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5

Australia's system of innovation

Jane Marceau & Karen Manley

There is overwhelming evidence that innovation and knowledge-intensity are key factors promoting growth in modern economies. Since the early 1990s, OECD analysts have focussed increasingly on the growing knowledge-intensity of modern economies and the strong links between knowledge-intensity and economic growth such that knowledge-intensive economies have become known as 'knowledge economies'. These economies are 'directly based on the production, distribution and use of knowledge and information' (OECD 1996a, p.7).

The 'knowledge' of the knowledge economy involves '…something more than information. Information corresponds to the specific elements of knowledge which can be broken down into bits and sent long distances by means of information infrastructures' (Lundvall 1996, p,3). Rather, economically-useful 'knowledge' corresponds to bits of information that have been transformed by human skills (1996, p.3). In turn, innovation involves 'the transformation of knowledge into new products, processes and services' (US Council on Competitiveness 1999, p.12). Innovation becomes more important in the context of a knowledge-based economy. As the new economies develop, high level skills and competencies are needed to turn information into usable knowledge and knowledge into innovations.

Innovation has been shown in turn to flourish most successfully in the context of knowledge-intensive industrial structures (for example, OECD 1996a, 1999a). This is a circular positive relationship. Innovation improves the knowledge-intensity of the industrial structure by

encouraging the emergence of new innovative businesses and industries while, at the same time, the knowledge-intensity of the industrial structure will feed the innovation process since new innovative businesses interact with other businesses influencing their capabilities and aspirations.

This chapter examines contemporary work about different kinds of innovation and explores Australia's national system of innovation.

The nature of innovation

There is a common misconception that only areas such as information and communication technologies (ICT) are the hallmark of a knowledge-intensive economy. It should be understood, however, that while knowledge-intensive industries are likely to grow more rapidly than other industries in a knowledge economy, this trend 'does not signal a science-based economy dominated by high-tech firms' (Lundvall 1996, p.3). Innovation in traditional raw-material based industries, for example, has been critical to economic growth in some European countries (Smith 1998). Indeed, a major new report has concluded that

> *innovation can drive productivity improvement across all industrial sectors. In this sense, there are not 'low tech' industries – only low technology companies that fail to incorporate new ideas and methods into their products and processes. Innovation opportunities are present today in virtually any industry. Although industries producing enabling technologies such as computers, software, and communications have received much attention, opportunities to apply advanced technology are present in fields as disparate as textiles, machinery, and financial services* (US Council on Competitiveness 1999, p.12).

Nor is innovation tied only to the use of 'advanced physical technologies'. Changes in the way businesses organise themselves may also be highly innovative and yield rapid growth. R&D statistics capture these organisational innovations only to a limited extent. OECD research

suggests that some low R&D-intensive industries may enjoy strong growth due to high levels of innovation based on non-R&D inputs. This research found that:

> *…the knowledge bases of apparently low and medium technology industries…are in fact deep, complex, science-based and above all systemic (in the sense of involving complex and sustained institutional interactions)* (Smith 1998, p.1).

This shows that, although R&D statistics tell a large part of the innovation story, they cannot tell the whole story. As far as possible, therefore, the present chapter considers both R&D and non-R&D indicators.

The notion of a knowledge-economy implies that there has been a change in the basis of competition across *all* sectors. Information, knowledge and ideas, incorporated in innovation processes, now constitute critical competitive competencies in all areas. The success of individuals, firms, regions and national economies depends on their innovation capabilities.

Recognition of the importance of innovation to economic growth has prompted wide-ranging research into the sources, nature and determinants of innovation. One perspective is becoming increasingly important, especially over the last two years or so in Australia. This is the shift towards looking at systems of innovation rather than individual activities which affect innovation, either positively or negatively. It has also become evident that innovation does not occur randomly but in patterned ways. It has been a source of puzzlement to analysts and policymakers alike that some countries have greater rates of innovation than do others. One answer has been to suggest that a country's innovation rates are affected by the institutional arrangements in which innovative activities take place.

Many studies of innovation processes point to well-functioning systems of linkages (communication systems) between key players as central mechanisms encouraging successful

innovation (see for example, OECD 1999b). These systemic approaches focus attention on the interaction between knowledge institutions (R&D and training) and industrial players, between regulators generating the 'rules of the game' and players in other public and private organisations. These linkages ensure that knowledge developed is relevant to users and their needs within individual firms.

For this reason, recent conceptions of how innovation occurs *within the firm* emphasise the interactions between and integration of different players *outside the firm*. Looking inside the firm, such approaches demonstrate the feedback processes operating between scientific research, technical development and production – the simultaneity of R&D activities – but they also emphasise the interaction among various actors in the innovation arenas broadly defined. Innovation thus becomes a team effort inside the firm, where all aspects of product generation and marketing are considered together, but innovation is also more likely to occur when the relevant sections of a firm interact positively with players in the broader economic system.

Recent empirical research (for example, Lundvall & Christensen 1999) has shown the importance for innovating firms of working both with other firms and with a range of other organisations. Collaboration is therefore newly recognised as one of the keys to a more innovative and more competitive national economic base.

In summary, therefore, the different players working on new products and services inside firms are seen as working within a context composed of a broader scientific and technological community and as critically influenced by relationships with suppliers, customers, regulators and research and training organisations. The overall pattern of the innovation process can thus be thought of as a complex network of interactions, both inside firms and inside nations and even the broader international community.

National systems of innovation

Recognition of the systemic nature of innovation has led in the past decade to international work on national systems of innovation as part of the search for the sources of national competitive advantage. Studies of NIS began with Freeman's analysis of the Japanese system (1987). Since then several countries in the OECD have been carrying out studies of the functioning of their national systems of innovation and there is now increasing interest in how different ones compare. The OECD is now the leading international authority on the empirical evidence, drawing together work by several international academic centres as well as government statistical agencies (for example, OECD 1996a, 1999a, 1999c, 1999d), which has been supported by developments in traditional economic theory.

