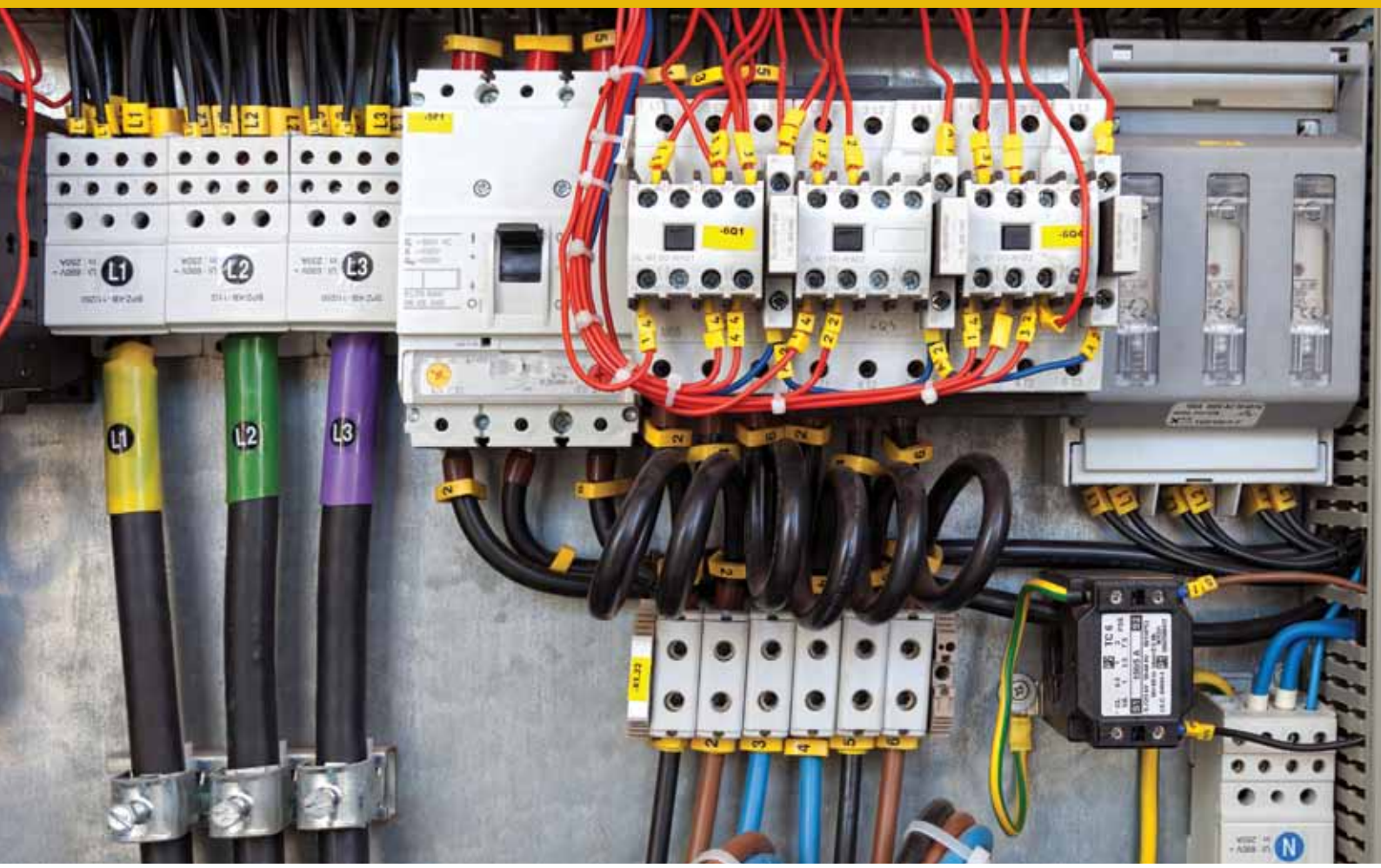

3. Advanced manufacturing: A smarter approach for Australia

Innes Willox

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

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The need for a fresh manufacturing approach

