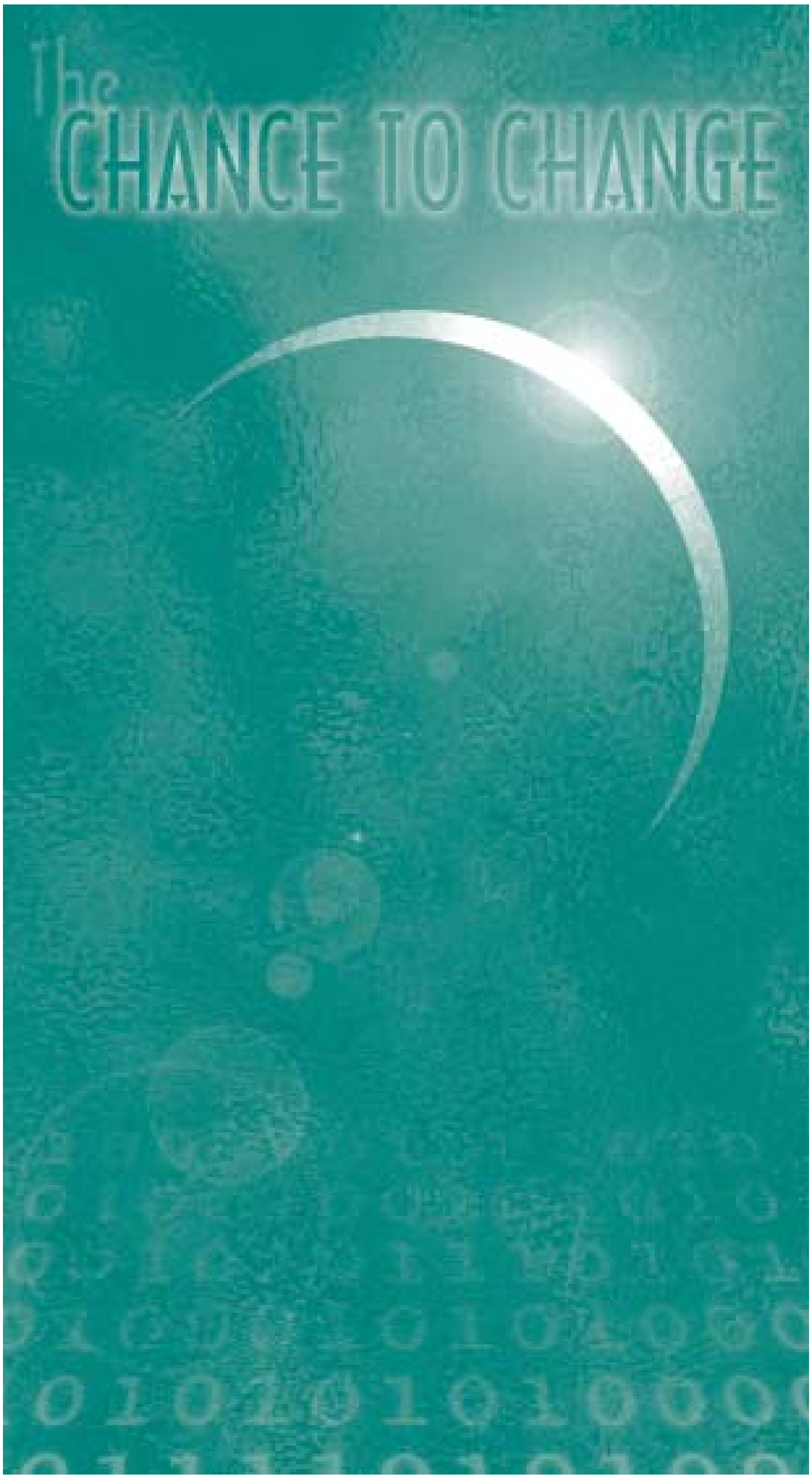

Final Report by the Chief Scientist

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Chief Scientist

In recognition of the importance of the science, engineering and technology (SET) base to Australia's future, the Minister for Industry, Science and Resources, Senator the Hon Nick Minchin, has asked me to assess its capabilities to ensure it can meet the needs of Australians in the 21st Century.

The Australian Science Capability Review commenced in September last year. I started by inviting submissions from the community to comment on Australia's SET capability. I was very pleased to receive a large number of submissions to the Review which commended the high quality of research performance in Australia. I became concerned, however, at a large body of submissions which brought to my attention some of the issues which the community felt were hindering the realisation of Australia's full potential.

In April this year, I visited a number of nations which appear to be striking a new direction in the way they are anticipating change. The insights I gained from my international consultations have contributed to this set of proposals for government consideration.

On 17 August 2000, I released *The Chance to Change –A Discussion Paper*. In conjunction with the release of the discussion paper, I visited every capital city in Australia to hold public consultations. I am delighted to report that the response to that paper is overwhelmingly in support of the proposed recommendations. The support has been extensive and this covers business, industry associations, as well as research providers. It has also included unusual public support from peak industry bodies, the Learned Academies and Academe.

In this Final Report, I have taken into account all submissions to the Review, letters of support, the public consultations and the advice of my Strategic Advisers to present a set of recommendations which I believe the Australian government must adopt if world perceptions of this country are to change and we are to maintain real choices in terms of jobs, sustainable development and lifestyle.

This Review has closely followed the work of the Innovation Summit Implementation Group following the National Innovation Summit in February 2000. ISIG's final report, *Innovation – Unlocking the Future* provides government decision makers with some new and exciting ideas on what needs to be done to stimulate innovative activity in Australia.

I commend this report to government.

Dr Robin Batterham
Chief Scientist
November 2000

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Acknowledgments

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Acknowledgments

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Queensland Department of State Development

ACT Chief Minister's Department

The Australian Science Capability Review Team

Commonwealth Departments of Industry, Science and Resources and Education, Training and Youth Affairs

Executive Summary

Executive Summary

Innovation—The Only Way Forward

Science, engineering and technology underpins our future as a thriving, cultured and responsible community.

The return to the community from investing in Australia's SET base will be:

- An economically strong and prosperous nation
- Acceptance at the highest scientific levels internationally
- A responsible, informed and responsive society

"OUR LIVES WOULD BE UNIMAGINABLE WITHOUT SCIENCE" [1]

Innovation—the only way forward

Innovation is the driver of every modern economy – it is the key to competitiveness, employment growth and social well being.

The cycle of innovation must be fed by new ideas and basic knowledge which are capable of being transferred and accepted by end-users.

Our international partners and competitors are investing heavily in their SET bases. Clearly the pace of development is quickening. For Australia to participate and thrive, we must, first, be part of this international process and, second, be committed to developing an innovation process for pursuing scientific advances and implementing them successfully. It is not sufficient for Australia to be a fast user of other nations' technology. We must have leading edge capabilities so that we can develop pioneering technologies that will ensure the competitiveness of our industry in the global marketplace of the future. Global customers are both discerning and demanding.

What Must Change

Without additional strategically driven investment, it is likely that the SET capability will lack the critical mass needed for the future. Simply increasing funding based on the *status quo*, however, will not ensure a more seamless and active innovation process. We need a SET capability that is an integral part of the national innovation capability and has the best chance of supporting economic and social goals in the 21st Century. We need to be able to measure more clearly our investment, to test whether we are getting value for money. The objective of new funding should be new business and wealth creation.

Our competitors in other countries are showing the way. Their governments are viewing the systems that generate and translate knowledge into wealth as the primary focus for sustainable economic development. The themes of investment which are emerging are:

- *People and Culture*
- *Ideas*
- *Commercialisation*

[1] *Excellence and Opportunity - a science and innovation policy for the 21st century*, UK Science and Innovation White Paper, July 2000.

This report outlines an integrated investment strategy based on these themes. All the government-funded elements of the SET system have been subject to funding pressures, especially the university research sector. The proposed investment targets the areas of greatest need and opportunity. Many of the recommendations are complementary or indeed overlapping with those of the ISIG report, *Innovation-Unlocking the Future*.

People and Culture

People matter. Without people, Australia has no vision, no ideas and no SET base to create and anchor ideas and turn them into products and processes that enhance the quality of our lives. The SET base is reliant upon people who have progressed through a supportive educational system, from primary school through to tertiary, and beyond. As well, people in SET need to have the skills to communicate with the business world and with the rest of the community.

The culture needs to change. We need more support for those who inspire our children to study science and maths. We need to encourage more of our young people to consider studying science in tertiary institutions and we need those students to have a broader range of skills than they currently have, to prepare them for exciting projects in the business world. We should be able to inspire our researchers to enter the teaching world with much greater ease, to transfer crucial knowledge and help excite our children about careers in SET.

Science and innovation need a transparent framework of public support within which they can flourish. Public awareness and involvement in the SET base are vital.

Ideas

Ideas have the potential to dramatically change the way we live. Ideas, when translated, can improve our health, sustain our environment, and help us communicate better and quicker. Australia needs to create environments in which the best ideas are identified quickly and easily, to promote our contribution to the global knowledge pool and to respond to business and community needs. A much larger commitment to the ideas generation process needs to be made, both in terms of financial support for the SET base in universities and CRCs and the broad research infrastructure.

Excellence must be combined with relevance in a successful modern public sector research environment. Contestability of funding is needed to ensure excellent research, wherever it is conducted, is supported – this is less likely to happen in a system that is clearly partitioned.

We need to create:

- new and innovative mechanisms by which ideas are translated into achieving societal goals and economic growth
- new ways of linking infrastructure strengths and pooling scarce resources, and
- new ways of ensuring that excellent research raises the profile of Australia internationally

Commercialisation

The ultimate measure of success in innovation is the value placed on it by consumers and the community. Integrating the innovation system across all points can increase the chance of generating more products and processes that enhance our lifestyle. The innovation system is dependent on strong links between all players, government, industry and research performers. Government has a special role to play in aiding the linkage process. We need to think about new ways to develop alliances, connections and partnerships between the SET base and other players.

Government plays the central role in building the environment for change. Successful government initiatives should be expanded, and the recipients of government research funding encouraged to play a greater role in making connections with the business community in line with the changing needs of society and national priorities. In particular, the government - funded research agencies must play a stronger role in the creation of new businesses by a much improved effort at business incubation. Such a commitment is consistent with their essential mission of conducting research for the benefit of the Australian community.

In conjunction with this, we need to introduce incentives for researchers in universities and government research agencies to make the most of the knowledge they create, and build upon this to elevate their role in the economy. The challenge for them is to stimulate and facilitate the increased transfer of knowledge to business and society, across all sectors of the economy

Recommendations

The major recommendations for enhancement of the SET base to emerge from the Review are:

People and Culture

- Provide 200 HECS scholarships for students undertaking combined science/education qualifications and 300 for students of the enabling sciences - maths/physics/chemistry.
- Increase the number of Australian postdoctoral fellowships – doubling would be appropriate. These would be tenable at universities, government - funded research agencies and internationally recognised institutes.
- The Commonwealth Government fund the establishment of Federation Industry Chairs in universities or a research entity affiliated with a university on a competitive basis for five years.
- Redesign and expand R&D *Start* Graduate to place SET graduates in SMEs.
- The Commonwealth Government show leadership and initiative to raise the importance and profile of science awareness. Activities with a high public profile, such as National Science Week, be expanded.

Ideas

- Implement a priority review process R&D for funding across the Commonwealth Government.
- Over five years, double funding for the Australian Research Council's competitive grants and related infrastructure activities, consistent with the commitments already made for increased funding of health and medical research.
- CSIRO, ANSTO and AIMS be given access to competitive R&D funding mechanisms, including commercial loans; be assessed against outputs; and reform incentives for researchers to encourage new business creation.
- Consideration of intellectual property be prominent in assessing ARC grant applications, similar to the NHMRC process.
- Expand the funding for university research infrastructure (RIBG) and provide a commensurate increase in support for research infrastructure at non-university institutions eligible to receive ARC and NHMRC research grants.
- Develop a pilot scheme to test a national site license concept between higher education institutions, government-funded research agencies and publishers in an attempt to keep the price of journals down.
- Commonwealth Government fund fifty per cent of the cost of creating new major research facilities on a competitive basis in conjunction with the States/Territories, publicly-funded research institutions and commercial interests.
- Government-funded research agencies, CRCs, and RDCs have access to the initiatives outlined in this report, including Major Research Facilities, pre-seed funds and Innovation Centres.

Commercialisation

- Create a cash-out option under the R&D tax concession for R&D expenditure by SMEs and provide suitable incentives to attract significant R&D projects to Australia.
- ARC and the NHMRC develop stronger guidelines on commercialisation of research.
- Expand the CRC program to encourage greater SME access and to facilitate stronger networks between the SET base and industry, nationally and internationally.
- Establish Innovation Centres to provide universities and government-funded research agencies with support in commercialising research.
- Establish a pre-seed capital fund for universities, Innovation Centres and government-funded research agencies, such as CSIRO, RDCs and CRCs.
- Universities and government-funded research agencies review opportunities

for researchers to better share in the benefits of commercialisation with particular encouragement for formation of start-up and spin-off companies.

- Universities and government-funded research agencies adopt a more strategic approach to the management of intellectual property.

General

- Any additional funding for the SET base should be closely linked to measurable performance indicators.
- A Science Capability Implementation Group be established to implement the recommendations endorsed by Government.

I am also proposing a number of other strategies that deserve consideration, as well as some thoughts on what should be driving government policy, the research community and industry in the future. These can be found throughout the report and in the appendices.

Priorities

The SET base would provide greater returns to the community if a priority review process was clearly articulated across government as a whole. It is possible to prioritise R&D in a publicly defensible way based on excellence of the R&D and its impact on the community. I propose that PMSEIC have a greater role in advising government of priorities for research and initiatives across different elements of the SET base.

Implementation

Investment is, by nature, a risky business. To justify the investment proposed in this discussion paper, close scrutiny and sound measures of accountability are required to maintain public confidence in the SET system. As well, monitoring the SET system will enable government to respond more quickly to priority needs. The community needs to know that the return on its investment will lead to improvements in quality of life.

To implement the plan for increasing Australia's return on investment in the SET base, an implementation committee should be formed, possibly chaired by the Chief Scientist, to ensure that the recommendations of the Review accord with government and community objectives. The Science Capability Implementation Group would, report to the Prime Minister's Science, Engineering and Innovation Council on progress with implementation.

Robin Batterham

Dr Robin Batterham
Chief Scientist

Chapter one

Definitions

1.1 The Knowledge Economy

'Knowledge has become perhaps the most important factor determining the standard of living—more than land, than tools, than labour. Today's most technologically advanced economies are truly knowledge-based.'[2]

Contemporary industry and society are often described as being 'knowledge-based'. Knowledge is seen as the major force to increase productivity and economic growth, not only in high-tech areas but also in traditional manufacturing, construction, and engineering as well as the service sector from retailing to banking.

Use of the term 'knowledge economy' denotes the shift from *material* to *knowledge and intellectual resources* as the base for economic growth. A distinguishing feature of the knowledge economy is the increased importance of tacit, as opposed to codified, knowledge and intangible capital. The knowledge economy is not only about new creative industries and high-tech businesses, it also has relevance to traditional manufacturing, mining, primary and service industries.

A number of drivers are behind the move to the knowledge economy. First, the escalating knowledge intensity of the innovation process—generating, producing and commercialising new goods and services. Second, the exponential growth in the capacity of information and communication technologies to store, process and deliver vast amounts of information. Third, the process of globalisation.[3]

Thirty years ago, knowledge doubled every fourteen years—it is now doubling every seven years. Not only is the speed of discovery increasing, but the rate at which knowledge is applied has also become more rapid.

It is estimated that more than 50% of GDP in the major OECD economies is knowledge-based.[4]

1.2 What is innovation?

Where knowledge is an essential ingredient, innovation is the activity that utilises that resource. As sunlight is to photosynthesis, knowledge is to innovation. Innovation is the process that translates knowledge into economic growth.

Innovation is much more than invention or R&D. It encompasses all activities encouraging the commercialisation and utilisation of new technologies—scientific, technological, organisational, financial and business.

It is now widely accepted that innovation is the key to future prosperity.

1.3 National Systems of Innovation

Nations have different capacities to encourage innovation, reflected in the behaviour of their firms, the institutions that foster innovation, and the policies of government. Understanding these differences has led to analyses of 'national systems of innovation'.

[2] World Bank, *World Development Report 1998/99*, Washington:World Bank, 1998.

[3] Dodgson, M, *The Management of Technological Innovation, An International and Strategic Approach*, Oxford University Press, 2000.

[4] Stevens, C , 'The Knowledge-Driven Economy', *OECD Observer*, 200:6-10, 1996.

Such analyses consider how:

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.[5]

A nation that excels at innovation will thrive in the knowledge economy. A properly functioning National Innovation System (NIS) underpins the innovative capacities of business and industry by providing collectively what firms cannot individually produce or afford themselves. These factors include an educated populace, 'public good' research and the development of expertise on a broad range of fronts. This is especially true in small countries with small firms that have too few resources to meet the costs of research of a more basic or promising, but initially tangential, kind.

1.4 Defining the SET base

A nation's science, engineering and technology (SET) base is a fundamental component of its national system of innovation.

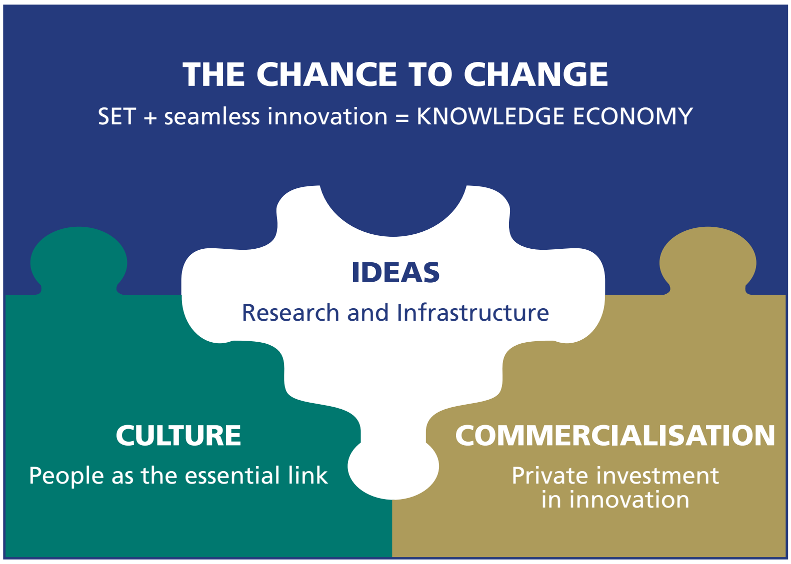
The SET base consists of people, the organisations in which they operate and the infrastructure that supports them. This Review analyses the SET base in terms of *Culture* – with people as the essential link, *Ideas* – which are dependent upon infrastructure and research, and *Commercialisation* – the translation of ideas into benefits for society. In reality, culture, ideas and commercialisation encompass broadly overlapping and intertwined entities intrinsic to the SET base.

A powerful SET base within a properly functioning national system of innovation will deliver a robust knowledge-based economy.

Put simply, the SET base is the engine-room that powers and ultimately underpins a nation's position in the knowledge economy.

Figure1.1

The integral nature of SET and innovation



[5] OECD, *Science, Technology and Industry Outlook*, 2000.

1.5 Australia's SET base

This report presents a review of the current capability and future potential of Australia's SET base. The major components and principal activities of Australia's SET base are presented in the table below. The investment strategy proposed in this report blurs these traditional boundaries in recognition of the need for greater connectivity within Australia's National Innovation System.