The system of innovation which has received most analytical attention is a country's *national innovation system*. Most commonly, a national system of innovation is seen as composed of the relationships between the national institutions of finance, education, law and science and technology, corporate activities (particularly those which are research oriented) and government policies, and their influence on the propensity for innovation (Nelson 1993). Analyses of NISs investigate the ways in which firms access knowledge structures and the flows of information between players. The OECD describes the importance of a well functioning NIS as follows:

> *...as there is an increasing number of institutions with specialised knowledge of very different kinds, the ability to access different sources of knowledge and to apply these to their own needs becomes crucial for the innovativeness of firms. It is the configuration of these institutions and the [resulting] flows of knowledge which characterise different*

national systems of innovation and underlie the innovative performance of countries (1996b, p.3).

This suggests that in well-functioning systems, innovation is both more frequent and better managed, leading to more substantial national competitive advantage. This occurs when the elements of the broader environment surrounding firms'activities are well articulated into a system of information sharing, rather than situations where each element works largely in isolation. Thus, as the OECD (1994, p.4) has put it, the overall innovation performance of an economy depends not so much on how specific formal institutions (firms, research institutes, universities etc.) perform, but on how they interact with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (such as values, norms and legal frameworks).

In other words, a properly functioning NIS underpins the innovative capacities of firms because the institutional/organisational structure provides collectively what firms cannot provide individually. Well-functioning NISs are especially important in small countries and in small firms which have too few resources to meet the cost of research of a more basic or promising but initially tangential kind. For this reason, despite the lack of conscious design of the system, a nation's system of innovation has clear effects on the development of the economy.

National innovation systems and the productive structure

OECD and other work has indicated that any NIS is both constrained by and benefits from the underlying industrial structure of an economy. The ability of an NIS to support innovation partly depends on the strength of the underlying industrial structure since firms and their strategies are included as a major element in the system. A 'patchy' industrial structure, for instance, where public sector research is linked only to a few companies or industries, breaks down the

effectiveness of linkages within the national innovation system because firms can find few partners. Similarly, an industrial structure which contains a majority of 'low tech' industries will show lower levels of innovation as measured by R&D (and some other) indicators than will an economy where there are lots of high technology sectors such as electronics. While it is clear that some so-called low-technology sectors can include very high-technology areas and may be quite technology-intensive as Smith (1998) has argued, the bases for overall technology-intensity may not be present.

The continued importance of the nation

Central to NIS analysis is the recognition that, despite contemporary increases in globalisation, the nation remains the most important innovation arena. It is still what happens inside national borders that largely determines the success of the national economic endeavour in terms of its capacity to innovate. It is still within the national arena, for example, that policies for research, for training, for the protection of intellectual property, for access to finance for development and so on are decided. Two experts in international trade, Archibugi & Michie (1995), for example, present evidence that, although transnational firms exploit technological opportunities in a global context and collaborate internationally, they also rely heavily on home-based technological infrastructure for the generation of technology. Moreover, if the home market is not appropriate (if, in other words, it has the wrong industrial and especially customer mix, a poor R&D base, poor provision of finance etc), initial marketing, sales and product testing cannot be carried out effectively. Archibugi & Michie conclude that national innovation policy remains an important determinant of the international competitiveness of nations, despite the globalisation trend.

The comment that Archibugi & Michie make as to the location of R&D confirms the earlier work of Patel & Pavitt which indicates that, although some changes are currently taking

place, most multinational companies see their R&D as a core competitive strength and therefore carry it out at home (1991). This tendency means that countries such as Australia which have very few home-based multinationals, may miss out on many innovation opportunities because the research and development needed is not carried out in the host country. It is this factor which, to some extent at least, explains the adverse comparisons which will be made below between the innovation situation in Australia and other relatively small industrialised nations. It is for reasons such as those outlined above that Porter concluded that:

> *... while globalisation of competition might appear to make the nation less important, instead it seems to make it more so. With fewer impediments to trade to shelter uncompetitive domestic firms and industries, the home nation takes on growing significance because it is the source of the skills and technology that underpin competitive advantage.* (1990, p.19).

The particular problems of small countries, including Australia

Successful interaction among the different elements of an NIS is especially important for smaller industrial nations. Small countries have small populations and thus small home markets, especially for specialised products, in which to test innovations and derive profits. This means that firms based in small countries generally have to export from an early stage. Small nations have few large firms, especially few which operate as home based transnationals. This means that there are likely to be gaps in the 'complementary assets' (especially global scale distribution channels) needed for innovation locally available to domestic innovators and producers.

In addition, they have only relatively and absolutely small amounts of finance available for R&D and other innovation-related expenditure and little international market power. Some international firms indeed spend more on R&D themselves than do entire national R&D budgets

of countries such as Australia. The small size of nations such as Australia makes getting the maximum from what is available especially important because it has to go a long way. There is little room in the system for wastage of talent or innovative potential. A properly functioning innovation system at all levels, sub-national as well as national, ensures the timely and effective information flows and the tight user-producer relations critical to innovation.

In a globalising market place, lacking such access can be devastating for smaller economies in the absence of some forms of policy intervention. But the margins for such policy action are themselves being reduced by international agreements such as the WTO and ongoing international races related to deregulation, internationalisation and emulation in core technologies, the international search for strategic partners and the race to attract foreign investment.

Sub-national systems of innovation

Analysts recognise several systems of innovation which operate at sub-national levels. These are sometime geographical in focus and sometimes sectoral and/or technological. These are mentioned briefly here because there are few statistics which indicate their operation within countries such as Australia. This does not mean that they are not important for the overall performance of the nation but does mean that the analyst is reliant of special studies of which there are almost none in Australia (see Marceau & Manley 1999 for a lament about the lack of rigorous information about the existence and functioning of industrial clusters here).

In geographic terms, systems of innovation operate at regional and local as well as national levels. Some can be extremely effective and major hotbeds of innovation. The geographical proximity of firms developing and using similar and related products and technologies can produce positive sum gains for business and innovation. Since the economist

Alfred Marshall showed the importance of ‘industrial districts’ in providing various supports and synergies for firms in the 1920s, a great deal of research has examined the innovation-promoting potential of firms working and competing together in close geographical proximity. Michael Porter, for example, argues that it is the clustering of industries into systems connected by horizontal and vertical relationships, in combination with factor and demand conditions and firm strategies, that creates innovation and international competitiveness (Porter 1990).

