AUSTRALIAN INNOVATION IN MANUFACTURING:

RESULTS FROM AN INTERNATIONAL SURVEY

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PREFACE

ABOUT THE AUTHORS

Professor Mark Dodgson is Director of the Technology and Innovation Management Centre at the University of Queensland Business School. He has been an innovation researcher for 30 years. His research interests are in the areas of corporate strategies and government policies for technology and innovation. He has authored over 60 refereed articles and book chapters, and 9 books.

Mark is an advisor and consultant to numerous international agencies and has been an invited participant at international conferences in over 35 countries. He is a Visiting Professor at Imperial College London, and International Fellow at the UK's Advanced Institute of Management Research. Mark is a Founding Director of the Think, Play, Do Group, a London-based innovation advisory company. He is a Fellow of the Royal Society of Arts and of the Academy of Social Sciences in Australia.

His 10th book on innovation, *The Management of Technological Innovation*, will be published by Oxford University Press in 2007.

Dr Peter Innes teaches in research methods specialising in computer assisted analysis of quantitative and qualitative data at the University of Queensland Business School. Peter has previously worked for SPSS Australasia as an external consultant assisting a diverse range of public and private organisations. His PhD (University of London, 2003) research focused on downsizing among professionals in large Australian firms from 1990 to 1999. A neo-institutional and economics approach were used to highlight the role of rational and normative elements in determining organisational change over time. Peter's teaching and research interests include Human Resource Management, Organisational Behaviour, and Organisational Theory.

ABOUT THE AUSTRALIAN BUSINESS FOUNDATION

The Australian Business Foundation is an independent research think tank founded in 1997 by the eminent industry organisation, Australian Business Limited, to help foster fresh insights and practical intelligence to boost Australia's capabilities and global competitiveness. The body of research generated over nine years focuses on business innovation, new forms of competitiveness and opportunities arising from a knowledge-based economy.

For more information and background on earlier research reports, visit the Australian Business Foundation at www.abfoundation.com.au.

EXECUTIVE SUMMARY

OVERVIEW

Innovation is crucially important for the future competitiveness of Australian manufacturing industry. This report offers an in-depth survey of a sample of small and medium-sized Australian manufacturing firms conducted as part of a large international study. The study sought to develop a more finely-grained view of the nature of innovation in these firms beyond the aggregate of research and development expenditure and the introduction of new products.

The study found that, while there is evidence of manufacturers engaging in some innovative business practices, especially towards achieving production efficiencies, they generally fail to appreciate and employ innovation as a decisive competitive strategy.

Unlike their European counterparts, there is little evidence that Australian manufacturers see innovation as a tool to transform the way they do business or to respond proactively to the problems and/or opportunities presented by an increasingly globalised, knowledge-intensive marketplace. European firms were two-and-a-half times more likely to consider innovation/technology as an important factor for their competitiveness.

KEY FINDINGS

Innovation is defined as the successful application of new ideas – in products, processes, organisational practices and business models. Importantly, to achieve its full potential, innovation in all these aspects must be integrated to support the distinctive competitive strategies of firms.

Competing on the basis of innovation provides an alternative to competing either primarily on high quality (which is now almost universally achieved) or on price, which is easily eroded by low cost suppliers globally.

This study showed that in some areas, Australian manufacturing firms have successfully adopted innovation practices. They are, for example, ably managing many of the challenges of process innovation. They are focusing on reducing costs in production and assembly and balancing the technological investments and organisational changes required to respond to their customers' demands quickly and effectively. They are highly encouraging of teamwork and employee consultation and are involved in the restructuring and redesign of jobs, both of which are actions conducive to innovation.

However, their main shortcomings lie in not managing the challenges of innovation in product development and in business models. There is little evidence of investment in advanced technologies for product design, techniques for organising new product development, effective linkages with innovation-demanding customers, and the packaging of services around product offerings. The Australian firms in the sample have short-term planning horizons and are not adopting the formal continuous improvement processes that drive sustained step-change improvements as a coherent innovation strategy for long term competitive advantage.

IMPLICATIONS

The lack of a strategic approach to innovation poses a significant problem for Australian manufacturing. Strategies in successful manufacturing firms involve not only improving existing ways of doing things in a few areas, but also developing new innovation activities across the board. The only way to compete is to stay ahead of the game and this means doing whatever it takes – developing new products, using advanced technologies, bundling products and services, using better processes for market intelligence and assessing customer responses – in a coherent, strategic manner.

At present, when it comes to innovation, many Australian manufacturing firms are not addressing the challenges that confront the sector. Despite the adoption and use of process technologies and techniques, Australian manufacturing firms face an underlying vulnerability to international competitors with better innovation strategies that focus on transforming and making their enterprises more responsive to market opportunities. Instead, Australian manufacturers are focusing on operational efficiencies to compete on costs, an unsustainable strategy given the extent of international competition from countries like China.

This shortcoming requires action by managers and governments to improve awareness of the importance of the competitive and strategic use of innovation and to increase the capabilities of manufacturing firms in this regard.

WHY INNOVATION IN MANUFACTURING MATTERS

THE IMPORTANCE OF MANUFACTURING TO THE ECONOMY

Manufacturing industry is a centrally important component of modern economies. In 2004, Donald Evans, then US Secretary of Commerce, described manufacturing as the 'backbone' of the US economy. Günter Verheugen, Vice President of the European Commission, said in 2005 that "manufacturing has a vital role to play in securing Europe's financial prosperity". The US government 2004 report *Manufacturing in America* says "a healthy manufacturing sector is key to better jobs, fostering innovation, rising productivity, and higher standards of living…"

Manufacturing also has a crucially important role to play in the Australian economy. It makes a substantial contribution to output, employment, productivity and exports. It is a major source and user of technological change and innovation; it contributes to environmental improvements and sustainability; and its products provide crucial links with the primary and services sectors to create value in the economy.

In 2003-04, output in manufacturing exceeded that of agriculture and mining combined, whilst employment in manufacturing was double that of these two sectors. Manufacturing production in Australia has quadrupled in the past 50 years and exceeds $275 billion a year, of which gross value added is currently $79 billion annually. The sector employs over 1 million workers and it exports around one-quarter of its output.

Although the overall contribution of manufacturing to GDP in Australia is declining relative to the services sector - a common feature of all industrialised nations, and explained in part by increased productivity and the outsourcing of services by manufacturing firms – its absolute contribution is increasing. Manufacturing remains an engine of productivity growth. The Productivity Commission estimates that the multi-factor productivity growth of 1.6% a year between 1974-5 and 2001-2 represented a productivity dividend to Australians of $400 billion over the relevant period.

In Australia, manufacturing accounts for 48% of exports, a figure which contrasts with services' contribution of 21%. The strongest growth in exports is seen in higher value added goods, so-called elaborately transformed manufactures. Amongst the most noticeable aggregate trends in the constitution of Australian manufacturing are the decline of less complex goods and the increase of more differentiated products with higher skills and research and development intensities (Productivity Commission, 2003).

MANUFACTURING AND INNOVATION

Aggregate national data shows how manufacturing is a major conduit for technological change and an important source of innovation in Australia. The manufacturing sector conducted 45% of Australia's business research and development in 2001-2, and contributed the highest proportion of innovation expenditure (27%) of all sectors of Australian business (DEST, 2005a). Between 2001 and 2003, over 45% of manufacturing businesses were innovative – defined as having introduced a new or substantially improved good, service or process over the previous three years. This compares to an average of 38% in finance, insurance, communication and business services (DEST, 2005a).

Manufacturing shows above average industry performance in innovation in goods and services, operational processes and organisational innovation (ABS/DITR 2006).

The highest proportion of researchers working in business is employed in manufacturing. In 2002/03 the manufacturing sector employed researchers for 20,040 person years, with health the next highest sector with 18,395 person years (DEST, 2005a).

An additional reason for the importance of innovation in manufacturing is the way it helps produce cleaner, less wasteful and more sustainable production processes, improving the environment in which we live and work. In the ABS survey of Innovation in Manufacturing 1996/7, nearly 70% of firms cited 'being environmentally aware' as an important objective of innovation.

The various elements of the economy - resources, manufacturing and services - are increasingly and ever more tightly bound together. This is seen in the expansion in production networks and supply chains as manufacturing firms outsource more and more services and in the growth of service-enhanced products (ABF, 2002; Davies et al, 2003). The Productivity Commission report on *Trends in Australian Manufacturing*, shows very strong links between manufacturing and Australia's natural endowments of food, forestry and minerals (Productivity Commission, 2003).

As the Australia Business Foundation report on *Selling Solutions* shows, there are increasing opportunities provided by adding service offerings to products (ABF, 2002). Products or processes can be used as platforms for the provision of services. The boundaries of manufacturing are also changing as the knowledge intensity of products and production require better links with sources of new ideas, such as research institutes and universities. Research has also shown how there are important spill-overs from innovation in manufacturing into services, for example in the area of quality management.

The continuing competitiveness of the manufacturing sector depends in large part on its capacity to be innovative (Lester, 1998; EEF, 2001, 2004). As the sector is so central to the Australian economy, as shown in the figures above, the innovation performance of manufacturing industry is therefore important to Australia's overall economic prosperity. If the capacity of Australian manufacturing to be innovative grows, then the ability of the Australian economy to be innovative also improves. Alternatively, if manufacturing industry becomes less innovative, then the economy becomes less innovative.

THE INNOVATION CHALLENGES CONFRONTING MANUFACTURING

Innovation can be defined as the successful application of new ideas. The importance of innovation, and the extent to which it is being used to its full potential, can be considered according to the ways in which it supports competitive strategies in firms. This includes the ways in which they are developing and using new technologies, work practices and organisational structures, and business relationships and models.