Figure:1.2

A general overview of Australia's current SET base

	Component	Principal Activities
People	Scientists, Technologists, Engineers Educators Users	Ideas generation, Knowledge creation Technology/Skill transfer
Organisation	Higher Education Institutions	Education Research / Research Training
	Business	Applied R&D targeting innovation Sponsor external research
	GFRAs	Public good R&D Technology transfer Innovation facilitators
	CRCs	Cooperative research Training Network generation
	Medical Research Institutes/Hospitals	Health and medical research and training
	RDCs	Directed research - rural
Infrastructure	The facilities and equipment needed to support innovation	

Chapter two

Chapter two

Introduction

2.1 Vision

Australia truly is fortunate. Our country has abundant natural resources, a wonderful climate and a stable and tolerant population that is ambitious for itself and for its children. Today, Australia stands at the crossroads —- it can continue to do in the future what is has done in the past and continue to slip behind other countries *or* it can take a bold step and move into a new and exciting era. Our entry into this new realm will provide us with keys to sustainable outcomes that meet societal and environmental needs. Now is the chance to change.

2.2 Goals

1) We see the chance for an ideas-based 'can do' Australia, building on our success and competing with the world. We see an Australia where the words science, technology and entrepreneurialism are synonymous with excitement.
2) Australia's SET base will be renowned for generating leading-edge ideas and technologies.
3) We will have an ideas-based economy with tremendous growth and dynamism, in which start-ups and spin-offs are commonplace, and an environment that actively encourages Australian companies and individuals to embrace innovation. This can be the broad reality—one not limited to just biotechnology or ICT but one that will bring clear benefits to *all* industries from clean-green-production enterprises to defence technologies.
4) Australia takes its place among the top 10 countries as measured by relevant OECD rankings, such as BERD and GERD.
5) Ideas generation and their effective translation into successful businesses, jobs and wealth become the norm, as evidenced by:
    - The number of start-up/ spin-off companies being increased by a factor of 10.
    - The formation of globally recognised, technology-based companies.
    - Producing five companies per year that reach the billion dollar stage. (the first five took us ten years).
6) Australia is an innovation environment that attracts global giants to undertake R&D.

2.3 The Value Proposition

This Review sees carefully focused investment in Australia's SET base resulting in high social and economic value creation that will shape and enhance our nation's standing, rather than a cost to be minimised by government.

"Something special has happened to the American economy in recent years…a remarkable run of economic growth that appears to have its roots in ongoing advances in technology." Alan Greenspan[6]

[6] Greenspan, A, Comment to the Joint Economic Committee, 14 June, 1999.

The links between innovation and growth are now well established, as evidenced the following (see also Table 2.1 below):

- Reviews of growth accounting models show that, in the US, 49 per cent of current economic growth came from technical progress and that 88 per cent of growth in the first half of the twentieth century came from technical change.[7] This was acknowledged in September 1998 by the US House of Representatives Committee on Science.
- R&D provides an important contribution to output and total factor productivity growth. Empirical evidence typically shows that a 1per cent increase in the stock of R&D leads to a rise in output of 0.05-0.15 per cent of GDP. Just imagine if this was linearly extrapolated to the levels of GERD seen in Finland (3 per cent of GDP spent on R&D) – Australia's GDP would increase by a massive 24 per cent.[8]
- Estimates of the private rate of return in the US on private R&D investments are in the range of 7–43 per cent and, owing to technology spillovers, social rates of return to R&D investment are significantly higher[8] in the range 123–270 per cent per annum.[9]
- There is a close relationship between investment in technology at firm level and productivity performance.[10]
- The economic foundation of a sustainable rate of technological innovation is based on an ideas production function in which the rate of new ideas produced is a function of the number of ideas workers and the stock of ideas already available to these researchers.[11]

The key pay-off to the community from investing in Australia's SET base will be to strengthen our capacity to succeed in the knowledge economy of the 21st Century. This is because an investment in our SET base will enhance our innovative capacity. There is no simple equation to define a direct mode of action when it comes to public investment stimulating innovation, however a recent study found that a nation's SET base contributes to innovation through the following:

- Increasing the stock of useful information
- Supply of quality graduates
- Creation of new instrumentation and methods
- Development of new networks
- Enhancement of technological problem solving capacity

[7] Boskin, M J and Lau, L J, *Capital Technology and Economic Growth*, in Nathan Rosenberg, R Landau, and D C Mowery (eds), *Technology and the Wealth of Nations,* Stanford University Press, CA, 1992 and Solow, R, *Technical Change and the Aggregate Production Function*, Review of Economics and Statistics, v39, pp312-320, 1957.

[8] Cameron, G., *Innovation and Growth: A survey of the empirical evidence*, Oxford: Nuffield College. Available at http://hicks.nuff.oz.ac.uk/users/cameron/research/downloads/html, 1998.

[9] Quoted in Business Higher Education Round Table, *The Case for Additional Investment in Basic Research in Australia — A Policy Statement*, April 1999, p.3.

[10] 'Innovation and Economic Performance' in *OECD Science, Technology and Industry Outlook, 2000*.

[11] Romer, P., 'Endogenous Technological Change', *Journal of Political Economy*, 98, S71-S102, 1990.

- Generation of new businesses, and
- Provision of social knowledge[12]

The benefits from investment in the SET base are dynamic in nature and derived over different time periods. Furthermore, these intangible returns while being critical factors for future wealth generation, are not easily measured by traditional economic indicators.

An investment in the SET base also acts synergistically. For example, the process of increasing Australia's stock of knowledge is intimately related to the production of skilled graduates, who are vital for innovative companies' success in adopting, using and developing new (or improved) technologies.

Investing in the SET base is particularly potent for small economies, like Australia's, that need to 'punch above their weight' in the global knowledge economy. Through dynamic international networks, Australia gains access to the global knowledge base. More crucially, investment in the SET base allows Australia to leverage such knowledge via international technology transfer, where globally sought ideas are absorbed and effectively translated into new or improved products and processes. Finally, investment in the SET base will ensure that the history of productive interaction between our top-notch scientists, leading-edge institutions and businesses overseas will continue.

The quality of Australia's SET base will attract research-related foreign direct investment. There is a growing tendency for the world's leading knowledge–based companies to locate research-related investments outside their home bases and to outsource considerable proportions of their total R&D budgets.[13] For example, Glaxo SmithKline recently announced its intention to locate a billion dollar research investment in Singapore. An equivalent investment is being forecast in four years time, which begs the question of whether Australia's SET base will be considered sufficiently attractive for it to be located here.

It is also important to note that while investment in the SET base can most certainly complement private investment, it cannot be a substitute. Research shows that innovative firms that invest in R&D are better able to exploit the public research base and thereby support their internal innovative activities and potential for growth.[14] The recent Narin study shows that the development of private sector patented technology is highly reliant on publicly-funded scientific research, with 90 per cent of papers cited in private sector Australian-invented US patents authored in publicly funded institutions.[15] Thus, the innovative capacity

[12] In response to the current British Government's second 'Comprehensive Spending Review', the Committee of Vice-Chancellors and Principals (CVCP) and the Higher Education Funding Council for England (HEFCE) commissioned SPRU (Science and Technology Policy Research Unit, University of Sussex) to report on the impact of publicly funded research on innovation in the UK. The final SPRU report found research contributed to innovation indirectly, ie through the quoted list of 'channels'. Reference details: Slater A., D'Este P., Pavitt K., Scott A., Martin B., Geuna A., Nightingale P., Patel P., *Talent, Not Technology: The Impact of Publicly Funded Research on Innovation*, SPRU or PDF file <http://www.sussex.ac.uk/spru/news/talent.pdf>http://www.sussex.ac.uk/spru/news/talent.pdf>, June 22, 2000.

[13] OECD, *Globalisation of Industrial R&D: Policy Issues*,1999,p.13.

[14] Slater A., D'Este P., Pavitt K., Scott A., Martin B., Geuna A., Nightingale P., Patel P., *Talent, Not Technology: The Impact of Publicly Funded Research on Innovation*, SPRU, June 22, 2000.

[15] Narin, F, Albert M, Kroll P, Hicks D, *Inventing Our Future - The link between Australian patenting and basic science*, AusInfo, Canberra, 2000, p.11.

of the private sector is a crucial ingredient for maximising the return on public investment in the SET base and conversely, a vibrant SET base provides the essential foundation.

Table 2.1

Australian and international reports demonstrating a return on investment in innovation

- In 1993, the Bureau of Industry Economics concluded that the spillover return is 78 per cent of the investment cost of induced R&D projects.[16]
- The Industry Commission estimated the social rate of return to R&D spending in Australia to be as high as 50 per cent.[17]
- The OECD reports that increases in multifactor-productivity and the rapid improvements in the quality of capital and labour indicate that innovation and technological change are important determinants of economic growth.[18]
- A recent OECD report notes that innovation and technological change are commonly considered as being among the most important drivers of economic growth.[19]
- OECD analysis of studies in the US, Japan, Germany, Canada and the UK across individual firms, industry and the whole economy showed that there are high direct rates of return on investment in R&D. These rates of return are typically between 10 and 20 per cent, making investment in R&D a profitable undertaking.[20] This compares well with the analysis endorsed by the US House of Representatives Committee on Science in 1998.

In summary

"…the federal investment in science and technology is about as good an investment as you can possibly make with the American taxpayer's money."[21]

This Review regards investment in the SET base as a source of value creation rather than a cost centre. The proposals in this report are bound to measures of performance, because the community has the right to know the value of their investment. Because the investment proposed by the Review will alter the way the SET base operates, the opportunity must be taken to measure the change.

The return on investment in the SET base will be in terms of higher incomes, more and better jobs and superior goods and services as knowledge is converted into improved competitiveness for existing industries and the creation of new businesses and industries, and informed citizens.

The Australian community will benefit from a more secure economic future, a healthier environment, stronger links to regional centres and better management of its natural resources.

Australia can ill afford to ignore this chance to change…

[16] R&D *Innovation and Competitiveness*, BIE Research Report 50, 1993.
[17] *Research and Development*, Industry Commission report no.44, 1995.
[18] OECD, *Innovation and Economic Performance*, March 2000.
[19] OECD, *A New Economy?: The Changing Role of Innovation and Information Technology in Growth*, June 2000.
[20] OECD, *Science, Technology and Industry Outlook*, September 2000.
[21] Dr Neal Lane, Assistant to the President for Science and Technology, January 2000.

Chapter three

Investment: maximising a return

3.1 International Success Stories

Studies have shown that the relationship between publicly-funded research and business performance is far from linear, or one-sided in the favour of business. Spin-off, knowledge-based businesses and the creation of income and jobs around the world's leading universities demonstrate the power of the relationship to build strong regional economies. Good examples of this are Stanford University and Silicon Valley, MIT and Route 128 in Boston, the University of Texas and the surrounding area in Austin, and Cambridge University and the so–called Silicon Fen.

Box 3.1

In Canada, a new National Research Council (CSIRO equivalent) research centre, the Advanced Aluminium Technology Centre, has been funded to meet the needs of industry in a regional area as well as having a positive impact on employment in associated aluminium processing companies. A focus has been to create an environment that encourages industry clustering. Its establishment demonstrates the Canadian government's strategy of developing technological niches in communities and of responding to identified national priorities, in this case, strengthening Canada's position in the aluminium-processing sector.

Source: The Hon Martin Cauchon, Secretary of State for Canada Economic Development, media release, October 2000.

Furthermore, the escalating knowledge intensity of the innovation process has introduced anticipation of even greater returns than those received during the 1990s.

There are big opportunities based on information technology and biotechnology, telecommunications and other technologies, where explosive growth creates niches for Australia, not only as market opportunities in themselves, but also as a means for greatly enhancing the existing industry base. It is likely that entering the field at a later time will require a much larger investment and the available rates of return and benefits will be diminished.

"High tech firms are building much more on the intellectual capital of key personnel than on physical assets, and firms built around the best scientists are most likely to be successful in commercialising breakthrough technologies. As a result such firms are expected to have higher market values than similar firms less well endowed"[22]

[22] Michael Darby, Qiao Liu and Lynne Zucker, *'Stakes and Stars: The Effect of Intellectual Human Capital on the Level and Variability of High-Tech Firms' Market Values'*, National Bureau of Economic Research, Working Paper 7201, 1999.

3.2 The Investment Strategy—People and Culture, Ideas and Commercialisation

If the S&T revolution bypasses much of our populace, they are left without vital tools to make critical decisions in this increasingly complex world… They may become poorly informed voters, jurors and citizens.[23]

The nature of the SET base is changing. Australian universities are following a worldwide trend to become more active in commercialising research and GFRAs are becoming increasingly applied in their research activities. New industries are dominating the global landscape, for example, in ICT and biotechnology; their impact is profound and far-reaching, both socially and commercially.

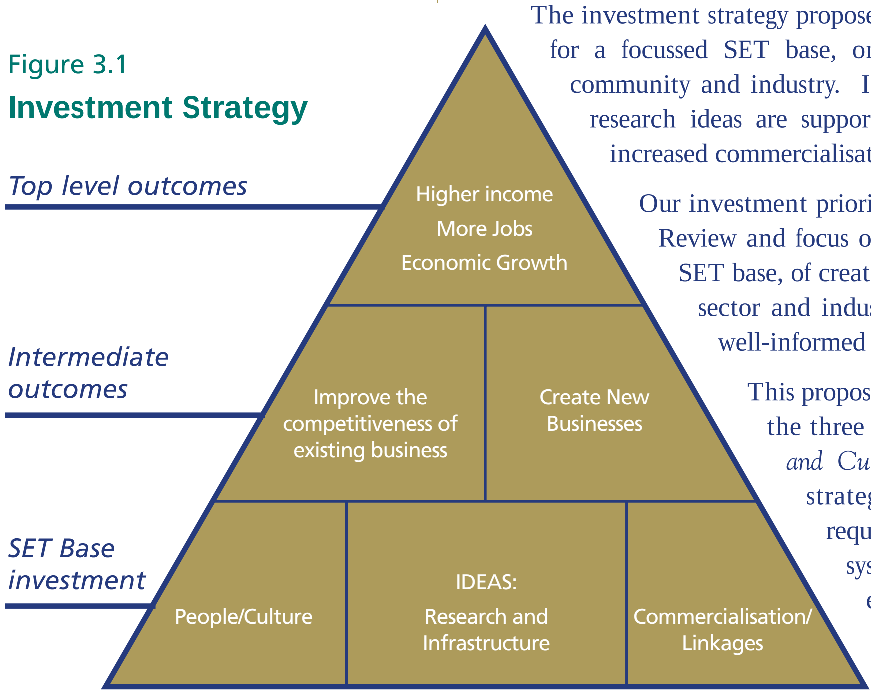
A new approach is necessary for Australia to keep in touch with the directions being set by knowledge advancement and industry development world wide. This approach must focus on new business creation. Australia must be smarter about the way in which it supports and leverages its SET base. Government plays a critical role in 'setting the scene' and creating an ideas culture. It is this environment which encourages national and international business investment. It is in no way sufficient to be a fast follower—global customers are demanding and discerning. They want the latest products, the most complete services and the best price. This requires products, be they services, digital content or devices to embed the latest technology. Second best technology produces second best products. Hence, we must have significant leading-edge capacity to ensure our products are competitive. In short, we need to create a dynamic SET base and domestic innovative capacity in order to participate successfully in the new global market place.

The investment strategy proposed in this Review will provide the platform for a focussed SET base, one that interacts more closely with the community and industry. It is designed to ensure that only the best research ideas are supported and that prospects are improved for increased commercialisation.

Our investment priorities are consistent with submissions to the Review and focus on the importance of maintaining a robust SET base, of creating effective linkages between the research sector and industry, an excellent education system and a well-informed community.

This proposed investment strategy is structured around the three primary elements of the SET base—*People and Culture*, *Ideas* and *Commercialisation*. The strategy is designed to address investment requirements for a seamless national innovation system and a competitive knowledge base for economic growth and social well-being.

Figure 3.1
Investment Strategy



[23] Dr Rita Colwell, US National Science Foundation Director.

Community and, therefore, government investment in the SET base generates an economic environment where incomes are higher, sustaining the taxation base, and providing increased opportunity for further government financial renewal of the base.

This Review proposes the following investment priorities for creating our vision and achieving our goals:

People and Culture

- an ideas culture needs skills development, commercially viable intellectual property systems, a scientifically aware population and an environment that supports the innovation process;

Ideas

- a nation's potential for innovation is strongly linked to its research capacity, the generation and utilisation of ideas requires excellent facilities that enable our scientists, engineers and technologists to innovate as well as providing a stimulating and challenging environment for students; and

Commercialisation

- encourage close networks of companies and publicly funded research providers in order to facilitate the smooth translation of ideas into innovative products and services.

The investment priorities set out in the Review (details in Chapters 5, 6 & 7) are complementary to the initiatives in: the White Paper on higher education research and research training[24]; the Wills Report on medical and health research[25], and with the initiatives considered by the Innovation Summit Implementation Group (ISIG) in its report *Innovation - Unlocking the Future*, following from the Innovation Summit.

3.3 What this report does not cover

The higher education system is an intrinsic component of the SET base. In Australia, it accounts for 29.4 per cent of public expenditure on R&D and has formal responsibility for all research training at the graduate, doctoral and postdoctoral levels. Many of the major recommendations and strategies presented here represent a direct response to the significant strain under which our higher education system has been operating.

The *current* funding framework for the higher education sector has created both sectoral and institutional level inflexibilities reflected in, amongst other things, industrial relations. Addressing such difficulties is beyond the scope of this report. However given the importance of the higher education sector to the SET base, it is recommended that it continues to be monitored to determine the impact of the changes proposed in this Review.

[24] The Hon Dr D A Kemp, MP, Minister for Education, Training and Youth Affairs, *Knowledge and Innovation - A policy statement on research and research training*, December, 1999.

[25] Commonwealth Department of Health and Aged Care, *The Virtuous Cycle - Working together for health and medical research, Health and Medical Research Strategic Review*, 1999, "The Wills Report".

Chapter four

Chapter four

Setting the case for Australia

The Australian Information Economy Advisory Council submission to the Review notes that:

> *We [Australia] are coming from behind and we need to mount a vigorous policy and industry response in order to recover lost ground. A national innovation policy that does not address these shifts will fail to capitalise on the emergence of an information economy. This will result in continued pressure on the Australian currency, and our competitiveness.*

4.1 Australia's traditional comparative advantage

Traditionally, Australia's comparative advantage has been based on its enormous endowments of minerals and agricultural land. Economic development has relied heavily upon the exploitation of natural resources, areas that traditionally have a low innovation intensity measured in terms of R&D expenditure relative to turnover. Investment in Australia's SET base is characterised by a weak degree of private investment, and a history of protection from international market forces. As a result, Australia's national system of innovation is fragile in the sense that it has few large innovative manufacturing firms and a high degree of dependence on R&D-intensive industry by overseas firms. Even though the mix of Australia's exports has shifted in the last decade away from primary products towards more highly transformed manufactured products and services, the fact remains that Australia's export profile is still heavily dependent on traditional commodities.

The success of Australia's traditional economic base, including, for example, the ascent of its world leading minerals and agricultural industries, was firmly underpinned by the SET-derived knowledge base. Radical and incremental innovations associated with plant breeding, transportation of perishable foods, mineral exploration and mineral treatment technologies have been absolutely central to establishing and maintaining Australia's position in these industries.

