on environmentally and socially responsible industry performance by companies, governments, communities and consumers. Environmental and social credentials will be an increasingly important differentiator for consumer products and major corporate or government contracts. The social licence to operate will obtain elevated importance. Recycling and waste management will gain greater attention.

Cleantech is a growing sector as China's 12th five-year plan, 2011-2015 identifies 'New Energy': nuclear, wind and solar power, as one of seven priority industries for investment and aims to increase non-fossil fuel use to 11.4% by 2015 [33]. Ernst & Young's 2013 'Cleantech industry performance' report lists an 18% global market capitalisation growth over the previous 12 months. The Asia Pacific region experienced the greatest increase in the number of companies and employees in this market [34].

Company engagement with corporate sustainability and the triple bottom line is shifting from being of moral importance to a necessity for companies operating in the 21st century. An Australasian Investor Relations Associations' investor survey found that investors are requesting more information on a company's operational impacts and governance [35]. All aspects of company operations are coming under scrutiny. KPMG's survey on corporate responsibility reporting found 93% of the world's largest 250 companies now report on their environmental and social activities. The biggest increase in reporting rates is from the Asia Pacific region [36].





3.5 Technological advances

The pace of technological development in the manufacturing industry is rapid. Future advances have the capability to substantially alter production processes, supply chains and the competitiveness of companies and the whole industry. These technological advances will help manufacturers reduce and avoid costs, and also innovate and access new markets.

Disruptive technologies are hard to see coming [37]. These technologies have the potential for a significant transformative effect on the way businesses operate and people live. The Economist Intelligence Unit [38] forecasts a continuing increase in the rate of technology disruption over the coming decade.

Some examples of the technologies likely to influence the manufacturing industry in Australia and around the world include additive manufacturing, automation, and intelligent robotics, seizing the power of the industrial internet, flexible electronics and resource-efficient technologies such as flow chemistry.

Technological advances will help manufacturers reduce and avoid costs



PART 2: WHAT ARE THE MANUFACTURING OPPORTUNITIES FOR AUSTRALIA?

The consumer trends, outlined in the previous section, point to a proliferation of niche markets for those manufacturers who are technologically prepared, ready to listen to their customers, and deliver a product that is individualised and accounts for rapidly changing preferences.

Meanwhile, the megatrends influencing manufacturing point to where the drivers of change reside, namely, in a steep technological trajectory. This is due, in part, to increasing aggregate R&D expenditure across the globe and a simultaneous need to produce customised goods both efficiently and sustainably (two goals that would typically be mutually exclusive without technological advances).

Opportunities for Australian manufacturers exist where middle class consumer trends in Asia meet the megatrends that are driving change in the manufacturing landscape. However, the opportunities we discuss in this section are not only open to Australian manufacturers. The global innovation at the heart of megatrends means that other manufacturers, from both emerging and developed countries, are either already seeking to target these opportunities, or are not far from their Eureka moment.

The following section describes four ways in which Australian manufacturing can access the new markets created by the emerging Asian middle class.

4 RESOURCE-EFFICIENT MANUFACTURING

4.1 Overview

Efficiency and innovation are not the mutually exclusive domains they were once considered to be. The pursuit of each in its own right is not only increasingly legitimate, but also necessary to compete. A manufacturer achieving both will enjoy advantages in a sector recognised for regular, almost constant technological advancement globally, and pressure on margins locally.

Resource-efficient manufacturing is supported by three manufacturing megatrends, including resource scarcity, responsible industry and technological advances, as depicted in Figure 6. Resource-efficient manufacturing delivers a combination of economic and environmental benefits through reduced resource consumption and less waste, resulting in reduced costs.

A key enabler of resource-efficient manufacturing is the adoption of new technological advances, such as additive manufacturing (AM)

Resource efficiency supports the principles of sustainable or green manufacturing by employing processes or technologies that minimise negative environmental impacts, conserve energy and natural resources. The Asian demand trend 'Personal and Environmental Health Gains in Importance' indicates that the demands for products that are 'green' or eco-friendly are rising.

Efficient manufacturing could therefore support an improved environmental image and brand, and the production of manufactured products with superior environmental credentials. It could encompass new market opportunities through the delivery of manufactured goods into cleantech markets, such as renewable energy or waste management solutions, to support the quality of modern life in the rapidly growing and emerging economies. Cleantech markets are particularly relevant for China as it plans to invest RMB 3.4 trillion on environmental protection during 2011-2015. It is estimated that environmental degradation costs China 8% GDP per annum [39].

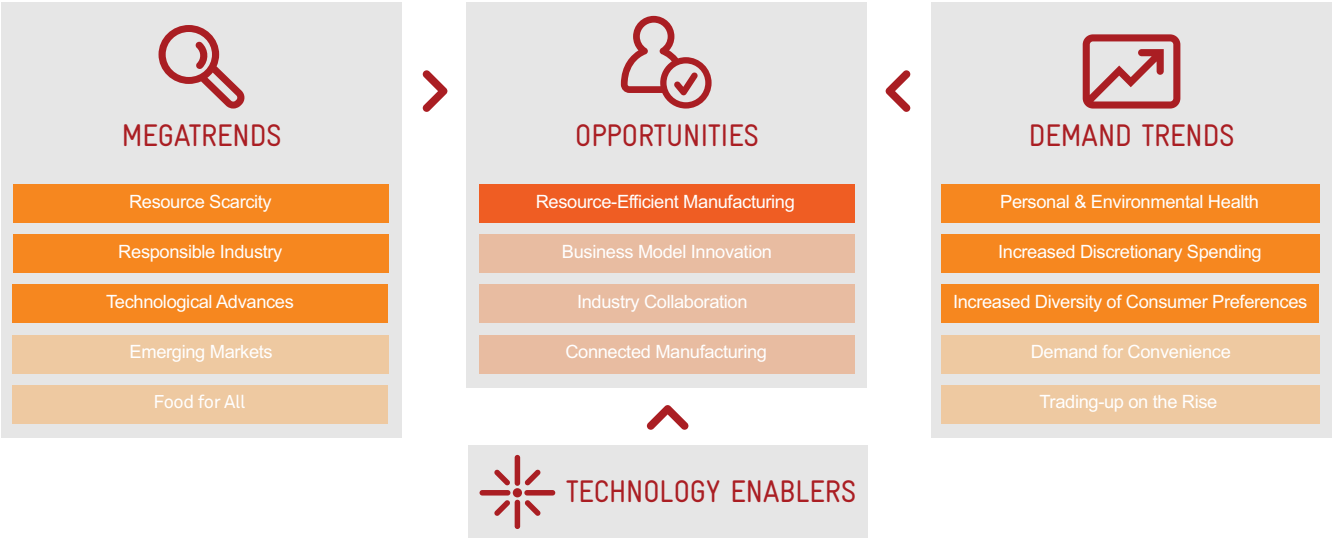
A key enabler of resource-efficient manufacturing is the adoption of new technological advances, such as additive manufacturing (AM). AM has application in the aerospace, construction and the automotive sectors, but the biggest opportunity relevant to the Asian middle class market is within the health sector.

4.2 Additive manufacturing for the Asian health sector

Additive manufacturing (AM) technologies, including 3D printing, have the potential to improve business operations by facilitating the more efficient use of resources in manufacturing. Additive manufacturing creates objects layer by layer (as opposed to subtractive manufacturing, which removes material to create an object).

3D models are no longer just generated on screen, but are created in real time using 3D printing. The part to be manufactured is sliced into stacks of layers and read into the additive manufacturing process, with the part built up layer by layer until complete. Additive manufacturing has the potential to use less raw material, create less waste and eliminate the need

Figure 6: Resource-efficient manufacturing opportunity supported by Asian demand trends and megatrends



for retooling [40]. By using less material, the process makes more efficient use of valuable resources and significantly reduces costs. For example, Timberland shoes typically spent one week and \$1,200 to design a new shoe sole, but this process now takes 90 minutes and \$35 with a 3D printer [41].

The ability of AM technology to significantly improve the cost and speed of the product design process both creates new business models and makes such iterative prototyping approaches accessible to a much wider range of manufacturers.

The flexibility of AM is bringing manufacturing closer to the consumer while also allowing the individual to play a greater role in the creation of a product. For example, individuals are now able to upload their own designs for affordable manufacturing, collaborate on designs via open source software or even sell their designs directly.

Bringing manufacturing closer to the consumer

Companies such as Ponoko (New Zealand based) and Shapeways (Netherlands based) act as manufacturer, retailer, broker and design marketplace – connecting individuals to potential buyers through their online network [42]. Combined with digital software, novel designs and new business models, AM is fuelling a manufacturing revolution. This revolution allows a far more rapid and potentially much cheaper R&D and prototyping process, permitting quicker speed to market for new products and easier and faster redevelopment of existing products (often linked to customer closeness in the design process).

AM supports the transition from mass production to mass customisation; that is, from competing based on high volume manufacturing to high tech, high value manufacturing of customised products delivered en masse. Custom product applications, such as dental crowns or medical implants, will benefit from AM technology as they could be produced economically in low volumes.

There are other applications of AM in the health care sector. AM techniques are being used in the production of medical implants such as the titanium implants used in hip and knee replacements.

AM is also capable of building complex geometries that cannot be fabricated by any other means [43]. Bioengineering start-up company Organovo has developed a 3D bioprinter that uses human cells to print functional human tissue. Potentially such techniques might be capable of producing complete human organs for transplant, for example, into soldiers injured in combat [44] or cancer victims with disease-ridden organs [45].

