Submission to:
The House of Representatives Standing Committee on Science and Innovation
Inquiry into pathways to technological innovation

Why we need to focus on Strengthening the Learning Economy rather than Focusing Exclusively on Commercialisation.

Don Scott-Kemmis
Director, Innovation Management and Policy Program
College of Business and Economics
Australian National University
don.scott-kemmis@anu.edu.au

Introduction

This submission concentrates on the 'Pathways to Innovation' and argues that focusing primarily on technological innovation and on the challenges of commercialisation is not justified by our knowledge of the processes of innovation. It will argue that a key issue is how public sector research organisations can contribute to strengthening the capacities of industry to innovate successfully, recognising that the public sector can support but cannot substitute for that capability.

This submission will discuss this wider perspective - many of the submissions already received deal well with the specific issue of commercialisation of public sector research. It is not possible in the scope of this submission to address all of issues identified in the terms of reference.

The following comments are based in large part on a study of the Australian Innovation Systems (AUSIS study[1]) which was supported by the Australian Research Council, the Australian Business Foundation, the Department of Industry Tourism and Resources, Department of Agriculture, Fisheries and Forestry, Department of Communications, Information Technology and the Arts and CSIRO and which was undertaken over three years up to mid 2005. The study analysed the role of innovation in the development of seven sectors over the past twenty years. These sectors were: Motor Vehicles, Photovoltaics, Dairy Products, Wine, Computer Games, Mineral Exploration, Oil and gas engineering.

An early phase of the study, based on the analysis of indicators of innovation-related performance (eg R&D, patents, exports) had suggested that:

- A large proportion of innovation in Australia is a form of 'systems integration', combining imported technology, old knowledge, and local problem solving to develop new products and production systems[2];
- Australia has not developed any major new sectors over the past 20 years, in contrast with significant structural change in many other countries, and hence the factors that shape the emergence of new firms and new industries are of particular importance in Australia.

[1] See http://ngsm.anu.edu.au/Research/_documents/NoSimpleSolutions.pdf

[2] In fact, this is probably the major form of innovation internationally, but is even more important in Australia.

The AUSIS study concluded that learning where to innovate, how to access knowledge, how to innovate, how to collaborate, and in particular, *how to capture the benefits of innovation* were key issues for potential innovators. Innovation is as much about identifying and exploiting the potential of new combinations of knowledge addressing new opportunities as it is about discovering new technical knowledge. In this context a diverse range of organisations play roles in the storage and transmission of knowledge, and formal research is only one type of activity for the knowledge acquisition, assessment and re-combination. Hence 'research' is far more heterogeneous and widespread than formal R&D statistics would suggest[3].

It is unfortunate that Australia's heavy policy focus on issues concerning formal R&D has swamped proper consideration of innovation policy issues that are at least equally important. These are those concerning the institutional, social and cultural issues that shape approaches to risk taking, responsiveness to new challenges and collaboration.

The statistically-driven approach to innovation policy has centred on some key facts:

- Australia has a relatively low level of Business Enterprise R&D (BERD), but a relatively high level GDP per capita, a relatively very high rate of economic growth, but a relatively high level of dependence on primary product exports;
- Australia has also been remote from the major markets or Europe and North America – unlike most countries with which we compare ourselves.

Debate about the innovation policy implications of this situation has tended to centre around three positions concerning the facts above:

1. The low levels of BERD and international patenting signals weaknesses in the 'national innovation system' that will ultimately lead to diminishing competitiveness and living standards. Consequently, it is essential to stimulate industry to increase R&D investment.
2. The high and sustained rates of productivity growth signal the essential strength of the 'national innovation system' and the correctness of the policy settings of the past two decades. There is no persuasive or urgent case for major change in innovation policy, and there is perhaps even some over-investment in public sector research – as there is little evidence that this investment has been a major driver of productivity growth.
3. The low levels of BERD and patenting are simply reflections of our industrial structure. These low levels may nevertheless be quite consistent with high rates of innovation in sectors where R&D is not a dominant driver of innovation. However, Australia may well risk losing future degrees of freedom if its current level of specialisation narrows even further and major new firms and industries do not develop.