The perception of Australia's economic performance in the context of the knowledge economy is that Australia is too heavily reliant on its traditional 'old economy' industries. This is reflected in international comparisons of market-to-book ratios that demonstrate that Australian companies are increasing their intangible value very slowly, and from a low base, in comparison to other nations where governments have focussed on new industry development.

We recognise, however, that Australia's traditional SET base has provided a foundation to take up a strong position in the 'new' economy. Our innovative capacity provides the platform from which to establish a position in the 'new economy'. The shift Australia must make to take up this position is outlined in the table below. It is primarily the responsibility of Government to enable this transition by enacting the comprehensive investment strategy proposed in this Review. It is only with public support for the SET base that Australia can be a vibrant economy with a range of knowledge-based industries, attract major international investment and further benefit from solid participation in the knowledge economy.

Table 4.1

A comparison of 'old' and 'new' economy factors

Old Paradigm	New Paradigm
1. Key factors – capital, and labour resources	1. Key factors – knowledge, creativity, innovation
2. Export profile essentially dependent on resource-based industries	2. Addition of knowledge-based activity and knowledge-based parts of resource industry
3. With relatively few exceptions, most businesses serve local market	3. Firms going global and subject to global competition
4. Primary focus on cost competitiveness	4. Imperative is to deliver superior value to customers through innovation
5. Relatively long product cycles	5. Trend to shorter product cycles
6. Getting more out of existing businesses	6. Creating new businesses and placing a premium on risk taking and entrepreneurial behaviour
7. Very difficult to find venture capital	7. Venture capital becomes a key part of new business development
8. Little incentive for collaboration.	8. Shift to strategic alliances and other forms of collaboration

4.2 The current state of Australia's SET base

Only by supporting research where the returns are not guaranteed can we ensure the steady, gradual progress that underpins front-page news stories that accompany each new success. Taking a risk on open-ended research, whose cost-effectiveness is often difficult to guarantee, sometimes generates the greatest economic returns.[26]

Australia's national innovation system continues to be characterised by a comparative paucity of private investment, as evidenced by our very low ranking in BERD. A common belief, however, is that this failing within Australia's NIS is offset by our comparatively rich support for the public sector R&D, ranking 4th in OECD international lists based on 1996-97 ABS data. Australia's scientific activity produces nearly 3 per cent of the world's scientific research papers.

[26] Dr Neal Lane, Assistant to the President for Science and Technology, June 2000.

To date, the Government has taken a number of measures to address some of the shortcomings in the SET base and the national innovation system in general. For example, a lack of venture capital and related financial and management skills has impeded the creation of new businesses. Measures such as the Innovation Investment Fund and the recent changes to the capital gains tax are well on the way to promoting a more vibrant and well-resourced venture capital industry in Australia. There has been a step function increase in the amount of venture capital available, although concerns remain about the adequacy of pre-seed and true-seed capital for early stage start–up companies.

New analysis on the comparative performance of Australia's SET base demonstrates that there is no room for complacency. The underlying reason for Australia's relatively high ranking in international comparisons of public expenditure on R&D (PUBLERD[27]) has not been widely understood. Public sector R&D expenditure is relatively high because a substantial proportion of this investment has been devoted to the specific requirements arising from supporting a relatively large agricultural sector in Australia's challenging climatic, soil and water environments and high degree of biodiversity.

In particular, 18 per cent of public sector R&D is directed to agricultural purposes, even though this sector only constitutes 3 per cent of our economy. As a percentage of GDP, this expenditure is significantly higher than other OECD countries, most of which undertake little publicly-funded agricultural R&D.[28]

Omitting agriculture, Australia's public R&D effort would stand at only 0.64 per cent of GDP in 2000-01, below the international average of 0.66 per cent. This implies that Australian public sector R&D expenditure is much lower in areas such as engineering, information technologies, and physical and applied sciences than is the case for most other developed countries. The latter disciplines are fundamental in terms of growth in knowledge-based activity. Research in these disciplines provides complementary support in terms of early awareness of leading-edge technological developments and supplies skilled researchers for a high value-added business sector.

Thus, even our seemingly high level of public R&D may be misleading in terms of competing in the knowledge economy. This is not an argument for reducing or redirecting agricultural R&D. As stated above, preserving our current SET base is crucial for establishing Australia's comparative advantage in the knowledge economy. The Review argues that Australia needs to complement its excellence in agricultural and minerals related research with the disciplines that are seen world wide to be driving the knowledge economy.

A final reality for Australia is that public sector R&D expenditure in Australia has fallen from 0.83 per cent of GDP in 1996-97 to a projected value of 0.74 per cent in 2000-01. A steady decline at this rate suggests that we could drop to the region of 13th or lower by 2005-06, compared with our current position of 4th.[29]

[27]Aggregate R&D data (Gross Expenditure on R&D or GERD) comprises R&D undertaken within 4 sectors: business; general government (Federal and State); higher eduction; and private non-profit. However, reports on R&D expenditure tend to focus upon only two components of GERD: business expenditure on R&D (BERD); and public sector R&D expenditure (PUBLERD—the sum of R&D expenditure in the general government and higher education sectors). These aggregates are the most relevant for international comparisons and time series analyses of R&D expenditure.

[28]Department of Industry, Science and Resources analysis based on ABS and OECD data, 2000.

[29]Department of Industry, Science and Resources, 2000.

4.3 Australia's current performance in the knowledge economy—how do we compare?

Assessing the innovative capacity of a nation and its performance in the knowledge economy is not straightforward. This section of the Review presents an assessment of Australia's innovative capacity based on nine indicators including:

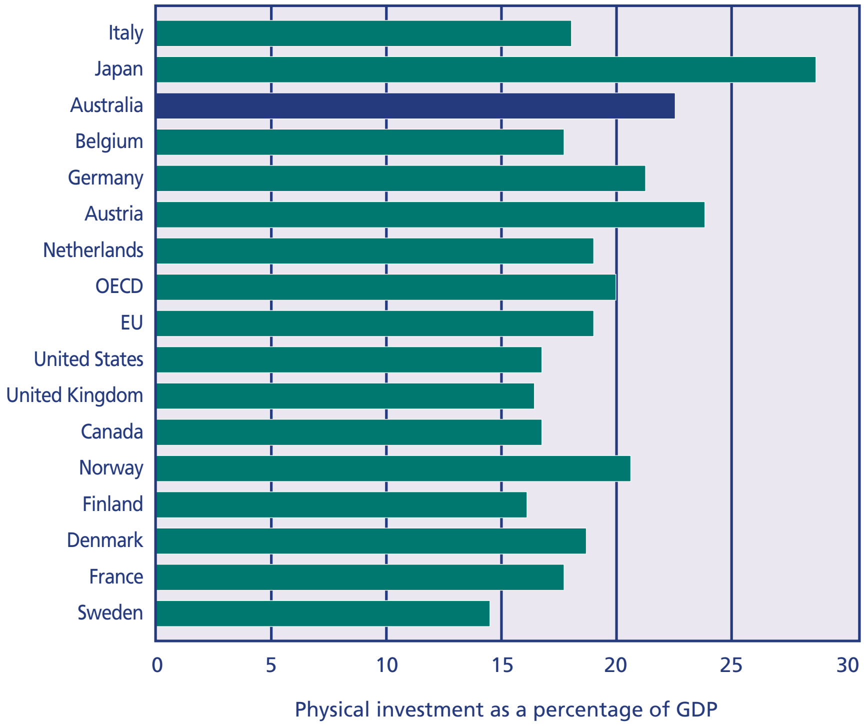
1) Investment in machinery and equipment – 'physical investment' in the SET base
2) Technology balance of payments
3) Support for knowledge generation – investment in R&D, software and education
4) ICT investment
5) Private sector's innovative capacity
6) High-tech exports as a percentage of merchandise exports
7) Product and process turnover and growth in Australian firms
8) Investment in intangible capital – market-to-book ratio and market size of Australian firms
9) Evaluation of patenting

1) Physical Investment

'Physical investment' is an indicator that measures capital expenditure on machinery and equipment. In 1995, Australia was ranked 3rd in the OECD for physical investment as a percentage of GDP and 5th in terms of growth in investment on machinery and equipment, see Figure 4.1.

Figure 4.1

Physical investment as a percentage of GDP, 1995



Source: OECD, *The Knowledge-Based Economy: A Set of Facts and Figures*, Meeting of the Committee for Scientific and Technological Policy, 22-23 June, 2000, p.9.

2) Technology balance of payments

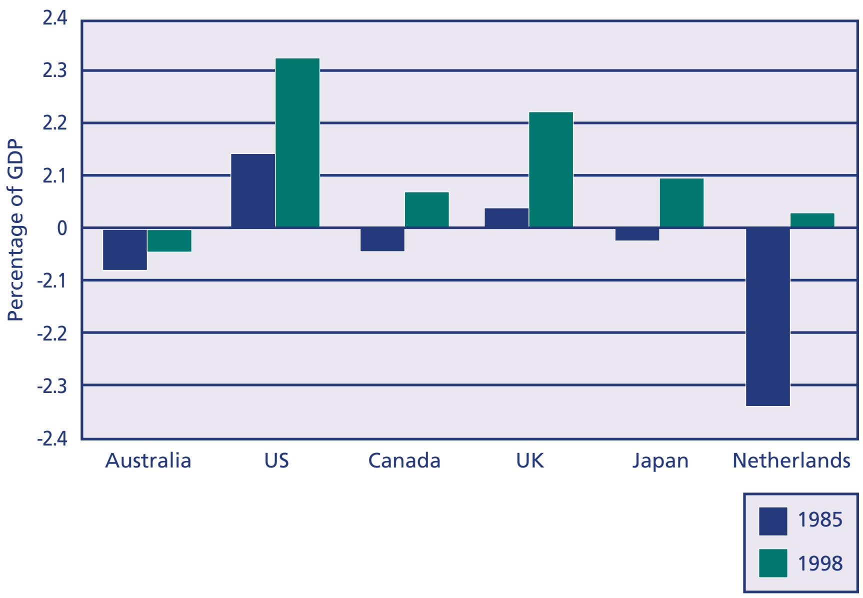
In relation to knowledge investment, however, there is clearly a different picture emerging for Australia.

The technology balance of payments is one measure used by the OECD as an indicator of the output of knowledge-creation processes within a country. It includes international transfers of technology, licences, patents, know-how and research and technical assistance. In the context of globalisation, these transfers of disembodied technologies, together with transfers of technology embodied in products and in persons (migration), have greatly increased during the 1990s for most OECD countries.

Figure 4.2 shows that Australia's technology balance of payments as a percentage of GDP has increased from 1985 to 1998, but from a low and negative base.

Figure 4.2

Technology balance of payments as a percentage of GDP



Source: OECD Science, Technology and Industry Outlook, 2000.

3) Support for knowledge generation – investment in R&D, software and education

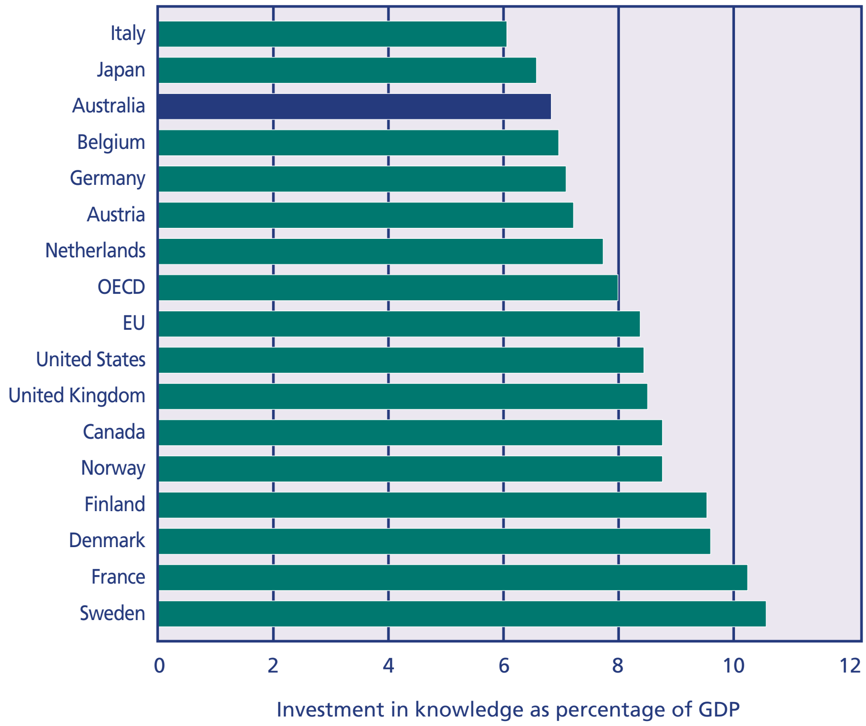
Knowledge generation is a primary driver in the knowledge economy. This indicator measures investment in knowledge generation by accounting for investment in R&D, software and public expenditure on education as a percentage of GDP.

Knowledge-intensive activities can be found across all industrial sectors. For example, the Australian mining sector is regarded as an 'old' economy industry, however, intangible products, in the form of mining software, are its 6th largest export. High-technology sectors are most strongly correlated with knowledge-intensive activities.

According to this indicator, Australian investment in knowledge generation was 8 per cent below the OECD average in 1995. Thus, Australia fits the trend among OECD counties – where nations with a high degree of physical investment tend to invest less in knowledge generation (compare Figures 4.1 and 4.3).

Figure 4.3

Investment in knowledge as a percentage of GDP, 1995



Source: OECD, *The Knowledge-Based Economy: A Set of Facts and Figures*, Meeting of the Committee for Scientific and Technological Policy, 22-23 June, 2000, p.9.

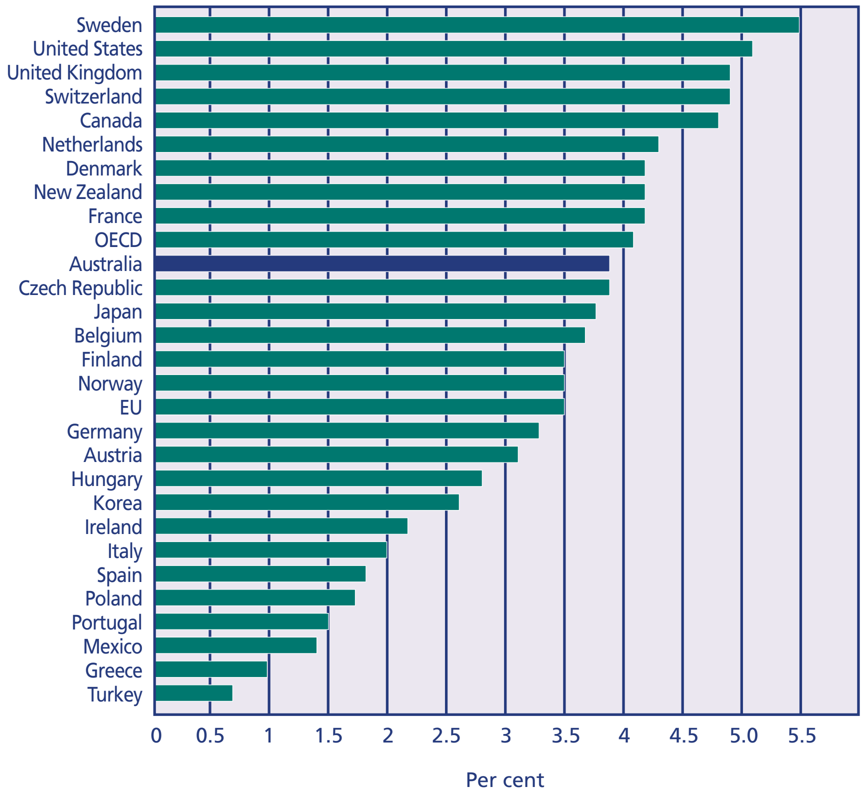
4) ICT Investment

Information technology plays an important role in the move towards becoming a knowledge-based economy. Take-up rates and generation of new products and services are indicators of how quickly a nation is making this transition. OECD studies have shown that there is a "first mover" advantage in ICT that underpins the development of competitiveness across all industries, and particularly services. The US economy's current strength draws heavily from the 'first mover' advantage it enjoys across information and communications technology industries generally, and particularly in Internet-related technology industries. In ICT investment in information technology hardware, software and services, the US ranks second and Australia, eleventh– just below the OECD average. Australia cannot be complacent about its fast uptake of ICT in recent years, ie internet usage and mobile telecommunications. Other nations are recognising the value-add ICT can give all industry sectors and are increasingly investing in both off the shelf product and in R&D to develop new products and services.

Australian ICT research cannot provide all the solutions for problems that growing businesses face in IT, or ensure that existing industries remain competitive, However, research skills in IT are crucial for making intelligent purchases from the international marketplace and for creating opportunities for new niche industries.

Figure 4.4

ICT Expenditure as a % of GDP, 1997



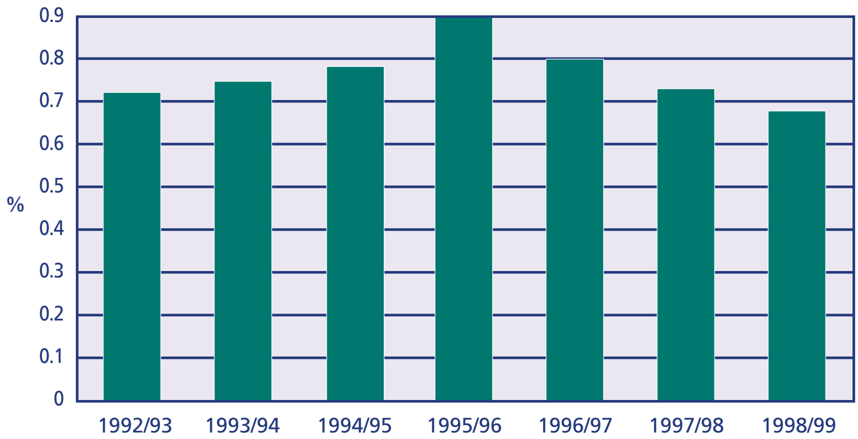
Source: OECD Science, Technology and Industry Outlook, 2000.

5) Private sector's innovative capacity

A key determinant of national innovative capacity is the level at which the private sector invests in research. With some notable exceptions, Australian business generally has a poor record of investing in research. Business investment in R&D as a percentage of gross domestic product is low relative to that in competitor industrial nations.

Figure 4.5

Business investment in R&D as a percentage of GDP



Source: Australian Bureau of Statistics, Catalogue 8104.0, July 2000.

Australian business currently invests around $4 billion in R&D per annum. Recent analysis by the Australian Bureau of Statistics (ABS) demonstrates that business investment in R&D in Australia declined by 5 per cent in 1997-98 compared to 1996-97 and that Australia has in fact been on a downward slide since 1995/96.[30] In stark contrast, business investment in R&D in other industrial nations has increased markedly.