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

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

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

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

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

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

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

TABLE 1
CHARACTERISTICS OF TRADITIONAL AND ADVANCED MANUFACTURING

Traditional manufacturing	Advanced manufacturing
Focused on the production of goods	Value creation is extended, so manufacturing is no longer just about production – services and manufacturing are inextricably linked, so that production is now the core of a much wider set of activities – the 'virtual' part of the total business – geared towards creating a tailored experience for individual consumers • In 2011, only 28 per cent of Australian manufacturers with more than 100 employees derived value from services related to their products, compared with the United States and Finland, where the figure was closer to 55 per cent of manufacturers. • Newcastle-based **Banlaw** decided some years ago that it needed to move away from just being a manufacturer of fuel management systems to a company that helps unify its clients' fuel supply with products, systems and ongoing support. Service provision now accounts for about 30 per cent of Banlaw's revenue and has enabled the company to diversify its offering and revenue from existing clients, as well as providing a 'way in' for new clients.
Much of the workforce is employed in low skilled, blue collar or production roles. Technical competencies are much more common than commercial competencies	High skilled operations that harness a wider skill base, including both technical and commercial competencies, and employ fewer people on the factory floor • **ResMed** designs, manufactures and distributes devices to assist those with sleep-related respiratory disorders. The company's highly qualified employees, including medical and engineering researchers, clinicians and technicians, have been awarded numerous scientific and research accolades. The company's founder was named the US 2005 Entrepreneur of the Year in Health Sciences, the 2001 Australian Entrepreneur of the Year, and is Chair of the Executive Council of the Harvard Medical School Division of Sleep Medicine (2010).
Firms compete on the basis of their own strengths. Competitiveness is based on stocks of knowledge, mostly developed and retained in house. Strategies focus on the company: cost control, 'total quality' and continuous productivity improvement	A solely internal focus is no longer sufficient to be competitive. Competitiveness is based on the ability to identify and harness globalised knowledge flows – the production, diffusion and use of knowledge. Individual firms cannot access all the information required to be competitive, so the depth and quality of a company's networks and interactions is critical to its competitiveness. • Knowledge production has shifted from individuals to groups, and includes interactions between organisations across sectors, fields and borders. • Businesses are connected to 'global webs of activity' and value chains compete against each other to deliver value to customers. • **Landis+Gyr** is a global leader in total metering solutions for electricity and gas. The company's Sydney research and development (R&D) centre is viewed as an important innovation hub. Staff at the Sydney office have seized opportunities in Asia by identifying and partnering with best-in-class companies across the industry value chain and investing in R&D capabilities to provide customised products for local customers in the region. More recently, the company has partnered with utility companies in China and India to install smart metering solutions that will enable businesses and consumers to manage energy better.

Traditional manufacturing	Advanced manufacturing
Mass manufacturing of commodity goods – "Any colour, so long as it's black" approach – with manufacturing functions typically bound to localities and conducted in large capital and labour intensive factories	Firms rapidly and economically adapt physical and intellectual capital to exploit changes in technology, markets and customer demand. • A strong customer orientation, including mass customisation or short runs. • The changing workplace – greater flexibility in how and where people are employed. • Global firms operating across national boundaries and in close proximity to cheap manufacturing inputs, and large sources of demand and innovation. • **Centor** is a multi-award winning designer and manufacturer of architectural hardware systems and an example of a truly Australian global company. Headquartered in Brisbane, they also have production facilities in Birmingham (UK), Chicago (USA) and Nanjing (China), and distribution centres and branches across Australia and the rest of the world. As such, the company has a comprehensive distribution supply system, which automatically re-supplies Centor's 6000 items worldwide, while managing three languages; staff in over 10 time zones; complying with 42 statutory authorities; and a lead-time of up to 211 days.
Energy intensive with large waste streams	Manufacturing processes and products are more sustainable, including a move towards low-emissions, zero waste and zero carbon manufacturing. • Manufacturing practices include built-in reuse; remanufacturing and recycling for products reaching the ends of their useful lives; turning waste streams into sources of value creation; and additive, rather than subtractive manufacturing techniques. • By applying innovative and cost effective 'whole of life' approaches to everything it does, NSW company **Ontera Modular Carpets** has nearly halved the amount of energy and water used in the manufacture of its carpet tiles; reduced waste to landfill by over 25 per cent; and increased the recycled content of its carpets by over 50 per cent. In addition to being designed for longevity, Ontera's carpets are purposely designed for disassembly, so that individual components can be efficiently separated for reuse and recycling. The company's EarthPlus® reuse program takes product back at the end of its useful life, and has diverted 175,000m^2 of carpet tile from landfill, thereby retaining the energy embodied in it.