The AUSIS study (on which this submission draws) sought primarily to explore the third of the three positions above — and chose to adopt and extend a recently developed

[3] This is no reason to disparage the usefulness or validity of such statistics when used appropriately and with a sound understanding of where R&D stands in relation to other aspects of innovation. In the broader sense used here, 'research' is any form of searching and learning.

methodology more sensitive to institutional, social and cultural issues than traditional statistical approaches.

Pathways to commercialisation:

What is innovation?
While a great deal of the policy focus in Australia is on technological innovation through commercialisation, this is a small (although important) component of innovation in the economy. To illustrate this point it is worth drawing attention some of the ways of categorising the basic types of innovation and the sources of knowledge:

- Technological and non-technological innovation (eg new ways of organising production, new business models like e-Bay or Amazon or new financial service products);
- Major or incremental innovation – the history of innovation is one of constant improvement by small changes with occasional leaps. . Frequently, it is a combination of small or subsidiary innovations that make major technological breakthroughs more readily marketable and acceptable (eg, the role of MS Windows and other software products in making PCs much more usable for customers).
- Product, process or organisational innovation – Henry Ford's innovation of the mass production system essentially used product and process technology that already existed but he organised these into a far more effective organisational and business model.
- There are four major sources of knowledge that firms draw on for innovation: in-house sources, including the knowledge of their staff used for problem solving, engineering, and formal or informal R&D; other firms (particularly customers and suppliers); public sources (magazines, journals, conferences) and public sector research organisations.

Innovation is a driver of and a response to processes of industrial transformation in which the central actors are firms. While the generation, transfer and application of knowledge are increasingly important, an increasingly diverse array of organisations play roles in all aspects of knowledge generation, diffusion and application. And suppliers of knowledge (and other inputs to innovation) and users of knowledge are increasingly international.

These are illustrated in Figure 1. We can make four sound generalisations about these types of innovation and sources of knowledge:

- The significance of particular types of innovation and sources of knowledge vary substantially from one sector to another;
- The significance of particular types of innovation and sources of knowledge tend to change as a particular sector evolves through different stages;
- The diffusion of technology, often involving incremental innovation in the process of applying technology in a new situation, is both a major contributor to productivity growth and a source of the dynamism that encourages more high risk innovation;
- In a strong innovation system all types of innovation and all sources of knowledge are important and inter-dependent. For example, investment in public sector R&D would have a very low return if firms in the economy lacked the capacities to innovate and market – that investment in the public sector would be far more likely to provide knowledge for firms in other countries.

These issues are of particular importance in Australia, where:

- There is a relatively very small 'high tech' sector – these are the sectors that in OECD countries account a large proportion of public sector R&D and of industry-public sector research links;
- The majority of knowledge used in innovation in Australia comes from overseas;
- Non-technological innovation (often combined with technological innovation), incremental process innovation and organisational innovation are major drivers of productivity growth — and these are all most commonly based on in-house sources and other firms.

Hence, the focus shown in Figure 1.B is a narrowly conceived sub-set of the issues relevant to innovation in Australia — though it is, unfortunately, the view that has traditionally received most attention.