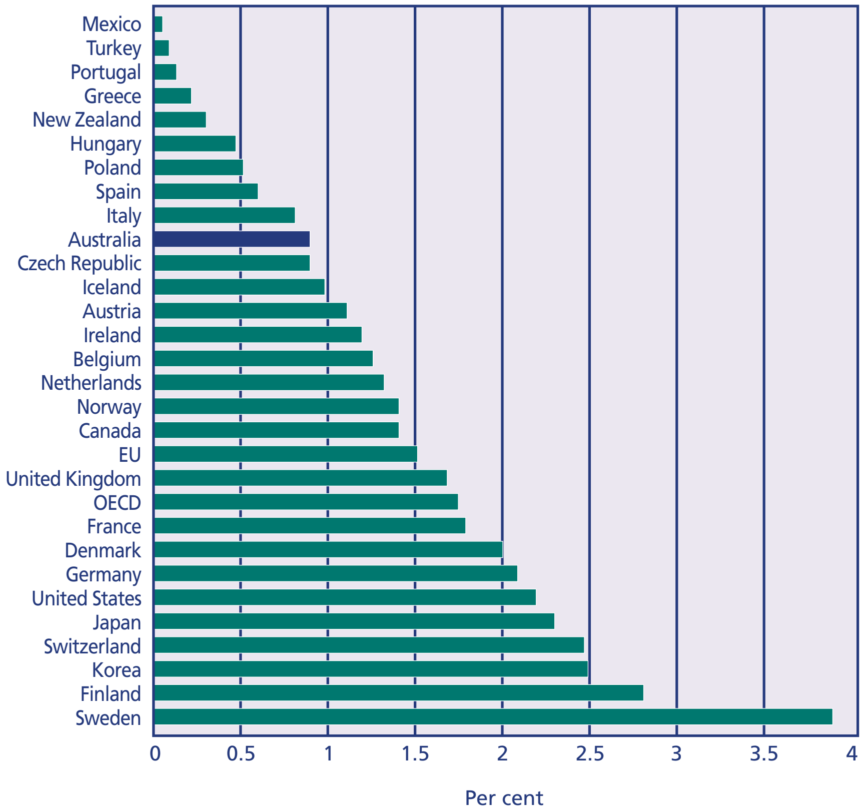
Business R&D intensity reflects the degree to which businesses use innovation as a primary source of increased competitive advantage. As stated earlier, the innovative capacity of a nation's private sector is a critical component of a national innovation system.

[30] ABS Catalogue No. 8112.0, 2000.

The relatively small number of innovative firms in Australia's industrial and business sector is consistent with its position of 19th among OECD countries. This weakness is reducing the uptake of public research, its effective translation into new or improved products and processes, and ultimately, Australia's performance in the knowledge economy.

Figure 4.6

Intensity of business R&D in domestic product of industry, 1997 or latest available year



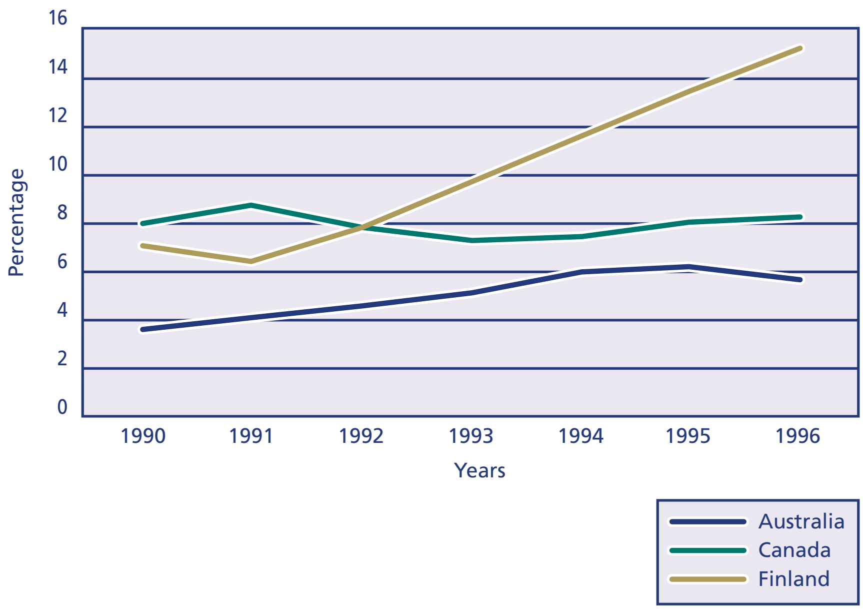
Source: OECD, *The Knowledge-Based Economy: A Set of Facts and Figures*, Meeting of the Committee for Scientific and Technological Policy, 22-23 June, 2000, p.13.

6) High-tech exports as a percentage of merchandise exports

It is interesting to compare Australia's high-tech exports with those of Canada and Finland, as these countries have a historical base in 'old' economy, commodity-based exports. Australia's high-tech exports as a share of merchandise exports grew from a low base, by over 2 per cent between 1990-95 to reach 6 per cent; this growth dipped in 1995-96. Canada's high-tech exports have fluctuated around 8 per cent of merchandise exports. Finland, on the other hand, experienced spectacular growth from 6 per cent in 1991 to about 15 per cent in 1996.

Figure 4.7

High-tech exports as a percentage of merchandise exports in Australia, Canada and Finland



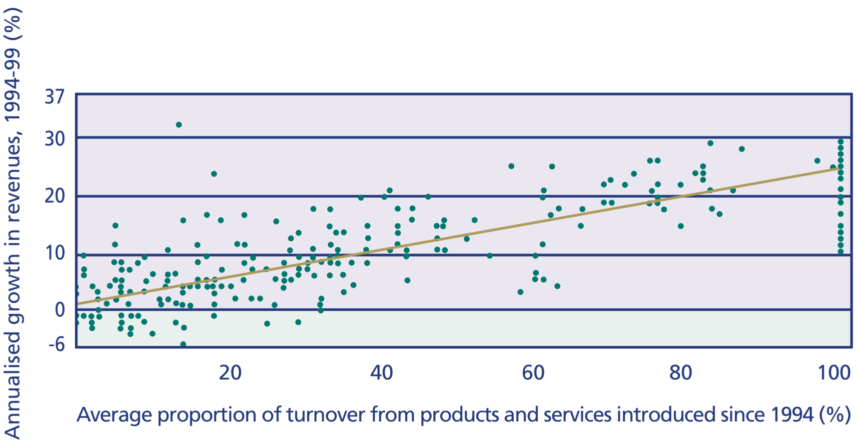
Source: OECD *Main Industrial Indicators 1999*, and *United Nations and the International Trade Statistics Yearbook*, Volume 1, 1997.

7) Product and process turnover and growth in Australian firms

PricewaterhouseCoopers examined the relationship between business growth and innovation by the comparison of annual growth in Australian business revenue between 1994-99, with the turnover of new products and services introduced since 1994. The result shows a positive relationship, meaning that innovative Australian firms are more likely to experience annual revenue growth.

Figure 4.8

Link between growth and innovation



Source: PricewaterhouseCoopers.

8) Investment in intangible capital – market-to-book ratio and market size of Australian firms

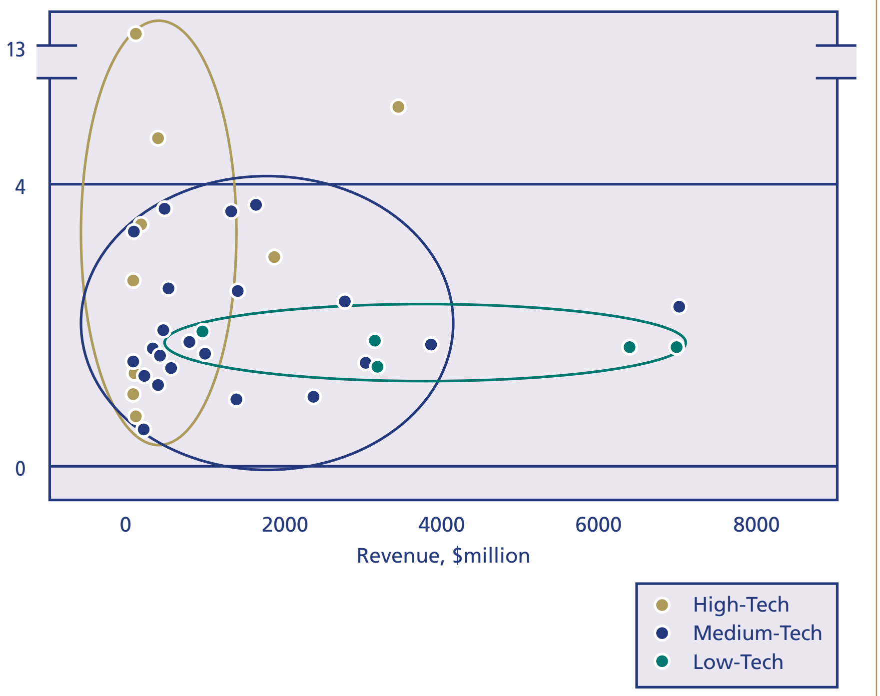
A key characteristic of the knowledge economy is the central role played by knowledge. This is reflected in the value that markets place on companies that capitalise on knowledge and other forms of intangible capital.

Studies on the valuation of high-tech, knowledge-based companies have highlighted the growing gap between their book-value and market capitalisation. This type of valuation is increasingly promoted by financial markets and is related to the recognition of a positive relationship between a business' innovative capacity and its potential market growth.

The Australian companies represented in Figure 4.9 are classified according to the technology intensity of their industries, as defined by the OECD (1997). This figure demonstrates that knowledge-intensive goods and services tend to be higher value added, than those that are not. That is, companies in low-tech industries have relatively low market valuations, in spite of very large revenues. Even though high tech companies' revenue streams are lower, their market values tend to be much higher. Companies in medium-tech industries occupy a middle ground in terms of valuations.

Figure 4.9

Market to book ratio and market size of Australian firms – 1998



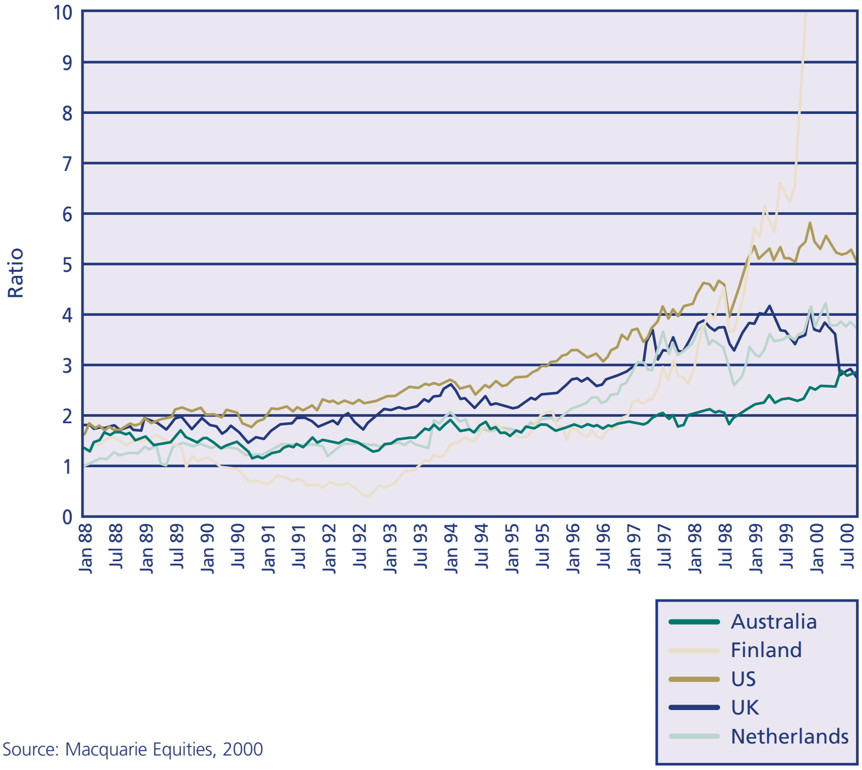
Source: Department of Industry, Science and Resources, 2000.

The increasing importance of intangible capital, as demonstrated by the comparison of market capitalisation with book price, is even more apparent when an analysis includes countries that do not attract the 'old economy' tag. Finland, for example, demonstrates high market capitalisation based on intangible capital.

Figure 4.10 demonstrates the growing importance of intangible capital, particularly in the 1990s. It also shows Australian accumulation of intangible capital building from a low base and at a rate significantly slower than for competitor economies.

Figure 4.10

Price to Book Ratio - International Comparison



Source: Macquarie Equities, 2000

9) Evaluation of patenting

Patents can reveal a great deal of information about a nation and/or its constituents' innovative capacity and performance in the knowledge economy. The recent Narin study of Australian-invented US patents combined various methods of patent analysis to assess the performance of Australia's SET base and highlighted Australia's contribution to technological development.[31]

In broad terms, the analysis highlights the major role played by public science in the support of the strongest areas of Australia's technology. However, notable conclusions are:

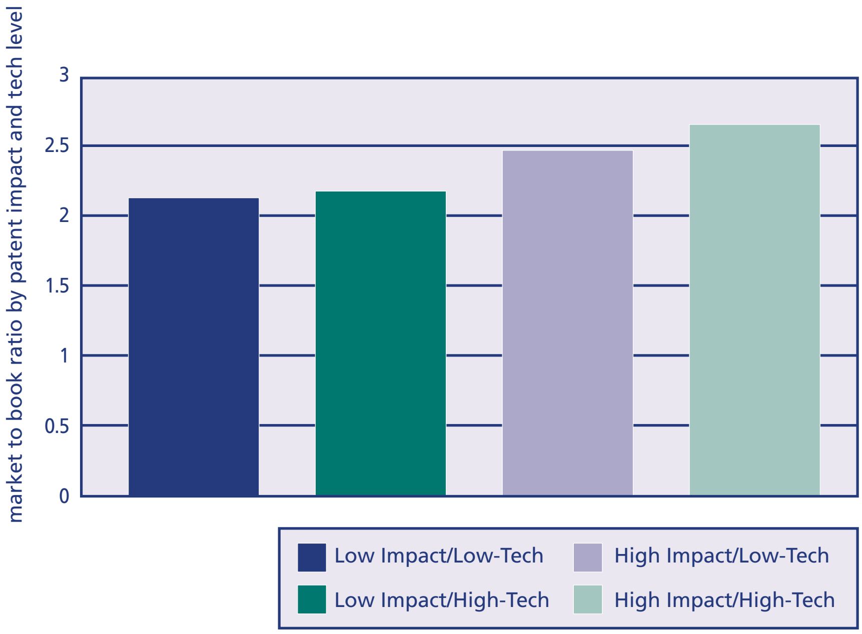
- *Australia should have 548 patents more than it does when its patent activities are adjusted in relation to GDP. This represents a 40 per cent deficit to average performance by the rest of the world;*
- *Older, less science linked areas of technology dominate the scene; and*
- *Australian science is not sufficiently visible to the rest of the world.*

[31] Narin F, Albert M, Kroll P, Hicks D, *Inventing Our Future - The link between Australian patenting and basic science*, AusInfo, Canberra, 2000.

The analysis also underlined the considerable return on investment that may be delivered from investment in innovative activities. Australian companies with highly cited, science-linked patents were characterised by 25 per cent higher market-to-book valuations. Furthermore, such high valuations were sustained for up to three years.

Figure 4.11

Median market-to-book ratios of portfolios



Countries with dynamic knowledge economies are increasingly dependent upon linkages between their public SET base and knowledge-based, highly innovative companies. The Narin analysis drew upon previous research that has shown:

- a strong increase in citations in US patents to scientific research over the past two decades;
- research published in leading international journals had over nine times the chance of being cited in patents than research published in lesser journals. Clearly, excellence measured by peer review is important; and
- that there is a very strong link in patent-to-paper citation.

These findings have been widely accepted as evidence of the critical role that publicly sponsored basic research plays in the development of leading-edge technologies such as pharmaceuticals, chemicals, advanced electronics and, especially biotechnology.[33] Further, the findings emphasise that public expenditure is most effective when directed towards R&D that is peer reviewed as excellent.

"the intangible value of quality technology may become tangible after all, at least in the capital markets."[32]

[32] *Ibid*, p. 23.

[33] *Ibid*, p.11.

Summary

The summation of these indicators of Australia's current innovative capacity point to the fragility of Australia's innovation system and highlight inadequacies in Australia's SET base to support a transition to a knowledge economy. Investment in innovation serves an additional and important role in small economies like Australia, because it facilitates international technology transfer.[34] This is vital for small economies, because, by their nature, they cannot be active across the entire globalised knowledge base. Therefore, in order to effectively compete in the global economy, small economies need to leverage returns from R&D conducted abroad.

> *Only by continually producing new innovation and thus sustaining a 'technology gap' [can] a country maintain a comparative advantage in new products over time.*[35]

In addition, Australia needs to dramatically boost the innovative performance of its private sector and, in particular, increase the creation of new businesses. In a knowledge economy, a company's competitive advantage lies in continuous, effective innovation for the constant delivery of new or improved products and services. Simply being a fast follower in this environment will not be competitive for Australia in the long-term.

4.4 Country Comparisons

The following section puts Australia's performance in the knowledge economy into an international perspective by examining the initiatives and consequential structural transformations under way in a number of OECD and Asian countries. By and large, our competitors and economic partners are adopting different combinations of integrated measures to strengthen their capacity to innovate. Although the pace of progress across these countries fluctuates, they are constant in their drive towards knowledge-based economies. Four indicators highlight this trend:

1) a shift of dominant economic activities among sectors of the economy;
2) a changing pattern of investment – increased emphasis on intangible knowledge-based activities;
3) a general 'upskilling' of the workforce; and
4) export growth in high technology products.

Awareness of the importance of the knowledge economy and its link to domestic innovative capacity took off during the late 1990s, as evidenced by:

- Many Asian economies maintaining growth in public investment in R&D despite the Asian economic crisis.

[34] Griffith R, Redding S and van Reenen J (1998) *Productivity Growth in OECD Industries: Identifying the Role of R&D, Skills and Trade*, London, Institute of Fiscal Studies (mimeo).

[35] Posner in Freeman C. and Soete L., *The Economics of Industrial Innovation 3rd Edition*, Pinter, London & Washington, page 339, 1997.

- Additional funding for public R&D ahead of competing budget priorities in countries including the United States, Japan, Germany, UK, Canada, Singapore, South Korea and other Asian economies.

The following case studies observe the broad policy choices that other countries with strong economies and sophisticated workforces are making, especially where the drivers for these choices are similar to Australia's. Countries are adopting different approaches to dealing with the rapidly changing knowledge-based environment, in accordance with their political and economic systems, societal needs and expectations, and the historical development of their SET base.

The case studies also identify the clear signals our industrialised competitors are sending with respect to the vital role of the SET bases in creating opportunities for economic growth. All these nations accept that knowledge and its application is the driving force behind economic performance and that there is *an important facilitation role for government*.

United States – Continuing at the Leading Edge of Learning and Discovery

Since World War II, the United States has maintained a position of world leadership in basic research and is continuing to support increases in R&D expenditure as a means of ensuring the continued prosperity of the nation. Recent initiatives include:

- Doubling of funds over 5 years for the National Institutes of Health (NIH), the major source of government health and medical research funds, over 5 years.
- A 25 per cent increase in postdoctoral salaries in recognition of increased global competition for skilled researchers.

Under plans for 2001 Budget bid (not yet law) include:

- Across-the-board increases for the entire breadth of R&D programs in the federal portfolio -public R&D investment totals US$91.0 billion in FY 2001, an increase of 9.2 per cent. Almost all the increases passed by Congress exceed the President's initial request.
- US$42.9 billion for the President's 21st Century Research Fund for 'world leadership' in science and technology (exceeded by Congress). This is a US$2.9 billion or 7 per cent increase over current year funding and represents a 45 per cent increase since 1993.
- Federally funded university R&D to rise US$1.3 billion or by 8 per cent for R&D performed in the tertiary sector. This represents a 53 per cent increase since 1993.
- US$4.4 billion or 14 per cent funding increase for the National Science Foundation. This represents the largest dollar increase in the NSF's history. Congressional supporters of the NSF plan to double funding for the NSF over five years.