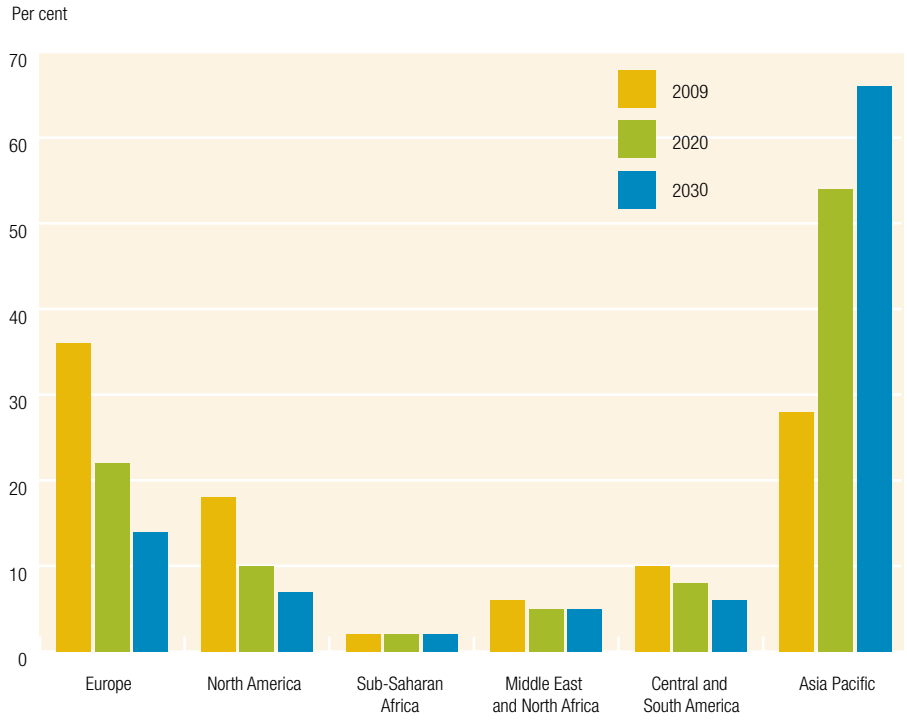
A focus on advanced approaches to manufacturing is a good fit for Australian manufacturers on a number of levels:

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

Estimates of the potential gain to be made by enhancing the adoption of advanced approaches to manufacturing in Australia are fraught. The skills and knowledge of Australia's workforce and the perception of Australian manufacturing will be critical to realising any gain, and are discussed in greater detail in this paper. How much we stand to gain depends on how far you think Australian manufacturing has come and how much further you think it can go. If we truly want to be advanced we shouldn't be placing any upper bound on the latter. Ultimately, it will come down to the extent to which the adoption of smarter or more advanced manufacturing practices is able to boost the demand for Australian manufactured goods and associated services.