Figure 1A: Innovation Types and Pathways

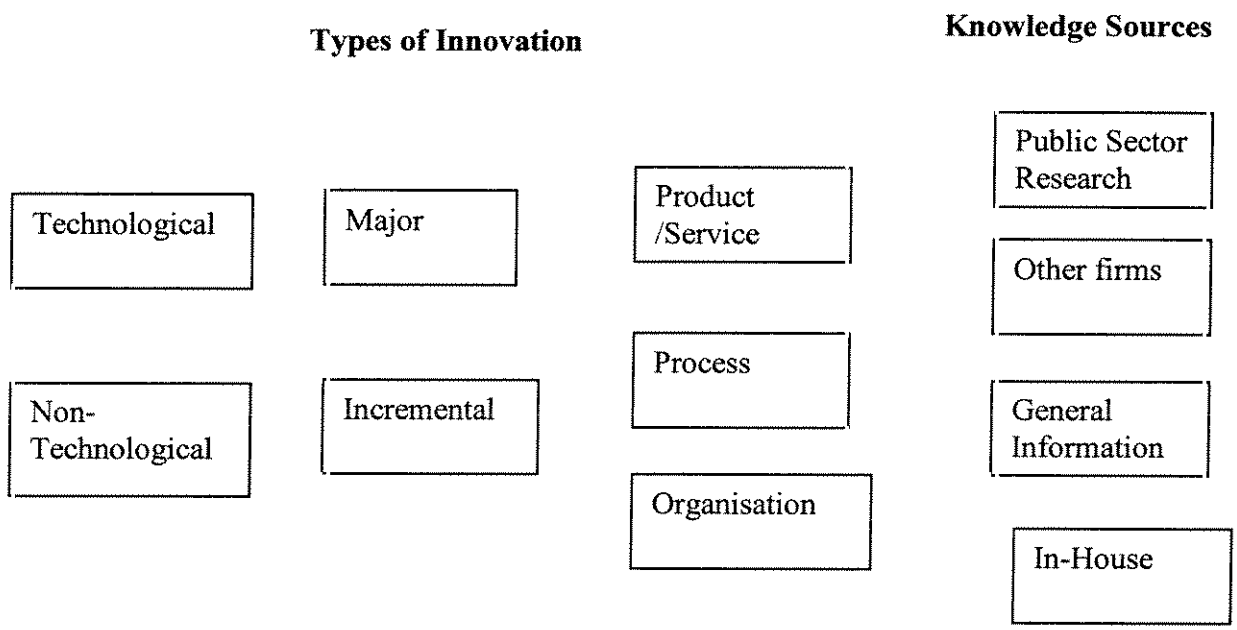
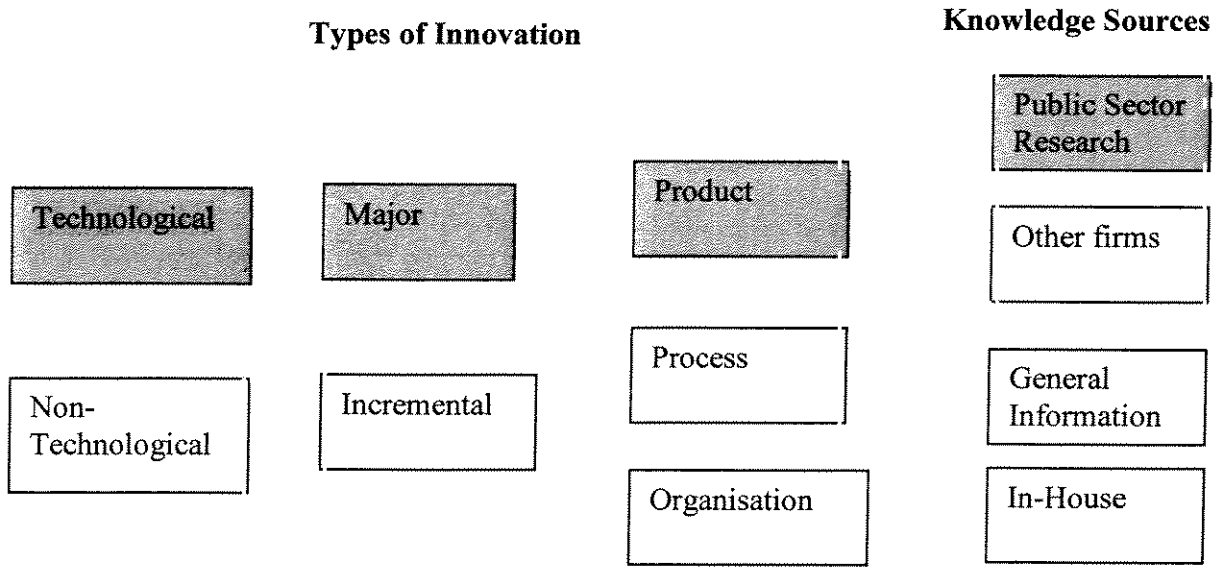
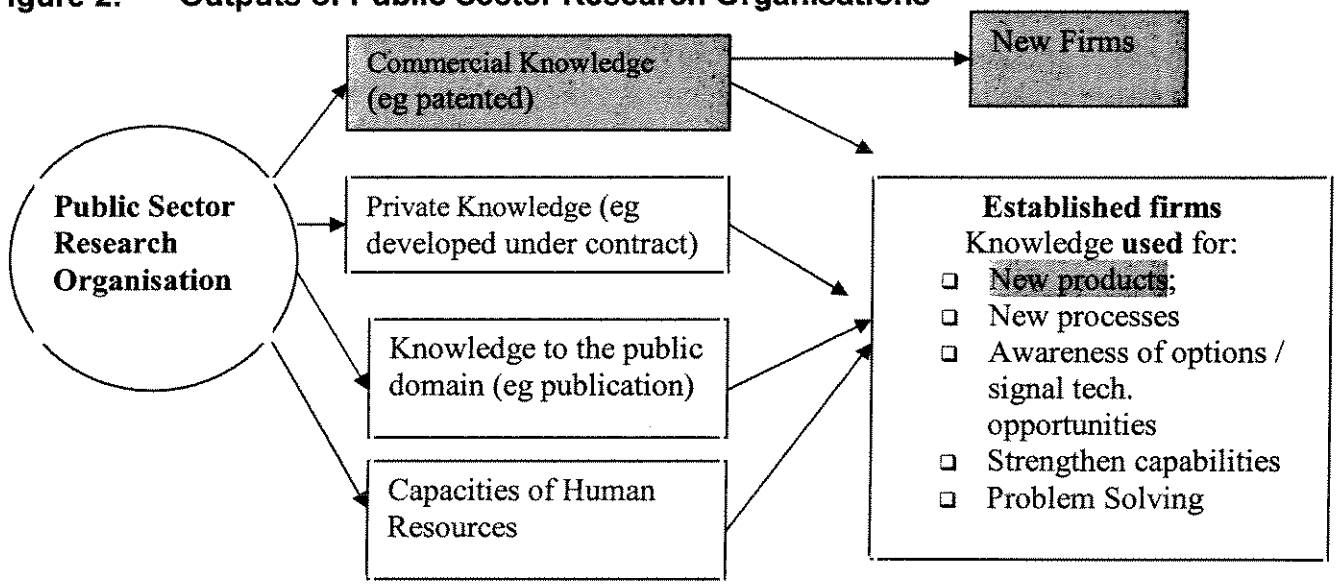