The 21st Century Research Fund represents the basic science half of US Federal R&D activities. It addresses three national priorities including:

- Creative efforts that maintain US leadership in science and technology.
- The innovation stream that ensures continued national prosperity in the 21st Century.
- Restoring the balance between biomedical research and the rest of the United States R&D portfolio.

United Kingdom – Reinvigorating the Science System

There has been an increasing recognition by the UK government of the need to invest in education, skills and infrastructure, in the context of reinvigorating its innovative capacity. The government's position was highlighted in the 1998 White Paper, *Our Competitive Future: Building the Knowledge Driven Economy*. Investments in the SET base for 1999-2001 were announced in the paper and include:

- £1,107 million additional funding.
- £400 million from the Wellcome Trust for research infrastructure and research grants in priority areas over three years 1999-2001.

The Prime Minister's announcement endorsed additional funding for public investment in knowledge generation at universities.[37]

The 2000 Science and Innovation White Paper, *Excellence and Opportunity - a science and innovation policy for the 21st century*, announced:

- Additional £1 billion in 2002-2003 and 2003-2004 for SET base infrastructure in partnership with the Wellcome Trust of which £675 million is for university-based infrastructure and allocated on the basis of excellence and research income
- Universities to provide 25 per cent of funds for infrastructure projects according to their independent investment priorities.

White Paper initiatives to enable close links between private research investment and public sector R&D:

- Higher Education Innovation Fund, £140 million over 3 years, to assist commercialisation of university based research and enhance the productivity and competitiveness of SMEs.
- Additional funding for the Science Enterprise Challenge Scheme, which aims to create up to 8 new Enterprise Centres based at universities to facilitate commercialisation.
- Additional funding for the University Challenge Competition, that provides seed-funding for university based commercialisation.

"Science is a major priority for the government and a key driver for both wealth creation and employment in this country and overseas. It is an essential component in improving the quality of life in the UK."[36]

[36] Lord Sainsbury, Minister for Science in the UK, June 1999.

[37] Business Higher Education Round Table, *The Case for Additional Investment in Basic Research in Australia - A Policy Statement*, April 1999, p.5.

The UK also provides a 150 per cent R&D tax concession (or cash) for SMEs. This targeted tax cut is expected to underwrite almost one third of R&D costs for small business.

Canada – Transition from Commodity Exports to High Technology Industry

Canada is experiencing shortages of professional scientists in fields ranging from ICT and computer science to health and biotechnology.[38] In response, Canada has undertaken specific initiatives to boost its SET capabilities and stop the ongoing movement of investment and people from Canada to the United States, in particular.

The increased investment in the SET base is partly being directed towards creating incentives to retain highly trained younger Canadians in employment within Canadian research institutions, government and business.[39]

Canada is making the transition from its traditional reliance on a commodity-based economy to an innovative knowledge-based economy.

The Canadian government has introduced:

- An infrastructure fund, CA $1.9 billion for universities, hospitals and other institutions
- Two thousand new Research Chairs, CA $900 million[40]
- An R&D tax credit scheme, CA $1 billion per annum.

The Networks of Centres of Excellence program, CA $77 million per annum, is an important initiative as it aims to develop closer linkages within the SET base and participants including:

- 463 companies
- 61 universities
- 44 hospitals
- over 100 government agencies.

Linkage development programs are further enhanced by excellent ICT infrastructure – the most advanced, high speed coast-to-coast optical network in the world (CA*Net 3). Canada ranks second in global Internet use and was the first country to connect all of its public schools and libraries to the Internet.

[38] Quoted in Business Higher Education Round Table, *The Case for Additional Investment in Basic Research in Australia - A Policy Statement*, April 1999, p.7 from "Expanding Canada's Knowledge Base", Nature, Volume 397, 11 February 1999, p.543.

[39] Business Higher Education Round Table, *The Case for Additional Investment in Basic Research in Australia - A Policy Statement*, April 1999, p.7

[40] 35 % of these Chairs will be allocated to the fields of inquiry funded by the newly-created Canadian Institutes of Health Research (CIHR) (formerly the Medical Research Council), 45 % to the fields funded by the Natural Sciences and Engineering Research Council (NSERC) and 20 % to the Social Sciences and Humanities Research (SSHRC) Council.

Funding for the 3 research granting councils has been increased by CA $600 million, in particular:

- Health and medical research doubled to CA $484 million over 4 years to 2000/01; and
- Non-medical research councils increased to CA $400 million.

The Economic Statement and Budget update on 18 October 2000, included additional funding for the Canadian Foundation for Innovation (CFI):

- CA $250 million, for infrastructure awards to Canada Research Chairs, with no matching funding requirement for Chairs at smaller universities;
- CA $400 million, for operating costs incurred at public research facilities – tertiary institutions and hospitals; and
- CA $100 million, for participation in international research projects.

The Canadian government is also funding research centres with particular technology focuses, to create niche industries and enhance the competitiveness of existing industries, such as the new Advanced Aluminium Technology Centre.

"In the past two years, the Government has pursued an ambitious agenda to improve its support for advanced research in Canada. To build on this agenda, the Government will increase its support to the Granting Councils, enabling them to forge new partnerships with our universities to attract the best research minds in the world..."[41]

Japan – A New Commitment to Public Investment in Knowledge

Japan is an interesting case study as it demonstrates the mistake of a nation neglecting its own knowledge base and relying on the exploitation of imported knowledge. Although Japan's strategy to exploit imported knowledge was extremely successful during the 1970-80s, it proved to be unsustainable in the long-term. Japan now recognises that the dominance of the United States in the knowledge economy is related to its long-term commitment to basic research.

Japan's response to its situation includes:

- Enactment of the Science and Technology Basic Law;
- The 1996 Science and Technology Plan doubling investment in basic research between 1996 and 2000;
- Total government investment in R&D in this period is a projected US$155 billion; and
- The 1999 budget confirms that the planned increased investment is on track, despite considerable difficulties experienced in recent years by the Japanese economy.[42]

[41] Speech from the throne to open the Second Session of the Thirty-Sixth Parliament of Canada.

[42] "Japanese Budget Boosts Science Funding", *Nature*, volume 397, 7 January 1999, p.5.

"We have always invested in knowledge and skills and we will continue to do so—after all, apart from forests, we have hardly any other natural resources on which to base our industrial and commercial activities. We believe this is Finland's way to success also in the global marketplace of the future. Naturally, all this requires an efficient and comprehensive general education system." [43]

Finland – The Innovative Society

Finland's government considers a strong knowledge base to be central to economic growth, employment and social welfare and a basis for income and intellectual growth.[44] It appears that this has become part of Finland's culture as both public and private R&D expenditure have been growing since 1985.

Finland's strengths lie in high technology capabilities, high quality communications and information technology infrastructure, internationally competitive business taxation rates and a highly educated population. Finnish economic success flows from a concerted effort to invest in development of their national innovation system, with an emphasis on R&D.

- As a proportion of GDP, expenditure on R&D has risen from approximately 1.5 per cent in 1985, to 3.1 per cent of GDP in 1999.[45] This equates to EUR 3.7 billion.
- 70 per cent or EUR 2.6 billion of Finland's total R&D was invested by the private sector.
- Since 1990, exports of high technology products have grown from EUR 1 billion to EUR 8 billion and by 1999 high technology products represented 21 per cent of all exported goods.

The National Technology Agency (TEKES) is the government's R&D funding body targeting business development. In 1999:

- Funding was increased from EUR 360 million per annum to EUR 400 million.
- These funds were invested in over 2400 research and development projects with a total value of EUR 1 billion.
- Nearly half of TEKES' direct funding goes to projects in SMEs.

The Finland Academy of Science, a granting body equivalent to the ARC and NHMRC plus Learned Academy activities, will receive a significant increase in funding in 2001.[46]

[43] Mr Erkki Tuomioja, Minister of Trade and Industry, Finland, 1999

[44] Science and Technology Policy Council of Finland, *Finland - A Knowledge-based Society*, Helsinki, 1999

[45] Business Higher Education Round Table, *The Case for Additional Investment in Basic Research in Australia - A Policy Statement*, April 1999, p.7.

[46] Chief Scientist discussions with the President of the Academy of Finland, Professor Vihko, October 2000.

Ireland – Dynamic Economy Based on Communications and Information Technology Exports

Ireland's recent economic success has largely involved replacing traditional manufacturing industries with rapidly growing ICT export industries, based on a highly competitive tax regime and a strong education system which produces highly adaptable people with good training in science and technology.

Recent investment in the Irish SET base included:

- IR£1.95 billion for research, technology and innovation activities from 2000-2006 of which £560 million is directed to a Foresight Program aimed at creating niches of leading research capabilities in the ICT and biotechnology industries.

The Foresight Program requires a strong partnership between industry, tertiary colleges, research institutes and research funding bodies to achieve the objective of promoting Ireland as an attractive location for R&D.

Ireland has recently become the world's leading software exporter:

- the software industry employs approximately 24,000 people; and
- software industry participants are multinational companies and over 600 Irish software start-ups are working in business, banking and finance, niche product development, telecommunications software and Internet products and services.

Singapore – A Leading Economy in Knowledge-Based Technology, Infrastructure and Business

Singapore is consistently ranked first or second in the world in terms of international competitiveness by the World Economic Forum and the World Competitiveness Scoreboard for the Institute for Management Developments.[47] This is based upon a range of factors including science, technology and infrastructure.

Leading most OECD countries, Singapore has over 60 research scientists and engineers for every 10,000 people in the work force.[48]

Underpinning Singapore's achievements is its commitment to public investment in science and technology. In 2000, such investment includes:

- Funding under the S$4 billion second five year National Science and Technology Plan. A new S$7 billion five year plan commences in 2001; and

[47] World Competitiveness Online: The World Competitiveness Scoreboard, 1998 as at www.imd.ch/wey/wey_online.html

[48] Summarised from information provided at the Singapore National Science and Technology Board website(http://www.nstb.gov.ag, February 1999) and quoted in the Business Higher Education Round Table, *The Case for Additional Investment in Basic Research in Australia - A Policy Statement*, April 1999, p.6.

- Plans to build a S$5 billion Science Hub, consisting of 2 science parks in a 176 hectare facility. The completed Science Hub will house over 200 high technology companies and renowned institutions, such as the Johns Hopkins University.

Strategic investment in world class research infrastructure to serve academic and industry needs include plans for:

- A second major national high performance computing and communications facility; and
- A new synchrotron light source.[49]

China – Enhancing the Higher Education System

China has undertaken extensive reforms over the past decade to improve its science and technology system. In 1999, the government announced a *'Decision on Encouraging Technological Innovation, Developing High-Technology and Realising Commercialisation of New Technologies'*. Under these policy guidelines, ministry-owned research institutes have become more market oriented and active in the commercialisation of their research.

Particular reforms to universities include:

- Introduction of the Chang-Kieng Scholar Award program in 1998, designed to attract top level researchers and academics, enhance the academic status of tertiary education institutions, and boost higher education;
- 300- 500 new professor positions in key disciplinary areas, to be established by the Ministry of Education in around 60 participating higher education institutions over the next 3-5 years. A wide range of disciplines is covered including mathematics, physics, biochemistry, computer science, optics, palaeontology and stratigraphy, aircraft design, genetics and plant breeding; and
- The establishment of a committee of internationally acknowledged scholars to assess the applications for the new professor positions and the Chang-Kieng Scholar Achievement Award.[50]

[49] Business Higher Education Round Table, The Case for Additional Investment in Basic Research in Australia - A Policy Statement, April 1999, p.6.

[50] www.chinaembassy.org.au/education

Chapter five

Chapter five

Investing in People and Innovation Culture

5.1 Introduction

Numerous OECD reports on investment patterns and discussions of national innovation systems all converge on the simple proposition: a knowledge based economy requires a supportive, innovative culture, a culture in which entrepreneurship and enterprise are taught at all levels (primary through to postgraduate) and are appreciated and applied widely in the community. Our community must have a high awareness of science and an appreciation of the role of SET in deciding our options in life, in particular, how SET affects wealth generation, job creation, sustainable environments and provides solutions to social concerns.

Given that knowledge is doubling so rapidly, especially our base of scientific knowledge, there is a driving imperative for science awareness and literacy to be taken very seriously. This, of course, means that as strategy of lifelong learning must be added to the key areas of science in schools, SET teaching and learning, and science awareness.

Strategy

Lifelong learning must become a key strategy for education providers and employees

5.2 Science in Schools

It is important to have a strong base for SET education at a school level, for it is here that interest in science, engineering and technology is first sparked and nurtured. Australia needs to provide advanced science education so that all our children have the opportunity to better understand the rapidly changing world around them and have the option to pursue a career in science, engineering or technology. Australia's success as a knowledge economy is dependent on a highly skilled, informed and scientifically literate workforce who receive a strong foundation of SET knowledge throughout their primary and secondary schooling.

Mathematics, science and technology comprise three of the eight agreed key learning areas of the school curriculum. In the 1999 Adelaide Declaration of National Goals for Schooling in the 21st Century, the Commonwealth, State and Territory Ministers for Education agreed that students should attain high standards of knowledge, skills and understanding through a comprehensive and balanced curriculum in the compulsory years of schooling across these areas, as well as an understanding of the interrelationships between these subjects. The Review notes that the Minister for Education, Training and Youth Affairs has commissioned two reports on the quality of teaching and learning of science and technology in Australia's schools. These reports are likely to be valuable in informing government on future policy directions in these important areas.

5.3 School Enrolments

The Review is concerned at the number of children losing interest in science and mathematics, as demonstrated by falling enrolments in science and mathematics in the senior years at secondary school, particularly in the specialist mathematics which are so much needed for wider career choices.

While total Year 12 enrolments have nearly doubled in the period 1980 to 1998, enrolment growth in most mathematics and science subjects has been much less marked.[51]

Strategy

Inspire students to study SET-based subjects

Despite an overall increase in mathematics and science enrolments over the period from 1986 to 1998, the number of enrolments has been decreasing since 1992.[52] This decline has been felt hardest in subjects such as geology, physics and chemistry. Approximately 22 per cent of students who commenced university study in 1998 chose a science course (including information technology) and 10.5 per cent enrolled in engineering.[53] This compares to 28.1 per cent studying Arts and 23.1 per cent studying business. International comparisons in this area are difficult to make but broad comparisons can be made in the enabling sciences. Finland, for example, produces twice as many mathematics graduates as Australia, as a proportion of total graduates, and over three times as many physical sciences graduates.[54]

Students need to be encouraged from an early age to consider careers in science, technology or engineering, including teaching. They are, of course, more likely to do so if they have reasonable expectations of ultimately receiving tangible rewards such as prestige and salaries commensurate with other professional fields. Paradoxically, science is currently viewed as being for the elite, but is relatively lowly paid.

5.4 SET Teaching and Learning

One way of arresting the decline in enrolments is to increase the skills and job satisfaction of those teachers who possess these highly valuable skills required for the knowledge-based economy.

Excellent teachers are the key to exciting and sustaining interest in science in schools.

Submissions to the Review indicate that the supply of suitably qualified teachers is insufficient and that science teachers are dissatisfied with the profession in terms of its status and rewards. This needs urgent attention and although the

[51] Report commissioned by DETYA - not yet completed.

[52] Australian Council of Deans of Science, *Trends in Science Education: Learning Teaching and Outcomes 1989-1997*.

[53] Curriculum Corporation, 1998, *Annual National Report on Schooling*.

[54] OECD Education database, 1998.

Commonwealth is currently awaiting reports on the status and quality of teaching and learning of science and technology in schools, it should be noted, that the principal constitutional responsibility for schooling and the employment of teachers rests with the States and Territories.

Strategy

Reward excellent SET teachers

The Review is concerned about the less than satisfactory level of skills and knowledge possessed by science teachers. The Review notes that while one of the priorities of the Commonwealth's Quality Teacher program is the renewal of teacher skills and understanding in science, it believes that more work needs to be carried out in this area. This could include teacher placements in industry and increased interactions between professionals in the knowledge economy and schools. It is vital that teachers are given widespread opportunities for their professional development, to ensure that their skills and understanding of the application of science in the broader community are up to date and at international levels.

Strategy

Specialist intensive training for teachers

Teacher education practices should be crafted to ensure that SET students gain the knowledge and skills required to best prepare them for careers in research. It is likely that a current SPIRT project involving the Australian Science Teachers' Association in the development of performance standards of science teachers will provide some direction on this issue.

School curricula need to make science more exciting and be designed to foster creative, innovative approaches to problem solving. There may be a role here for appropriate professional organisations[55] to explore new ways of making science and engineering subjects more appealing and perhaps investigate improved teaching methods for complex subjects. Alliances with industry and researchers from universities can demonstrate the real applications of science and technology to students and teachers. Such contact can provide students with valuable insights into SET careers. This coordinated effort can become a key element of the seamless innovation system

Information technology will certainly play a bigger role in developing new and engaging curricular material. It has already been shown to have positive impacts on student motivation and opportunities for communication and collaboration outside the classroom.

[55] such as the ARC, the Australian Science Teachers' Association, the Australian Council of Deans of Science, the Australian Council of Engineering Deans and GFRAs

5.5 University Students

University enrolments in mathematics and physical sciences, including physics, chemistry and geology, have declined over the past decade despite an overall increase in enrolments in the sciences, engineering and technology fields generally. Since 1996, growth in computer science and information systems has increased significantly, while engineering and life sciences have enjoyed steady increases over this time period.[56]

Despite a steady increase in the number of students graduating with a science or engineering degree since 1993 this number represents less than 20 per cent of the total number of university graduates - approximately 14 per cent in the sciences and 6 per cent per cent in engineering.[57] In 1998 the profile of bachelor degrees awarded was:

- Science - 17 000
- Engineering - 6500
- Health science - 14 000
- Business administration and economics - 27 000
- Arts and humanities - 25 000[58]

The picture for first degrees is worrying. The number of young people graduating in science, engineering and technology is not increasing as fast as the total number of graduates and there is a distinct fall in the number of students of mathematics, physics and chemistry. Furthermore, the HECS[59] rate for science studies at tertiary institutions is currently higher than that for many social sciences and humanities subjects. Education is in the lowest band for HECS. The relatively higher rate of HECS for science students may be a further disincentive to a career in science teaching.

Unless appropriate action is taken, Australia runs the risk of not being able to provide emerging industries like bioinformatics and nanotechnology with the required human capital. The Review notes submissions that identify a current shortage of people with skills, particularly mathematics, required by the information technology industry. We also run the risk of effectively disabling the public's ability to understand the implications of scientific activity and to contribute to increasingly important debates about the direction of science and its impact on societal goals. Companies fear that the overall technological competence of the Australian workforce will not be adequate to take advantage of new technologies. Moreover, a scientifically informed and technically skilled workforce creates a demanding customer base. Well-educated Australians, through exercising their choice as consumers, focus commercialisation activities on producing cutting edge products and processes.

[56] DETYA statistics

[57] DETYA Selected Higher Education Student Statistics, 1999

[58] *Ibid.* Note, "bachelor degree" includes bachelor with Honours.

[59] Higher Education Contribution Scheme

To improve the number of enabling science graduates and to create a new generation of committed science and mathematics teachers, 500 HECS scholarships should be created for the enabling sciences of mathematics, chemistry and physics, as well as combined enabling science/education degrees. These scholarships should be available until numbers of students graduating from tertiary institutions are boosted sufficiently to support industry and teaching needs. The Review notes that ISIG has also recognised the shortage of graduates with appropriate skills for a knowledge-based economy and recommends (Recommendation 6) the creation of places in universities in these areas.

1 Major Recommendation

Provide 200 HECS scholarships for students undertaking combined science/education qualifications and 300 for students of the enabling sciences – mathematics/physics/chemistry.