Internationally, there is a growing body of work on technological and sectoral systems of innovation. Unfortunately these are only just being undertaken in Australia. Technological systems of innovation as discussed by Carlsson & Stankiewicz (1991) are seen through the functioning of interlinkages between the different elements of specific technologies. The notion of technological system is more technology - and industry - specific than are the national or other geographically-bounded systems but Carlsson and his colleague define a technological system as a ‘network of agents interacting in a specific economic/industrial area’ (1991, p.111). Technological systems of innovation are thus an element of national systems of innovation and need to be understood by policymakers if their development potential is to be maximised.

One reason why the analysts are increasingly using systems approaches to understanding innovation is that technological innovation is rarely a discrete, atomistic event. It almost invariably builds on extant technology or contributes to change as an element of a broader technological system. Successful innovators are those which integrate their operations with broader developing aspects of the technological systems of which they are part. Technological capabilities differ both between and within nations: Japan is strong in electronics whilst Australia is relatively strong in services associated with resource areas, such as software technologies for

mining. Understanding the basis on which existing technologies have developed is therefore critical to developing forward-looking frameworks for activity.

A second more technologically-oriented concept of innovation systems focuses on what Breschi & Malerba call 'sectoral innovation systems' (1997, p.130). A sectoral system of innovation is a system (group) composed of firms active in developing and making a sector's products and in generating and utilising a sector's technologies (1997, p.130). Firms in a sector may collaborate or compete in the development of this technology but are likely to be related in some ways.

Networks, clusters and complexes as part of national innovation systems

Just as recent investigations of the role of technology as an endogenous factor have shifted the terms of the debate about the role of technology in economic growth so the same work has indicated clearly the need to view the functioning of the components of the economy differently. The innovation literature recently developed indicates numerous reasons for reconsidering the ways in which firms interact with different elements of their environment when developing new products or processes. The literature emphasises the importance of understanding that, rather than being autarkic, atomistic organisations, firms are part of numerous systems which link their activities. Suddenly firms are no longer viewed as isolated entities with 'walls' around them, each one doing its own thing and developing its own strategies, creating its own knowledge base and new products. Instead, firms are seen as economic actors collaborating to survive and grow through the sharing of information and other activities related to successful innovation. Indeed, finding their competitive advantage is for many firms a collaborative process. Many international studies have now shown how important this collaboration is, especially for innovative work (see for example, Lundvall & Christensen 1999). Such interactions indicate that analysts seeking to

understand the functioning of an economy must look for networks and clusters and, as we suggest below, for ‘complexes’ of activity rather than the traditional industrial sectors.

Networks, clusters and complexes are all critical elements of successful national innovation systems. One of the key features of innovation is the extent to which it involves complicated information and technology flows and the possibility of successful innovation is enhanced through the regular use of multiple channels of communication. **Networks**, considered as an open system of inter-connected firms and institutions with related interests are powerful mechanisms for communication, offering a rich web of credible channels of information flow, many of them informal.

Networks can be formal or informal, consist of general cooperation mechanisms or be specifically related to single firm functions such as marketing or purchasing equipment. They may be a means for firms to deal with the burdens of financial, technological and information needs, having then some of the characteristics of joint ventures, strategic alliances and other more formal and structural links.

Clusters share many of the characteristics of networks. Some clusters are formed of firms linked into a system of collaborative relationships which just happen to involve inter-firm rather than intra-firm relationships. They may be composed of small, interdependent firms, either making the same products or acting as suppliers and clients at different points in the chain of production in the field. In some clusters one or several lead firms have historically encouraged smaller suppliers to co-locate, creating the cluster through common links to a major client. In many countries, examples of this type of cluster are found in ‘assembler’ industries such as that of vehicle manufacture. Such clusters usually involve considerable dependence of the suppliers on the lead firm’s activities.

In some other industries analysts have found examples of new clusters which are emerging because of some common resource needs. Examples within Australia could include the multi-media cluster emerging around the production houses which in turn cluster around the ABC headquarters in Crows Nest in Sydney or the software firms co-located in Ryde. Emerging clusters may gradually develop through increasing buyer-supplier links among member firms who have complementary rather than competing interests and output.

Thus in some clusters firms are in the same or related industries. The wool textile cluster in Prato, in Italy, for example, includes both textile companies and engineering firms which make textile equipment. Similarly, the Finnish forest cluster includes machinery manufacturers as well as both paper manufacturers and the emerging firms with the environmental technologies to clean up after the paper processes. In other cases, the firms in the clusters work in the same segments of an industry, all making leather goods or ceramic tiles or whatever, but are linked through their inputs to different activities in the production chain.

Perhaps what all clusters have in common is that they are sites for networks of innovative activity which are greater among these enterprises than ‘normal’ market analysis would expect. Development of such networks is increasingly seen as the way forward in the innovation race, especially for SMEs, and thus deserving of specific public policy encouragement (see, for example, Roelandt 1999).

Network relationships may assist firms to link with both public sector research generators and with governments, the latter in their several capacities as regulators, as funds providers and as information diffusion agencies, and, hence, assist firms in their innovation activities.

The role of governments and networks as diffusers of information is particularly important as the economic competences of firms (the ability to identify, expand and exploit

business opportunities) affect the degree to which firms, institutions and networks become locked into using old technologies or can shift to using new ones. Firms and related organisations need to search outside their traditional areas but do so in a localised fashion to maximise chances of success. The character of the networks to which firms belong has a bearing on the types of information and knowledge to which the system as a whole gives companies access and hence on the likelihood that firms will at least have the opportunity to shift to new technologies. The role of intermediary agents providing new information to the firm may be crucial here (Dodgson & Bessant 1997).

A further analytical 'lens' can be useful here in understanding what systems of innovation do and how policymakers can intervene to improve their functioning. This is the lens which sees firms as operating in a network of co-operation which includes four key sets of players: producers (industrial firms), users (usually other firms), public sector research and training organisations and regulators (at different levels of government).

Using this lens enables us to look more closely at the information flows and relationships which are critical to successful innovation as they occur sector by sector. Thus, for example, innovation in the construction industry production system (see Gann et al. forthcoming) is affected by regulations concerning environmental impact and planning needs, by the strengths and weaknesses of supplier companies and client service providers and by public sector R&D and training (see Figure 5.1). In the health care complex, government purchasing decisions, hospital funding arrangements and the statutory obligations of health authorities all may profoundly affect local levels of innovation found in pharmaceutical and medical equipment companies (Marceau 1998).