Figure 1B: Innovation Types and Pathways: the Linear Model



It is also useful at the outset to identify some of the roles of public sector research organisations. Figure 2 illustrates the major outputs of a public sector research organisation and the types of interaction between these outputs and industry. The pathway through commercialisable knowledge (often patented) to either spin-offs, or licences to existing firms as the basis for new products, is only one possible pathway. While the current phase of the development of biotechnology is characterised by the importance of this pathway, overall this is not the most important – although it is probably the easiest to measure. The UK report *Talent and Not Technology* provides a very useful and comprehensive review of the roles of the public sector research system [see Box 1.]. See also the useful report by Howard and Associates: ***The Emerging Business of Knowledge Transfer.***
http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/commercialisation/knowledge.htm

Figure 2: Outputs of Public Sector Research Organisations



Box 1 UK Report on the Role of Publicly Funded Research

Talent, Not Technology: Publicly Funded Research and Innovation in the UK

SPRU - Science and Technology Policy Research Unit, University of Sussex

22 June 2000. **http://www.sussex.ac.uk/spru/1-4-14-1-2.html**

The report was commissioned by the Committee of Vice-Chancellors and Principals and the Higher Education Funding Council for England, and updated a 1996 report for the Treasury. Among the conclusions are:

Research, innovation and economic performance are intimately linked in the knowledge-driven economy. Research expands our capabilities to solve technical and social problems and it underpins innovation within firms. Yet there is increasing evidence that the amount of support for public and private research in the UK has not been adequate.