The potential of AM to revolutionise many aspects of manufacturing for the health sector point to a significant opportunity in the Asian market. Like many regions, Asia has an ageing population. The median age in Asia has already risen from 21.2 in 1980 to 29.5 in 2011 and will continue to increase to 41 in 2050 [46]. By 2050, Asia will be home to 24 percent of those aged over 60 [46]. Japan has Asia's oldest population while China is home to the largest population of aged individuals [47]. Increased life expectancy and decreased fertility are contributing to growth of the ageing population [46]. This will have significant implications for the Asian economy, not least for health care expenditure. Also, as the ageing population are seeking to preserve a high quality of life for much longer, this leads to greater demand for products such as dental implants and titanium hip replacements.

Technology enablers for resource-efficient manufacturing

Additive manufacturing/3D printing

– costs are forecast to drop by 79% over the next five years and 92% over the next 10 years [1]. This makes AM even more cost effective for Australia manufacturers.

Digital product design software

– AM begins with a digital 3D design and there are multiple software packages available. This allows early collaboration between the manufacturer and consumer or end user.

Data security for digital product designs

– As value shifts from the product to the design, or the physical to the digital, technologies that provide IP protection, data encryption or rules for file access are increasingly important.

ICT collaboration platforms

– Manufacturers need to establish closer relationships with customers, consumers and suppliers across the supply chain. This supports the transition from mass production to mass customisation. Technologies including social media and networking, cloud-based video conferencing, and virtual collaboration tools could support “cloud manufacturing” – where design and manufacturing services are sourced from the cloud and manufacturing becomes distributed.

ICT Networks – fast, secure and reliable fixed and wireless networks to support, for example, mobile communication, internet-enabled applications and access to cloud-based services.

4 RESOURCE-EFFICIENT MANUFACTURING (CONT.)

Australia has a significant competitive advantage in meeting future demands for titanium medical implants using AM techniques. In 2011, Australia was the world's second largest producer of titanium and also holds the second largest titanium reserves (China has the largest reserves and is the largest producer [48]). Research is already well progressed in the development of efficient and effective AM processes and methods that could be transferred to applications in the health sector.

In this example, the focus has been on AM; however, broader health and healthcare delivery considerations are driving demand among the emerging middle class in much of Asia.

Unlike patterns of economic development among already industrialised nations, there remains an acute susceptibility to loss of income and wealth across newly industrialising countries such as China, India, Vietnam, Cambodia, Thailand and beyond. A high proportion of the middle class here operates in informal sectors, and as noted by the OECD, "if those in the middle have precarious incomes and unstable employment, their consumption cannot be counted upon" [14].

But in countries where the health and welfare systems have not kept pace with meteoric economic development, and where the user retains the ability to pay, there exists a strong market for health and medical interventions – from medical devices, to biopharmaceuticals, vitamin supplements and nutraceuticals, to hospital equipment, sports, leisure and fitness equipment, sensor and monitoring devices and remedial health products.

Extensive niche opportunities for Australia's more astute manufacturers

The growing concern for personal and environmental health, coupled with the discretionary spending and diversity of preference trends, points to extensive niche opportunities for Australia's more astute manufacturers.



4.3 Implications for manufacturers

Australia already has a very strong design component in our manufacturing industries. AM increases the importance of this capability. Even Australia's highly regulated intellectual property regime, with registered IP such as registered designs, patent and trademarks, offers manufacturers advantages over in-country competitors in Asia via strengthened brands and clearly recognised quality parameters.

In order to capitalise on this opportunity, however, manufacturers need to be prepared for a digital and software revolution. Further action needs to be taken to develop this opportunity in connection with serving an Asian middle class market. This will not be a problem for those who are already, or seek to be, on a global footing.

Steps to achieve this are identified as follows:

1. **Get closer to the end user.** Building customer links through digital, internet or cloud-based systems supports greater customer engagement, product usage and application knowledge and feedback.
2. **Understand the market segment.** Research the Asian health sector demand for products that can be delivered with AM technology.
3. **Undertake R&D to develop fit-for-purpose products.** Matching AM techniques, materials and design for the chosen medical application will result in valuable IP that can be leveraged by Australian manufacturers. Technology that supports data security and IP protection is paramount.
4. **Leverage the greater flexibility in your manufacturing operations that AM delivers.** For example, products could be designed in Australia and manufactured close to markets.
5. **Investigate opportunities to collaborate.** For example, secure access to AM machines to evaluate the technology, receive technical advice and de-risk capital investment. The CSIRO recently established the first Arcam AM facility in the southern hemisphere to provide industry with access to AM technologies [49].



5 BUSINESS MODEL INNOVATION

5.1 Overview

Business model innovation requires building an agile, flexible, highly-connected business that is intensively innovative (usually built on strong R&D expenditure) and has responsive manufacturing processes that rapidly transition from prototype to product. It requires extensive coordination internally – so that both efficiency and novelty can be achieved – and externally to ensure the opportunities and insights partners bring are fully integrated into the product and service pipeline.

Speed and agility are at the core, with fail-fast strategies being supported by rapid retooling, the flexibility of simulation, modelling and 3D printing technologies, to match the fast-search market intelligence that comes from being highly-connected across a global business network.

Global competition brings with it the increased likelihood of disruptive technologies emerging in manufacturing. However, disruption can be seen as either positive or negative, depending on how innovative and how prepared for change your business is.

Those who succeed as innovators are able to establish a dominant design, build their brand and attract collaborators as well as competitors

The increasing complexity of the emerging economies of Asia also means that disruptive technologies can no longer be expected to emanate from industrialised countries alone. Being prepared, not only to be the innovator, but also to respond rapidly to the almost constant innovations that dictate the technological trajectories pointed to by the megatrends. Those who succeed as innovators are able to establish a dominant design, build their brand and attract collaborators as well as competitors.

The combination of megatrends, emerging markets and technological advances (see Figure 7) has created opportunities for those companies that have built a reputation for strong intellectual property founded on research and development. Those who can seize the manufacturing opportunities with their own disruptive technologies (or with a model that leverages the capabilities of collaborators, offers enhanced features beyond the basic product, and provides the sensation of personalisation and customisation) have a distinct advantage in markets where competitors are not as advanced.

Figure 7: Business model innovation manufacturing opportunity supported by Asian demand trends



Technology Enablers for Business Model Innovation

ICT collaboration platforms – To build a digital relationship (B2B or B2C) with the end user to facilitate greater levels of customisation or understanding of a market. This includes tools to monitor service delivery and client satisfaction e.g. NPS, survey monkey, and the delivery of product system services such as post-sale maintenance or services.

Additive manufacturing/3D printing technologies – To enable rapid prototyping, customisation and faster, cheaper, more efficient development and production processes.

Data security for intellectual property – Innovative companies developing unique, high-quality solutions require IP protection or data encryption to protect their competitive advantage.

Cloud services – Providing access to services anywhere and, importantly, from a position of location independence. Cloud services may provide the ability to rapidly relocate points of production, which has the potential to de-risk capital investment. Cloud services enable cloud manufacturing.

5.2 Adding value through innovation and servitisation

5.2.1 Disruptive technologies – the R&D intensity of cochlear

Cochlear is the pioneering hearing device company that is at the forefront of the success of Australia's medical device industry, along with the respiratory sleep device company, ResMed. These two global successes point to our developed capabilities in this field, which leverage our world-beating capabilities in health and medical research.

Cochlear's hallmark as an innovator is built on intensive investment in R&D. It has established over many years a large patent portfolio, and continues to lead on a global scale. Cochlear's success is not just product based. The company has established a strong network of research, manufacturing and distribution collaborators. Companies such as ResMed and Cochlear offer products that are high-cost and sophisticated, but life-changing. Uptake has been strongest in high-wealth countries such as the US, and in countries with well subsidised health systems such as Australia and Canada. Cochlear is penetrating the Asian markets even where the health systems are not well subsidised because their product offers dramatic improvements to quality of life for the hearing impaired and productivity improvements on traditional hearing devices. Uptake in Asian countries has increased dramatically in the last five years, led by Singapore, Japan and China.

Despite being in North America and Europe for over 20 years, currently 'The proportion of Cochlear's sales to end customers by region is approximately: Americas 40%, EMEA 40% and Asia Pacific 20%' [50]. In the last year alone, Asia Pacific sales revenue of \$147.6 million increased 20%. Indicative of the opportunities in Asia, a Central Government tender sale into China of approximately 2,800 units was won this year [50]. With each unit being worth over \$50,000, this is a major step into a very lucrative market.

Concerns raised about the inability to protect intellectual property in some Asian countries are real, though that reality is diminishing in China since it signed the TRIPS (Trade Related Aspects of Intellectual Property Rights) agreement. As countries play a more significant role in global trade, they cannot afford to ignore world standards of intellectual property. Legal systems are also starting to catch up, with legislation supporting intellectual property recognition in many of the emerging economies of Asia.

Evidence is emerging that Chinese companies are concerned about protecting their own intellectual property rights as they deal with Australian, US and European firms.

5.2.2 Servitisation – no boundaries between manufacturing and service solutions

The provision of manufacturing services is the simplest form of business model innovation for manufacturers. This can be described as 'additional services to complement a tangible product offering in order to add value'. This denotes a shift to a product-service relationship with customers, which creates lengthier relationships, potentially excluding competitors, improves the longevity of a product's life and produces more reliable revenue streams. Globally, an average manufacturing services firm has around 30% of sales as services [51]. In Australia, around 23% of Australian manufacturing companies already provide a service [52]. There is room for more firms to adopt this strategy to add value and deliver services to Asian markets.