Insert Figure 5.1 about here

In a ‘properly functioning’ complex, information flows freely between all the major players. In practice, however, information seldom flows so freely. The analyst of the functioning of a complex can therefore focus attention onto the blockages and impediments preventing such free flow and assist the policymaker interested in encouraging innovation to pinpoint areas for action and consultation with the players.

In summary, many studies now identify the range of actors and institutions involved in business and innovation systems, the way these combine competitively and cooperatively, and the social and cultural bases of these interactions (Edquist 1997). By highlighting the systemic nature of business innovation, system approaches can valuably identify weaknesses which can then be addressed to enhance systemic strength.

Australia’s national system of innovation

As we have seen above, there are many elements to systems of innovation and many factors which potentially affect their functioning. Australia’s national system of innovation, like those of other OECD countries, has several key elements. The most important that we are going to deal with here include research and development, the propensity of firms to train staff, to invest in new capital equipment, to employ scientists and engineers and to collaborate. It is these factors which underpin the propensity of firms to innovate and to develop the intellectual property that can be seen in patents, copyrighted material, designs and new products.

Recent work we have undertaken for the Australian Business Foundation has focused on these issues. In 1997 we reviewed Australia’s innovation performance and in 1999 we brought our findings up to date. *The High Road or the Low Road? Alternatives for Australia’s Future*, our 1997 work, showed that on the indicators available Australia was at a crossroads. We suggested that the country needed to make a choice about whether we were to advance along the

'High Road' of knowledge-based wealth creation, as other OECD countries were doing, or whether we would go down the 'Low Road' of an economy where competition was based on wage and international currency exchange rates. This road, we suggested, would be disastrous for the country in the longer term because we cannot compete in a world of low wages and maintain the standard of living which Australians expect. In addition, we do not control our exchange rate.

On the other hand, were we to advance along the High Road we would have to invest more in knowledge generation and diffusion, employ more scientific and other highly trained industrial personnel, invest more in training, innovate more by developing more new products and collaborate more to make up for the small average size of our enterprises and to reach far flung export markets.

Innovation Checkpoint 1999, our most recent investigation of trends, indicates that since our first study some progress has been made along the High Road but that the steps are somewhat stumbling and not all our investments are going in the right direction. The risk of going down the low road has not passed.

Performance summary

We found that on the indicators available there are four key areas where Australia's innovation system has performed relatively well over recent years (see Figure 5.2).

Insert Figure 5.2 about here

The report uncovered five particularly concerning negative trends which are outlined in Figure 3.

Insert Figure 5.3 about here

On balance, therefore, Australia's innovation performance has been relatively poor over the past few years. The five problems noted in Figure 5.3 significantly constrain Australia's innovation

performance. Appropriate action, taken by both the private and public sectors, is required if Australia is to maximise its innovation potential.

Innovation indicators: Australia in the OECD context

This section reviews Australia's performance according to selected innovation indicators in the international context. These indicators cover input measures of innovation (R&D), output measures of innovation (machinery and equipment investment) and structural measures of innovation (industrial structure and trade patterns).

Insert Figure 5.4 about here

Figure 5.4 ranks Australian manufacturing and service sector business R&D investment as a percentage of value added in the context of various OECD countries' performance in the latest available year. Australia is thus clearly closer to OECD averages in the services sector than in the manufacturing sector.

Insert Figure 5.5 about here

Business R&D activity can also be usefully analysed by employment trends, as shown in Figure 5.5. Of the 24 countries shown, Australia is ranked sixth last, appearing between Iceland and Poland. The contrasts with the top performers are striking. The situation in Australia relative to that of other smaller economies such as Finland, Norway, Ireland, the Netherlands or the Czech Republic is in some ways even more worrying because of both size and some structural similarities in the economies of these nations when compared to Australia. In particular, it should be noted that the Netherlands has almost exactly the same population and GDP as Australia and yet Netherlands enterprises employ proportionately almost twice the proportion of R&D personnel as do Australian businesses.

Insert Table 5.1 about here

Table 5.1 reviews Australia's machinery and equipment investment in the international context, providing a structural measure of our relative innovation performance. These most up-to-date international data indicate that Australia's performance in the international context is a little above the OECD average. Australia's very strong growth between 1991/92 and 1994/95 has contributed to this good international ranking. However, we remain below other industrialised countries such as Japan, Denmark, Switzerland and Italy, and not greatly above Canada, the Netherlands and Sweden who may have started from a better base.

By this measure, compared to international performance, Australia has relatively high recent investment in embodied R&D and relatively rapid technology diffusion, increasing the knowledge-intensity of the economy. This recent activity represents a good deal of 'catch-up' (recovering from poor historical performance – see Marceau & Manley 1999a) and perhaps the opening of the economy to greater external competition as well as the world-wide shift to IT core technologies.

Turning now to structural measures of innovation potential, Figure 5.6 shows the share of GDP contributed by manufacturing across OECD countries. The maintenance of a robust manufacturing sector is important because the sector contains 'complementary assets' such as marketing expertise, distribution channels and production capacity, which support the commercialisation phase of innovation activity; and service sector growth.

Insert Figure 5.6 about here

Figure 5.6 shows that by 1997 the contribution of manufacturing to GDP in Australia placed us third last out of 19 OECD counties, ahead only of Norway — another resource-based economy — and Greece. Again, the Netherlands should be noted for its position five places

above us. Denmark and Canada, two other countries often used as comparators for Australia, have also retained somewhat higher proportions of manufacturing in their economies. Two further resource intensive economies — Finland and Sweden — are also well ahead of us.

Another perspective on industry structure and innovation potential is provided by a recent OECD publication which combines data related to the share of GDP contributed by high and medium-high technology manufacturing sectors with the share contributed by key knowledge-intensive service industries to arrive at a measure for 'total knowledge-based industries'. Growth in these industries across the OECD is shown in Figure 5.7.