This report brings together, for the first time, three crucial aspects of this debate. It examines the empirical evidence about the role of publicly funded research in innovation in the UK, it gives a comparison of the UK's research investment in relation to that of other leading countries, and it places this evidence in the context of an integrated research-innovation framework.

This report offers the following key insights:

- The research capacity of the commercial sector is a crucial ingredient for enhancing the innovation system.

Where firms invest in research and innovation, they are able to exploit the quality of the research base to support their innovative activities. Public investment in research can certainly complement private investment, but it cannot act as a substitute for it.

- Research supports innovation through a series of channels. These are:
  - increasing the stock of useful knowledge;
  - supply of skilled graduates;
  - creation of new instrumentation and methods;
  - development of new networks;
  - enhancement of technological problem-solving capacity;
  - generation of new firms; and
  - provision of social knowledge.
- The report finds that innovation is becoming increasingly international in scope and that participation in networks of innovation requires substantial investment.
- Policy-makers should also attempt to develop better indicators of the role of research in innovation; help to bridge the gap between research and practice; expand beyond publication metrics in their assessments and understanding of the impact of research; and use the research sector to promote talent rather than technology.

Our work in the AUSIS study shows that innovation is best thought of as change with a significant degree of novelty (and hence risk) – which is fairly close to the concept of innovation as the application of new ideas. We see that:

- A great deal of innovation involves small improvements and that these can over time deliver major changes in productivity and competitiveness;
- That technological and non-technological innovation are important and very often interdependent, for example a new product may need innovations in marketing, or a new production process may require changes to training;
- Services innovation may be enabled by innovations in technology, for example, innovations in business models (such as e-Bay, or Amazon) based on ICT and the internet
- R&D may be essential for some innovation, important in problem solving (rather than generating ideas) in other cases, and quite unimportant in other cases.

Who innovates and who are the central actors in the innovation process

Firms are the central actors in innovation. In initiating and undertaking innovation firms draw on a wide range of sources for ideas, knowledge, specialised inputs etc. We see that in general in-house sources of knowledge and knowledge from suppliers and customers are far more important sources of ideas and new knowledge than are public sector research organisations. Hence, intra and inter-industry flows of knowledge play a key role in innovation. The overall evidence shows that as competition has increased, and become more international, and the technologies of products and production have become more complex, firms have tended to become more specialised in their products and markets and hence in innovation. As a result innovation has become increasingly interactive as firms must source critical inputs to innovation from external sources. As result the role of consultants and specialist suppliers of 'knowledge intensive services' (eg ICT services, testing, design, market analysis ....) has increased. These organisations play an increasing role in the diffusion of new (and old) knowledge.

There are many actors in innovation, ranging from specialist suppliers of equipment, components, complementary products, services, customers who create new demands for improved products or services, new flexible firms that pursue opportunities before established firms, large firms that can undertake the level of investment in plant and marketing required for some major new innovations, public sector research organisations, regulatory agencies. The case studies that inform the '*No Simple Solutions*' report show that the significance of different actors varies from sector to sector and across time. There is no standard model. Robertson and Patel make the point that sectors in an economy are interdependent, and the what are commonly thought of as 'low tech' sectors are often major users of the products and services of so-called 'high tech' sectors[4].