An Australian example of business model innovation that has helped penetrate Asian markets in a highly competitive environment comes from the mining sector. High value service occurs in Orica Mining Services through the provision of exploration and customer solutions. Orica's focus is no longer just explosives and chemical compounds, but also assisting the rapid movement of minerals through to market. This has also provided an improvement in margin for Orica. As Orica builds a more substantial service delivery function, this not only augments its products, but also drives penetration into new markets. In Asia, these include a strong presence in China, India, Indonesia, Japan, Kazakhstan, Malaysia, Philippines, Singapore, Taiwan, Thailand, and Vietnam. The benefits for Orica include a higher margin business model. Orica's profit jumped to \$602M on the strength of its innovative changes [53]. Orica believes it will 'Succeed through collaboration' [54].

5 BUSINESS MODEL INNOVATION (CONT.)

5.2.3 Collaborative manufacturing – global supply chains in an instant

Not all opportunities for our manufacturers lie in the advanced manufacturing or large scale industry markets. Just because an industry is mature it doesn't mean there are no niches left to exploit. Enabling technologies have increased market access to new and small innovative firms with less disruptive technologies. Braaap Motorcycles offers one such example, as shown in the following case study.

Braaap is a 2013 Telstra Business Awards Victorian Business of the Year. It was established by Brad Smith, a motorcycle enthusiast who wanted to give people motorbikes that could compete with custom designers from the US, but also be affordable. To do this Braaap sought out like minded manufacturers from around the globe who could integrate his Australian designed components in to their manufacturing processes. While many rejected the ideas put forward by Brad Smith, a small number of foresighted collaborators came on board. The business model that has emerged can be outlined by their need to compete in a heavily contested space. Their business model has helped capture markets in China, India, Mongolia, the Middle East and Papua New Guinea. Braaap's strategy fits ideally with the Asian consumer demand trends, with discretionary spending directed at recreational and leisure pursuits that enhance personal well-being through play.

Their financing options, which have seen them grow 300% above industry average in the last three years, taps in to a demand for convenience. The custom nature of the motorbikes satisfies the increased diversity of consumer preferences that offers the niche market opportunities that Braaap is fulfilling [55]. So how do you measure their success? "We are the only motorcycle on the planet with lifetime warranty and we are the only motorcycle brand to win back-to-back championships at the world title for our sport [56]."

5.3 Implications for manufacturers

There are many ways to employ agility and implement business model innovation in Asian markets, including mix-n-matching strategies. For example, Cochlear has successfully captured individual needs and demands through a premium product. Its markets are niche, and it can protect its position through the proven high quality standards that have built its reputation. This reputation offers a level of branding that will sustain its market position.

Orica has leveraged its high quality standards to move beyond its product base. The service focus has also permitted an emphasis on its environmental credentials that would be difficult to achieve as an explosives and chemical compound business.

In general terms, manufacturers seeking to take advantage of business model innovation should:

1. **Be prepared to move into niche markets by always inventing, innovating and undertaking new product development.** Employ developmental technologies such as simulation, modelling and AM technologies to ensure rapid and effective new product development, where fast-fail means more likelihood of creating a successful new product. Use these strengths to attract collaborators or local Asian partners of similar calibre who can open doors to new niches.
2. **Connect to a strong network** – for access to partners' insights, ideas, solutions to problems and greater access to technical and market knowledge. This is more than just a supply chain; it is a value web, where all partners are interconnected. Increasingly, these network partners are going to be found in the Asian countries that Australian manufacturers want to target. Their capabilities have increased and their value adding potential dramatically improved. Seek them out.
3. **In the health sector, take a two-pronged approach.** Direct targeting of both middle class consumers and governments whose health spending has increased dramatically in recent years.
4. **Add value.** This is key for Australian manufacturing. Stand out from the crowd with a whole-of-life offering that is solution-focused. Partner with other local service providers to enhance the value of manufactured products.



6 INDUSTRY COLLABORATION

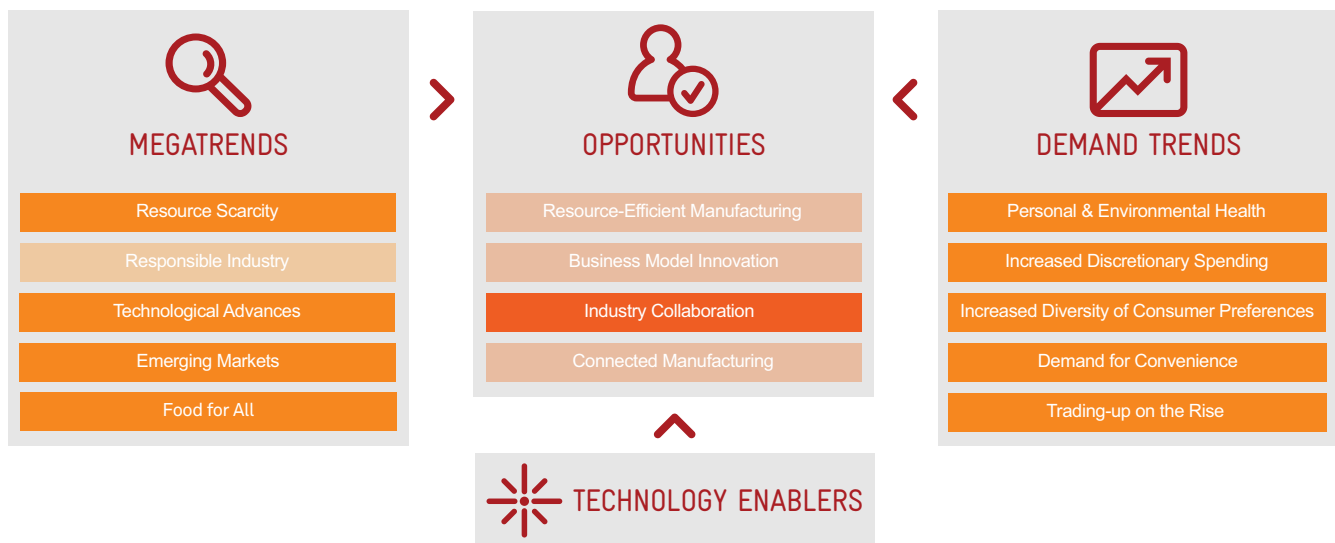
6.1 Overview

Industry collaboration is closely linked with innovation, productivity and competitiveness, as shown in Figure 8. It is supported by all Asian demand trends, and also by resource scarcity, technological advances, food for all and the emerging market megatrends shown in Figure 9.

Figure 8: Industry collaboration is the antecedence of innovation, productivity and competitiveness



Figure 9: Industry collaboration supported by megatrends and Asian demand trends



“If you want to go fast, go alone; if you want to go far, go together.” An African proverb

Much has been written about the challenge faced by Australian manufacturing in raising its productivity and responding to competition. It must be remembered, however, that Australian industry was coming off a high productivity base established in the 80s and 90s, so maintaining the same momentum was always going to be difficult. Nevertheless, innovation is recognised as being a key contributor to improving productivity, and collaboration is essential to innovation. Innovation will help manufacturers to mobilise to take advantage of opportunities in Asia.

Collaborative partnerships can reduce the cost and risks of innovation

Innovation is credited with increasing competitiveness. Businesses actively engaging in innovation are more likely to engage in the digital economy, and invest in problem solving capabilities, collaborate across the supply chain and with competitors – creating new services and products to meet customer needs and engaging with new technology and processes [57]. Innovation active companies are also:

- 42% more likely to report an increase in profitability
- Three times more likely to export
- 18 times more likely to increase the number of export markets targeted
- Four times more likely to increase their range of goods and services [57].

These are impressive and enviable metrics although it's worth reflecting on the barriers to innovation for SMEs, in particular. The top three barriers nominated in a 2012 Australian Government report were [58]:

- Lack of access to funds
- Cost of development or implementation
- Lack of skilled people.

Each of these barriers can be reduced through collaborative partnerships that can reduce cost and risks of innovation. Moreover, by collaborating with people outside the organisation, it's possible to gain access to new knowledge that addresses a lack of access to skilled people. If another reason to collaborate was needed, recent neuroscience research shows that our brains are wired to cooperate [59].

The collaboration imperative is upon us. Industry collaboration is without a doubt a necessary feature of success in an increasingly fast-paced, competitive, globally-connected world. The latest global GE innovation barometer study found that 87% of respondents believe innovation would be better if they partnered rather than embarked on their own innovation projects. The top reasons for collaborating with other companies are:

- Access to new technologies and markets
- Increasing speed to market
- Improving an existing product or service [60].

The Australian data from the GE survey reported an overwhelming 92% of Australian respondents strongly agree that partnerships would ensure they were more successful at innovation.

Yet Australia's track record on collaboration is far from commendable. Australia is last on two OECD league tables, 2008-2010; percentage of firms collaborating with suppliers and clients, and percentage of firms collaborating with publicly funded research organisations [61].

Collaboration data is acknowledged to be volatile and varies from year to year [57]. Regardless, Australia is lagging behind in the collaboration stakes and could be doing better. A lack of collaboration and low levels of industry innovation is bad for business and bad for Australia's prospects in delivering goods and services to the emerging Asian middle classes.

Industry collaboration and innovation are intricately linked, as shown in Figure 8, and are essential ingredients for the success of Australian manufacturers in Asia.