INNOVATION AND COMPETITIVE STRATEGIES

As the Australian Industry Group's 2005 Report *Manufacturing Futures* says…

> *"Manufacturing companies operate in the most competitive market in the world. In this market, industrialised countries are competing on high value, innovative products, ground breaking processes and management tools."*

Rapid developments in materials, the technology of design and production and cheap communications and transportation, have all significantly expanded the numbers of potential competitors for Australian manufacturers. The forces of globalisation, manifested in changes such as tariff reductions, have exposed manufacturers to greater competitive threats from cheaper international suppliers. Because of the growth of lower labour cost competitors, in Asia and elsewhere, innovation has become a primary means of maintaining and improving industrial competitiveness in firms of all sizes.

Due to the labour cost advantages elsewhere, Australian firms cannot compete on price alone, and as high quality is now almost universally achieved, there is often no option but to develop strategies to compete on innovation in products, processes, organisation and business models.

This applies to both large and small firms. As larger firms increasingly outsource, smaller firms have to become more innovative. In major sectors, such as aerospace and automobiles, for example, suppliers are required to assume a larger role in design and innovation.

It is recognised internationally that manufacturing firms need to develop new innovation strategies. A recent UK survey of 500 manufacturing companies, for example, conducted for the Engineering Employers' Federation, found two-thirds were using innovation as their dominant competitive strategy, with another 15% considering or planning to do so (EEF, 2004). The survey shows just under 60% of firms employing less than 50 people, and 80% of firms employing over 500, are increasing their focus on innovation.

An increased focus on innovation was the preferred strategy, rather than aggressive price cutting or concentration on niche production, for all size categories of firms.

As stated in the EEF report…

> *"Innovating faster and smarter is a tried and tested way of keeping abreast of the competition and is critical to the success of manufacturing. Product and process innovation can lead to productivity improvements at both the firm and industry level and can enhance profitability. The need to innovate grows as lower cost countries develop expertise and increase their own innovation potential."*[1]

Evidence from Australia, however, shows that the proportion of Australian manufacturing businesses that are innovating is, at best, static, and at worst, declining. The ABS shows that in 1991-93, 41.7% of manufacturing firms innovated, in 1994-97 this was 36.4% and in 2001-03 it was 39.5%. Figure 1 shows the proportion of firms innovating in goods and services and operational processes.

In contrast, the Community Innovation Survey (CIS) in the European Union showed that 69% of German, and 59% of UK manufacturing firms had introduced a new or improved product or process in the 3 years prior to the CIS survey in 1996.

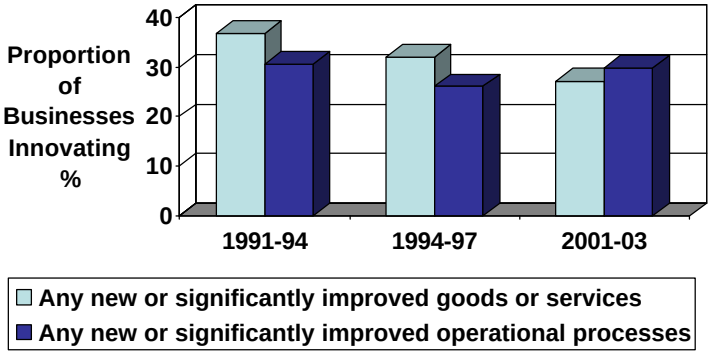

Figure 1: Manufacturing industry - proportion of businesses (Source: ABS)

The 1997 ABS survey of innovation found the major barriers to innovation to be lack of finance and high cost. Other barriers included lack of skilled personnel, long pay-back periods, legislation, regulation, standards and taxation and excessive perceived risk.

From this evidence, therefore, it would appear overall that much of Australian manufacturing is not turning to innovation to improve its competitive position. But this picture is highly aggregated and more important is the need to understand the type of and level at which innovation is pursued – distinguishing, for example, between innovation in products and processes, in organisation and business relationships and whether strategies are proactive or reactive.

The challenges of innovation are becoming ever greater. The 2003 EEF/NOP EU Productivity Survey shows how, in US manufacturing firms, 19% of turnover is accounted for by new products developed in the previous two years, a rate of change which may see a completely new product portfolio every decade. The figures for domestic companies in Germany, France and the UK, were 19%, 17% and 12% respectively[2]. The challenge from erstwhile low cost manufacturers is also extending, as investments in research and development and innovation are increasing in Asia, Central Europe and Latin America. Perhaps of most concern for Australian manufacturing is the growing innovation capability in China: UNCTAD statistics show that high tech exports as a proportion of total exports from China have increased from 22% in 1997 to 35% in 2002.

In summary, Australian industry faces a major strategic challenge which is to develop strategies for innovation in products, services and processes to maintain and improve competitiveness.

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A number of inter-related elements of this strategic challenge can be considered: the use of new technology, new internal organisation and practices, and developing new business relationships for innovation.

New Technology

It has long been known how the effective use of new technology in manufacturing can bring productivity improvements, reduce production costs and shorten set up and lead times, as well as improve quality and overall process innovation. Generations of

computer-controlled production equipment, from computer numerical control machine tools to highly automated flexible manufacturing systems incorporating machining centres and robots, have significantly improved the performance of manufacturing (Brown, Lamming et al, 2005).

As Roth says…

> *"The ability to rapidly alter the production of diverse products can provide manufacturers with a distinct competitive advantage. Companies adopting flexible manufacturing technology rather than conventional manufacturing technology can react more quickly to market changes, provide certain economies, enhance customer satisfaction and increase profitability. Research shows the adoption and use of technological bases determines an organization's future level of competitiveness. Corporate strategy based on flexible manufacturing technology enables firms to be better positioned in the battles that lie ahead in the global arena." (1996:30).*

In addition to these production technologies, there are numerous technologies for product innovation, such as Computer-Aided Design (CAD). A new class of technologies is also emerging, such as simulation and modelling, visualisation and rapid prototyping that are increasing speed, reducing costs and improving innovation processes. These technologies are being used widely by innovators in a broad range of industries, and in firms of all sizes (Dodgson, Gann and Salter, 2005). Further developments in e-business, in logistics and operations technologies, such as Enterprise Resource Planning (ERP), and the future opportunities provided by nanotechnology and bioengineering also add to the huge potential provided by new technology.

Research into investments into new technology in manufacturing firms has consistently shown how success depends upon the development of a strategic framework (Clark and Wheelwright, 1993; Burgleman, Christensen and Wheelwright, 2004; Brown, Lamming et al, 2005). Failure to get the best returns from technological investments are shown to derive from a lack of a strategic framework, an absence of planning and foresight, risk averse and short-term attitudes, an inability to understand the advantages of systems integration, a lack of concern for related organisation and skills issues, and a reactive rather than a proactive approach.

Australian manufacturing firms therefore face the strategic challenge: to invest in new technologies to support and deliver innovation in products, processes and services.

New Internal Organisation and Practices

Effective technological innovation depends upon related organisational innovation. For innovation to drive competitiveness it must become a core business process, a fundamental element of the organisational routines, practices and culture of the firm. Little of this supportive organisational innovation has been measured in the past. The ABS, for example, recognises that the focus of its past surveys, like most innovation surveys internationally, has been on technological innovation, rather than organisational innovation, and it is now including questions on organisational issues.

It is important therefore to assess the extent to which firms are restructuring, improving communications, and integrating job tasks and product and process innovation, components of high intensity or high performance workplaces (Bessant, 2003). It is also important to assess firms' capacities to link effectively with sources of new ideas and innovations.

Recent discussion of manufacturing competitiveness has focused or the concept of 'agility'. In a highly connected and competitive environment, the expectation now is not for trade-offs (e.g. quality vs. price, or delivery reliability vs. variety) but rather for 'bundles' of 'order winning' factors. The situation has evolved to the point where strong demand, together with widespread and globally available supply, means that markets can demand not only this "bundling of advantage" but also the ability to change and reconfigure the bundle of offerings as needed – i.e. agility (Bessant, Francis, Meredith, Kaplinsky and Brown, 2001).

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New Business Relationships and Models

As a response to their highly competitive and fast-changing business environment, contemporary manufacturing firms have embraced a number of approaches, such as mass customisation, flexible specialisation and lean production, which have changed the nature of relationships of firms with their customers, suppliers and partners.[3] Mass customisation entails producing in both volume and to the requirements of individual customer needs. Flexible specialisation particularly involves smaller firms in evolving production networks. Lean production involves the elimination of waste in a production system, in part from highly efficient supply chain integration, through mechanisms such as just-in-time delivery - often on an international scale. The key features of all these approaches are the production of high volume and high variety, maximised efficiencies and minimised costs, combined with continual and rapid innovation.

Innovation has become a more 'open' process than in the past. As Chesbrough (2003) argues, small firms, consultancies, universities and research institutes, consortia of firms, and individual entrepreneurs, scientists and engineers, all contribute to an increasingly 'distributed' or 'open' innovation process. Often these relationships are designed to help merge different knowledge sets, for example in service enhanced products, to produce new value-creating opportunities. One indicator of this behaviour is the outsourcing of production.

Both these contemporary manufacturing techniques and the increasingly open and collaborative approach to innovation itself necessitate different and evolving business relationships and models.

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All these extraordinary demands raise considerable new requirements for the technology, internal organisation and the business relationships and models manufacturing firms use. This survey aims to assess how Australian manufacturing firms are responding to these demands.

ABOUT THE AUSTRALIAN INNOVATION IN MANUFACTURING SURVEY

WHY THIS SURVEY?

Generally, national surveys of innovation, such as that undertaken periodically by the ABS, are only broadly indicative of practices undertaken, and their principal purpose is to ascertain levels of investment in research and development and of whether or not firms are innovative, measured primarily by their introduction of new products. As a result, little is known about the specific nature of innovation in firms. There is little research into the organisational and managerial circumstances, use of specific technologies, and the presence of key processes that underpin innovation.