Investment: $26.4 million over five years

The impending shortage of teachers can also be addressed in other ways. Graduate scientists, engineers and technologists who are already in the workforce might be attracted to take on a new career in teaching. Incentives (such as taxation relief and HECS exemption) would be appropriate while they undertook the necessary training, for example, a Diploma of Education.

Strategy

Opportunities for SET graduates already in the workforce to enter the teaching system

5.6 Attracting and retaining the best researchers

Australia needs skilled people in research institutions in order to facilitate its participation in the global SET arena. There are currently areas of concern in terms of the people element of Australia's science capability.

5.6.1 Postdoctoral Fellowships

Many of our brightest researchers are pursuing their careers outside the country, as other locations, especially the United States, provide more attractive research environments. As pointed out by the Wills Report[60], if this trend continues, it will jeopardise Australia's innovative capacity with adverse consequences for the generation of new business opportunities based on commercialising research outcomes.

There is currently little to attract bright students to a career in Australia in research and innovation.

[60] Commonwealth Department of Health and Aged Care, *The Virtuous Cycle - Working together for health and medical research, Health and Medical Research Strategic Review*, 1999, "The Wills Report".

Postdoctoral research represents the first step in a research career for graduates and is an important means of nurturing the next generation of Australian researchers. Opportunities for postdoctoral research, particularly those funded through programs referred to the ARC, have declined relative to the numbers of students completing postgraduate research degrees. This year, for example, the ARC offered 55 new postdoctoral fellowships and this falls well short of international standards. For example, the National Science and Engineering Research Council in Canada, one of three granting research councils, offered over 450 postdoctoral fellowships in 1997-98.

Table 5.1 shows that the number of Australian and overseas (including expatriate Australians) applicants for ARC fellowships has declined. There is also evidence of a rejection rate in the order of 25 per cent for successful applicants from overseas. This may be due to the level of financial support offered. The ARC has argued that their fellowships are no longer competitive by either national or international standards, as salaries fall approximately 9 per cent below average Australian academic salaries.

Table 5.1

Australian and overseas applicants for ARC fellowships[61]

Year of application	Number of application	Number of awards	Overall Success Rate	Aust applicants	Australian applicants (%)	Success Australian applicants	Success rate of Aust applicants	Austs who rejected a Fellowship	Overseas Applicants	Overseas applicants (%)	Success Overseas applicants	Success rate of Overseas applicants	Overseas applicants who rejected a Fellowship
1997	851	102	12.0%	649	76.3%	82	12.6%	6	202	23.7%	20	9.9%	5
1998	742	102	13.7%	609	82.1%	85	14.0%	10	133	17.9%	17	12.8%	4
1999	687	100	14.6%	548	79.8%	86	15.7%	2	139	20.2%	14	10.1%	3
2000	701	100	14.3%	575	82.0%				126	18.0%			

Source: ARC analysis of internal data, 2000

We are neither nationally nor internationally competitive in attracting and retaining high quality researchers in Australia.

[61] ACR Fellowships include Australian Postdoctoral Fellowships, Australian Research Fellowships, QEII and Senior Research Fellowships

There is a case for additional funding to be provided to support the creation of more, better-funded, research places tenable in universities, research agencies and internationally recognised institutes. Initial funding would be over five years. This will ensure that Australia will have a strong base from which to draw its future research workforce.

2 Major Recommendation

Increase the number of Australian postdoctoral fellowships - doubling would be appropriate. These would be tenable at universities, GFRAs and at internationally recognised institutes.

Investment: $38.6 million

5.6.2 Federation Industry Chairs

Regaining and attracting brilliant researchers must be a priority for Australia. Career paths in Australia for researchers are becoming increasingly uncompetitive by international standards. A combination of reduced funding for infrastructure and a lack of career paths has forced some bright Australian researchers overseas in search of more rewarding positions.

Federation Industry Chairs are viewed by this Review as a vehicle to provide career paths, stimulate link formation between universities and industry and to increase the potential for universities to develop commercially relevant research. These Chairs would be funded on a competitive basis for five years, and be based in universities or a research entity affiliated with the university. Selection of Chairs would be based on demonstration of a research project that would have a significant impact on the research field and potential for industry take-up. The successful candidates would be high quality researchers and the level of the package would reflect this. The program could be expanded with industry contributions and details could be worked out during implementation noting:

- Existing models of industry sponsorship of Chairs
- Industry institutions may well wish to sponsor infrastructure
- The potential for individual companies to form close links with universities.

3 Major Recommendation

That the Commonwealth Government fund the establishment of fifty Federation Industry Chairs in universities or a research entity affiliated with a university on a competitive basis for five years. The Chairs would be new places, funded at $300 000 per annum per Chair.

Investment: $75 million over five years

This modest number of Chairs would be a clear signal of intent, albeit small by comparison with the 2000 Chairs initiative in Canada.

5.6.3 R&D *Start* Graduate Scheme for SMEs

Much of Australian industry comprises SMEs. Surveys indicate that the majority of SMEs are not involved in technological innovation. Globalisation of trade, therefore, poses a great risk to these companies. By way of example, a recent Australian Bureau of Statistics survey showed that in the manufacturing industry, three quarters of firms are inactive in technological innovation. The remaining quarter employs two thirds of staff in the manufacturing sector and is responsible for three quarters of the turnover. Clearly, there is an imperative to encourage three quarters of firms to shift to the behaviour of the active quartile.

For some years, the UK government has run a scheme that provides a new graduate to a firm for a period of up to two years to work on a development project of strategic significance to the participating SME. Supervision is provided part-time from an appropriate local research institution. Over 70 percent of graduates participating in the scheme gain permanent employment with the host companies.

A scheme close to this is already in existence, viz the R&D *Start* Graduate Scheme, administered through AusIndustry[62] by the IR&D Board with funding of around $1 million per year. The scheme places around 10 graduates per year in industry with the aim of exposing them to commercialisation culture, to help raise awareness in business of the value in employing people with these specific qualifications and to build closer links with the university system. To date, industry take-up of the scheme has been low and awareness of the scheme is also low. A powerful case exists for substantially expanding this program to allow business to grasp the new and rapidly emerging opportunities that exist in a knowledge-based economy.

The Review notes that ISIG considered this issue and recommended (Recommendation 7) that the government undertake a review to develop a new program more attractive to graduates and business using the UK's Teaching Company Scheme as a model.

The Review recommends that the IR&D Board redesigns and expands the R&D *Start* Graduate Scheme to improve its attractiveness to industry and graduates, and markets it more vigorously.

4 Major Recommendation

Redesign and expand the R&D Start *Graduate Scheme to place SET graduates in SMEs.*

Investment: $50 million over five years

[61] Commonwealth Department of Industry, Science and Resources.

5.7 SET Awareness

Science has a direct impact on the whole community. A SET literate community is more able to understand scientific developments and is able to make better choices concerning society's goals. Science that is dependent on public funding cannot be conducted in isolation from the community. Science awareness is a critical lever in ensuring science meets society's goals.

Public confidence in the ability of the SET base to deliver returns on investment is an important indicator of the success of government policy. Despite the government's endeavours in increasing science awareness, the Review considers that substantial further efforts need to be made.

Some of this effort can come from recipients of public funding, who should be providing information to the public in plain English in relation to the outcomes they generate and, more importantly, how these outcomes are contributing to social and economic well-being. The need is such that these institutions and researchers should take a more active role in raising public awareness, visiting schools, other learning institutions and community groups.

"Science cannot be 'for society' unless society is 'for science'; but equally, society cannot be 'for science' unless science in turn is 'for society'."[63]

Strategy

Institutions and researchers take more of an active role in promoting SET awareness

Overall, greater transparency is needed regarding the operation of the SET base. The community should be more involved in important debates about the direction of scientific research and have real influence. The scientific community should be more accountable to those that provide investment in research, particularly government funded research. The CSIRO/Biotechnology Australia initiative on promoting informed debate on genetically-modified organisms is a good example of the type of initiatives that should be fostered. The community must have access to information that will enable it to participate in debates about scientific and economic progress that will impact on the way we live our lives. There is an important role for GFRAs in terms of being able to offer independent expert advice on matters of national concern—a new social contract between science and society must be created.

Strategy

A new social contract between science and society must be created

Leadership and initiative by government are needed to raise the importance and profile of science awareness. Activities with high public profile should be expanded. As a start, the Prime Minister's prize currently awarded for excellence

[63] Dr John Durant, Professor of Public Understanding of Science, Imperial College, London, 1999.

in science should be maintained. Further prizes for excellence in raising community awareness in science should also be created, to provide an additional incentive for scientists to communicate the value of the work they are doing.

There is an on-going role for government to bring science to the community through the initial set-up and on-going support for such initiatives as National Science Week, Science Now, and through support and encouragement to science centres, such as Questacon-The National Science and Technology Centre and museums.

Awareness and demonstration of relevance are responsibilities of all in the SET base. There is a role for students and recent graduates of SET to interact with students in schools.

Strategy

More communication between researchers and the public, including schools

Much more is needed here to create public confidence that matches the interest already shown in science and technology.

5 Major Recommendation

Consideration should be given to:

- *continuing the award of high profile prizes, such as the Prime Minister's Prize for Science while continuing to develop new ways of rewarding excellence in science;*
- *encouraging SET institutions to undertake greater roles in public awareness;*
- *requiring all grant applications and final reports to have plain English summaries;*
- *funding and encouraging researchers to communicate with the public—especially with local schools, institutions and non-government organisations. Direct contact is the best approach; and*
- *encouraging debate, with the government seeking and tabling the best scientific advice available on issues of community concern for public discussion;*
- *greater support for initiatives targeting science awareness such as National Science Week, Science Now and science centres such as Questacon-The National Science and Technology Centre and museums.*

Investment: $10 million over five years

Chapter six
Chapter six

Investing in Ideas: research and infrastructure

6.1 Introduction

While Australia is able to draw on the world stock of knowledge and research results, to succeed in the emerging global knowledge economy it is essential to have the capability to perform cutting-edge research. Such research is the key source of knowledge and new ideas that provide the essential ingredients for innovation both in terms of the creation of new businesses and to improve the competitiveness of existing businesses.

Managing our natural resources and the often fragile environment in a sustainable way requires the presence of a strong knowledge base resting upon first class research. Government has a special role to play because of the public good nature of much of this research

The Commonwealth Government is providing substantial support for research and research training which is vital to the quality and dynamism of the research base. Over $1 billion goes each year to support higher education research and research training. Over $4.5 billion is expected to be spent in 2000-01 for major science and innovation programs, such as granting agencies like the ARC and NHMRC, the GFRAs, including CSIRO, and joint government-industry schemes like the Rural Research and Development Corporations.

The Review has found that the SET base is showing increasing signs of strain, reflected in difficulties keeping increasingly expensive research infrastructure up to date and providing support for excellent research at levels comparable to those available in North America and other leading OECD countries. There are also concerns that we may be missing the boat in some of the emerging technologies. Unless a major and well-integrated effort is made to reinvigorate our SET base, there is a risk we will fall behind world leaders in research and not participate as fully or effectively as we might in the great research-based technological revolutions now under way.

Australia cannot be number one in every field, because of its size, but we can expect to have a real impact in a number of fields where we have built up our capabilities. These are well linked to special Australian challenges and our economic and business potential.

6.2 Research Priorities

The question of priority setting in scientific and technological research was addressed in detail by the immediate past Chief Scientist, Professor John Stocker, in his review *Priority Matters*, presented to the Minister for Science and Technology in 1997. The Stocker review broadly endorsed the current pluralistic system of scientific and technological research, where priorities are largely determined at the sectoral level, 'close to the action' rather than imposed by a central body.

"Wherever we turn in our daily lives, we constantly encounter reminders of the contributions of science and technology….For the most part, they could not have been foreseen decades earlier, when the research was being done, and would not have been available without vigilance and patience in R&D funding. The technologies we enjoy today - eg those dealing with information, global positioning, and biomedical advancement, to pick just three - are really the fruits of research seeds planted decades ago"[64]

[64] Dr Neal Lane, Assistant to the President of the United States of America for Science and Technology, from a speech at the Australian National Press Club, October 31, 2000.

A range of priority setting mechanisms exist at the sectoral level. CSIRO, for example, undertakes an extensive and rigorous priority setting exercise every three years based on an assessment framework that looks at:

(i) Return to Australia—

Attractiveness: Potential benefits and ability to capture them

Feasibility: R&D potential and R&D capacity

(ii) CSIRO's role and its investment strategy

The ARC, the NHMRC, the RDCs and the CRCs also have their own priority setting methodologies. Increasingly, there is a dialogue between the research funding and performing agencies about joint investment strategies and priority setting.

Australia's economy and SET base are small on a world scale. The nation must, therefore, ensure that its investment in the SET base and particularly in research, is made wisely and that resources are not wasted by spreading them too thinly. The principles of excellence, connectivity, collaboration and relevance should be 'front of mind' in priority setting and investment decisions.

The Review acknowledges that there is a legitimate need to develop an integrated priority setting mechanism across the whole of the Commonwealth Government R&D investment, to assist in both providing solutions to national problems and to maximise returns to the community. This is a difficult task in a SET system characterised by pluralism and diversity of funding sources. The following initiatives should be undertaken:

- The Prime Minister's Science, Engineering and Innovation Council (PMSEIC) should continue to consider the contribution of science, engineering and technology to issues of national importance.
- Building on the analysis of the SET system already undertaken as part of the *Science and Technology Budget Statement*[65], a report of Australia's pattern of investment in the SET base should be considered by PMSEIC on an annual basis. The PMSEIC discussion should encompass creating a more contestable funding environment that could assist in the setting of national priorities as well as targeting quality research outcomes.
- Identifying gaps in funding for emerging industries and changing societal needs to enable government to respond more quickly to matters of national interest. By way of example, if ICT is accepted as a priority area, PMSEIC may recommend that investments in CSIRO, the ARC, along with the selection process for CRC's and MRFs, be weighted towards the priority area, to match and complement any additional funds available. This would be more efficient than simply allocating new funds to a new scheme and not tapping into the complementary efforts in other agencies or utilising their separate internal priority setting processes based on *excellence* and *benefit* to the Australian community.

[65] Annual publication released by the Minister for Industry, Science and Resources.

Any system of priority setting for research must be publicly defensible. This will require that, to the greatest extent possible:

- there will be a transparent process to allow consideration of competing claims for priority;
- judgements of priority will be based on a clear demonstration of need or opportunity;
- ideally, there will be a consensus of expert judgement, amongst both research providers and users of research and stakeholder interests;
- judgements of priority will be evidence-based; and
- the selection process for individual projects would remain as it is now, primarily on excellence of the proposed research project.

6 Major Recommendation

A whole-of-government annual priority review process be established in PMSEIC, to assess outcomes of public investment in the SET base and to suggest areas of importance for further attention.

6.3 Encouraging Leading-Edge Research

As already noted, success in global competition requires real excellence in research and research training.

Research undertaken in Australia is well regarded internationally and, relative to its size, Australia performs well in: medical and biological science; atomic, molecular and chemical physics; astronomy; and astrophysics.[66] Across a range of other fields, Australia's share of the production of knowledge, as measured by its output of scientific publications, significantly exceeds its share of world trade.

6.3.1 The Australian Research Council

The Australian Research Council (ARC) provides support for high-quality research, principally in the higher education sector. The ARC supports research in all fields, except for clinical medicine and dentistry, which is the responsibility of the National Health and Medical Research Council (NHMRC). Following the recent review of health and medical research, the Commonwealth Government announced that funding would double for the NHMRC by 2004. This additional investment is justified by the quality of research performance in this field and by economic and social benefits.

Potential for economic and social returns exists across a broader spectrum of research. Research activities spanning traditional discipline boundaries are particularly important, for research in these areas may yield new processes for generating knowledge and applying it to good effect in modern industrial settings.

[66] Katz, JS, *Scale-Independent Indicators and Research Evaluation*, SPRU electronic working paper series, paper number 41, University of Sussex, 2000.

Within the context of a broad framework of reform for university research and training, the Commonwealth Government has recently put in place new arrangements for the ARC to award competitive grants to university researchers. The grants contribute towards the costs of research centres, fellowships, consumables, equipment and research assistance.

As shown in the following table (see Table 6.1), Commonwealth funding for such programs has stabilised in recent years following an earlier period of growth.

Table 6.1

Competitive research grants and infrastructure programs administered by ARC

1996	1997	1998	1999	2000	2001	2002
$m	$m	$m	$m	$m	$m	$m
$199.6	$216.5	$238.5	$231.1	$240.7	$239.2	$238.7

All outlays are expressed in constant terms, at 2000 cost levels

By contrast, a range of other countries, including the US, the UK, Japan, Singapore, South Korea, Canada, France, Germany and Finland, have recently announced significant increases in investment for similar public sector research programs. While in some cases these increases have merely reversed the impact of budget cuts made in the early-mid 1990s, in other cases the increases have been substantial. The US government, for example, increased funding by 7 per cent and 15 per cent for the NSF and NIH respectively in 1999. Congress has proposed a 14 per cent increase in funding of the National Science Foundation for 2000, taking its budget to US$4.4 billion.

Reflecting budgetary constraints and the keen competition for available funds, both the 20 per cent success rate of applicants for ARC large grants and the average size of these grants, A$55,000, are low by international standards. By comparison, National Science Foundation grants have a success rate of 31 per cent and an average size of US$98,000. In the UK, the success rate for grants administered by the research councils is between 25-35 per cent, and grants are in the A$180,000 to A$453,000 range (including funding for research infrastructure) (see Table 6.2.)

Table 6.2

Comparative grants data for ARC, UK research councils and the National Science Foundation (US)

	ARC	UKRC*	NSF (US)
Average Research Grant Size	A$55,000 (includes social sciences and humanities)	A$180,000-$453,000 (includes social sciences)	A$165,000 (includes social sciences)
Success rate	20%	25-35%	31%
Average Research Grant Size, excluding social sciences and humanities	$61, 878	$216,000- 453,000	NA
Success rate	22%	25-35%	NA
Direct Costs - (In Australia this includes salaries of staff, travel, consumables and some equipment)	Approx.75% (doesn't include Chief Investigator Salary) The remaining 25 % is sourced from the universities	100 % (doesn't include Chief Investigator Salary)	100 % (includes all salaries)
Indirect costs	**	45% of salary costs	***

Notes: The ARC grants are allocated to the sciences, the humanities and the social sciences, whereas the UK and US grants are allocated to the sciences and the social sciences. By not including the social sciences, the average grant size in Australia increases to around $61,878 and in the UK, increases to $216,000 based on mid-year 2000 exchange rates. As a consequence these figures do not reflect the downward movement in the Australian dollar in recent months.

* includes data for the following UK Research Councils: Biotechnology and Biological Sciences Research Council, Engineering and Physical Sciences Research Council, Economics and Social Sciences Research Council, Particle Physics and Astronomy Research Council and Natural Environment Research Council.

** Research Infrastructure Block Grants paid to universities at approx 19 cents in the ARC grants dollar and Chief Investigator salaries paid by universities.

***overhead costs negotiated by NSF directly with universities at average of 50 cents in the grant dollar.

Source: Provided by the ARC.