Technology Enablers for Industry Collaboration

ICT collaboration platforms – To enable access to social media or open source software to support collaboration and the relationship between manufacturers, suppliers, customers, and innovation partners. This supports the collection of consumer insights from Asian markets back to Australia.

RFID, Micro-Electro-Mechanical Systems (MEMS) & GPS – These technologies are particularly important for maintaining quality and proving the provenance of Australian food and beverage products by enabling real time logistics tracking, product traceability and quality assurance.

Data Analytics – To support the analysis of Asian consumer insights or logistics data. Analytics in the food processing sector could support quality improvement or the development of new, innovative products. Data visualisation tools could support the synthesis or interpretation of big datasets.

ICT Networks – To support virtual collaboration across the manufacturing sector or supply chain.

6 INDUSTRY COLLABORATION (CONT.)

6.2 Australian food and beverage goods to feed a growing and demanding Asia

Demand for high quality food products is being driven by rapid population growth and the expanding middle class – supported by the megatrends ‘Food for All’ and ‘Emerging Markets’.

People in developing countries are, on average, increasing meat consumption at the rate of 5 % per year, with expectations of future growth ahead [31]. In Asia, meat consumption increased by a factor of 14 between 1961 and 2009 [62]. Developing nations’ diets are shifting towards greater consumption of processed foods, fats and animal protein. This drives demand for meat and dairy products and, indirectly, livestock feed [28, 63]. Global demand for fish protein means production in global fisheries and aquaculture will grow by 15% from 2012 to 2021 [28]. These trends drastically change the types of food demanded.

Increased diversity of consumer preferences and a stronger demand for convenience

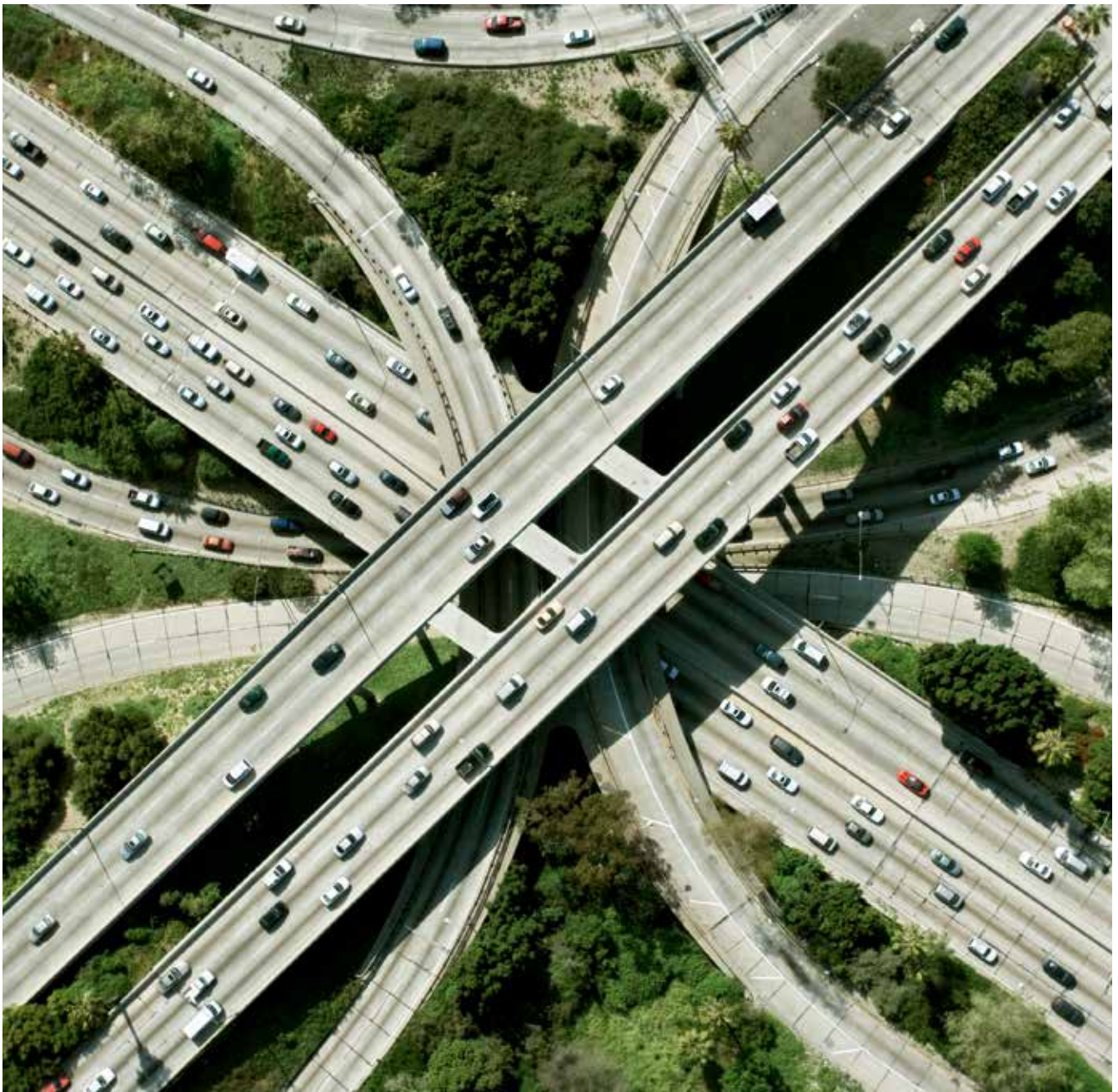
Australian food and beverage manufacturers have a significant opportunity to cater for the emerging Asian market by delivering high-value, processed food and beverages and associated services. The Australian Trade Commission reports that processed food exports to China have doubled from \$794 million to \$1.511 billion over the last five years. Market research demonstrates particular Australian opportunities in China for milk powder, seafood, processed foods, wine, beer, convenience foods, confectionery and snacks [39].

The Asian demand trends connected to this opportunity include increased diversity of consumer preferences and a stronger demand for convenience, both of which connect with the type of food products consumers will purchase. Understanding consumer demand and feedback is crucial as it is likely to vary across the Asian region.

For example, a Singapore food and beverage company understands the need for product differentiation as their product formulations vary by country [21]. It is therefore vital for Australian manufacturers to secure feedback directly from Asian consumers to support future sales. Digital technologies can play a role in capturing this information from the consumer or facilitating feedback through the supply chain.

The Australian sector is highly regulated and compliance with safety standards should be advertised as part of marketing Australian products, as it is important to build Asian consumer awareness of food security and safety within the Australian industry. Food safety is a valuable attribute for foreign processed food in China, particularly milk products following the 2008 scandal of melamine added to powder. This event caused six infant deaths and induced pain in 300,000 children. This single event has repercussions felt today as Chinese parents still prefer foreign brands to domestic ones [64].





Informing the consumer could be achieved directly through product packaging; however, a strategy such as linking a product through a QR code, social media or an online presence can cater for a more discerning, technology savvy, Asian consumer with greater discretionary income. The benefit of this approach is that a greater amount of information can be conveyed; for example, information about traceability and the product's regional origin, safety and quality standards, owners, brand, company vision or environmental credentials e.g. GM free or organic. This strategy could also support a connection between the source of a food product and Australian tourism by advertising the Australian brand and key locations such as the wine regions of South Australia or cheese of Tasmania. This type of cross-sector collaboration could positively influence both the manufacturing and tourism sectors.

6.3 Implications for manufacturers

Above all other manufacturing subsectors, there is a significant opportunity for the Australian Food and Beverage sector to deliver products for the ever-demanding Asian middle class. The strength of Australia's high quality products, stringent quality control and brands can be leveraged for the benefit of all firms. However, the ability to secure these bountiful opportunities will be dependent upon collaboration and innovation. Examples of how manufacturers can address industry collaboration include:

1. **Consider collaborating on product development or sourcing market segment or customer information.** This will reduce your costs. Open innovation – sourcing knowledge from outside the organisation – can add value to your business, and collaborative R&D partnerships can reduce risks.

2. **Data networks that support the flow of information from product to the consumer are vital.** Partnerships with technology service providers, such as Telstra, will enable the infrastructure to support this information.
3. **Develop an online presence or social media profile.** This should target the increasingly savvy Asian middle class and aim to influence their purchase of a prestigious Australian-made product by educating consumers on food source, relevant company information, brand, and safety and quality standards.
4. **Build connections and partnerships with government initiatives and agencies that can help.** The Food Industry Innovation Precinct is one example. Austrade have informative market-based information and tools such as the 'International readiness calculator' that support manufacturing exports into Asia.

7 CONNECTED MANUFACTURING

7.1 Overview

The opportunity for connected manufacturing (CM) arises from the convergence of technologies: sensors, automation, intelligent robotics, embedded electronics and their internet connectivity.

These technologies are the foundation for developing greater capacity for data capture and analytics across the factory and supply chain, enabling digital connections and the integration of data across manufacturing functions and value chains.

Full data integration between the physical and digital world is often referred to as the 'industrial internet' or 'internet of things', where everything will be connected, everything will be intelligent and everything that can be measured, is measured.

All of the demand trends are relevant to this opportunity. Technological advances also have a strong influence (see Figure 10) and this report applies an example from the food sector to illustrate CM's potential.

In particular, recent achievements in sensing systems, machine learning, navigation and dexterous manipulation have created a new breed of intelligent robots capable of sensing, reacting and interacting with the external environment [65]. These technologies are increasingly accessible due to their low cost. The newest generation of intelligent robotics cost as little as USD \$25,000 and can be operational within one day [1]. Their agility provides manufacturers with competitive advantage through better quality assurance, management of resources, and reduced costs. These technologies also have the potential to generate valuable information for production processes, as well as customer and supplier relationships.