The survey reported here maps in a more finely-grained manner the contours of innovation in manufacturing firms according to the strategic challenges described earlier.

Whilst ABS information can be very useful for analysis by firms, industry and business groups and governments, the aggregate ABS data is limited in both aim and scope. The focus on research and development statistics, for example, tells us *which* industrial sectors are research and development intensive but not *why*.

The innovation surveys examine *whether* firms are innovative or not and ignore *how* underlying organisational and managerial processes underpin innovation.

At best, the ABS data allow international comparisons only by aggregate ratio, and is used most commonly by commentators and analysts to contrast Business Expenditure on Research and Development (BERD) in Australia to other OECD members.

Such broad-brush indicators fail to account for differences in industrial structure and ownership across nations and also fail to examine the processes driving innovation.

In a modern economy, businesses need to compare their performance with international competitors. Firms, industry and business groups, and governments need to know how Australian manufacturing firms are approaching and managing innovation so as to compare performance with that of companies overseas. Are we subject to the same pressures, and are we responding similarly or differently? More effective and refined strategies and policies would result from this information. This study allows international comparisons between Australian and European manufacturing.[4] The international study included responses from 2,249 manufacturing firms in 9 countries: Switzerland, Austria, Germany, France, Croatia, Turkey, Italy, UK and Slovenia.

> *What are the key drivers of innovation in Australia? How are these different to those drivers in other countries? Then, armed with this information, What can be done to improve innovation performance?*

Such cross-national comparisons provide a patterning of innovation behind our national distinctiveness. Furthermore, the international comparisons also provide an insight into the strategic decision-making processes underpinning national competitive advantage. It potentially allows Australian managers and stakeholders to ask the questions: What are the key drivers of innovation in Australia? How are these different to those drivers in other countries? Then, armed with this information: What can be done to improve innovation performance?

THE AUSTRALIAN AND INTERNATIONAL SAMPLES

The International Sample: Firm characteristics

The international samples were coordinated by the Fraunhofer Institute for Systems and Innovation Research in Germany. Eight other European countries each participated by converting the German survey instrument to national languages and were responsible for administering, coding and cleaning the survey data. The sample sizes varied considerably from country to country with the largest sample coming from Germany (see Table 1).

	Sample Size	Response Rate	% with 0-99 Employees	% Industry: Machinery*
Australia	**41**	**17%**	**83**	**54**
Austria	161	9.4%	39	35
Croatia	42	8%	36	19
France	73	na	45	27
Germany	1301	11%	57	31
Italy	225	5%	**	36
Slovenia	67	14%	52	17
Switzerland	254	7.5%	65	31
Turkey	46	na	50	30
United Kingdom	64	na	39	17

*European surveys included 27% to 47% 'Other' industries comprising computers/electronic/engineering/precision instruments and motor vehicles, parts/ other transport

**Italian numbers based on charts approx 99% < 100 employees

Table 1: International survey characteristics

The Australian Sample: Bias, response rate and firm characteristics

The pilot Australian Innovation in Manufacturing survey initially involved phone contact with over 300 firms. Firms were sampled in proportion to a sampling frame generated from ABS and other data sources. Three industries were sampled: Metal Product Manufacturing; Machinery and Equipment Manufacturing; and Petroleum, Coal, Chemical and Associated Product Manufacturing[5].

The sample frame characteristics showed that approximately half of the firms were from New South Wales and half from Queensland. After clarification of the sampling database and elimination of closed businesses or refusals, 231 surveys were delivered. Using phone and mail for reminder and replacement survey follow-up, 41 firms provided comprehensive data on all 393 individual firm-level observations. In all, this represents a 17% response rate. In general terms, this is a low but typical response rate for such detailed firm-based surveys. In comparison with the international partners in this project, this response rate is average. Overall, the sample size is small and some care should be taken in interpreting the trends. However, statistically we are able to make inferences about the population of manufacturing firms in our selected sectors.

The alignment between the location-industry-size characteristics of respondents and non-respondents shows some degree of bias. First, there is a small bias towards firms responding in Queensland (approximately 2:1). Second, despite small sample sizes, there is a small over-representation of firms with under 100 employees to firms with

more than 100 employees. Metals in general and Metal Product Manufacturing in NSW are underrepresented in comparison with other industries. Table 2 shows the location-size-industry matching between the ideal sample frame and the actual respondent firms.

QLD %	Metals		Machinery		Petroleum	
20-50	69	(40)	65	(75)	61	(80)
50-99	13	(20)	18	(25)	21	(10)
100+	18	(40)	17	(0)	18	(10)

NSW %	Metals		Machinery		Petroleum	
20-99	66	(0)	79	(60)	69	(100)
100+	34	(0)	21	(40)	31	(0)

Table 2: Sampling From Percentages
IDEAL (ACTUAL)

The companies in the sample have an average of 65 employees, with a range from 6 to 370 (in contrast the average firm size in the European data was 311). Average turnover in 2004 was $17 million with a combined $583 million annual sales across all 41 firms. The companies are enjoying growth, with aggregated sales increasing 48% between 2002 and 2004 (increasing from A$393 million to A$593 million) and employment increasing 21% in the same period. Return on sales (before tax) was an average of 15.7% in 2004, similar to the 15.4% reported in 2002, with 49% of firms reporting an increase during this period.

The issue of the size difference in the average European and Australian firm may introduce an element of bias in comparisons. This is noted in the text where it may be of relevance. It is worth noting, however, that the employment structure of the percentage of employees in particular functions in the Australian and international firms are highly comparable, that is they are very similar kinds of firm. Furthermore, the ABS/DITR Report (2006) shows that 52% of Australian firms in the 50-99 employee size category, and 63% in the 250 + employee category, are innovative. The differences in innovation performance between our sample and larger Australian firms may not be that marked.

Characteristics of Production

The sample firms produced a wide range of products, but with relatively little diversification in products in each firm: 73% of sales on average derive from the firm's main product groups. Most firms are producers of finished products (69%); 31% are Original Equipment Manufacturers (OEM) suppliers. On average 14% of production is outsourced.

The following charts show the major features of the sample firms' products:

- Products tend to be tailored or customised rather than being standardised. This would imply a need for close interaction with customers in innovation activities.
- Most production is based on batches, which would infer that there are advantages in having flexibility in manufacturing processes.
- Most production/assembly is conducted to receipt of order rather than for stock, which implies the need for short-term production decisions and responsiveness. It also produces the circumstances where firms are led to limit variety in their product range, as producing high variety on demand can be very expensive due to continual machine resetting.

- There is considerable diversity in the complexity of products produced in the sample firms, ranging from simple, one-piece products to complex systems.

Since the empirical study of innovation in manufacturing industry began in the UK in the 1950s and 1960s, conducted by researchers such as Joan Woodward (1965) and Burns and Stalker (1961), it has been understood that the way work is organized, and innovation occurs, is strongly influenced by the extent to which firms' output is produced in one-offs, small or large batches, or flow production, and the nature of the product being produced.

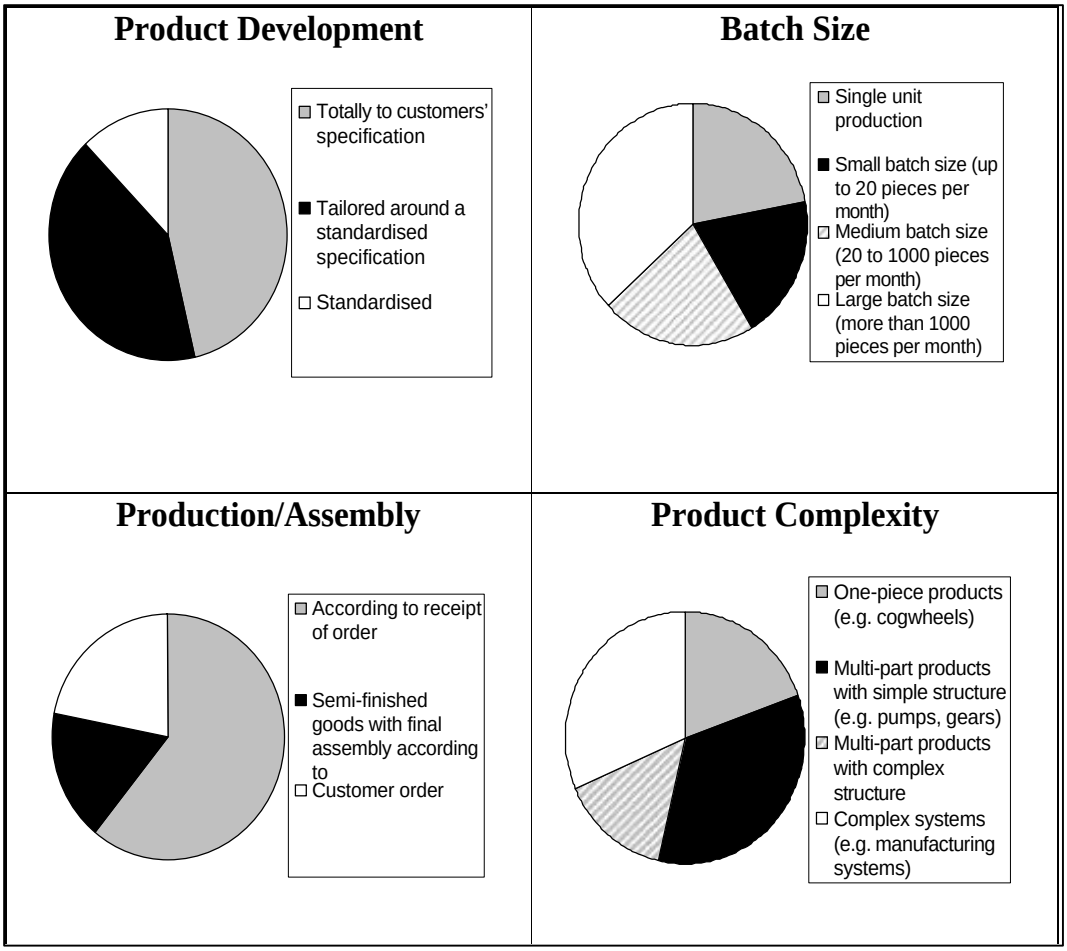

Figure 2: Major features of sample firms' products

Figure 2 presents the four key production characteristics of our sample firms based on: product development, production/assembly, batch size, and product complexity.