What is the impetus for innovation?
Firms pursue opportunities and respond to problems in a continuous process of improvement. The search for new opportunities and new knowledge tends to develop particular patterns in particular sectors – although each firm will also have firm-specific patterns. The 'how' to search tends to become associated with the organisation of in-house research and specific patterns of external linkage- all of which require time and investment. The 'what' of search is associated not only with the specific problems that confront sectors and firms (eg improve energy efficiency or low unit costs) but also expectations about the potential for new knowledge in particular areas. For example, pharmaceutical firms now look to biotechnology, rather than only chemistry, as a major source of new opportunities for innovation in drugs. This shift in where to look for opportunities necessitated a shift in 'how' to look as these firms did not have the required in-house competencies and had to build external alliances to access these new capabilities.

Hence, one of the important roles for public sector research is that of signalling new areas of technological opportunity and providing firms with competent human resources (to strengthen capacities to absorb knowledge from any source) to pursue those opportunities.

Where do new ideas come from and what drives and shapes innovation?
Innovation is typically a complex process of combining new and old knowledge and in-house and external competencies in addressing the technological and non-technological challenges of opportunities and problems. Knowledge flows are becoming more diverse, deeper and more international – one need only look at the growing role of the World Wide Web, the increase in the volume of publications, the higher frequency of conferences, the greater mobility of specialists and the more rapid growth of collaboration.

In this context, the competencies[5] of entrepreneurs and the innovativeness of existing firms, their capacities to identify emerging opportunities, the capacities of the innovation system to support innovation (specialist suppliers, human resources, investment..) and the responsiveness of the innovation system to new directions (eg the need for change in regulations, or new investment in training or infrastructure) are of more immediate relevance than the generation of relevant new knowledge by domestic public sector research organisations. In many cases (and we can expect increasingly) the new knowledge may come from overseas and the primary role of the domestic research system is to assist firms to absorb that new knowledge.

The AUSIS study found that the successful sectors studied where characterised by:

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[4] Robertson, P. and Patel, P. (2005) New Wine in Old Bottles. Conference on Low-Tech as Misnomer. Brussels. June 2005. www.pilot-project.org/papers/**robertson**.pdf

[5] Competency includes all aspects of management for effective innovation and competition in increasingly global industries.

- Strong pressure to upgrade due to competition and often demanding customers;
- The capacity to identify new opportunities arising from change in technology, markets etc;
- The capacity to respond to problems and opportunities, including the capacities to absorb and apply knowledge and attain overall competitive performance;
- The availability of complementary assets – eg marketing services, specialised production facilities;
- The capacity to capture the benefits of innovation – ie to appropriate the returns. Strong overall competitiveness and reputation (including brand names) are generally more important for appropriation than patenting – particularly in Australia's major industries.
- Institutional change that enabled the sector to effectively respond to problems or pursue opportunities. For example, the success of minerals exploration in Australia has depended not only on excellent research but also on the development of new forms of collaboration between the public and the private sector, new industry associations that coordinate research, new regulations (such as the JORC code), and inter alia, a stock exchange that financed high risk ventures in these particular industries.

In short it was not a 'one size fits all' approach to the role of public sector research and training, or the role of regulation, but an alignment of capability and opportunity at all levels: knowledge, organisation and institutional. This echoes the history of innovation which shows that knowledge, technologies, firms, economies and societies co-evolve, with problems and opportunities emerging at each level and creating problems and opportunities at other levels.

Opportunities for innovation arise from changes in knowledge, technologies, markets, infrastructure etc. There are many pathways through which knowledge is acquired by firms and used in their (diverse) innovation processes. Flows of knowledge from public sector research organisations can play an important role in many sectors, although the pathways for the transfer of knowledge may be indirect, and often embodied in people and hence dependent on mobility. The direct commercialisation of intellectual property developed through research in the public sector is only one pathway in a maze of routes and in many innovations and sectors is of little importance.

However, the role of public sector research in industrial innovation is more often associated with sustained and flexible collaboration, and often the development of new institutional arrangements that facilitate close links between researchers from different organisations and from the public and private sectors. In Australia, the CRCs and specialised, often industry led, public-private, research organisations in the mining and wine sectors are examples of such institutional innovation. An excessive focus on cost recovery for research performed on behalf of the private sector may inhibit some forms of collaboration that are economically justified.