Insert Figure 5.7 about here

Figure 5.7 indicates that between 1985 and 1996 the average annual growth of Australia's knowledge-based industries as a proportion of business-sector value-added was the third highest of the countries listed. This result supports the conclusion of Sheehan et al. (1995, pp.iv-vi) that Australia has strong growth opportunities in these industries in the global context. Given the absence of strong growth in high-technology manufacturing sectors (see Marceau & Manley 1999a), it is likely that the growth shown in Figure 5.7 relates primarily to service industries.

Insert Table 5.2 here

We now turn our attention to trade structure and innovation performance. Table 5.2 shows export performance by sectors defined by technology-intensity. Of the countries shown, Australia ranks fourth last in the high technology sector and second last in the medium-high technology sector. With very low export intensity in these sectors compared to other OECD countries, Australia's

incentive to innovate, provided by outward looking competitive strategies, is lower than that of all other countries except the US, Japan and Greece. Note also that outward looking strategies in these sectors are much more important for Australia than, say, for the US and Japan, because of the relative absence of technologically demanding customers in Australia as well as our small domestic market. Overseas customers may act as a spur to innovation in manufacturing firms and in turn manufacturing firms may become technologically demanding customers themselves in relation to Australian suppliers.

This review of selected innovation indicators in the international context shows that in some areas Australia's relative performance has been good in recent years, yet we still have major problems with our capacity to commercialise our R&D outputs as shown in the lack of manufacturing-related complementary assets, and in our incentives to innovate, with poor export performance in higher-technology manufacturing sectors.

The Future

We saw above that innovation in the services arena in Australia more nearly reaches the OECD average than does innovation in the manufacturing sector. This is important because services, as measured by the ABS, reach nearly two thirds of employment and three quarters of GDP. While it is still true in general that the manufacturing sector is more innovative than the services sector, we also need to bear in mind that to a large degree the development of services is intimately linked to that of manufacturing. Thus, Sheehan & Pappas (1998) talk of an integrated manufacturing-service sector which accounts for half or more of all activity in Australia. This is commensurate with the findings of Karaomerlioglu & Carlsson (1999) for Sweden. What manufacturing does is therefore of major importance both to the services sector and to the

growth of the Australian economy as a whole. It is clear that such inter-linkages can only increase in importance and spread. Indeed, it seems increasingly likely that many products can no longer be sold without the associated services. Some firms can no longer really distinguish between the products and services they offer, as we found in a recent study of some major supplier firms in the building and construction product system (Marceau & Manley 1999b).

These linkages also help us understand the investment in innovation apparent in some major service companies and reported on the R&D Scoreboard of 1996-97 (ISR 1998). One third of all firms reporting are in service arenas as diverse as financial services, transport and core technologies such as telecommunications. Indeed, 23 of the 235 companies on the Scoreboard are in telecommunications services while a considerable proportion are in computer services and software.

These figures help us understand another aspect of Australia's systems of innovation. This refers essentially to the close linkage between innovation in services and shifts in the operations of basic industries, including those in the resources sector as well as manufacturing and services to services. Anecdotal evidence suggests that innovation in Australia is occurring in the 'interstices' of the industrial structure. Thus, we have patches of very innovative activity but that it is not visible in most statistical collections used by policymakers and analysts. Software for the mining industry, engineering services for building and construction, IT and design for everybody, environmental remediation, sustainable energy (solar) development. In these areas it seems that networks, clusters, and complexes have developed close inter-linkages between users and producers and between all players and the public sector research and training systems and effective interactions with regulators and broader policymaking institutions.

Such activities are critical to future development in Australia. It is clear, however, that these activities are extremely dependent on the presence of vibrant industries based on other activities. Thus, if the mining sector were to become uneconomic, we would lose the basis for our related software and engineering services activities unless we could sell them overseas. Hence the importance of developing an export-orientation in these areas from the beginning. Similarly in building and construction, if local firms can no longer compete in terms of the core technologies they use the flourishing client services activities related to them would vanish. Hence the importance of improved investment in all the different aspects that ensure competitiveness in core arenas if Australia is to move along the High Road.

In the future, therefore, it will be important for Australia that the national innovation system takes due account of such shifts so that appropriate investments can be encouraged. Tax concessions related to the conduct of R&D, for example, may have to define what they mean more carefully so as not to exclude critical investments. Research policies for the funding of public sector research may have to take note that basic scientific research related to product development may need supplementary research in the social and organisational sciences if its potential is to be realised. It is significant that all new European Union Framework Research programs include a mix of natural and social sciences. Australian policies have been slow to recognise such interactions on all counts and this neglect needs to be rectified if the national system of innovation is to be more effective, both in terms of generating wealth and social wellbeing for the nation.

In short, the public policymaking that is at the heart of the ‘redesign’ of the nation’s innovation systems must become more deft and sophisticated in the information that it seeks and

interprets. Policymakers must become more aware of the differences in innovation systems between sectors and technologies and between the various geographical regions of the country. Diverse, but complementary, policies must be developed to meet the needs of the different systems. Overarching all must be the development of new partnerships between players in both public and private sectors so as to ensure that strategies for development are appropriate, recognise relevant differences and similarities and are ‘owned’ by all major players in the country’s innovation systems.

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Figure 5.1: Impact of regulation on innovation in the building and construction product system

Building and construction activities bring together services and manufacturing in unusual ways. The industry can be considered as one which is a precursor to trends which see modern manufacturing emerging as a 'project-based' activity in which products and services are linked and managed together to increase value-added.

The building and construction sector is led by 'project firms' whose principal role or core technology is project management. These firms, of which there are a dozen or so major players in Australia, use their technical expertise to create 'products' within the built environment. The products vary from houses to office blocks to airports, mines and major transport developments, tunnels and roads.

The constructions are often large and complex, involving multiple functions, clients, players and end-users. Buildings and other constructions such as roads are long-lasting, expensive and highly visible. They involve many concerns about aesthetics, functionality, especially over the longer term, environmental sustainability, and cost. These many facets mean that the product system also offers many opportunities for innovation. Some of these involve products, some services, some training, some research and development. Some income is a mixture of all of these.

The products of the industry involve complex mixes of components, equipment and services which are 'engineered' in special ways for a particular building or other constructed item.