Based on international comparisons, there is a strong case to at least double funding for ARC competitive grants to ensure that Australia's investment in research conducted in the tertiary sector is maintained at competitive levels across a broad range of disciplines. Present funding levels are inadequate to achieve this objective. Beyond the commitments already made in areas such as biotechnology, environmental sustainability and health and medical research, we must nurture our research capabilities in the 'enabling' sciences of physics, chemistry and mathematics, and also in the humanities and social sciences. Research in the humanities and social sciences, for example, can enhance the organisational, management, legal and marketing knowledge that is critical for successful innovation. Submissions to the Review from the Academies of Social Sciences and Humanities reaffirmed the importance of these research disciplines to facilitate better understanding of issues raised through research in SET and more generally.

Increasing the ARC's competitive grants is consistent with the theme of excellence developed in the Wills Report. The Review also notes ISIG Recommendation 12 in *Innovation - Unlocking the Future* supports a doubling of funding for the ARC. ISIG confirms that current funding levels are low by international standards for competitive grants.

6.3.2 Broader access to ARC grants

An issue that has arisen in the course of the Review is whether access to the ARC competitive grants scheme should be limited, as is presently the case, to university researchers or whether access should be broadened to include researchers in the government-funded research agencies. CSIRO, ANSTO and AIMS argue in their submissions on the discussion paper that their researchers should have access to ARC competitive grants.

The case for extending access rests on the benefits that can be expected to flow from introducing greater contestability for competitive grants among researchers, irrespective of the agencies where they work. This issue was considered by the Wills Report, where the question was whether the block funded medical research institutes should be given access to NHMRC grants. Support was given on the grounds it would lead to greater contestability and thereby target the highest quality research. There is a risk in a sharply partitioned system that the best quality research would not always get funding ahead of lesser quality research. The Wills Report recognised that there was an entry price to be paid by the block funded medical research institutes for gaining access to NHMRC grants in terms of giving up part of their block funding to top up NHMRC funds.

This Review takes a similar view to the Wills Report, namely, that access to ARC competitive grants should be widened beyond the universities to include researchers in the GFRAs. It is always better to widen the scope of competition than to operate a series of non-competing groups. In an effort to increase links between the GFRAs and the business community, the GFRAs should have access to those areas of the ARC programs that encourage linkage formation and collaboration. This means that GFRA proposals of a collaborative nature, based on merit, would be funded.

The Review notes that decisions taken, following the White Paper to consolidate a number of ARC competitive grants programs into Discovery and Linkage grants, provide a suitable framework for the widening of access to ARC competitive grants. It is expected that the balance between the two main elements may tend to shift over time towards 'linkage grants' where benefit to the community can be more readily identified.

Subject to appropriate outcome measures, consideration may be given in the implementation phase to wider competition in basic research and an argument made for GFRAs accessing the ARC competitive grants for Discovery. The Review notes that such a proposal should be on the same basis as the block funded medical research institutes gained access to NHMRC grants, viz. an entry price would be paid by the GFRAs to the ARC.

6.3.3 ARC and Intellectual Property

A further element that the Review considers to be of central importance is the question of the approach to be adopted by the ARC to intellectual property created as a result of research supported by ARC grants. The aim should be to structure the intellectual property rules so that they do not act as an impediment to the subsequent commercial exploitation of research outcomes. The Review considers there should be consistency of approach by the ARC to the treatment of intellectual property with that adopted by the NHMRC granting scheme.

7 Major Recommendation

1. *Over five years, double funding for the Australian Research Council's grants and related infrastructure activities, consistent with the commitments already made for increased funding of health and medical research.*
2. *Broaden access to the Australian Research Council's competitive grants beyond the universities to the government funded research agencies. Entry to the competitive process for additional funds should be limited initially to joint research proposals based on merit.*
3. *Ensure consistency of approach for the rules governing intellectual property under the ARC and NHMRC granting schemes.*

Investment: $660 million over five years.

6.4 Encouraging Leading-Edge Infrastructure

The term 'infrastructure' loosely covers the people, equipment and facilities that support the SET base. It is confusingly applied to all of these elements at various times. In terms of Commonwealth support for research infrastructure funding, the term applies to institutional resources essential for the mounting of high quality research projects, including associated indirect costs, and excludes any direct project costs covered from other sources of funding.

Research infrastructure is not necessarily restricted to institutional boundaries and may include facilities that enhance the research capacity of groups of institutions, or of the higher education system as a whole. Because of the lack of definitional clarity for the term 'infrastructure' it is difficult to measure accurately how much is spent on it. Added to that, only a portion of funding that is used to support 'infrastructure' is accountable to government. This includes both basic infrastructure that covers the indirect costs of research, as well as advanced technology and major facilities. Australian industry of the future will be reliant on researchers who have access to cutting edge equipment and facilities. Access to this infrastructure is a key ingredient in encouraging 'research stars' to return to Australia.

6.4.1 Investment in public sector infrastructure

'High quality research relies heavily on the availability of high quality infrastructure.' [67] This general statement was made by a large number of submissions to the Review in the context of the apparent decline in the quality of research infrastructure, particularly in universities. The last major published review of infrastructure in Australian universities was conducted by the Boston Consulting Group in 1993. This found that the provision of research infrastructure was under pressure and not keeping pace with growth in research capacity.

The costs of infrastructure are increasing, while funding for research infrastructure is either static or declining. The relative amount allocated for infrastructure costs compared to project grant expenditure appears to be declining in Australia. While not directly comparable to the Australian situation, funding provided for overheads or infrastructure in the US, Canada and the UK is above about 40 per cent of total project costs. The ARC states that the current level of infrastructure support through the Research Infrastructure Block Grant scheme for ARC supported research is approximately 19 cents in the dollar.[68]

While increases in basic infrastructure support for individual research projects will go some way toward addressing the needs of researchers, it will not completely overcome the problem. This is because a significant portion of the university research and teaching effort is funded from general university funds, including the operating grant from the Commonwealth. The impact of the small but significant decline in government expenditure on infrastructure, salaries and teaching, affects the baseline quality of scientific research and research training. ISIG strongly endorsed the provision of new funding for research infrastructure to support the generation of leading edge research, but did not detail which areas might best be supported.

The Review, therefore, considers that an increase in the competitive grants allocation program administered by the Australian Research Council, and the increase to the NHMRC, necessitates a commensurate increase in basic infrastructure for university research to ensure that the benefits of the total investment can be captured. Research organisations that will be able to access competitive grant schemes, as proposed above in 6.3.2 and others, and cannot be recipients of RIBG, should be allocated infrastructure funding through a new mechanism.

8 Major Recommendation

Expand the funding for university research infrastructure (RIBG) in proportion to ARC and NHMRC grants and provide a commensurate increase in support for research infrastructure at non-university institutions eligible to receive ARC and NHMRC research grants.

Investment: $275 million over five years

[67] Infrastructure here refers to buildings, equipment, libraries and databases, computing and communications systems and administrative support.

[68] ARC submission to the Review

6.4.2 Information Infrastructure

Access to information has fast become a significant infrastructure issue for the research community. Despite an increase in the output of the world's research information, the three years from 1996 to 1998 saw a significant decline in the purchase of print serial subscriptions and in the purchase of monographs. Whilst there was a 22 per cent increase in serial expenditure over the period, there was a 48 per cent decline in the number of print serial subscriptions purchased, with the majority of these estimated to be in the science, technology and medical disciplines. The increase in serial expenditure had a direct impact on monograph expenditure (a 9 per cent reduction) and has resulted in a 14 per cent reduction in volumes purchased.[69]

Table 6.3

CHANGES IN MONOGRAPH AND SERIALS PURCHASES BY AUSTRALIAN UNIVERSITY LIBRARIES 1996-1998

Year	Monographs		Serials	
	Cost ($)	Volume	Cost ($)(1)	Volume
1996	47,722,517	888,103	77,088,008	223,110
1997	48,984,406	839,194	81,354,008	139,431
1998	43,544,547	765,801	93,823,009	116,433

(1) Includes expenditure on aggregated databases of full text serials.

Source: Coalition for Innovation in Scholarly Communication Submission to the Review

The cost of obtaining information has also increased. There has been a global increase in the average price per serial title of between 8 per cent and 10 per cent a year over the past decade. The situation is much worse for Australia with the steady decline in the value of the Australian dollar against major international currencies. The growing reliance on the use of digital substitutes for print serials has necessitated additional expenditure on aggregated databases and technical infrastructure.[70]

While research libraries and university administrations are undertaking measures to ensure an adequate level of access to researchers, including forming consortia and sharing resources, a number of submissions to the Review have pointed to the need to address the issue of access to electronic journals for researchers.

In the UK, the National Electronic Site Licensing Initiative (NESLI) delivers a national electronic journal service for the British higher education and research community. It negotiates deals with scholarly publishers, handling subscriptions, access and technical questions of authentication. NESLI also encourages widespread acceptance by publishers of a standard Model Site Licence to ensure certainty in electronic copyright licensing.

[69] Submission from the Coalition for Innovation in Scholarly Communication - supplementary data.

[70] Amended submission from the Coalition for Innovation in Scholarly Communication, 3 November 2000.

The transition from paper-based publishing to digital publishing raises a number of important issues that are still being negotiated by the main players, libraries, users and publishers, around the world. Legislation to take account of the digital environment and new technologies with regard to copyright material in Australia is scheduled to commence early in 2001. The Review notes that CSIRO and ANSTO have already collaborated to subscribe to and negotiate reasonable price deals for on-line journals from several publishing houses.

ISIG also noted the declining number of journals and monographs being purchased in Australia. Given this environment, and acknowledging the need for Australian researchers to be able to tap into rapidly expanding global knowledge pools, the Review considers that this issue should be explored further with the establishment of a pilot scheme, focussing on the feasibility of a National Site Licence.

9 Major Recommendation

Develop a pilot scheme to test a National Site Licence concept between higher education institutions, government funded research agencies and publishers in an attempt to keep the price of journals down.

Investment: $5 million over five years

6.4.3 Major Research Facilities

Major Research Facilities (MRFs) are extremely expensive, one-off pieces of equipment or highly specialised laboratories which provide leading edge research capabilities.

Because of their very significant cost and specialised nature, these facilities are usually beyond the funding capability of any single institution or State/Territory Government and require investment at the Commonwealth Government level.

Australia's bid to host the Global Biodiversity Information Facility would benefit from a MRF Program. Bio21 is a MRF that will harness the biomedical research expertise at Melbourne and Monash Universities, as well as the major research institutes in Melbourne, through collaborative programs to expand key infrastructure. This new facility exists in a vital area of emerging technology, yet following development of the initial concept, has taken years to establish.

MRFs, including major international standards facilities such as the National Measurement Laboratory (NML), are also vital in attracting the world's best researchers to our universities and institutions, in keeping our own leading edge researchers in Australia and in encouraging the clustering of related and supporting start-ups, spin-offs and SMEs. The White Paper[71] clearly recognised the value of major national research facilities.

[71] The Hon Dr D A Kemp, MP, Minister for Education, Training and Youth Affairs, *Knowledge and Innovation - A policy statement on research and research training*, December, 1999.

MRFs facilitate cluster formation, the creation of more start-ups, and spin-offs and collaborative research across institutional boundaries. The results are clear-cut (see section 3.1), but we have far too few examples and we need more. An exception is the Waite campus, where the collaboration between CSIRO, the University of Adelaide, the South Australian Research and Development Institute, Primary Industries and Resources South Australia, the CRCs for Premium Quality Wool, Weed Management Systems, Viticulture and Molecular Plant Breeding and the Australian Wine Research Institute has produced a cluster of international quality with highly significant scientific and commercial outcomes.

There is, therefore, a need for the Commonwealth Government to develop a national program to support investments in MRFs. The program needs to determine, on a competitive basis, which MRFs would yield the highest benefits through adding strategic capability to the research infrastructure and would leverage Commonwealth funds with contributions from State and Territory Governments, publicly-funded research institutions and industry.

Participants in public discussion forums made a strong case for the non-Commonwealth contribution to MRFs to be less stringent for facilities proposed for the Northern Territory and the ACT, recognising the smaller budgets of the Territory Governments. There is also a case for separate consideration of the benefits that would arise from siting MRFs in regional Australia. These are issues that should be considered in the implementation phase of such a program.

In any development of a whole of government approach to priority setting, it is conceivable that the awarding of a MRF could be coupled with priority proposals to co-site activities funded by the ARC, NHMRC, the CRC program, RDC`s and GFRAs.

10 Major Recommendation

Commonwealth fund 50 per cent of the cost of creating new major research facilities on a competitive basis in conjunction with the States/Territories, publicly-funded research institutions and commercial interests.

Investment: $400 million over five years

6.5 Government-funded Research Agencies (GFRAs)

A national innovation system cannot function properly without a strong and healthy SET base. Australia's GFRAs perform a crucial role as part of the SET base in stimulating innovation (see the Value Proposition in Chapter 2).

The community expects our GFRAs to undertake activities that will contribute to national wealth and improve health, safety and the quality of life. They also play a unique role in providing the expertise and infrastructure to understand, predict and manage natural systems and the environment. There is a clear role for government in funding R&D and related activities not undertaken by the private sector, including:

- Informing government and the community on issues that are essential to understanding our environment and which affect our health, safety and the quality of our lives, in areas such as:
  - genetically modified food
  - dryland salinity
  - climate change
  - the Antarctic region
  - national measurement standards
  - health
- Supporting research where the critical mass of funding needed is prohibitive for business.
- Facilitating innovation, such as, by demonstrating technology platforms and encouraging network formation and technology diffusion.

The Commonwealth Government funds a number of research institutions to conduct public good research. These organisations have been encouraged by government to become more collaborative and attentive to commercially relevant research. The contribution the Commonwealth Government makes to research institutions is 22 per cent of total support for science and innovation through the budget.

6.5.1 CSIRO

CSIRO is a unique research institution whose origins go back to the establishment of the Council for Scientific and Industrial Research in 1926. The objectives of this forerunner to the present CSIRO were to promote scientific research for the benefit of primary and secondary industries, and to encourage the pursuit of 'pure' scientific research. Over time the CSIRO has been the subject of numerous reviews which have seen it focus more on applications-oriented research. Its funding originally came from a one-line appropriation. Since August 1988, it has been required to obtain 30 per cent of its total funding from external sources.

The organisation's investment portfolio is determined on a triennial basis via an intensive and comprehensive consultation process involving 22 sector advisory committees drawn from industry, the community and government.

Box 6.1

CSIRO is one of the world's largest and most diverse scientific research organisations. Its features include:

- *staff of 6300 in 20 divisions*
- *Activities in more than 70 countries with over 700 current or recently completed projects*
- *A total research effort that is 10% of Australia's total R&D, including about one quarter of the R&D contracted out by industry.*
- *A broad but reasonably concentrated customer base – 20% of customers provide well over 80% of the external revenue.*
- *Total revenue from—*
    - *Australian companies 9%,*
    - *Commonwealth, State and Local governments 8% over and above the 70 % of total appropriation,*
    - *RDCs 5%, and*
    - *CRCs and overseas entities each 4% of the total appropriation.*
- *In the 2000-03 triennium the government's $1.5 billion investment can be categorised[72] as—*
    - *agri-business 30%,*
    - *minerals and energy 17%*
    - *environment and natural resources 21%*
    - *manufacturing 25%*
    - *information and services 7%*

CSIRO's Strengths and Weaknesses

CSIRO has a number of strengths that have important implications for its position in Australia's national innovation system. Without seeking to be exhaustive, notable strengths are:

- the quality of its researchers and the diversity of its research capabilities;
- its capacity to establish multi-disciplinary teams to address specific Australian problems that a require critical mass and a sustained research effort;

[72] Provided by CSIRO. Manufacturing includes radioastronomy at 2.8% and Measurement at 2.2%.

- the depth of its research infrastructure – CSIRO operates a number of MRFs;
- the ability to redirect resources to reflect emerging priorities due to the critical mass of its research capabilities; and
- its support for the SET base via an extensive network of linkages among other publicly funded research agencies, and industry, nationally and internationally.

During the course of this Review, a number of submissions and consultations have pointed to particular concerns about CSIRO which suggest two possible areas where the performance of CSIRO needs to be improved. These are:

- Slowness in shifting resources into areas that underpin growth in the knowledge economy.
- The relatively slow rate at which CSIRO spins off new businesses compared to the results achieved by research bodies in the US and the UK.

New Business Creation

The spin-off model is becoming increasingly important as an indicator of the success of publicly-funded research in generating new businesses and facilitating technology transfer.

To date, there have only been 194 direct spin-offs from Australian research institutions, of these, 97 originated from universities, 8 from hospitals and 14 from Cooperative Research Centres. The remainder originate from GFRAs, including 56 from CSIRO, 11 from medical research institutes and 3 from DSTO.[73]

According to indicators developed in the United States, CSIRO's production of 2.5 start-ups per annum is under its projected potential for 7 start-ups per annum, during 1996-97. GFRAs do not have the substantial training responsibility of universities and therefore can be expected to make a stronger impact on industry development and the creation of new businesses.

Furthermore, the experience overseas and at some leading Australian universities, highlights the potential for CSIRO to exploit its intellectual property by significantly upgrading its involvement in the incubation of new businesses. CSIRO does this to a limited extent. What is being proposed, however, is that CSIRO set ambitious goals for itself in this area.

CSIRO's Business Plan

In order to play a much bigger role in incubation activities, CSIRO will need to develop a business plan which identifies the required skills, financial resources, internal incentives and management arrangements. It is likely that CSIRO will need to plan on the basis of gradually building up its activities in this field. The finance needed to support a major incubation strategy would have to come from re-ordering priorities and cutting back on some activities funded by the appropriation. This is hardly a desirable outcome given the agency's mission. To meet the objective of new business creation, there is a case for CSIRO gaining access to a new source of funding to support a major incubation initiative. Such a funding source is proposed below.

[73] Lyndal Thorburn, *Government Policies to Encourage Creation of Spin-off Firms for Academic Institutions*, paper presented at the APEC symposium on Intellectual Property Rights, February 28 to March 1 2000.

The 30 per cent external earnings target was established in an environment in which CSIRO's main activities were; conducting public good research funded by the appropriation, and conducting contract research on a fee-for-service basis. A much greater 'incubation and new business' creation effort opens the potential to generate a significant additional revenue flow based on the associated investment and increased value of intellectual property. Measuring such an enhanced potential return on investment will require CSIRO and the Commonwealth Government to develop a performance basis that clearly reflects this incubation and new business creation role.

6.5.2 Other Government Funded Research Agencies

The Defence Science and Technology Organisation (DSTO) is currently subject to a review involving broad public consultation in the context of Defence Review. A Defence White Paper responding to the latter review is to be released in late 2000. It would not be appropriate to make recommendations on DSTO in advance of this major review across the Defence portfolio.

The Australian Institute of Marine Science (AIMS) has recently been subject to a review of marine science infrastructure in the Townsville region, by the Chief Scientist. Following the review, the Commonwealth Government agreed to the $17 million refurbishment of the Cape Ferguson research laboratories and the design and construction of a new marine research vessel.

As AIMS resource requirements have recently been considered in some detail and responded to by the Commonwealth Government, they do not need to be considered further in the Science Capability Review. The Marine Science review contains other specific recommendations for future investment, for example:

- support for the Darwin Marine Research Centre
- support for smaller regional marine centres across northern Australia, and
- the National Tropical Marine Network initiative – to refurbish and re-network the island stations of the Great Barrier Reef Island Research Stations.

The Australian Nuclear Science and Technology Organisation (ANSTO) has not been considered in the same detail as CSIRO and AIMS because it is currently undergoing an output pricing review by the Department of Finance. ANSTO's funding requirements should be considered in the light of the outcome of this review. Nevertheless the Review has accepted ANSTO's submission which makes recommendations similar to those in submissions by other GFRAs.