Figure 10: Connected manufacturing supported by megatrends and Asian demand trends



Technologies that enable the integration of data across manufacturing functions and value chains

SMEs are an important group of manufacturers, comprising 89% (business by numbers) of the Australian manufacturing sector [58]. The integration of ICT and lightweight assistive manufacturing solutions (LAMS) for SMEs has been identified as a key enabler of competitiveness and access to new markets [66].

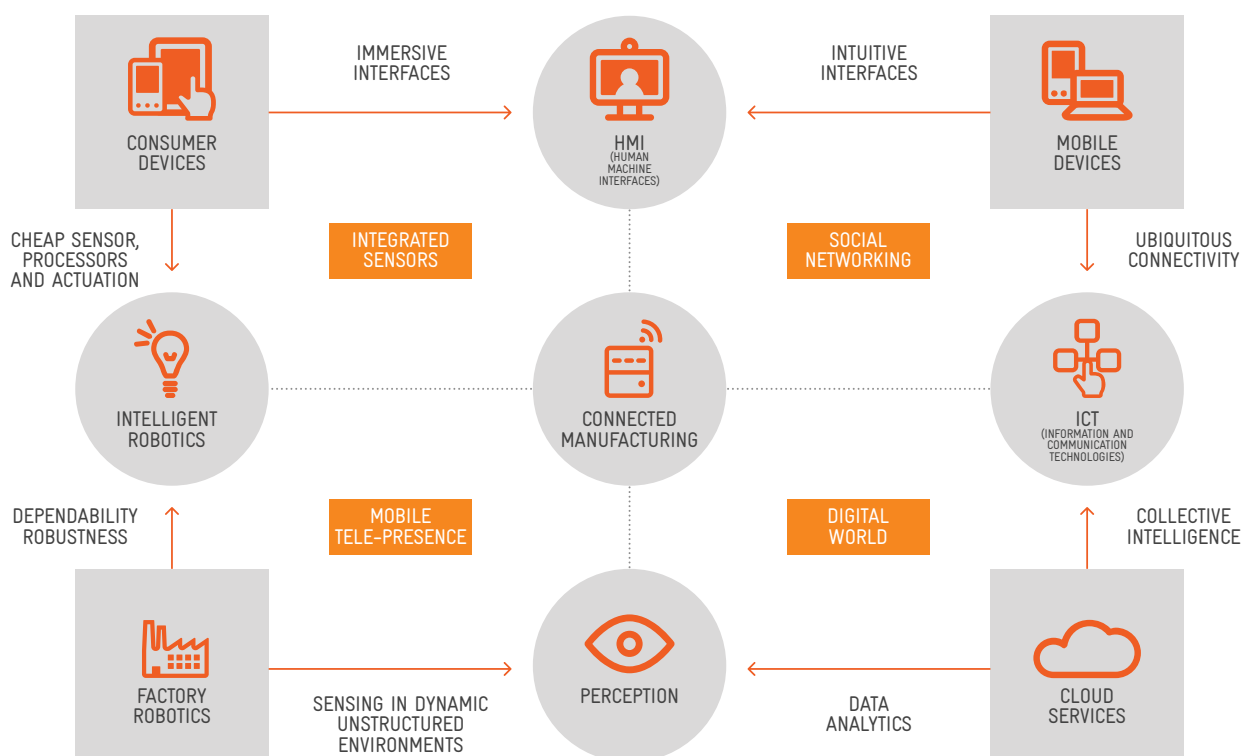
The potential of LAMS in the manufacturing environment is to augment worker capability, improve productivity by operating alongside workers and support tele-supervised operations for challenging and dangerous manufacturing environments [66]. These concepts are fundamental to CM and the technology enablers supporting CM are described in Figure 11, adapted from an earlier CSIRO report on LAMS [66].

CM is of relevance to the needs of the emerging Asian middle class by improving manufacturing flexibility.

This allows manufacturers to customise products for the Asian market and develop advanced, niche, high-tech products while also being cost effective.

CM technological advances offer substantial promise for Australia and this report describes a physical robotics example and digital scenario to illustrate how manufacturers could capitalise on this opportunity. Although this report provides only two sector examples – food, and mining equipment technology and services (METS) – the adoption of connected manufacturing will support agile Australian manufacturers in many other sectors as well.

Figure 11: Technology enablers influencing connected manufacturing



7 CONNECTED MANUFACTURING (CONT.)

7.2 Agility and market growth through automation in food processing

In manufacturing, the use of industrial automation has been associated with increased production efficiency, speed, precision, and reduced operational costs for high volume products [67]. Automation has proved to be an optimum way to improve productivity, particularly in sectors where economies of scale are relevant, and also where structured, highly repetitive tasks are required, such as in a bakery as outlined in the case study below.

Perryman's Bakery, a small artisan bakery manufacturer from Adelaide, decided to introduce an automation system into their gingerbread cookie production process in 2009 [68]. At that time, the objective was to increase their production output by automating the manual, yet demanding task of dotting the decoration on each biscuit. The implementation of an ABB industrial robot and computer vision system allowed them to increase overall output by three times.

Since implementation, staff numbers have increased which, in this case, nullifies the myth that automation is a threat to jobs [69]. The robotics system has also contributed to improved health and safety, as well as reduced waste. Importantly, there was absolutely no impact on the product recipe and homemade feel for which the Perryman's brand is well known.

Today, this acceleration of the production process has allowed Perryman's Bakery to grow and expand overseas, tackling export markets in New Zealand and Singapore [69]. The Perryman's Bakery example demonstrates the potential of automation and low-cost intelligent robotics for speeding production processes and supporting growth into Asian markets.

7.3 The potential for increased agility through digital connectivity

Pure automation is not enough for those who wish to remain responsive and agile. This is particularly true for complex, niche products that demand continuous adaptation via high-value-added activities such as engineering design, product evaluation for regulatory compliance, and significant amounts of integration of various components and technologies.

An example of where increased digital connectivity could be applied is in the METS sector, which includes equipment supply, mining consumables and software and advanced technologies. The Australian METS sector contributes \$10 billion annually to the economy, \$3 billion of which are exports. Importantly, Austrade has identified China, Indonesia, Papua New Guinea and India as priority growth markets [70].

An example of a METS sector SME is MineArc Systems, an award-winning, Perth-based manufacturer of refuge chambers and safety equipment for the underground mining, tunnelling, and chemical processing industries. The company has a strong presence in Asia, with projects deployed in China, Indonesia, Mongolia, Kazakhstan and Japan [71].

MineArc constantly deals with changes in mining regulatory rules that creates a dynamic environment for their production processes [72]. Asian demand for manufactured goods and population growth will indirectly drive an increased need for raw material in mining and chemical processing. For MineArc, agility is crucial to cope with this demand.

In an advanced manufacturing, high-tech, high-value niche market, such as where MineArc finds itself, connected manufacturing could enable a translation of digital information from technical specifications and quality assurance and standards requirements directly to the physical domain for immediate implementation by an intelligent robot.

Technology Enablers for Connected Manufacturing

Intelligent robotics – Low-cost, smart robotics located on the factory floor to automate manufacturing processes.

Mobile devices – Giving access and control over business and manufacturing processes in a variety of locations.

ICT networks – Both fixed and wireless, supporting the collection of data from sensors within the factory.

Integrated sensors – Within the factory to monitor energy, heat and emissions, factory processes monitoring productivity and quality and parts, or condition sensors that communicate environmental conditions across the supply chain.

RFID, Micro-Electro-Mechanical Systems (MEMS) & GPS – Enabling real time logistic tracking, product traceability and quality assurance.

Data analytics – Integrated data from multiple sources – parts, factory environment, supply chain – analysed in real time for rapid decision-making.

ICT collaboration platforms – To enable access to social media, HD video or open source software to support collaboration and the relationship between suppliers, customers, and innovation partners.

Cloud services – Providing access to services anywhere and, importantly, from a position of location independence.

Intelligent sensors, real-time visualisation systems and symmetric, high speed broadband technologies have the potential to facilitate this data translation between the digital and physical environments [73]. For MineArc, this digital to physical translation step could accelerate time-to-market and provide access to new business models that support the company's continued growth into Asia.

Furthermore, the integration of digital information with data analytics has the potential to shorten product launch cycles and speed up the reconfiguration and the customisation process – the latter being a crucial part of MineArc's business.

Moreover, embedded electronics and sensors could provide information to manufacturers about products during their use phase and proactively indicate service requirements for customers with enough lead-time to address issues before a catastrophic and costly failure. In short, connected manufacturing supports the flexibility and agility of manufacturers wishing to access niche, high value export markets.

The food and beverage sector is another example of where agility through digital connectivity could help Australian manufacturers seeking to enter the Asian market. Getting the product safely and quickly to the consumer is a major issue in food manufacturing where secondary processed foods must be delivered to retail outlets in multiple countries with as little deterioration in quality as possible. Integrated technologies and condition sensors are needed for successful cold chain management across monitoring, measurement, evaluation and improvement of packaging, and transport and logistics.