Innovation in the industry occurs in the different fields brought together. Innovation may lie in components, such as lifts or energy-efficient windows; or in materials, such as cements, types of glass or ceramics; or in services such as the use of computer-aided design by architects and the use of advanced IT to link design and manufacture. Innovation also occurs in the ways in which

these are put together, in the project management and building processes themselves. Thus, in recent years, IT has become a central component of the building and construction product system.

Innovation in this industry is thus complex. The players must work together to make sure that innovations in one area are compatible with those of others, much needs to be developed off-site, to be integrated by the coordinating firm in charge of a project. Sites are always different in key respects, the ‘plant’ keeps moving and the problems to solve with it. Good information flows are critical.

Innovation also occurs because the regulatory environment has changed. Public authorities have more recently shifted to regulation through use rather than via tight specifications. This means that project firms must ensure that what they put together works in use. They can no longer rely on testing and specification by regulators.

Increasing public concerns and new regulation about environmental sustainability and impact have also produced new opportunities for firms and several have added waste management businesses to their portfolio of activities.

Similarly, the shift from public sector to private sector provision of infrastructure has created opportunities for innovation through the entry of new players such as banks. These players may encourage innovation through their provision of new financial products or by encouraging new processes to meet financial and timeline targets. The shift has also meant that project firms have new responsibilities, for instance dealing with the public and specific end-users, and must develop new areas of expertise.

Figure 5.2: Successes in the Australian innovation system

Knowledge-Based Service Industries	Continued strong growth in knowledge-based service industries, albeit from a low base, suggests that Australia is improving its capability to meet the forecast explosion in international trade in high-value services and suggests that reliance on competition based on knowledge, innovation and productivity (rather than on wages and exchange rates) may be spreading among Australian businesses.
Machinery and Equipment Investment	Since 1990 there has been a strong increase in machinery and equipment investment, reflecting an improving stock of embodied knowledge and potentially rapid diffusion of innovations. This may indicate only a return to earlier levels, however.
Venture Capital Investment	Australia's recent growth in venture capital investment and greater attention to early-stage finance, if continued, will provide greater scope to turn ideas into commercialised outcomes. Australia's growth rates in venture capital continue to rank very low compared to other OECD countries, however.
High Skilled Jobs	The somewhat faster growth of high-skilled jobs compared to low-skilled jobs since 1996 indicates a positive turnaround in the trend witnessed over the previous decade. Again, this may represent the beginnings of a shift toward competition based on knowledge within the Australian economy.

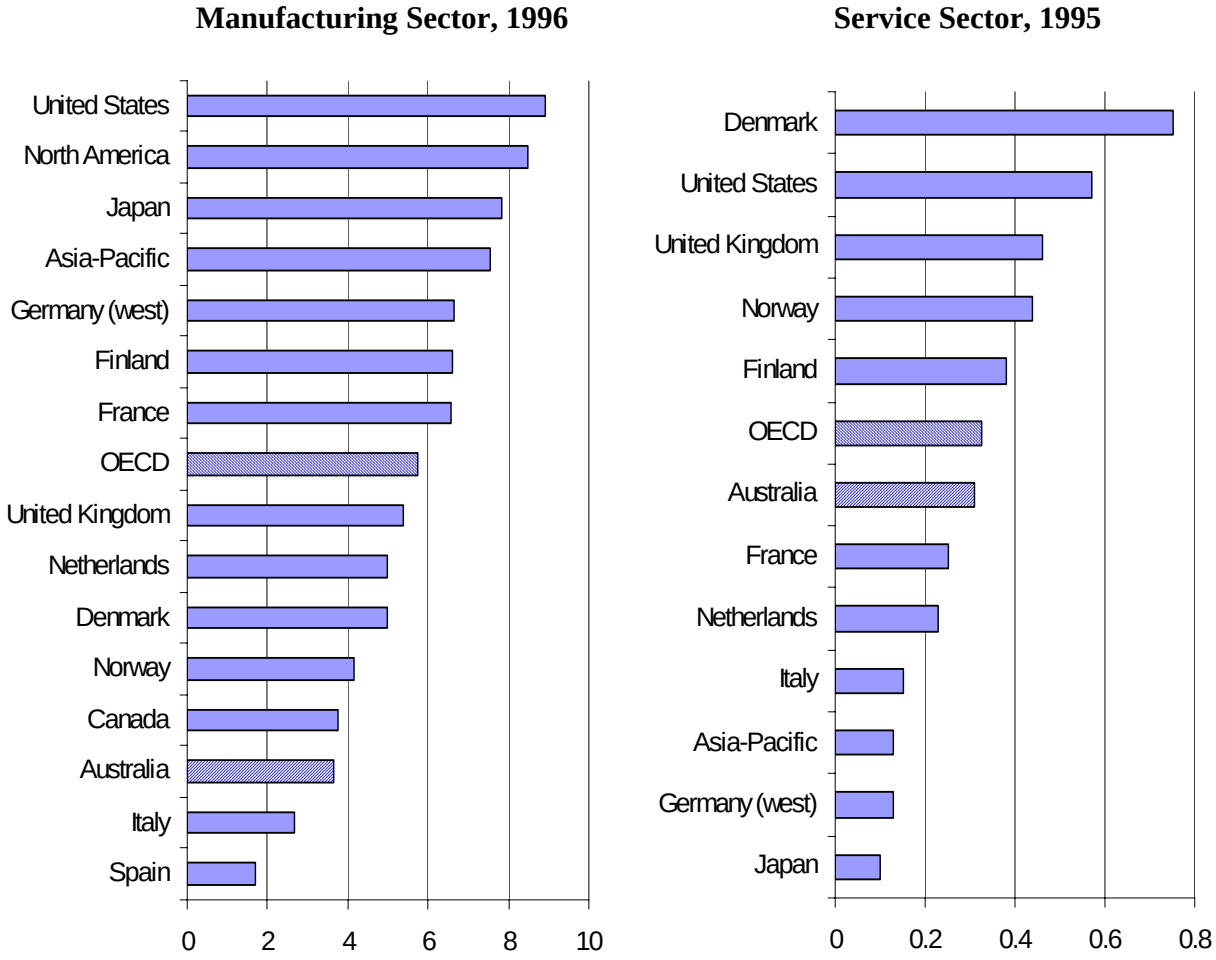
Figure 5.3: Negative trends in Australia's innovation system