A typology of firms based on batch size and complexity of product is created in Table 3, showing the sample covers the range of small batch/complex products to medium-large batch/simple products.

	Small batch size	Medium/large batch size
Complex products	22%	24%
Simple products	20%	34%

Table 3: Typology based on batch size and product complexity

Firms with medium to large batch sizes in production of simple or multipart products with simple structures make up about 34% of the sample. In contrast, only 22% of the sample was firms with small batch sizes and complex products.

On average, the time between customer order and delivery is 36 days, although removing one firm with a 365 day order and delivery time, reduces this average to just over 26 days. Similarly, 30 days are needed to produce the product or 22 days with the outlier removed.

FINDINGS

INNOVATION AND COMPETITIVE STRATEGIES

A range of indicators reveal how innovation has yet to become a core component of the strategies of the sample firms.

Factors driving competitiveness

The factors driving the competitiveness of the firms' major product line were ranked. The results, shown in Table 4, indicate that quality and price were ranked considerably higher than innovation/technology. Quality was ranked in the top 3 ranks by 95% of firms. While only 7.5% of firms ranked delivery on schedule/short delivery times as most important, 57.5% placed it within the top 3 factors. Innovation/Technology was ranked as most important by 5% of firms, but ranked in the top 3 by 27.5% of respondents. Service was placed in the top 3 ranks by 35% of firms.

Factor driving competitiveness	Australia		Europe	
	% ranked no. 1	% ranked top 3	% ranked no. 1	% ranked top 3
Quality	40	95	41.8	88.2
Price	37.5	65	27.6	68.3
Delivery on schedule / short delivery times	7.5	57.5	14.8	41.8
Innovation / Technology	5	27.5	12.7	63.3
Customised products	5	20	16.9	42.6
Service	5	35	5.9	22

Table 4: Factors driving competitiveness - Australia & Europe (ranking)

When compared with the international data, European firms similarly identify the importance of quality and price, but they are two-and-a-half more likely to rank innovation/technology as the most important factor or include it in their top 3 factors. Roughly two-thirds of European firms rank innovation/technology in their top 3 factors driving competitiveness, contrasted with less than one-third of Australian firms.

Planning time horizons

One of the most commonly identified issues explaining successful innovation is the need for long-term planning horizons. In our sample, 60% of firms had planning horizons of less than 1 year, and 20% had horizons of less than 6 months. Only 10% of firms had planning horizons over 2 years. No firms reported a time horizon for planning improvements for production activities of over 5 years (see Figure 3). In contrast, the European firms tend towards longer term planning, with 47% indicating a planning time horizon of up to 5 years and 28% of firms reporting time horizons of up to 2 years.

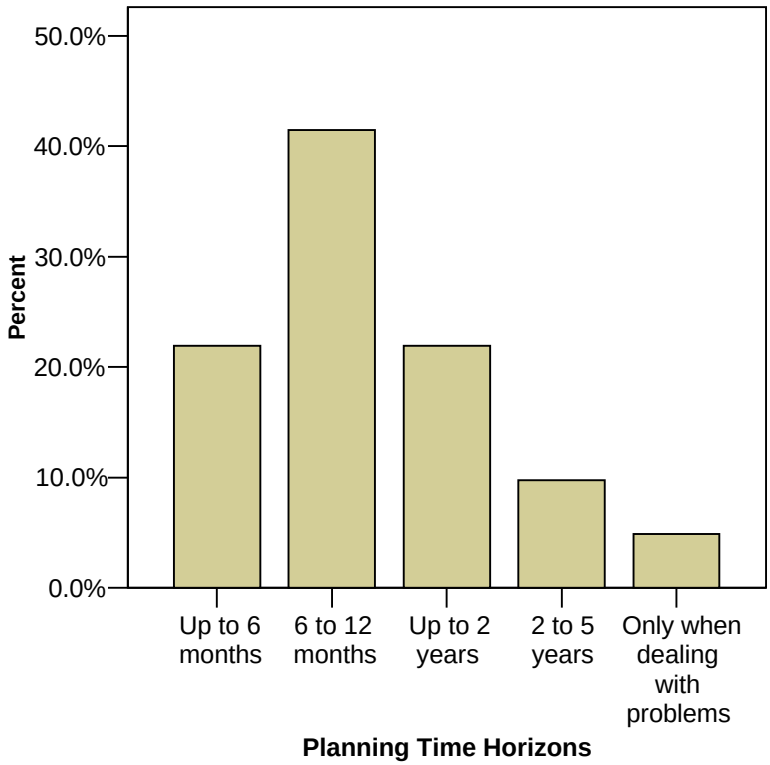

Figure 3: Time horizon for planning improvements for production activities

This relatively short time horizon is complemented by an average of just under 4 person-months per company a year used in resourcing planning improvements. The European data reports an average of 11.4 person-months per company per year. However, it should be noted that the median planning time for the same European data was 2.0 person-months, suggesting the influence of large European firms inflating the average figure.

Planning and improvement: upgrading

Upgrading company activities in the Australian firms surveyed were ranked, revealing two major processes as most important: *Modernisation of production* (37.5%) and *Development of new products* (37.5%). These two factors were equally ranked in the top 2 by about 65% of firms. *Upgrading of the product range by offering services* (12.5%)[6] and *Improvement in sales/marketing* (12.5%) were three times less likely to be ranked by firms as most important.

Improvement of production activities

The highest ranked factor used for the improvement of production activities was *Investment in machinery/equipment/information technology* (55%). Second-most important was *Personnel development (training etc.)* (32.5%) followed by *Organisational change (new organisational structures)* (12.5%).

Despite being ranked second, *Personnel development (training etc.)* was ranked in the top 2 by 90% of firms, eclipsing *Investment in machinery/equipment/information technology* ranked in the same top 2 by only 77.5% of firms.

In summary, investment in technology was the single most important element of the firms' approach. This was consistent with a focus on modernisation of production and

development of new products previously noted. However, more broadly, firms indicated that personnel development was more important in the top 2 priorities.

Planning for improvement

Firms were asked about the importance of eight issues used for the planning of improvements of production activities.

Importance of issues for planning the improvements	% Very Important	% Important	% Less Important	% Not Important
Developing trends in new machinery, equipment and processes	30	***50***	17.5	2.5
Changing prices for energy and raw materials	***55***	15	22.5	7.5
New technology incorporated into product	32.5	***45***	22.5	0
Developing trends in the organisation of production	12.5	***57.5***	17.5	12.5
Developments in the market for your product (batch size, number of variants)	27.5	***42.5***	27.5	2.5
New machining processes for innovative materials	15	***42.5***	30	12.5
Environmental effects	17.5	35	***45***	2.5
Developing trends in new information technology used in production	12.5	37.5	***47.5***	2.5

Table 5: Importance of issues for planning improvements in production activities

Table 5 reveals that, consistent with previous results, *Developing trends in new machinery, equipment and processes* was indicated as very important or important by 80% of firms. This indicates a high level of awareness about the technological trends affecting the sector. The survey was conducted during a period of rapidly increasing fuel prices, hence the single-most issue rated as 'very important' was *Changing prices for energy and raw materials*. The least-most important (less important) issue was *Developing trends in new information technology used in production* (47.5%) and *Environmental effects*.

The awareness of technological opportunities therefore feature centrally in these firms' plans for the future, both for new products and processes. The question is, even if this awareness is turned into actual investment plans, whether their ambitions would be realized. As we shall see in the following, our sample firms experienced difficulties in gaining the expected returns from innovation investments.

Returns to innovation

An indicator of a strategic approach to innovation is the extent to which ambitions for innovation have been achieved. Figure 4 shows the extent to which firms have met their expectations regarding innovation. It can be seen that only a small minority of firms have had their expectations of innovation met completely; about a quarter of firms have had their expectations mostly met; over half have had their expectations partially met; and 1 in 5 firms have had their expectations seldom met or not at all. There are no correlations between these findings and the size of the firm or the extent of its investment in research

and development. Collectively, the overall picture is of firms' inability to gain the potential returns to innovation.

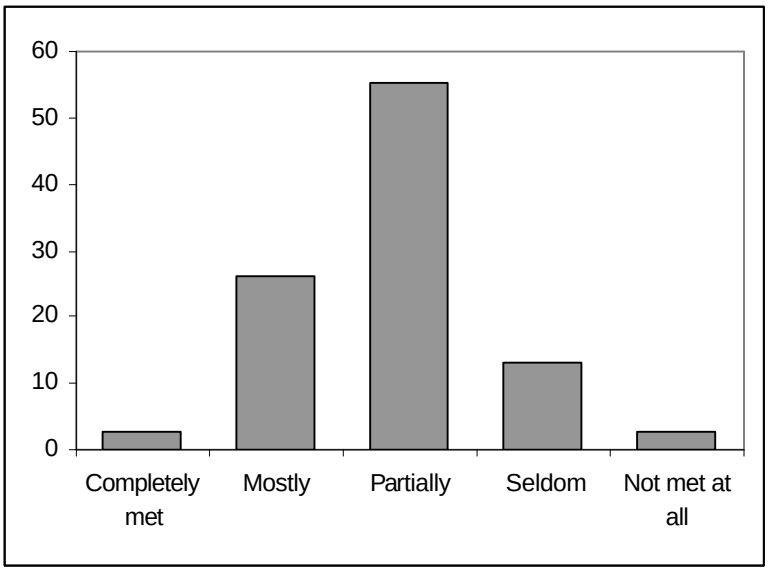

Figure 4: Extent (%) of expectations of innovation met

Other indicators

Various other indicators which point to the sample firms' lack of a strategic approach will be examined in later sections. One of the most relevant indicators is the comparative lack of the use of simultaneous engineering, which is an indicator of efforts to effectively combine product and process innovation, and a lack of the technological investments needed to encourage the engagement of customers and suppliers in innovation.