Telstra's collaboration with technology company Sendum shows what is possible in logistics, including the tracking, monitoring and protection of product. Sendum's technology, enabled through Telstra's telecoms framework, allows producers to GPS track packages in real-time along the cold chain, from inside warehouses, to semi-trailers, containers, rail cars, aircraft, and offices. Their trackers can monitor a range of parameters that affect quality during transport and storage, including temperature, humidity, motion, light, pressure and altitude – all simultaneously. There is also a protective aspect to their technology that alerts the manufacturer to product tampering and unauthorised use or movement. This is all achieved remotely using sophisticated sensor technology providing full web access [74].

Data from tracking technologies such as RFID, Micro-Electro-Mechanical Systems (MEMs), and GPS can be integrated with quality analytic technologies such as colour and flavour analysers, fluorescence scanning, mass spectrophotometers, phenotypes sensory testing, and product sampling using nuclear magnetic resonance (NMR) spectroscopy to permit molecular testing. Such integration facilitates real-time or near-real-time monitoring of product quality across the production and distribution chain, as well as helping to identify the cause of product deterioration. It is possible to better match different food types to suitable transport modes. Ultimately, this improves end product quality, reduces waste and enhances production credibility – all of which are key concerns for the Asian consumer, as outlined previously.

7.4 Implications for manufacturers

The implications vary depending on the level of engagement with CM technologies. One thing is certain: CM technologies support greater flexibility and agility – both of which are required by manufacturers hoping to deliver to the meganiches within the emerging Asian middle class.

1. Intelligent robotics are probably cheaper than one might expect.

Consider how intelligent robotics could support your business. Engaging in CM starts with low-cost automation and robotics, but these technologies set the foundation for more connected systems that support data analytics and highly flexible, customisable products.

2. Consider factors that were previously external to your business.

Every piece of information is vital. Data management and connectivity within and beyond the factory wall should be characterised by system integration, networking and analytics. The ability to deeply analyse data will help manufacturers be proactive rather than reactive towards market opportunities and address potential issues before they have a catastrophic business or brand impact.

3. Measure your agility.

Agile manufacturing helps companies to enhance efficiencies and maximise new opportunities. To support improved Australian manufacturing agility, an index for agility could be developed. This would allow manufacturers to rank their agility across functions and benchmark themselves against global competitors, thereby making them a more attractive market choice and also helping them to understand where they need to improve.

8 CONCLUSION

The emerging middle class in Asia presents many opportunities for Australian manufacturers. This report identified four opportunities for manufacturers:

1. Resource-efficient manufacturing
2. Business model innovation
3. Industry collaboration
4. Connected manufacturing.

These opportunities jointly build domestic competitiveness and support entry to the Asian market. Both consumer trends and manufacturing megatrends provide evidence for the abundant future that waits for Australia's manufacturers if they are innovative and agile enough to move into the niches that will constantly develop.

These niches, remember, are meganiches, with markets of 50-300 million people who are seeking a better quality of life and a reward for their risk and effort.

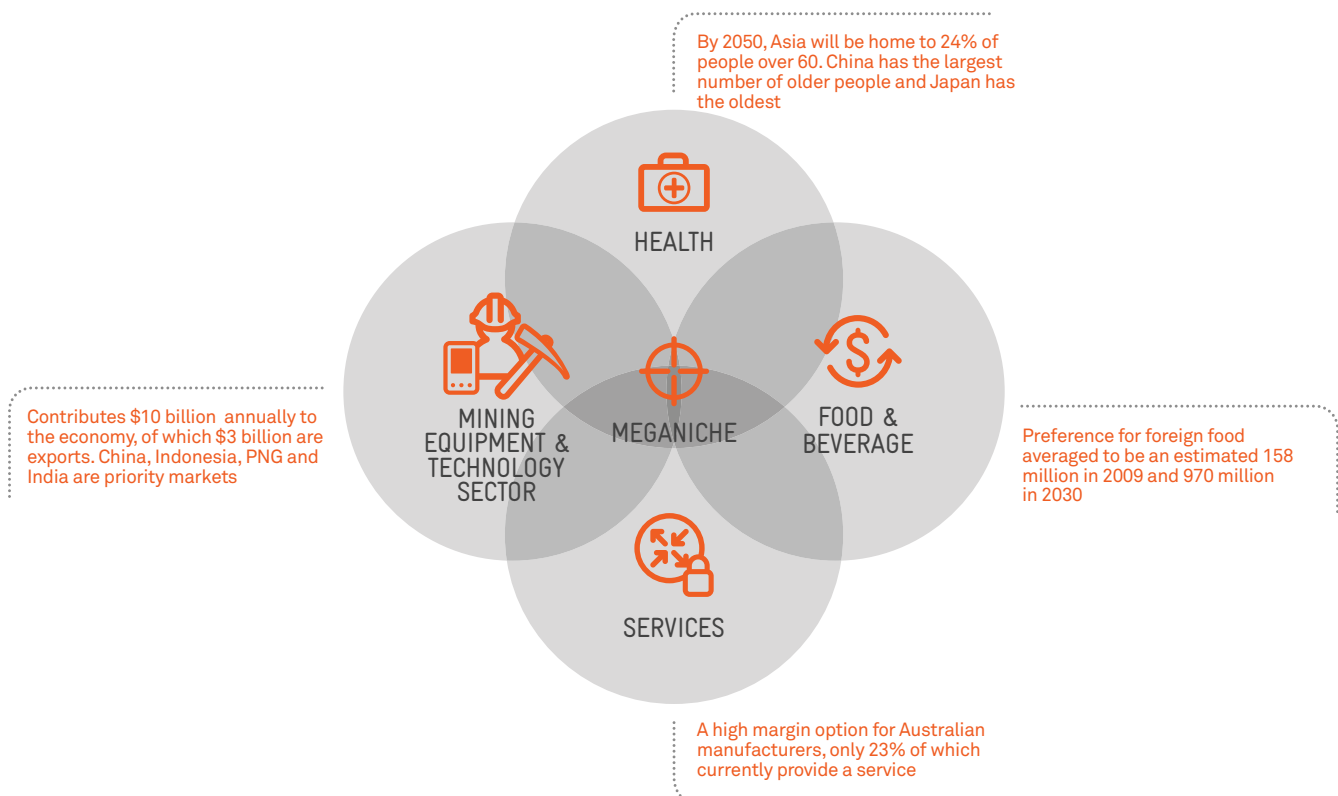
The four manufacturing opportunities have common elements that underscore the need for Australian manufacturers to be increasingly agile, including:

- Customisation, either to individuals or to the meganiche markets
- High tech, advanced manufacturing
- Innovation and R&D to build competitive advantage
- Increasing speed to market
- Closer relationship and engagement between the manufacturer and end user

- A transition from mass production to mass customisation
- Deriving additional value from service delivery or digital technologies.

Innovative Australian manufacturers will need to consider the entire value chain, from design, product development and manufacturing to distribution and services. These are no longer discrete linear phases conducted in isolation behind closed doors. We are truly in an era where networked and fully open innovation allows manufacturers to move quickly from idea to market, to respond rapidly to the changes in demand that discretionary spending patterns bring, and to move in and out of the niches as they evolve.

Figure 12: Manufacturing sector opportunities for the Asian market



Each of the four manufacturing opportunities reflects the current economic environment. As local and international competition increases, access to sophisticated knowledge bases allows any size of business to anticipate future demand patterns through deep analysis of big data. Every business now has access to this data, but in many cases they remain oblivious to it. This opportunity may be realised through connected manufacturing.

Rapid access to new knowledge is no longer a luxury but a necessity

Rapid access to new knowledge is no longer a luxury but a necessity. Monitoring of customer needs, buying patterns and shifts in demand – a rapid response to these changes is the way to create value and enhance competitiveness. This is supported by industry collaboration.

Innovative business models built on collaborative and open design and development offer a way for manufacturers to meet the changing needs and tastes of their middle class customers in lucrative Asian markets. Meanwhile, resource-efficient manufacturing ensures that the quality and product features that created the market opportunities are maintained.

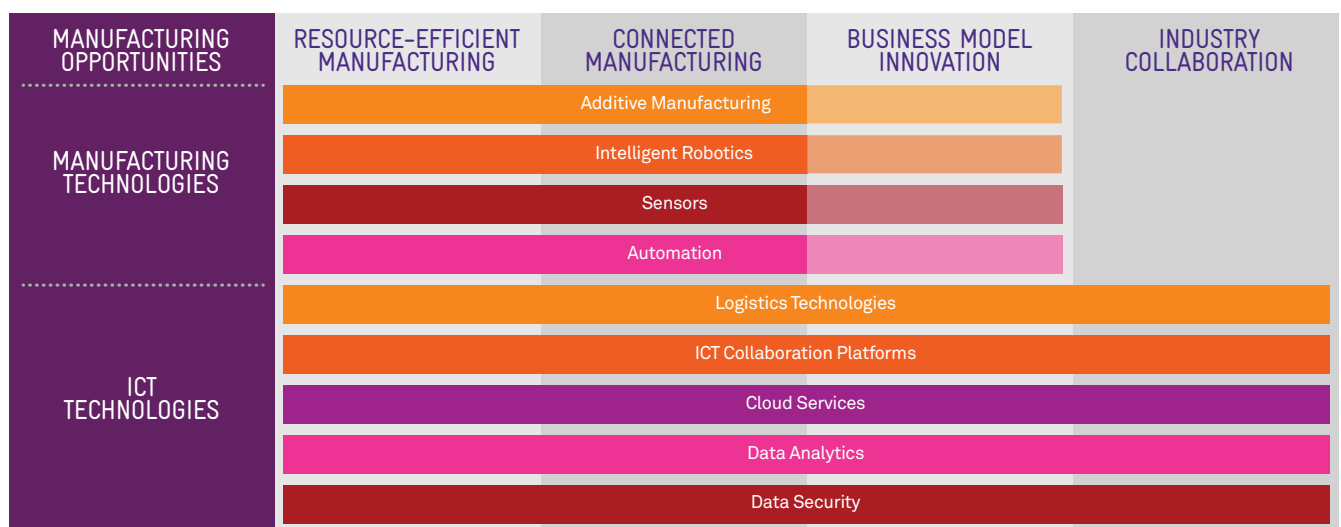
In this paper, we have highlighted the role of technology enablers in capturing opportunities. Two levels of technology enablers are identifiable as shown in Figure 13. Manufacturing technologies support the transformation of materials, and relate to and support resource efficient and connected manufacturing. These include automated production for efficiency, active and intelligent sensors, new technologies such as additive manufacturing and the new generation of intelligent, low-cost robotics.