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

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



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

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

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

The importance of people to the advanced manufacturing approach

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

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

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

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

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

Skills and knowledge in Australian manufacturing

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

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

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

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

TABLE 2

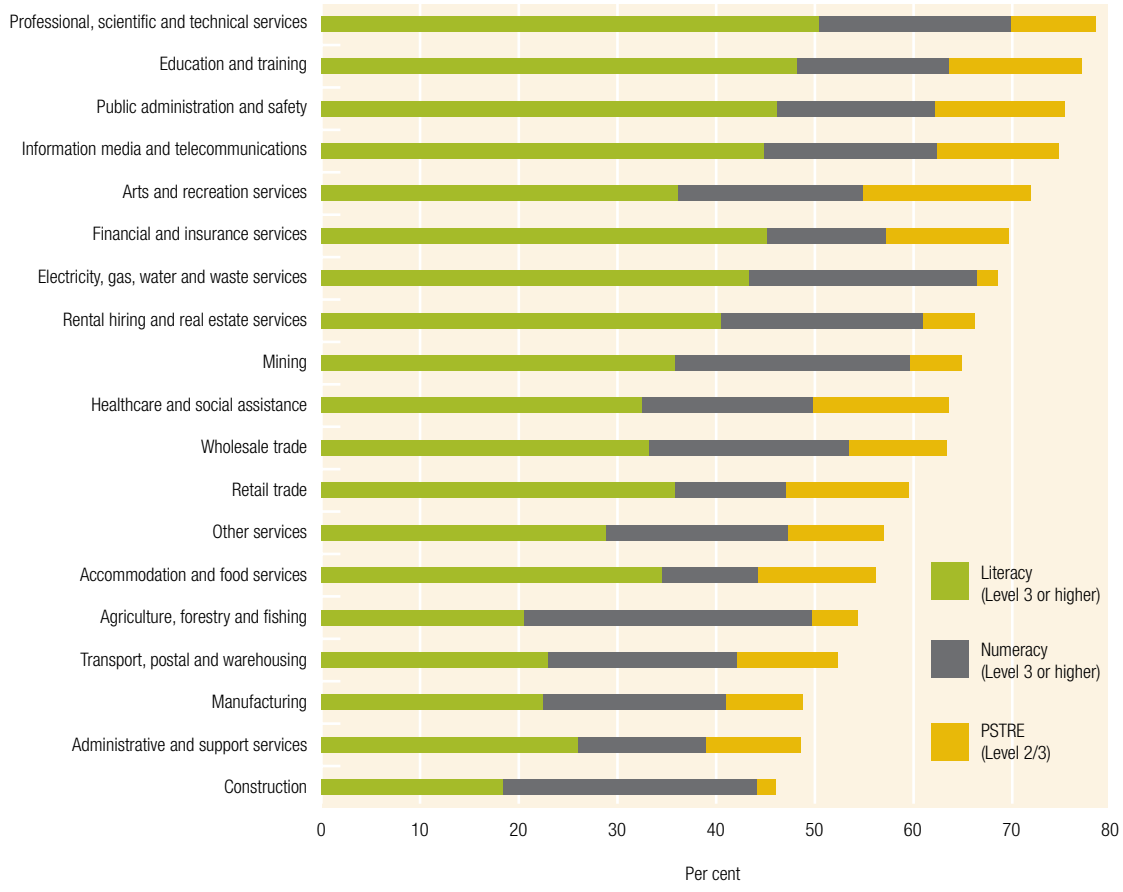
COMPARISON OF THE QUALIFICATIONS OF EMPLOYEES IN DIFFERENT SECTORS IN AUSTRALIA

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

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

FIGURE 2

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



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

How Australia's workforce compares internationally

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

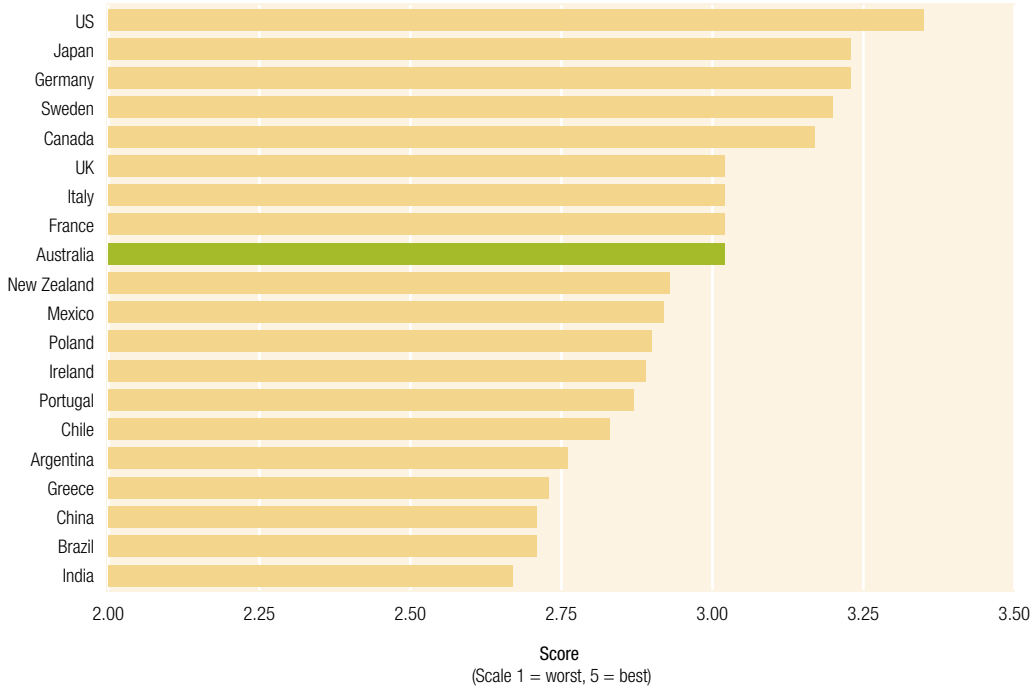
TABLE 3

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

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

Sources: [1] OECD, Main Science and Technology Indicators database, 2013/1. [2] OECD (various), Science, Technology and Industry Scoreboard. [3] OECD (various), Education at a Glance. [4] OECD, PISA 2012 Results.
*Data for 2010–11 or the latest available year

FIGURE 3
AVERAGE MANAGEMENT PERFORMANCE IN MANUFACTURING



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

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

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

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

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