Overall, we can see a picture of investments to gain operational improvements in existing businesses, rather than concerns about preparing for dealing with a shifting competitive environment.

The positive side of the picture is seen in the way firms in the sample report a concern for upgrading by modernising production and developing products.

NEW TECHNOLOGY

A high percentage of firms – roughly three-quarters of the sample - indicated they had integrated new technology into products (either production or product). For firms that had introduced new technologies, 55% had elements in these products that were new to the industry as well as the firm. This contrasts favourably with the sample of firms in the ABS/DITR (2006) study which shows 16% of manufacturing firms had introduced goods and services new to the industry.

These positive indicators have, however, to be tempered. The integration of technology in the sample firms was associated with products that represent a share of just less than 19% of total turnover. This finding accords with the ABS/DITR (2006) study which shows that in 55% of manufacturing firms, new goods and services account for less than 10% of turnover, and in 75% of these firms, innovative goods and services account for less than 25% of turnover.

Information technologies

Six different types of information technologies were examined for level of use, used potential and planned upgrades. Figure 5 presents the percentages grouped by each type of technology.

Figure 5 indicates that computer aided design (CAD) was the most commonly used technology. Further analysis with respect to the typology presented in Table 3 reveals that 78% of firms producing small batches and complex products used CAD, while only 64% of firms with large batches and simple products used CAD. This indicates that, while CAD is not restricted to flexible complex production over large batch simple production, it tends to be used more in the former.

Production planning and control includes all operational tasks of space, capacity and time planning. The latest production and planning software innovation, ERP integrates demand management, order release and monitoring, thereby integrating purchasing and sales more completely into manufacturing functions, and is designed primarily to minimise stocks and control costs. Around one-third of firms in the study use ERP. This is roughly equivalent to the number of firms using it in the UK (34%), but less than France (48%), Germany (57%), Austria (65%) and Switzerland (64%). On average around 50% of firms in the international study used ERP.

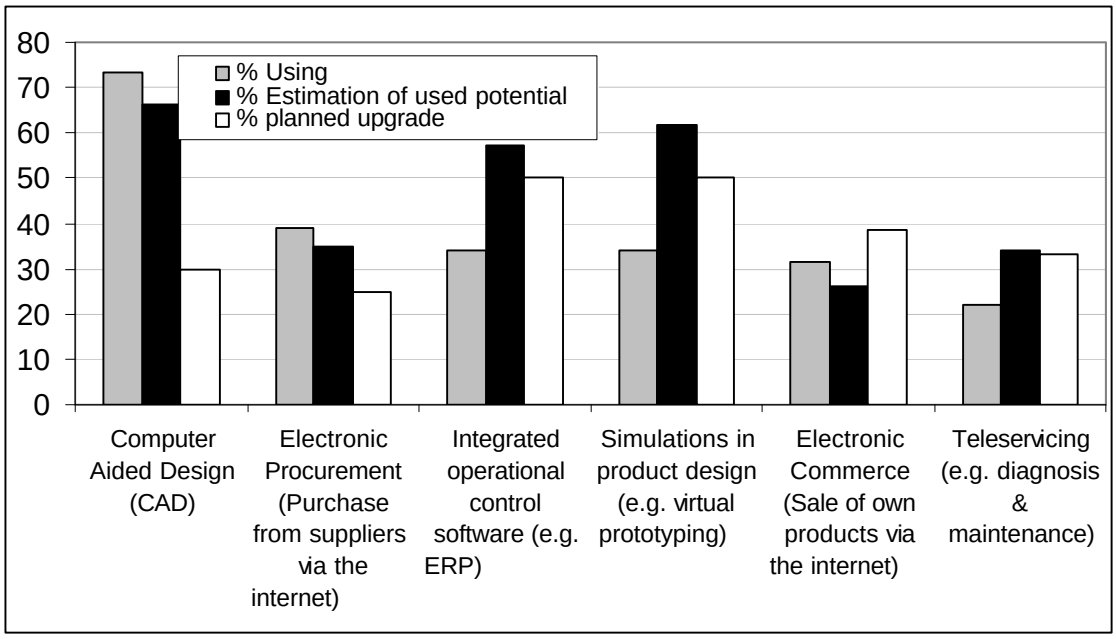

Figure 5: Information technologies by percentage used, usage and planned upgrades

Teleservice enables suppliers of technology to communicate process data from their customers' facilities to their own offices. It can facilitate remote diagnosis and assist repair in the case of malfunction, thereby reducing downtime. It is a means of adding a form of service to the sale of products. 22% of Australian firms use teleservice, compared to the average 30-50% in European firms. Over half of firms in Austria (66%), Switzerland (54%) used teleservice, and half of the German sample firms used teleservicing. Australian firms producing more complex products in smaller batches were significantly greater users of electronic procurement and teleservicing.

Planned upgrades are reported for a number of these technologies.

Machinery and equipment

Figure 6 indicates a relatively low percentage of the sample firms used advanced manufacturing technology. Although just over a third of firms used visual data processing in production, for example, in quality control and process management systems, only 1 in 5 firms, or fewer, used CNC machining centres, automated handling systems and robots or rapid tooling. In the UK sample, 27% of firms indicated the use of CNC machining centres, with 41% in France, 59% in Germany, and 64% in Switzerland. CNC machining centres are multi-purpose, stand-alone machine tools, found extensively throughout manufacturing industry in firms of all sizes, including the very smallest. They bring considerable operational advantages in the speed, quality and flexibility of productions.

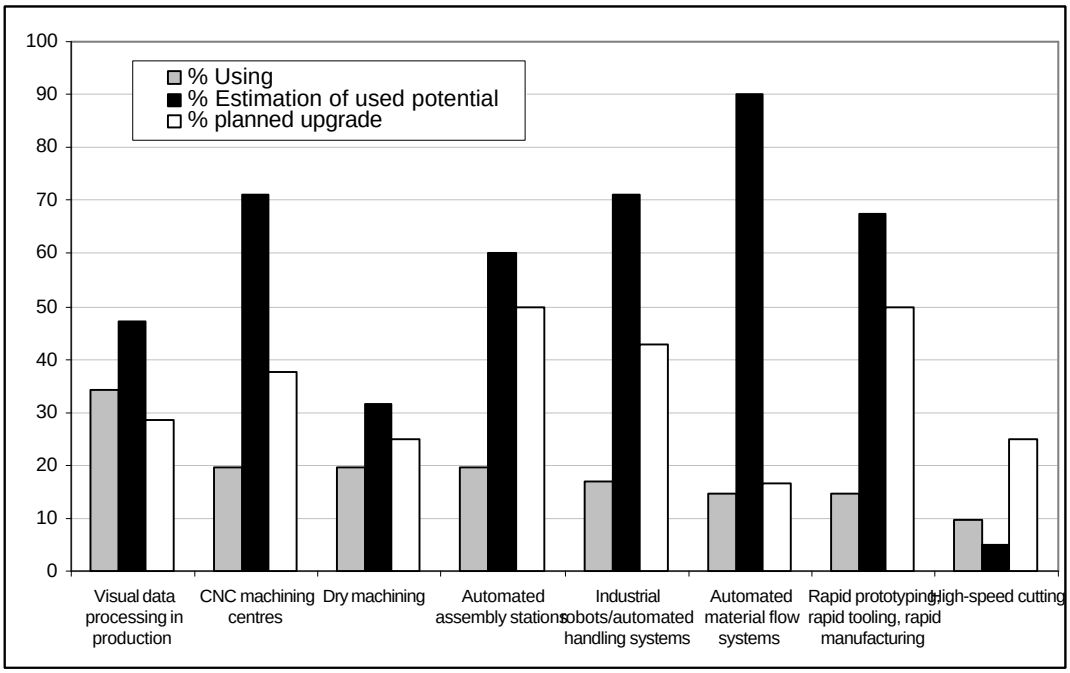

Figure 6: Machinery and equipment by percentage used, usage and planned upgrades

Whilst the Australian percentages are lower than the overall European data - the average uptake of automated handling systems and robots, for example, is 27% in Europe compared with 18% in Australia – there are significant differences in comparison with the better international performers. Over a third of firms use this technology in France, Austria and Switzerland, for example, diffusion at nearly twice the Australian level. Furthermore, given that the firms in the survey were batch producers and these forms of automation present many advantages for the flexibility of such production (allowing quick changes to tooling, for example), these low numbers may reflect a loss of potential advantage to be obtained from innovation. Figure 7 breaks down the usage of manufacturing equipment according to product complexity and batch size. It appears that advanced manufacturing technology is used primarily for the medium-large batch/simple products – at levels approximately equivalent to the UK (23%).

The striking implication of the breakdown presented in Figure 7 is that the considerable advantages these advanced manufacturing technologies provide in flexibility in small batch/complex products are not being realised.