Innovation Rates	The recently falling proportion of manufacturing businesses which claim to be in either product or process innovating cuts to the heart of Australia's innovation performance and, if continued, can be expected to seriously undermine our position as a knowledge-based economy. This problem has emerged since the Australian Business Foundation's last report on innovation in 1997.
R&D Personnel and Expenditure Levels	The substantial falls in R&D expenditure and employment by Australian businesses recorded since 1995 pose a significant threat to Australian innovation performance – particularly as R&D is widely considered an essential input to the innovation process. This is another problem that has only emerged over the last few years.
Australian Management Skills	A recent survey has again highlighted poor management skills in Australia, particularly in relation to capturing value from innovation. Australian management attitudes towards innovation have the potential to: constrain partnership opportunities available to Australian inventors; limit the rewards reaped from Australian ideas; and fail to maximise the opportunities available for sustainable business growth.
Size of the Manufacturing Sector	With a manufacturing sector that both continues to account for an extremely low proportion of GDP compared to many other OECD countries and is shrinking, Australia has limited manufacturing-related complementary assets (marketing, production) to support: the commercialisation phase of innovation activity; and service sector growth.

Training Commitment	The low and falling commitment of employers to staff training since 1990 was confirmed in new data released since the publication of *The High Road or the Low Road?* Given the importance of skills in transforming information into knowledge and knowledge into innovations, this trend will seriously undermine Australia's innovation efforts.

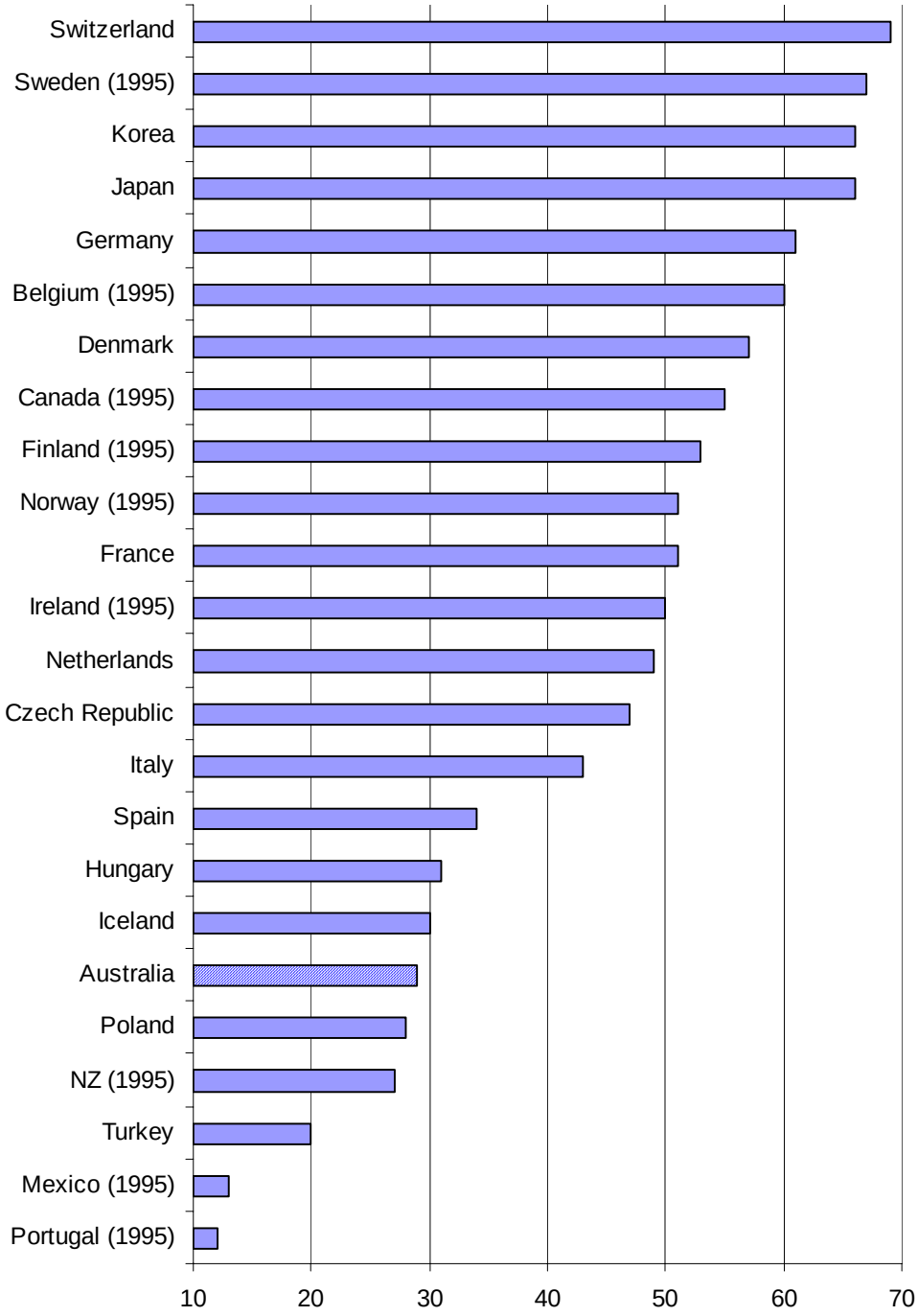
Figure 5.4: BERD as a percentage of value added,

various OECD countries



Note 1: OECD figure for both sectors is the average for the countries shown in each chart (excluding Australia).
Note 2: BERD is shown as a percentage of value-added by the relevant sectors.
Source: OECD 1999, Main Industrial Indicators Database

Figure 5.5: Business enterprise R&D personnel as a percentage of total R&D personnel, various OECD countries, 1996



Note 1: Countries shown are those for which data is available.
Note 2: Total R&D personnel is made up of business, government and higher education R&D personnel. Source: OECD 1999, MSTI Database