At a higher level, ICT technologies support all opportunities and, equally, all manufacturing sectors. There is a distinct need for manufacturers to understand the capabilities of ICTs and how to exploit them. They should also look to digital value, as well as traditional product value and quality.

While manufacturing technologies support the efficient production of goods, ICT technologies support improved connection with customers, collaboration and innovation, efficiencies across the supply chain and improved value beyond a physical object. These capabilities are increasingly required of competitive manufacturers.

Our collective challenge is to collaborate, innovate and leverage these technology enablers to secure value from the Asian middle class and be more competitive. The gates are open, but you'd better run fast. Others are already running, so don't be left behind – make for Asia.

Figure 13: Technology enablers (manufacturing and ICT) for each manufacturing opportunity



9 REFERENCES

1. BRODY, P. AND V. PURESWARAN, THE NEW SOFTWARE-DEFINED SUPPLY CHAIN – PREPARING FOR THE DISRUPTIVE TRANSFORMATION OF ELECTRONICS DESIGN AND MANUFACTURING, IN IBM GLOBAL BUSINESS SERVICES – EXECUTIVE REPORT 2013, IBM.
2. KHARAS, H. AND G. GERTZ, THE NEW GLOBAL MIDDLE CLASS: A CROSS-OVER FROM WEST TO EAST, 2010, WOLFENSOHN CENTER FOR DEVELOPMENT AT BROOKINGS.
3. THE WORLD BANK, WORLD DEVELOPMENT INDICATORS: IMPORTS OF GOODS AND SERVICES (% ANNUAL GROWTH), 2013.
4. UNITED NATIONS, WORLD URBANIZATION PROSPECTS: THE 2011 REVISION, 2012.
5. FEI, L. CENTRAL PROVINCES TO GET BOOST. 2010.
6. LYNE-SMITH, K., ASIAN CONSUMERS' CHANGING HABITS SPUR OPPORTUNITIES, IN JOURNAL OF SWISS ASIAN CHAMBER OF COMMERCE 2012, SWISS ASIAN CHAMBER OF COMMERCE.
7. MCKINSEY & COMPANY, MEET THE 2020 CHINESE CONSUMER, IN MCKINSEY CONSUMER & SHOPPER INSIGHTS 2012, MCKINSEY & COMPANY.
8. BBC, BEIJING TO RESTRICT PRIVATE CAR USE TO TACKLE POLLUTION. 2013.
9. GOODYEAR, S. PLUMMETING BIKE USE IN BEIJING, AND THE NEED FOR A GLOBAL STRATEGY. 2010.
10. ISUPPLI CORPORATION CHINA BECOMES WORLD'S LEADING PC MARKET IN 2012. 2013.
11. THE BOSTON CONSULTING GROUP, 2010 BCG GLOBAL REPORT ON CONSUMER SENTIMENT: A NEW WORLD ORDER OF CONSUMPTION, 2010, THE BOSTON CONSULTING GROUP.
12. CODA RESEARCH, WORLDWIDE SMARTPHONE SALES FORECAST TO 2015, 2010, CODA RESEARCH.
13. MCKINSEY & COMPANY, FROM MASS TO MAINSTREAM: KEEPING PACE WITH CHINA'S RAPIDLY CHANGING CONSUMERS, IN 2012 ANNUAL CHINESE CONSUMER REPORT 2012, MCKINSEY & COMPANY.
14. PEZZINI, M.D., OECD DEVELOPMENT CENTRE), AN EMERGING MIDDLE CLASS, OECD OBSERVER, IN OECD OBSERVER 2012, OECD: PARIS.
15. THE BOSTON CONSULTING GROUP, IMAGINING AUSTRALIA IN THE ASIAN CENTURY, 2012, THE BOSTON CONSULTING GROUP.
16. WORLD ECONOMIC FORUM, THE FUTURE OF MANUFACTURING: OPPORTUNITIES TO DRIVE ECONOMIC GROWTH, 2012, WORLD ECONOMIC FORUM.
17. GLOBAL INTELLIGENCE ALLIANCE CAPITALIZING ON SHIFTING CONSUMER TRENDS IN ASIA PACIFIC. 2011.
18. PRICEWATERHOUSECOOPERS, 2013 OUTLOOK FOR THE RETAIL AND CONSUMER PRODUCTS SECTOR IN ASIA, 2012, PRICEWATERHOUSECOOPERS.
19. ACCENTURE, ASIA CONSUMER PRODUCT TRENDS: IMPLICATIONS FOR RETAILERS AND MANUFACTURERS, 2011, ACCENTURE.
20. EMARKETER, ECOMMERCE SALES TOPPED \$1 TRILLION FOR FIRST TIME IN 2012, 2013.
21. ERNST & YOUNG, BEYOND ASIA – NEW PATTERNS OF TRADE, 2012.
22. OECD, THE EMERGING MIDDLE CLASS IN DEVELOPING COUNTRIES, IN WORKING PAPER NO. 285/2010, OECD DEVELOPMENT CENTRE: PARIS.
23. OECD, OECD ENVIRONMENTAL OUTLOOK TO 2050: THE CONSEQUENCES OF INACTION, 2012, ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT: PARIS.
24. IEA, WORLD ENERGY OUTLOOK 2011, 2011, INTERNATIONAL ENERGY AGENCY: PARIS.
25. MUDD, G.M., THE ENVIRONMENTAL SUSTAINABILITY OF MINING IN AUSTRALIA: KEY MEGA-TRENDS AND LOOMING CONSTRAINTS. RESOURCES POLICY, 2010. 35(2): P. 98-115.
26. ALEXANDRATOS, N. AND J. BRUINSMA, WORLD AGRICULTURE TOWARDS 2030/2050: THE 2012 REVISION, IN ESA WORKING PAPER NO. 12-03/2012, FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS: ROME.
27. WORLD BANK, GLOBAL ECONOMIC PROSPECTS JUNE 2012, IN COMMODITY ANNEX 2012, WORLD BANK: WASHINGTON D.C.
28. OECD & FAO, OECD-FAO AGRICULTURAL OUTLOOK 2012-2021, 2012, OECD PUBLISHING AND FAO: PARIS.
29. FROST & SULLIVAN, EASING PRESSURE ON FOOD PRICES: FOOD OUTLOOK 2012, IN PRESS RELEASE, 10 JANUARY 2012: CALIFORNIA.
30. GRIGG, D., THE PATTERN OF WORLD PROTEIN CONSUMPTION. GEOFORUM, 1995. 26(1): P. 1-17.
31. FAO, AGRICULTURE, FOOD AND WATER: A CONTRIBUTION TO THE WORLD WATER DEVELOPMENT REPORT. 2003, ROME: FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS.
32. UNCCD, DESERTIFICATION: A VISUAL SYNTHESIS. 2011, BONN, GERMANY: UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION. 50-50.
33. ERNST & YOUNG, THREE-QUARTERS OF GLOBAL CORPORATIONS PLAN TO INCREASE CLEANTECH INVESTMENTS. INVESTMENT WEEKLY NEWS. 2011, ATLANTA, UNITED STATES: ERNST & YOUNG. 892.
34. ERNST & YOUNG, CLEANTECH INDUSTRY PERFORMANCE – GLOBAL CLEANTECH PUBLIC PURE-PLAY (PPP) COMPANY ANALYSIS, 2013, ERNST & YOUNG.
35. AIRA, 2012 INVESTOR RELATIONS BENCHMARKING SURVEY, 2012, AUSTRALASIAN INVESTOR RELATIONS ASSOCIATION: SYDNEY.
36. KPMG, THE KPMG SURVEY OF CORPORATE RESPONSIBILITY REPORTING 2013, 2013, KPMG: SWITZERLAND.
37. BOWER, J.L. AND C.M. CHRISTENSEN, DISRUPTIVE TECHNOLOGIES: CATCHING THE WAVE. HARVARD BUSINESS REVIEW, 1995. JANUARY-FEBRUARY: P. 43-53.
38. ECONOMIST INTELLIGENCE UNIT, AGENT OF CHANGE: THE FUTURE OF TECHNOLOGY DISRUPTION IN BUSINESS, 2012, THE ECONOMIST: LONDON.
39. AUSTRALIAN TRADE COMMISSION. FOOD AND BEVERAGE TO CHINA. 2013 [CITED 2013 11 DECEMBER.]; AVAILABLE FROM: [HTTP://WWW.AUSTRADE.GOV.AU/EXPORT/EXPORT-MARKETS/COUNTRIES/CHINA/INDUSTRIES/FOOD-AND-BEVERAGE](http://www.austrade.gov.au/export/export-markets/countries/china/industries/food-and-beverage).
40. WOHLERS ASSOCIATES, ADDITIVE MANUFACTURING TECHNOLOGY ROADMAP FOR AUSTRALIA FORT COLLINS. 2011, AUSTRALIA: WOHLERS ASSOCIATES INC. .
41. BERMAN, B., 3-D PRINTING: THE NEW INDUSTRIAL REVOLUTION. BUSINESS HORIZONS, 2012. 55(2): P. 155-162.