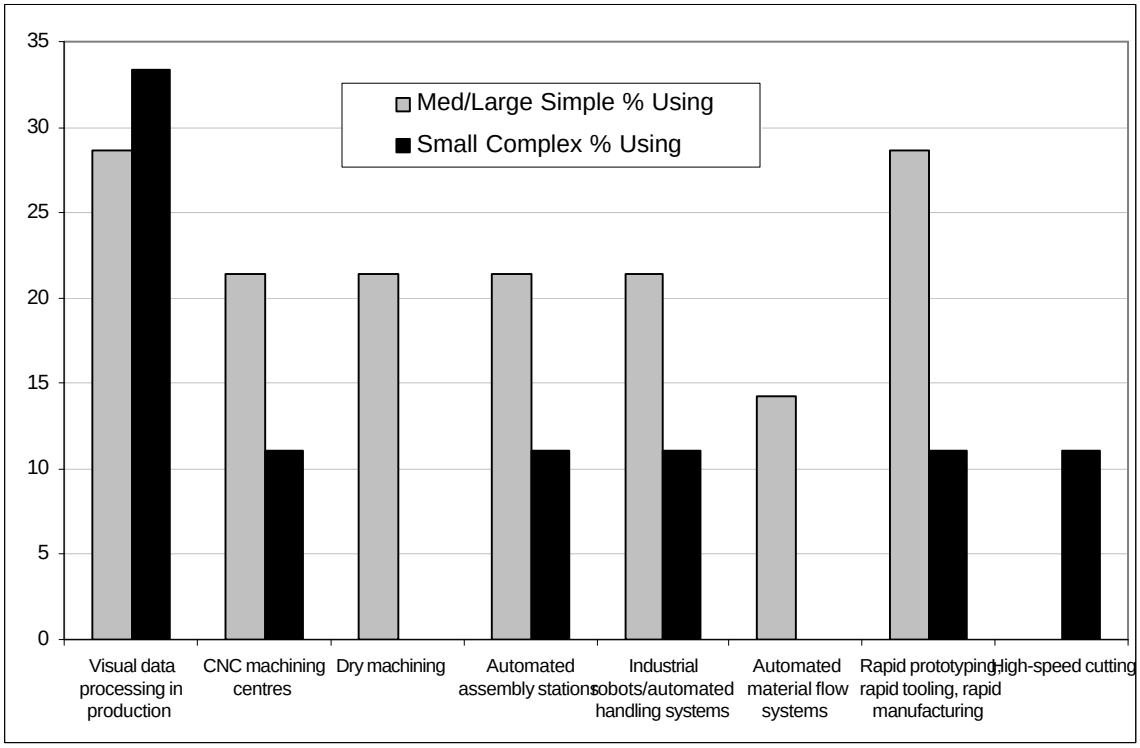

Figure 7: Machinery and Equipment by Med/Large Batch Simple Product and Small Batch Complex Product

On the positive side, Figure 6 shows that those firms that use advanced manufacturing technology do tend to use it at high levels of its potential. On the negative side, an examination of those firms that don't use the surveyed machinery and equipment reveals that they have no plan to adopt them over the next 2 years. There is also the question about whether the firms that are producing large and medium sized batches to customer order are leading to a position where they are offering a relatively narrow range of variety produced in substantial volumes. When world class customization aims to offer an economic batch size of one, with consequent very high variety implications, such firms may be left a long way behind international good practice.

Furthermore, there remains under-utilisation of production capacity. Utilisation rates of production capacity are an average of 78.5%, although 71% of firms reported an increase between 2002 and 2004. On average in the sample, 87% of products are delivered on schedule and 4% need to be reworked or scrapped. Given the importance of delivery times for competitiveness (see Table 4), and the fact that best practice quality systems now calculate quality in defects in parts per million, these data are sources for concern about the competitive potential of Australian manufacturing firms.

NEW INTERNAL ORGANISATION AND PRACTICES

Employment Structure

The typical breakdown of staff by function in the sample firms in Australia and Europe is shown in Figure 8. The focus of the firms is clearly on production (ie. planning, logistics, manufacture, assembly etc.), rather than on product development (ie. research and development and design).[7]

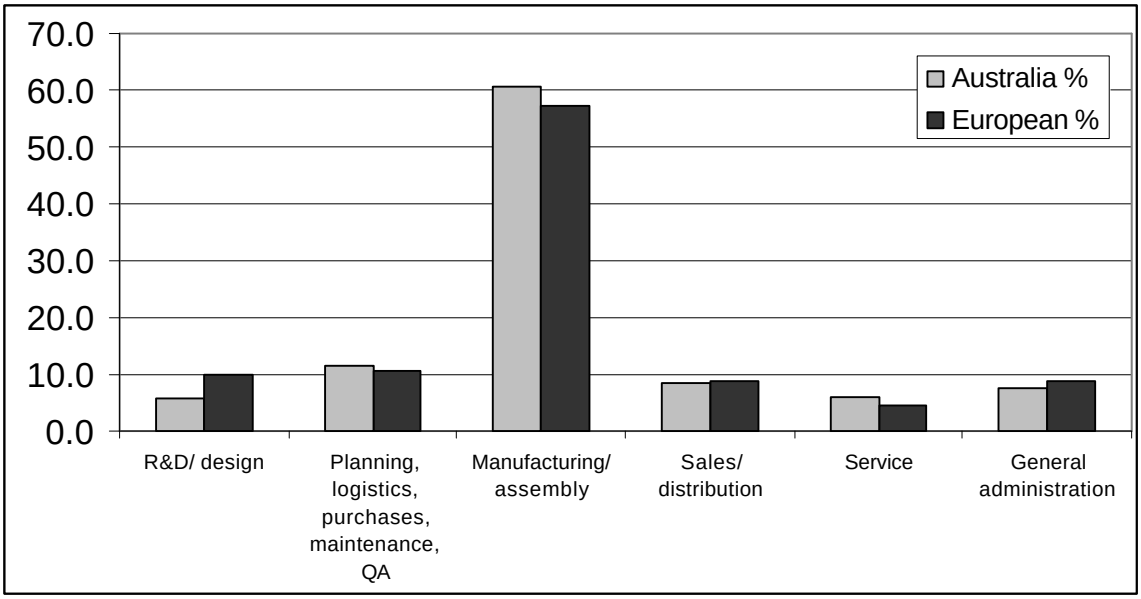

Figure 8: A Comparison of the sample Australian and European firm structures by functional area of organisation (%)

The breakdown of staff qualifications in the sample firms is shown in Table 6. There are broad similarities between the Australian and international sample, with the largest differences being in the Technician and Trades and Some Commercial and/or Technical Skills categories which may be a result of the notorious difficulties found in international comparisons of trade qualifications.

Employee Skill Classification	Australia		European	
	%	Average	%	Average
University graduates	6.7	4.9	6.6	20.6
TAFE graduates	7.3	5.4	8.8	27.4
Technicians and Trades	28.7	21.1	12.4	38.6
Some commercial &/or technical	12.9	9.5	37.2	115.9
Semiskilled/unskilled	34.4	25.3	29.4	91.6
Trainees	10.0	7.3	6	18.7

Table 6: Employee qualifications

Almost three-quarters (72%) of Australian manufacturing firms are responding to their changing and dynamic environment with a range of restructuring activities. The various forms of restructuring are presented in Table 7.

The redesign and reorganisation of jobs were the most prevalent approaches to restructuring. Redesign is being conducted in the context of increasing job numbers: there was a 20% increase in employee numbers from 2002 to 2004, and 39% of firms are planning future increases. This increase might be explained by the 29.3% of firms both reducing employee numbers and increasing casual/ part-time employee numbers. Very few firms were decreasing casual/ part-time employees, underscoring a focus on the importance of flexible working practices.

Internal Organisation and Practices

Figures 9a and 9b present some of the major organizational processes and applications used in manufacturing industry. Two-thirds of firms are responsible for their own planning, operating and control functions, in one-third of firms these responsibilities lie outside with parent firms.

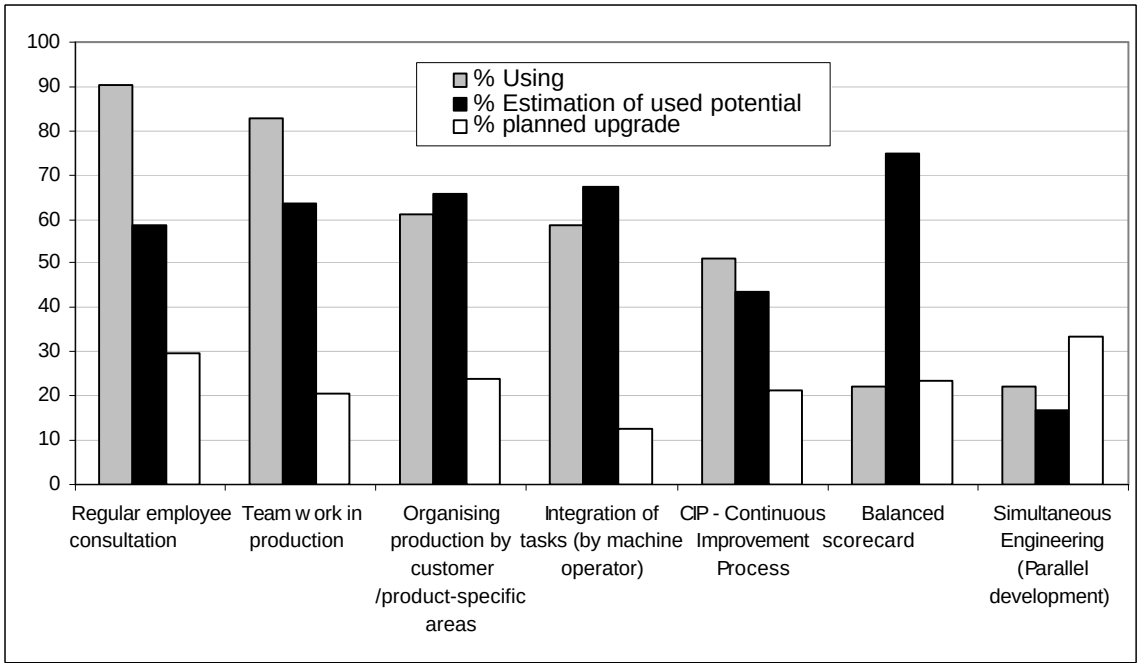

Figure 9a: Organisational practices by percentage used, usage and planned upgrades

The charts reveal high levels of employee consultation and teamworking, both factors conducive to the successful implementation of innovation (Applebaum, 2000; Michie and Sheehan, 1999; Bessant, 2003; DTI, 2002). Teamwork, for example, improves flexibility and productivity. On average over 75% of the sample European firms use teamwork, while the figure is 80% in Australia. Levels of regular employee consultation in Australian manufacturing are equivalent to those found in Switzerland (91%), which are higher than the UK (84%), France (83%), Austria (75%), Croatia (72%), Germany (65%), Slovenia (69%) and Turkey (44%).