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

Attracting talent to the manufacturing industry

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

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

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

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

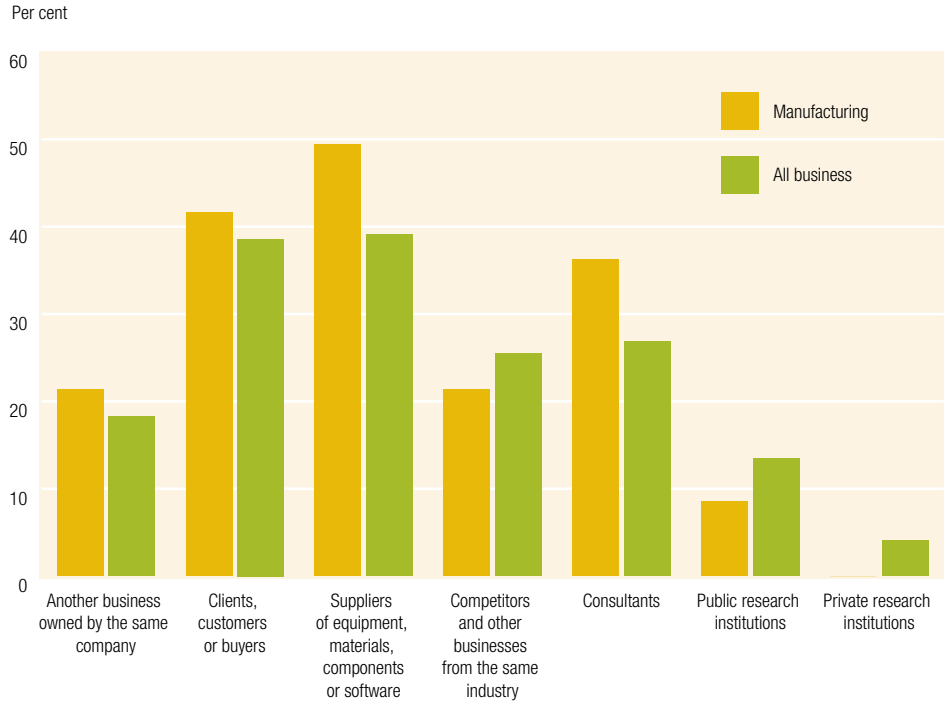
- Findings that, despite high university enrolments in science subjects, a high proportion of students studying enabling sciences such as chemistry, mathematics and physics, discontinue their study after the first year.[36]
- Research indicating that by 2020 the demand for people with higher degree research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

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

Collaboration and innovation in Australian manufacturing

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

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



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

Collaborative innovation is significantly correlated with the introduction of new-to-Australia or world-first innovations.[41]

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

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

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

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

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

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

What needs to be done?

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

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

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

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

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

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

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

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

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

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

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