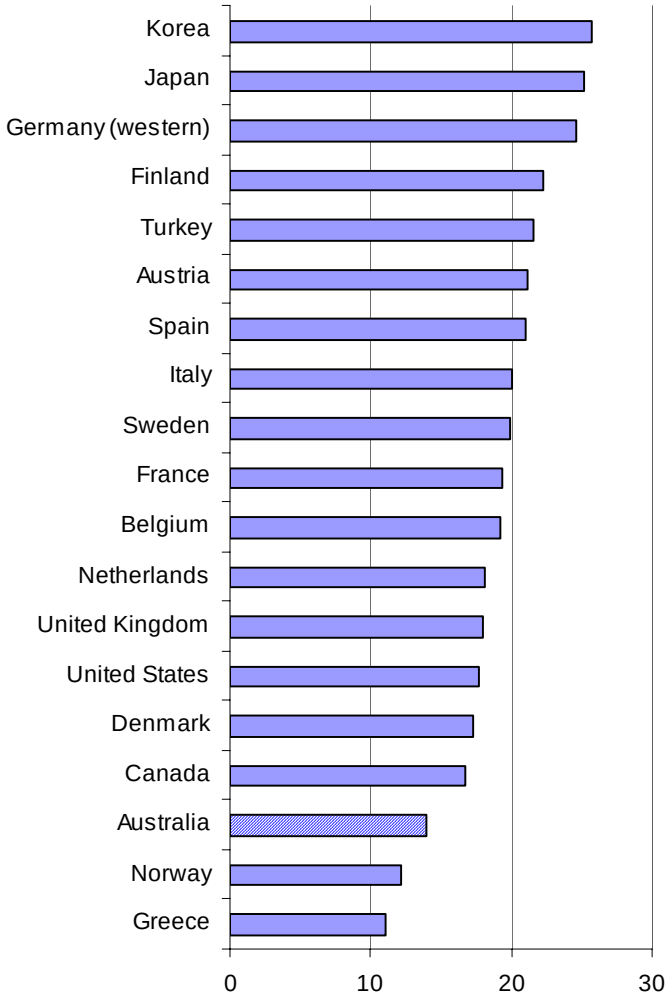
Table 5.1: Machinery and equipment investment as a percentage of GDP, various OECD countries, 1995

Korea	13.1
Turkey	10.8
Portugal	10.7
New Zealand	10.2
Japan	10.1
Denmark	9.5
Switzerland	9.3
Austria	9.1
Italy	9.0
Australia	***8.7***
Greece	8.4
UK	8.3
OECD	***8.3***
Canada	8.2
France	8.1
Netherlands	8.1
Sweden	7.7
Mexico	7.6
Germany	7.6
US	7.2
Belgium	7.1
Finland	7.0
Ireland	7.0
Spain	6.8
Iceland	4.6

Note 1: 1995 is the most recent international comparison available.

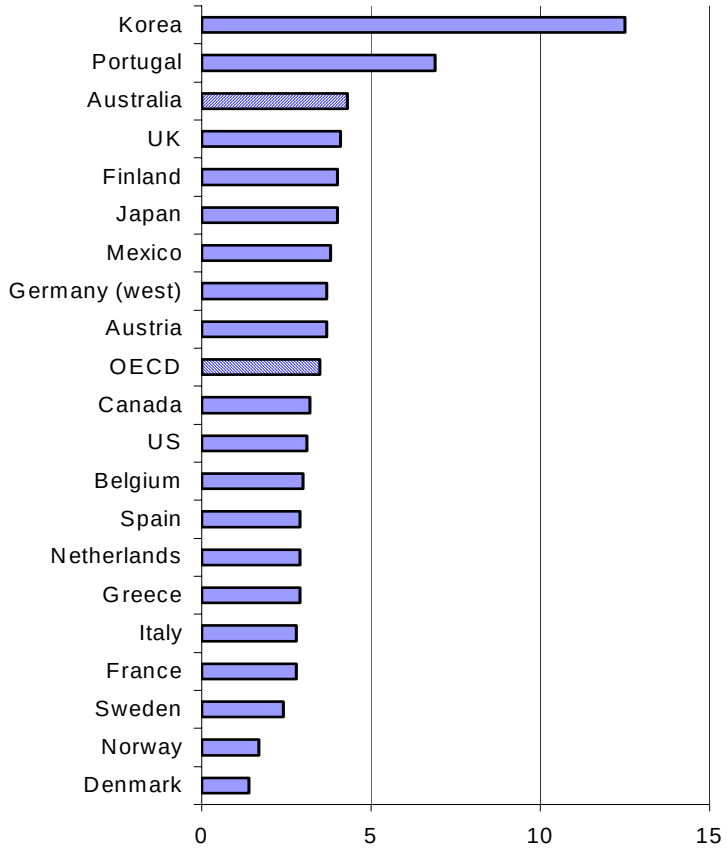
Source: OECD 1999a, p.114

Figure 5.6: Percentage of GDP contributed by manufacturing, various OECD countries, 1997



Source: OECD 1999, Main Industrial Indicators Database

Figure 5.7: Average annual growth, knowledge-based industries, percentage of business-sector value-added, 1985-1996, various OECD Countries



Note 1: Knowledge-based industries include high and medium-high technology manufacturing sectors, together with the selected service industries.

Note 2: There are slight variations in the period over which the average is calculated between countries and slight variations in the industries covered between countries.

Source: OECD 1999a, p.115

Table 5.2: Export shares of manufacturing production,

various OECD countries, 1996, percentage

High Technology Exports		*Medium-high Technology Exports*	
Proportion	*Country*	*Proportion*	*Country*
130.8	Denmark	117.12	Nether'ds
129.25	Nether'ds	68.67	Canada
75.12	UK	68.33	Denmark
72.05	Sweden	66.33	Portugal
70.09	Mexico	64.61	Mexico
65.08	Finland	64.23	Sweden
60.24	Canada	55.54	Finland
51.44	Italy	50.65	UK
50.16	Norway	49.31	France
48.55	Korea	46.77	Germany (west)
46.72	France	44.35	Spain
46.56	Portugal	42.47	Italy
45.64	Germany (west)	41.12	Norway
41.5	Spain	32.56	Greece
37.2	***Australia***	30.94	Korea
29.41	US	23.26	Japan
21.82	Japan	***22.8***	***Australia***
16.3	Greece	20.32	US

Note: Exports can exceed production, primarily due to re-export activity.

Source: OECD 1999, Main Industrial Indicators Database