There are also some international differences in the use of continuous improvement processes (CIP). CIP involves continual step-change improvements. Its main focus is the improvement of product and process quality to gain long-term competitive advantages. Around half of the Australian firms use CIP, in contrast with the proportion in the UK (80%), Switzerland (77%), Austria (79%), Turkey (89%), France (79%) and Slovenia (84%).

More than 50% of firms organised production by customer/product-specific areas (cells). This form of organisation is designed to improve responsiveness to customers. Over half the firms studied integrated tasks (combining planning, machine setting and operating, for example). This multi-skilling can provide flexibility by enabling staff to cover for each other. The firms that integrated tasks tend to be in the large batch, simple product category; firms producing more complex products in smaller batches tended to have less integration and hence more specialisation.

Few Australian firms use balanced scorecard processes (management by the measurement of key aspects in financial, customer, internal business processes, learning and growth areas) and simultaneous engineering. Only 20% of firms use simultaneous engineering, a practice that has become almost ubiquitous for firms wishing to integrate product and process innovation. Simultaneous engineering, sometimes called concurrent engineering, streamlines product and process innovation by involving both designers and product developers and production and operations staff in innovation activities. Most firms using simultaneous engineering tended to be producing more complex products in small batches.

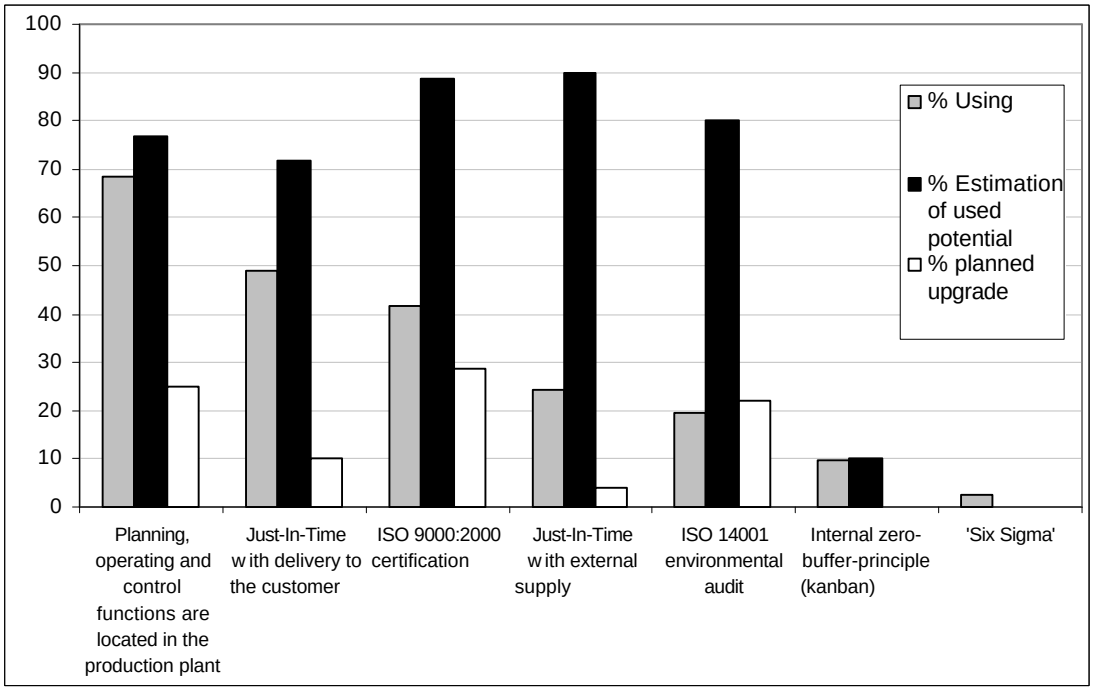

Figure 9b: Organisational practices by percentage used, usage and planned upgrades

Zero buffer systems and just-in-time (JIT) external supply – features of lean production – were rarely used. Australian levels of JIT-supply are just lower than those in Germany (29%) and far below the UK (59%). Figure 8 also shows that there is a greater emphasis on JIT focusing on delivery to the customer. In comparison to the European samples, Australia is placed just above the UK (46%) and France (47%) but still somewhat below Switzerland (61%).

Just under 60% of firms do not have ISO 9000 and only 3% of firms use Six Sigma, the world-best practice in quality management. ISO 9000 is one of the world's most widely recognized quality management system; it provides international recognition and many organizations require their suppliers to possess it.

Overall, and in line with the previous section, Australian firms studied show a lack of investment in new product development activities and in efforts to organise its integration with production innovation, for example through simultaneous engineering.

NEW BUSINESS RELATIONSHIPS AND MODELS

Outsourcing and internationalisation

Outsourcing is one of the most important contemporary issues in manufacturing. It is a major source of policy concern in the USA and Europe, as some commentators are pointing to the 'hollowing-out' of manufacturing capacity as production is taken offshore to low-cost nations, such as China. Table 7 reveals that about a quarter (26.8%) of the

sample firms in Australia were outsourcing work of any kind (including, for example, the professional services required for the operation of the company). This in contrast to the 14% of sample firms, previously discussed in this report, which were outsourcing production (ie. outsourcing part of the actual production of their saleable output).

Restructuring Activity	% Engaging
Redesign / reorganisation of jobs	63.4
Increasing the workforce	39
Workforce reduction	29.3
Increasing casual / part-time employees	29.3
Outsourcing	26.8
Decreasing casual / part-time employees	9.8

Table 7: Restructuring activity

There remain questions about *what* was being outsourced; whether, for example, work was being outsourced for the *transactional* purposes of accessing cost advantages from elsewhere ("your mess for less"), or for *transformational* purposes of accessing complementary technologies and capabilities. The qualitative survey questions revealed both to be important causes of outsourcing.

Outsourcing to other firms, particularly overseas, was seen as a cheaper solution to the purchase of expensive capital equipment. Other firms outsourced activities to deal with the complexity of production materials that require specialist machinery and specialised skills. Cost was thus not the only driver of outsourcing: issues related to complexity of production equipment, employee skills and product quality also played an important role.

As for internationalisation activities, over one-quarter of firms reported the relocation of production overseas in the past 2 years. The remaining nearly three-quarters of firms had not relocated production abroad, although just over 10% of these firms report planned relocation over the next few years. 10% of firms report the repatriation of production from abroad over the prior two years with 15% having foreign locations from which production is brought back to Australia. Those firms without either foreign repatriation or location of production do not plan to relocate sources of production.

Cooperative business relationships

	With local partners (distance < 50km)	With national partners (distance > 50km)	With international partners	No cooperation
R&D cooperation with customers or suppliers	18.4	**39.5**	10.5	31.6
Sales/distribution cooperation	10	**25**	12.5	52.5
Service cooperation	17.5	**20**	5	57.5
Purchasing cooperation	12.5	12.5	**17.5**	57.5
Production cooperation (capacity compensation)	15.8	15.8	5.3	63.2
Cooperation for the development of systems	7.7	15.4	5.1	71.8
R&D cooperation with companies in the same market	7.9	13.2	5.3	73.7
Vocational training	**23.1**	2.6	0	74.4

Table 8: Cooperative practices with local, national and international firms

Table 8 shows the extent to which firms cooperate with other companies in a number of fields and the geographical proximity of their partners. Looking firstly at research and development cooperation, several key observations emerge:

- Average research and development expenditure among the sample firms is relatively high, in contrast to the findings of the Department of Education, Science and Training (DEST, 2005b) which showed that Australia's manufacturing industry on average spends less than 1% of sales on research and development. Comparing 2002 with 2004, research and development was remarkable at 4.9% of sales among sample firms in 2002 and 5.2% in 2004. Even excluding one firm, which reported extraordinarily high research and development expenditure of 42% of sales, the figures are still comparatively high at 2.7% and 3.2% for 2002 to 2004 respectively. It is also worth noting that a sizeable proportion of firms (43%) did report an increase in research and development expenditure during this period.
- Cooperation with *customers and suppliers in research and development* is found in two-thirds of firms, with 18.4% of respondents reporting research and development collaboration with local partners (those within 50 km); just under 40% with national partners (further than 50 km); and 10.5% with international partners. *Research and development collaboration with companies in the same market* is unsurprisingly less common, although 13.2% report such activities with national partners.
- Putting the picture of the sample firms into context, the UK's 2001 CIS data showed that two-thirds of firms sourced knowledge from their suppliers and customers. 'Sourcing knowledge' is much more broadly defined than just research and development cooperation. This would appear, therefore, to confirm the incidence of research and development cooperation by the sample firms as being relatively high.

Relatively high degrees of cooperation are also found in *sales/distribution, service, purchasing, and production*, while low levels of cooperation are noted in vocational training, for research and development in the same market and for the development of systems.

With the exception of cooperation on vocational training, the firms studied appear not to be tied to their immediate geographical vicinity. They commonly cooperate with firms in excess of 50 km distant.