While it is essential to maintain a broad enabling research base oriented to the highest possible levels of excellence, there is also an ongoing need to align and re-align a substantial part of the public sector research (and capability development) activities to emerging priorities. In an increasingly competitive world, with shortening product cycles, major innovation projects are increasingly risky for firms. Collaboration among firms and with research organisations provides a stronger foundation for sustained innovation.

Intellectual property and patents;
From the perspective outlined here, the key issue is that of appropriating the returns to investment in innovation, as the incentive to innovate is directly related to the capacity to benefit. In most cases the capacity to capture the returns to innovation has more to do with a firm's overall competitive capacity and perhaps their speed to market than with their control of IP. In some sectors, such as pharmaceuticals and instruments, patenting plays a key role in appropriating the benefits of innovation - *but this is not the general rule* for most sectors

Skills and business knowledge;
This issue was addressed well in the neglected *Karpin Report* of 1995- see Box 2

Box 2
Report of the Industry Task Force on Leadership and Management Skills (the Karpin Report) 1995
See http://www.aim.com.au/research/EN_ExeSummary.pdf

The Karpin Task Force reviewed private sector management, although many of the findings are transferable to the public sector.

The Task Force based its report on a substantial research program (one of the biggest in Australia). The program included local researchers from top organisations (eg AGSM, Boston Consulting Group, Coopers and Lybrand) and international researchers of high repute (eg Rand Corporation). There was also about ten thousand firms, organisations and individuals consulted over the three years of the project, both in Australia and overseas, including institutions, companies and managers recognised as being leading edge in management development (eg General Motors Saturn Corporation, Motorola, NEC, Samsung, Lufthansa, BP International, Harvard, MIT, INSEAD, and a host of experts and managers from the small business area).

In addition, a number of comprehensive surveys of Australia's customers both national and international (particularly in Asia) were carried out to determine perceptions of the effectiveness of Australia's managers compared with those of our major competitor countries, from the customer's point of view. The review also considered how other countries similar to Australia in economic development terms are dealing strategically with management performance issues.

The major finding was that the best of Australia's managers and enterprises are equivalent to the best in the world, but there are too few of them - there is a long tail of poor performers trailing out behind the front runners. The problem exists in both the large and small business sectors, although with international pressures and more staff resources, big business has been more active in addressing issues of management improvement than has small business.

In summary, the Report found that skills limitations amongst managers constitutes one more restraint on firm and industry productivity, and that efforts to address productivity of workers will not 'fix' workplace productivity unless they are accompanied by efforts to improve management performance. In short, management reform is placed squarely in the basket of workplace and microeconomic reform.

The Report found that in general, while Australian managers have acknowledged strengths, they also have distinct weaknesses, and that these tend to cluster in those areas which are most critical for the successful manager and business profile for the 21st century. These areas include leadership including teamwork and empowerment, people skills including management of a diverse workforce, strategic skills, a learning focus, and international

orientation.

In short, Australian managers have strong functional skills (business efficiency and technical skills) but lack cross-functional, strategic and corporate skills. They have depth but lack breadth.

Underlying reasons for the problem were identified as the slow development of a competitive outlook produced by the history of protectionism in Australia, and an education culture (in the formal education system, in firms and among managers themselves) which gives limited attention to the personal and integrative skills that are critical to successful human resource management today and in the future.

The answer, according to the Task Force, is a comprehensive push in the area of management development and training at all levels and in all sectors, along with development of an enterprising culture.

In particular, mechanisms are needed to

- establish a strategic approach to achieving and maintaining management best practice in industry and business at all levels;
- develop an enterprising culture in Australia through the education system (schools, TAFE and higher education), and through community education achieve best practice management development in enterprises;
- upgrade the capabilities of TAFE and the VET sector in management training and in small business training;
- reform management education in the management schools and higher education; and
- harness the talents of the diverse working population more effectively.