42. IGOE, T. AND C. MOTA A STRATEGIST'S GUIDE TO DIGITAL FABRICATION. 2011.
43. HUANG, S., LIU, P., MOKASDAR, A., HOU, L., ADDITIVE MANUFACTURING AND ITS SOCIETAL IMPACT: A LITERATURE REVIEW. INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY, 2012.
44. HOPPERTON, L. 3D PRINTER COULD HELP BRITISH WAR VETERAN WALK AGAIN EUREKA 2012.
45. YONG, E. WILL WE EVER...GROW SYNTHETIC ORGANS IN THE LAB? 2012 [CITED 2012 01 NOVEMBER]; AVAILABLE FROM: [HTTP://WWW.BBC.COM/FUTURE/STORY/20120223-WILL-WE-EVER-CREATE-ORGANS](http://www.bbc.com/future/story/20120223-will-we-ever-create-organs).
46. UNITED NATIONS, WORLD POPULATION PROSPECTS, THE 2010 REVISION. 2011, NEW YORK: DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION, UNITED NATIONS.
47. FORESIGHT, THE FUTURE OF MANUFACTURING; A NEW ERA OF OPPORTUNITY AND CHALLENGE FOR THE UK, THE GOVERNMENT OFFICE FOR SCIENCE, EDITOR 2013: LONDON.
48. UNITED STATES GEOLOGICAL SURVEY, MINERAL COMMODITY SUMMARIES 2012: U.S. GEOLOGICAL SURVEY, 2012.
49. CSIRO, ARCAM, 2013, COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION: CANBERRA.
50. COCHLEAR, COCHLEAR ANNUAL REPORT 2013, 2013, COCHLEAR: SYDNEY, NSW.
51. VISNJIC, I. AND B. VAN LOOY, SERVITIZATION: DISENTANGLING THE IMPACT OF SERVICE BUSINESS MODEL INNOVATION ON THE PERFORMANCE OF MANUFACTURING FIRMS. ESADE BUSINESS SCHOOL RESEARCH PAPER, 2012. NO. 230.
52. AUSTRALIAN GOVERNMENT, AUSTRALIA - EUROPE BRIEF, A.T. COMMISSION, EDITOR 2011: CANBERRA.
53. ORICA LIMITED, PROFIT REPORT RESULTS FOR THE FULL YEAR ENDED 30 SEPTEMBER 2013, 2013, ORICA LIMITED: MELBOURNE, AUSTRALIA.
54. ORICA LIMITED, 2013 SUSTAINABILITY REPORT, 2013, ORICA LIMITED: MELBOURNE, AUSTRALIA.
55. ICM. BRAD SMITH., 2014 [CITED 2014 8 JANUARY,]; AVAILABLE FROM: [HTTP://WWW.ICMI.COM.AU/BRAD-SMITH](http://www.icmi.com.au/brad-smith).
56. BRAAP. BRAAP - WHO ARE WE? 2014 [CITED 2014 8 JANUARY]; AVAILABLE FROM: [HTTP://WWW.BRAAPMOTORCYCLES.COM/ABOUT](http://www.braapmotorcycles.com/about).
57. AUSTRALIAN GOVERNMENT, AUSTRALIAN INNOVATION SYSTEM REPORT 2012, DEPARTMENT OF INDUSTRY, INNOVATION, CLIMATE CHANGE, SCIENCE, RESEARCH AND TERTIARY EDUCATION, EDITOR 2012: CANBERRA.
58. AUSTRALIAN GOVERNMENT, AUSTRALIAN SMALL BUSINESS, KEY STATISTICS AND ANALYSIS, I. DEPARTMENT OF INDUSTRY, SCIENCE, RESEARCH AND TERTIARY EDUCATION, EDITOR 2012, AUSTRALIAN GOVERNMENT: CANBERRA.
59. BENKLER, Y., THE UNSELFISH GENE. HARVARD BUSINESS REVIEW, 2011. 89(7/8): P. 77-85.
60. GENERAL ELECTRIC, GE GLOBAL INNOVATION BAROMETER 2013, 2013: CT, USA.
61. OECD, OECD SCIENCE, TECHNOLOGY AND INDUSTRY SCOREBOARD: INNOVATION FOR GROWTH. 2013.
62. AUSTRALIAN GOVERNMENT, AUSTRALIA IN THE ASIAN CENTURY, AUSTRALIAN GOVERNMENT, EDITOR 2012: CANBERRA.
63. FAO, LOOKING AHEAD IN WORLD FOOD AND AGRICULTURE: PERSPECTIVES TO 2050, 2011, FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS: ROME.
64. ASIANEWS.IT. CHINA, AFTER MELAMINE MILK SCANDAL, POWDER MILK SMUGGLED FROM EUROPE AND HONG KONG., 2013 [CITED 2013 12 DECEMBER,]; AVAILABLE FROM: [HTTP://WWW.ASIANEWS.IT/NEWS-EN/CHINA,-AFTER-MELAMINE-MILK-SCANDAL,-POWDER-MILK-SMUGGLED-FROM-EUROPE-AND-HONG-KONG-27792.HTML](http://www.asianews.it/news-en/china,-after-melamine-milk-scandal,-powder-milk-smuggled-from-europe-and-hong-kong-27792.html).
65. MANYIKA, J., M. CHUI, J. BUGHIN, R. DOBBS, P. BISSON, AND A. MARRS, DISRUPTIVE TECHNOLOGIES: ADVANCES THAT WILL TRANSFORM LIFE, BUSINESS, AND THE GLOBAL ECONOMY 2013: MCKINSEY & COMPANY.
66. BREA, E., P. KAMBOURIS, A. ELFES, E. DUFF, M. BICK, A. BONCHIS, A. TEWS, AND L. LOPES, AN INITIATIVE TO ENHANCE SME PRODUCTIVITY THROUGH FIT FOR PURPOSE INFORMATION AND ROBOTIC TECHNOLOGIES: THE VALUE OF LIGHTWEIGHT ASSISTIVE MANUFACTURING SOLUTIONS. , CSIRO, EDITOR 2013, CSIRO: CANBERRA.
67. MCKINSEY GLOBAL INSTITUTE, MANUFACTURING THE FUTURE: THE NEXT ERA OF GLOBAL GROWTH AND INNOVATION, 2012, MCKINSEY GLOBAL INSTITUTE.
68. SAGE AUTOMATION, GINGERBREAD ICING ROBOT CELL. 2010.
69. ABB. ABB ROBOTS HELP PERRYMAN'S BAKERY INCREASE OUTPUT AND REDUCE WASTAGE. 2012 11-11-13 [CITED 2013 17 NOVEMBER]; AVAILABLE FROM: [HTTP://WWW.ABBAUSTRALIA.COM.AU/CAWP/SEITP202/0CBBCB6E3DC66FFB65257855002BAE2C.ASPX](http://www.abbaustralia.com.au/cawp/seitp202/0CBBCB6E3DC66FFB65257855002BAE2C.ASPX).
70. AUSTRALIAN TRADE COMMISSION. MINING EQUIPMENT TECHNOLOGY AND SERVICES OVERVIEW. 2013 [CITED 2013 12 DECEMBER]; AVAILABLE FROM: [HTTP://WWW.AUSTRADE.GOV.AU/MINING-EQUIPMENT-TECHNOLOGY-SERVICES-OVERVIEW/DEFAULT.ASPX](http://www.austrade.gov.au/mining-equipment-technology-services-overview/default.aspx).
71. MINEARC SYSTEMS. LATEST NEWS. 2013 [CITED 2013 23 NOVEMBER]; AVAILABLE FROM: [HTTP://WWW.MINEARC.COM.AU/ABOUT-MINEARC](http://www.minearc.com.au/about-minearc).
72. MINEARC SYSTEMS. MINEARC COALS SAFE REFUGE CHAMBER NOW MSHA-APPROVED. 2013 24-11-13 [CITED 2013 12 DECEMBER]; AVAILABLE FROM: [HTTP://WWW.MINING.COM/WEB/MINEARC-COALS SAFE-REFUGE-CHAMBER-NOW-MSHA-APPROVED/](http://www.mining.com/web/minearc-coalsafe-refuge-chamber-now-msha-approved/).
73. KOTEN, J. A REVOLUTION IN THE MAKING. 2013.
74. SENDUM. SENDUM - COMPACT WIRELESS LOCATION TRACKERS WITH REAL-TIME DATA LOGGING. 2014 [CITED 2014 12 JANUARY]; AVAILABLE FROM: [HTTP://SENDUM.COM/](http://sendum.com/).

CONTACT US

t 1300 363 400
+ 61 3 9545 2176
e enquiries@csiro.au
www.csiro.au/futuremanufacturing

FOR FURTHER INFORMATION

Future Manufacturing Flagship

Sarah King
t + 61 3 5246 4747
e sarah.king@csiro.au
www.csiro.au/futuremanufacturing

YOUR CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation.

MAKE FOR ASIA

CSIRO
Sarah King, Damian Hine,
Edgar Brea, Hannah Cook
Telstra
Charlie Macdonald

April 2014