Overall, within the sample, there is evidence of movement towards new forms of business relationships and partnerships, as can be seen in the extent of research and development cooperation locally and international. However, only a quarter of firms studied are internationalising production, outsourcing is not widely used (only 14% of sample firms) and there is not the level of engagement with customers and suppliers in the development of systems found amongst highly innovative firms (Dodgson, 2000).

CONCLUSIONS

DEBATE ON THE IMPORTANCE OF MANUFACTURING

There is a continuing debate about the role and importance of manufacturing industry in modern, advanced economies.

One view points to the way manufacturing comprises an ever-shrinking proportion of gross domestic product. It argues that manufacturing generally involves a relatively low value-added process of producing commodity-like outputs which can be outsourced overseas to low-labour cost nations, and all that matters for manufacturing industry is the retention of the high-value service activities of design and engineering research.

The contrasting view emphasises how manufacturing remains an important source of employment, productivity and exports and should be supported for these reasons. To this might be added the contention that manufacturing is an essential part of a nation's innovation efforts. This approach underlines the importance for innovation of the close integration of research, engineering, design and production in manufacturing, and how successfully innovative firms possess capabilities across this spectrum of activities (Dodgson, 2000). It highlights how products provide the platforms for service offerings, how manufacturing is the mechanism for turning inventions in areas like nanotechnology and biotechnology into commercial innovations, and how factories provide laboratories for exploring new organizational processes for controlling issues like quality and operations of relevance to all parts of the economy.

INNOVATION IS KEY TO MANUFACTURING COMPETITIVENESS

One thing is clear: the future competitiveness of manufacturing industry will depend upon a range of factors that will pose significant challenges to firms stuck with traditional approaches. Competitiveness will be derived from innovation, design, service integration and the managed coordination of networks of international operations. The innovation challenge is not only about manufacturers increasingly seeing it as a way to compete, but also about defining clearly which kinds of innovation are most important for them and why.

CHALLENGES FOR AUSTRALIAN MANUFACTURING

This survey provides us with an opportunity to consider the innovation performance of a sample of Australian small and medium-sized manufacturing firms. It allows us to consider where these firms are being innovative and where there is ground for improvement.

A number of challenges facing Australian manufacturing industry were described, related to the increasingly global and knowledge-intensive competitive environment in which they operate:

- developing strategies for innovation in products, services and processes to maintain and improve competitiveness;
- investing in new technologies to support and deliver innovation in products, processes and services;
- utilising work practices, and organisational structures and agility to support continuing innovation in products, processes and services; and
- building new business relationships and models with customers, suppliers and partners to facilitate continuing innovation.

A WIDER ANGLE ON INNOVATION

Implicit in these challenges is the understanding that innovation – the successful application of new ideas – is about much more than simply technologies and products. Innovation in Australian manufacturing firms can include:

- the successful application of new ideas in products and services, such as teleservicing;
- production and operations, such as using automated equipment;
- organisation, such as teamwork and outsourcing; and
- it is also crucially about strategy.

Being successfully innovative requires more than doing one or two things brilliantly – it requires doing all things well and making sure that they are all complementary, supportive and integrated. There is little advantage in developing superb new products that no-one wants to buy, or can't be made economically, or can be delivered faster with better quality assurance by international competitors. A firm's innovation strategy should cover the board from the development of new products and services to the management of operations and production to the way work is coordinated and structured.

POSITIVES AND NEGATIVES OF INNOVATION IN AUSTRALIAN MANUFACTURING

Work and employee organisation

In the face of some of these challenges, it can be seen Australian manufacturing firms are doing well. Indeed, especially when it comes to some of the work organization issues of innovation, such as consultation and teamworking, we outperform the European firms in the study. The sample firms were actively restructuring, with the redesign and reorganisation of jobs providing the most prevalent approach. Although this needs to be tempered by the increasing casualisation of the workforce (which may mitigate against the creation of the high involvement workplaces that encourage innovation), this appreciation of the human resource component of innovation, at least provides a basis on which these firms can build.

New technologies

There are shortcomings when it comes to the challenge of investing in new technologies, especially those for product and service development. We find the use of CAD, ERP and teleservicing in those firms producing more complex products in smaller batches. But firms producing larger batches of less complex products, which could benefit from these technologies, appear not to be attempting to do so. Furthermore, the considerable advantages that advanced manufacturing technologies such as CNC can provide in delivering production flexibility in small batch/complex products are not being sought.

On the positive side, we do see that firms that use advanced manufacturing technology have high levels of usage. On the negative side, an examination of those firms that do not use the surveyed machinery and equipment reveals that they have no plan to adopt them over the next 2 years.

Agility and collaboration

Overall, we have a picture of firms searching for the flexibility and agility needed to respond effectively to customer demands and achieving this through work restructuring, not through investments in technology. This is occurring despite a high level of awareness of technological opportunities in the firms' planning processes.

In contrast, we see high levels of investment in research and development, and impressive levels of cooperation in research and development. Such commitments to research and development are very important from an innovation perspective, but there

are questions about whether they are being supported by the strategies and other investments necessary for innovation to occur. The extent to which firms are making investments in research and development at the expense of the other supportive components of innovation may provide grounds for concern about whether they have the strategic balance necessary in their innovation investments.

Operations and internationalisation

There are also worrying shortcomings related to production and operations challenges. Over half the firms studied do not have formal Continuous Improvement Programs (CIP). In the European firms in the study, around 80% use CIP. Similarly, when it comes to quality management, there are disturbing signs: just below 60% of firms do not have ISO 9000, the most common international recognition of the application of a formal quality management approach, and only 3% of firms use Six Sigma, the current world best-practice in the field.

We do see some evidence of growing internationalisation, with about one-quarter of firms studied outsourcing work, and 14%, production. Given the huge topicality of this issue in other manufacturing sectors in the USA and Europe, further research into the extent to which this is transactional (ie. taking advantage of cheaper costs) or transformational (ie. leveraging and developing capabilities) is warranted.

Sustained strategic innovation

Overall, the picture is one of a lack of a strategic approach to innovation. European manufacturing firms are two-and-a-half times more likely to rate innovation/technology as important factors driving their competitiveness.

One of the major deficiencies seen in the pattern of investment in the Australian firms surveyed is their short-termism. Innovation takes time, and the implementation of an innovation strategy, covering all its components, cannot be assessed in a 6-12 month planning period, as are most investments in the sample.

We are of the view that manufacturing matters a great deal in Australia not only for the reasons of its contribution to employment, productivity and exports, but also for its role in innovation. Our sample firms show how many Australian manufacturing firms have yet to address some of the challenges we have described that confront manufacturing industry. In the new competitive environment, they are fighting yesterday's war.

The sample firms have grown over the past few years, for which they deserve plaudits, and in some areas their innovation performance has been laudable. The questions remain, however, of how sustainable this performance is in the light of increasing recent international competition from countries like China, and how much better could performance be in these firms if they adopted a more strategic approach to innovation and were innovative across a broader range of activities.

The firms we have studied have focused upon efficiency factors; but efficiency is about costs, and competing on costs with competitors like China is not a sensible strategy.

Implications and challenges

These findings pose a challenge for managers and also for governments. Public policy has a role to play in promoting innovation in such firms by informing them of the benefits of a broader and more strategic approach, and guiding the formulation and implementation of these strategies. This is not a new approach in Australia: it was a feature of the past National Industry Extension Service scheme (Dodgson and Bessant, 1996). Given the extent of the innovation challenge facing this important category of firm, it may be time to reconsider a similar scheme with an even stronger element of innovation strategy development.[8]

On the business side, there is little evidence in the survey of what might be called ‘innovation leaders’: the exemplars and key players in national industrial systems. These leading firms – which need not necessarily be large firms - would be investing in the new design and innovation infrastructure, such as simulation and modelling tools, quality management processes, such as Six Sigma, and international business relationships not seen in this sample.

One of the most important stimuli to improved innovation performance is increasing demand for innovation from customers. Unless the major customers of these firms start to demand more of their suppliers, then there is little incentive to increase efforts devoted to innovation.

This is a challenge for the market, but it is also a challenge to policy-makers. Such firms play such an important role in manufacturing industry that it is time to consider how to ‘support winners’. This is not to replicate past discredited policies of ‘picking winners’, but will entail well-informed, subtle and decisive policy supports for those firms that have demonstrated leadership capacity, but lack the capabilities to realize their potential.

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ENDNOTES

[1] Where Now for Manufacturing?, EEF, 2004

[2] Manufacturing in the New Europe, EEF, 2004

[3] There are many ways of analysing the changes occurring in manufacturing. The ideas of 'lean thinking' and 'agile manufacturing' can be added to the somewhat confusing recipe books available to manufacturing firms. The overall principles of all these approaches can however be encapsulated in the way the imperative for manufacturing is simultaneously to produce volume and variety, high quality and continual innovation.

[4] International surveys of this nature always require a trade-off between the breadth of questions relevant to all national research teams and the depth of questions relevant to particular country circumstances. We have tried to find a balance, which has meant that some questions have not been pursued to the depth we might like, in order to prioritize questions where comparative data can be collected. The questionnaire is highly detailed, and some of the rich data collected is not included in this Report, but its analysis will be reported in forthcoming academic publications by the authors.

[5] Industry classification was selected based on specific NACE industries sampled by the European survey counterparts. Equivalent ANSIC industries were selected. Please contact the authors for further technical details.

[6] The ABF Report *Selling Solutions* suggests that a high proportion of manufacturing firms (71%) offer services. The AIMS survey question here examined the relative importance of services in upgrading, rather than the extent of its occurrence.

[7] In the Australian sample, this is not a result of the outsourcing of these activities which, as shown later, focus primarily on manufacturing activities.

[8] A model might be the UK's recently introduced Innovation Advisory Service that offers up to 10 days free consultancy.

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