The Australian Geological Survey Organisation (AGSO) provides pre-competitive geoscience information that underpins cycles of mineral exploration, development and production. Discovery of Australia's next generation of valuable mineral and energy deposits will require the application of new technologies such as deep-sea drilling and gravity gradiometry. Government expenditure on these technologies should be a matter for consideration by the new priority setting mechanism proposed by the review, particularly considering the economic importance of the resources sector to the Australian economy.

Pending consideration of these investments, AGSO's current activities need additional support, especially pre-competitive investigation of potentially prospective offshore petroleum areas, which is vital to maintaining Australia's high level of self-sufficiency in liquid hydrocarbons.

There are a number of other scientific organisations that perform public good research and provide scientific advice to government, including the Bureau of Rural Sciences and the Bureau of Meteorology. These organisations need to be included in any priority setting system.

6.5.3 Future Directions for GFRAs

GFRAs provide a unique capability in Australia's national system of innovation, in particular the provision of early warning and response capabilities to what are often unpredictable changes that will occur in the knowledge economy. As might be expected, the agencies have views on future directions. In its submission on *The Chance to Change - a discussion paper*, CSIRO accords highest priority to mechanisms that will provide:

- Industry-linked postdoctoral fellowships
- Access to pre-seed capital
- Access to new resources for use-inspired basic research for all players in the science system
- Participation in a new MRF program
- Access to new infrastructure funding

CSIRO also notes the importance of an appropriate implementation process for considering and acting upon the recommendations of this Review.

These views are also supported by the submission from AIMS, which recognises the need for GFRAs to be able to access research funds allocated on a competitive basis, particularly postdoctoral fellowships.

The ANSTO submission also highlights the need to access competitive funding and pre-seed capital. The Review broadly agrees with CSIRO's assessment of the recommendations, particularly on how they might impact on the operations of GFRAs.

In Summary

1) CSIRO, ANSTO and AIMS should have access to the financial resources currently available to other research performers. This includes:

- the broad range of competitive schemes administered by the government and by government-funded granting bodies, like the ARC and the NHMRC. Entry to the competitive process for additional funds should be limited initially to joint research proposals based on merit. It is always better to widen the scope of competition than to operate a series of non-competing groups. Phasing in of this broadening of scope for the research councils should be in line with the increases to the ARC.
- commercial loan funds.

2) CSIRO, ANSTO and AIMS have considerable experience in developing strong and long-term industry-based networks. These should be capitalised upon to increase their capacity to produce spin-off companies, while still fulfilling their 'public-good' role, the provision of strategic advice and knowledge to government and the community. The following actions are proposed:

- Create incentives and rewards for public sector researchers, including new approaches to holding equity in spin-off companies.
- Introduce new performance measures that document the rate of spin-off company formation, the involvement of industry at the early stages of R&D and diffusion of knowledge and ideas into the private sector. These performance measures should be equally as important as external earnings in assessing these GFRA's overall performance. This suggests a modification of the current external earnings target.

11 Major Recommendation

CSIRO, ANSTO and AIM's should:

1 *have access to competitive R&D funding mechanisms, including commercial loans.*

2 *be assessed against new performance measures which value outputs more than inputs.*

3 *reform incentives for their researchers to encourage new business creation.*

6.6 Business & Government Research Funding Model— Rural Research and Development Corporations

The rural-industry-based Research and Development Corporations (RDCs) have, since their establishment in the 1980's, come to play an increasingly important role in the funding of rural R&D. They currently fund in excess of 40 per cent of total rural research.

The twelve industry-based RDCs are generally funded on the basis of industry levies. Levels are set by the relevant industry representative body and matching dollar-for-dollar funding is provided by the Commonwealth Government, up to a maximum of 0.5 per cent of the industry's gross value of production. The rationale for the funding of the RDCs is to address the market failure issues associated with problems of appropriating the benefits of research in industries with many small producers producing homogeneous products. The Land and Water Resources RDC and the Rural Industries RDC are mainly funded by way of government appropriation reflecting their responsibilities for environmental issues, and supporting new and emerging rural industries.

Major strengths of the RDC model – an application of the purchaser-provider principle, include:

- the incentive for the primary sector to increase R&D funding;
- the potential for developing a rational and integrated approach to R&D priority setting;
- the facilitation of industry's input to setting R&D priorities;
- the strong focus of outcomes with the associated likelihood of outcomes being adopted in practice;
- the contestability it brings between research providers; and
- dual accountability to both industry and government.

Overall in 1998-99, industry contributed $136 million in R&D levies and the Government provided $151 million by way of matching dollars and appropriation funds – total RDC expenditure was $320 million. The Grains RDC, which is the biggest of the RDCs, covering 22 products, invested about $90 million in R&D.

Benefit/cost studies show that R&D supported by the RDCs yields high returns and contribute significantly to the strong productivity growth needed to keep rural industries internationally competitive. In addition the RDC model supports innovation in SMEs which make up the bulk of the rural sectors.

A balance needs to be maintained between economies of scale and the ability of the RDCs to cater for its diverse customer base. This balance needs to be kept under review.

RDCs have become strategically important funders of rural research. While supporting the RDC model, the Review notes the need for the RDCs to take greater responsibility for the research infrastructure which they use. This could be done by inclusion of an appropriate allowance for infrastructure costs in the pricing of research contracts and/or making strategic investments in the research infrastructure. In this respect, the Review welcomes the cooperation between the Grains RDC and the ARC.

Strategy

RDCs to have greater responsibility for infrastructure.

6.7 National Measurement Laboratory

The National Measurement Laboratory (NML) is a MRF located within CSIRO. It provides the national standards of measurement for Australia and measurement traceability for industry, commerce, trade and defence. In so doing, it fulfils CSIRO's statutory responsibilities for measurement standards.

The role of NML in maintaining national measurement standards underpins

- testing
- product development
- technical innovation
- trade
- environmental measurement
- health and safety
- fair trading
- legal metrology and
- regulatory control

The NML needs an active R&D program to maintain its international credibility, as well as the credibility of Australian metrology. Research into measurement standards may in itself trigger scientific breakthroughs or affect R&D activities that are impeded due to the accuracy of available measurement techniques.

The NML faces a constant challenge in developing and upgrading standards to meet the demands of industry and the community, in the context of the rapidly changing global knowledge base.

The Kean Report into Australia's Standards and Conformance Infrastructure recognised the importance of adequate resourcing of the NML, recommending that it be funded under a separate line item in the Budget. The Commonwealth Government's response acknowledged the necessity of adequate funding for NML while indicating that NML would be maintained within CSIRO's one line budget. The Review's consultation with NML and submissions to the Review suggest that the logic behind this recommendation of the Kean Report is as strong as ever.

Physical, chemical, biological and legal metrology are thus fragmented across three organisations. The NML has responsibility within the Commonwealth for physical metrology. The Australian Government Analytical Laboratory (AGAL) is responsible for chemical metrology and some areas of biological metrology. AGAL's mandate and mode of operation is currently under review, with a report due to the Government shortly. Responsibility for legal metrology rests with the National Standards Commission, a statutory authority in the ISR portfolio.

Consolidation of these activities into one organisation would create critical mass and strengthen Australia's metrology infrastructure. This would have strong positive benefits in terms of the contribution metrology makes to the national interest.

Strategy

That a national measurement institute be established to consolidate chemical, physical, biological and legal metrology into one organisation

6.8 Linking public sector research performers

The GFRAs, CRCs and RDCs have strong links with each other in delivering research to address national priorities. These links assist the diffusion of knowledge and skilled people. All the research organisations discussed previously need to be further integrated into the national innovation system, and, accordingly, should have access to the initiatives outlined in this report, such as the expanded CRC program, the Innovation Centres, the pre-seed capital fund and the MRF program.

12 Major Recommendation

Government-funded research agencies, CRCs, and RDCs have access to the initiatives outlined in this report, including Major Research Facilities, pre-seed funds and Innovation Centres.

6.9 Connectivity between the Australian and international SET base—the importance of international collaboration

Australia needs to 'punch above its weight' in the knowledge economy. Australia only produces 2.7 per cent of the world's scientific papers and 98 per cent of its technological requirements are sourced internationally. To keep pace with exponential increases in new knowledge and ideas, the demands of a sophisticated and global customer-base, and to ultimately perform strongly in the knowledge economy, Australia's SET base must be a 'visible' and active partner in the global production of knowledge. Australia may then leverage its performance through the effective absorption and transfer of international ideas and knowledge into its domestic systems of innovation.

Dynamic international networks provide access to the global knowledge base. One way in which such networks are established and maintained is through collaborative research projects. On a global scale the intensity of international collaboration is increasing, as countries and businesses seek to keep abreast of scientific and technological advances and to maximise economic and social benefits from their own innovation activities.

Knowledge economies such as Japan, the EU and US are increasingly active in international collaboration. Examples include participation in the recently established OECD Global Science Forum and in international consultations on megascience facilities such as the Global Biodiversity Information Facility and the Square Kilometre Array Telescope.

For smaller countries, including Australia, international collaboration is vitally important. It has been said that the international science and technology links made by participants in the Australian SET base are just as crucial as international trade with regard to Australia's future competitiveness and economic growth. The Review, therefore, endorses the ISIG approach (Recommendation 19).

Australian industry is dominated by SMEs, of which most do not undertake R&D and rely upon access to technologies developed elsewhere. Australia's SET base needs to underpin the innovative capacity and competitiveness of our SMEs and to do so requires international collaboration.

The benefits to Australia derived from international science and technology collaboration include:

- Increased participation by Australian SET practitioners at the frontiers of science and technology, ie, a seat at the international table and sharing in new developments;
- A boost to 'science and technology intelligence gathering' activities with regard to international developments;
- An acceleration in the rate and success of knowledge and technology transfer by Australian businesses, particularly SMEs;
- International promotion for Australia's innovative capacity in the public and private sectors;
- Increased investment in Australia and exports of Australian goods and services; and
- Maintenance of Australia's participation in global decision making.

Strategy

Recognise the importance of international collaboration between universities, GFRAs and industry

Chapter seven

Chapter seven

Investing in Commercialisation

7.1 Introduction

In order to compete successfully, companies in a knowledge-based economy need to innovate to respond quickly and efficiently to increasingly sophisticated consumer demands.

Companies that invest in R&D and maintain strong linkages with the SET base are more likely to sustain a competitive advantage in this environment.

Private investment can be 'in-house' or conducted in publicly funded institutions. In view of Australia's considerable investment in public sector R&D, a near-term return from this investment depends on industry capturing and exploiting public research outputs – ideas, skilled people, for example.

We must support initiatives that encourage the take-up of researchers and research by industry. Companies that wish to succeed in the new economy must be prepared to invest in new skills and technologies and align themselves with research institutions that perform basic research. Without this access and alignment, the downstream benefits to our society of basic research will be greatly reduced.

Analysis of the public research system suggests that it is vital that appropriate *mechanisms* and *incentives* are in place to ensure industry has the best possible access to skilled people and cutting-edge research. This requires a concerted effort by all players in the national innovation system to build strong links between funding bodies, research institutions, the community and industry. Submissions by the business sector to this Review have highlighted the need for researchers to have a broader skill set, particularly with regard to commercialisation. This broad skill set is developed in part from the interactions researchers have in the domestic and international science arena, and associations with the commercial world.

Innovation surveys show that companies invest in innovation because they want to gain market share, reduce costs and increase profits. The connections between industry and the SET base, and the incentives associated with building these connections are the key to successful commercialisation. This is consistent with the Wills Report's 'virtuous cycle' of government, research and industry, namely that each component of the virtuous cycle will reinforce the others to build momentum in developing the knowledge base which, through business, is converted into increased jobs. Innovation and entrepreneurship play key roles in the 'virtuous cycle'. We need to focus on the engines of growth—the SMEs. We also need to encourage more business R&D investment activity, including from offshore.

'the key issue is not so much whether the benefits are there, but how best to organise the national research and innovation system to make the most effective use of them'.[74]

[74] Salter A, Martin B, *The Economic Benefits of Publicly Funded Research: A Critical Review*, Science Policy Research Unit, May 1999.

7.2 Recent initiatives to encourage business investment

Investments in start-up firms involved in high technology or innovative businesses typically provide returns on investment in the form of capital gains. They also tend to be higher risk investments. Previously, Australia's capital gains tax (CGT) regime impacted significantly on the capacity of such firms to obtain investors in Australia. As a result, Australia has lost many firms to countries with more investor-friendly taxation policies. This has reduced the incentive for other innovative businesses to seek to develop in Australia, and resulted in the loss of spin-off advantages from high growth, innovative companies. In recognition of this, the Commonwealth Government has already successfully implemented a variety of measures designed to promote a more vibrant and successful venture capital industry in Australia in order to encourage Australian investors to support these types of firms (see Box 7.1).

The changes to CGT rules were introduced in recognition of the fact that entrepreneurs often receive the reward for their investment when the venture reaches the initial public offer (IPO) stage. Under the previous CGT arrangements, however, if the IPO were to proceed as a scrip-for-scrip transaction, the entrepreneur would face a CGT liability even though there might be no cash payment. This would act as a disincentive for some embryonic businesses to remain in Australia. It was recognised that this issue would become more significant as globalisation of economic continued activity with the attendant growing importance of knowledge-based industries.

It appears that after a number of false dawns, Australia is going some way toward solving the longstanding venture capital problem (Box 7.1).

The emerging issue has, however, become the inadequacy of pre-seed funding in maximising the chances of potentially commercialisable research reaching the market (as discussed below in section 7.4.4). The Commonwealth Government has already achieved substantial improvements in encouraging the market capitalisation of high technology or innovative business in the upstream incubator and venture capital end of the innovation process. To keep up with international pace, however, Australia has to be far more active than it currently is.

BOX 7.1

OVERCOMING THE VENTURE CAPITAL PROBLEM — GOVERNMENT MEASURES

- *The Innovation Investment Fund (IIF) program*

  The IIF aims to provide access to equity capital to encourage new technology companies to improve the commercialisation outcomes of Australia's strong research and development capabilities and to create a self-sustaining, early-stage technology-based venture capital market. Together with private sector funding, the $221 million in funding provided by the Commonwealth Government over the ten years of the program will create an overall investment pool of over $330 million for early-stage venture capital investments;

- *The Pooled Development Fund (PDF) program*

  PDF's are taxed at 15% on the SME component of their investment income and at 25% on the unregulated investment component. PDF dividends are exempt from income tax and dividend withholding tax and any capital gains made by investors in selling their shares in the PDF are exempt from CGT, while any tax–preferred income received by a PDF retains its character when passed through to PDF shareholders. These incentives are designed to provide an incentive for local investment in venture capital projects:

- *Targeting tax capital gains tax relief for venture capital investment*

  By making Australia's CGT regime more competitive, this incentive is designed to stimulate venture capital funding from both domestic and non-resident sources;

- *The collective investment vehicles regime (CIVs)*

  This ensures that small investors have the opportunity to participate in such investments while diversifying the risk to acceptable levels; and

- *Scrip-for-scrip rollover relief*

The Commonwealth Government has also introduced measures designed to help at the incubator or 'proof of principle' stage of the innovation process. The $158 million Building on IT Strengths (BITS) program aims to build the strength and competitiveness of the Australian information industries sector. This involves fostering stronger commercialisation linkages with R&D organisations and creation of clusters of innovative information technology and telecommunications (IT&T) businesses.

In particular, it seeks to:

- increase the rate of new SME formation in the Australian information industries (especially from R&D organisations);
- foster linkages and networking between participants in the information industries sector;
- facilitate the availability and use of leading-edge network technologies by the information industries sectors, and
- develop further an internationally competitive IT&T sector in Tasmania.

7.3 Encouraging Private Investment in Innovation

Government approach to R&D funding must reflect the structural shifts necessary for Australia to make the transition to a knowledge-based economy. Significant changes in the amount of financial support governments provide for business R&D have occurred across OECD countries over the last ten years, with most countries, including Australia, measuring a decline. In 1999, government support accounted for, on average, less than 10 per cent of total business expenditure. The figure for Australia, however, is a quarter of this, at around 2.5 per cent, an OECD ranking of 28th.[75] There is a clear role for the Australian government to maintain its support for business investment in R&D, to stimulate industry investment. Improvements in the incubator and venture capital end of the innovation process will go a long way, but encouraging better utilisation of the SET base is crucial. Special assistance is required for SMEs.

7.3.1 Commercialising Research- special incentives for small business

The Commonwealth Government's suite of industry R&D incentives are designed to encourage business to make investments in Australian R&D. Programs such as the Cooperative Research Centres, R&D *Start*, the 125 per cent Tax Concession and the new Commercialising Emerging Technologies (COMET)[76] are designed to bolster R&D investment and thereby stimulate innovation and business growth.

[75] *OECD Science, Technology and Industry Outlook*, September 2000. This data does not include tax subsidies. OECD data for tax subsidy changes over the period 1990-1999 for 1US dollar of R&D shows that Australia has the greatest negative change for all OECD countries.

[76] The COMET program has a program budget of up to $30 million over three years from 1999 to 2000. Two forms of assistance are offered to clients of the program:

- Tailored Assistance for Commercialisation provides individually tailored assistance developed to meet a client's specific needs with regard to commercialisation; and/or
- Management Skills Development provides financial assistance to undertake an existing program of management development which will enable clients to increase their capacity for innovation and commercialisation.

COMET is a new Commonwealth Government program which supports firms in their early growth stage, including spin-offs from research institutions, through the key steps of the innovation process by assisting in:

- Developing sound management skills
- Creating an effective management team
- Developing an intellectual property strategy
- Accessing capital from venture capital funds or business angels
- Licensing
- Forming joint ventures or strategic alliances
- Developing a working prototype
- Conducting market research and
- Developing a well thought through and achievable business plan

The take-up rate for COMET has been much higher than expected and the program is well regarded by firms. Superior innovation performance relies heavily on excellent management skills and business practice. Highly developed skills in these areas increase the chance that company decisions are smart and include investment in new areas which strengthen their capacity for competitive product and process development. The Review, in particular, supports the ISIG recommendation (Recommendation 16) that funds for COMET be doubled to further stimulate business investment in R&D.

Strategy

Double COMET funding over five years

R&D *Start* for SMES

The R&D *Start* program[77] should be modified to allow for greater funding success for high technology projects and to encourage increased access by SMEs. This would involve a strengthening of the National Benefit Framework to include a specific criterion addressing R&D in technology areas that will be significant in a knowledge-based economy. Any such arrangement should be regularly reviewed to reflect emerging technologies.

Strategy

Modify R&D Start *to encourage SME participation*

[77] Administered by AusIndustry, Commonwealth Department of Industry, Science and Resources.

7.3.2 R&D tax concession

ISIG has recommended[78] three changes to the R&D tax incentive aimed at stimulating innovation through increased business investment in R&D.

These involve:

- increasing the basic rate from 125-130 per cent;
- raising the rate to between 170-200 per cent for the increment of R&D which is over and above a threshold base; and
- introducing a cash-out option for SMEs with a turnover of less than $1 million and an investment in R&D of less than $1 million based on the 130 per cent rate. This proposal would be attractive to SMEs in a tax loss position.[79]

As foreshadowed in the Discussion Paper, the introduction of a cash-out option for smaller business would encourage investment in innovation and, importantly, help expose SMEs to innovative activities with reduced financial risk.

It is the smaller companies in Australia where knowledge-intensive activity is greatest, and government must play a stronger role in ensuring that these companies face as few difficulties as possible in establishing themselves in the market place as a result of innovative activity.

The Review believes that the tax incentive has a valuable role to play in:

1) reducing the risks for existing performers of business R&D to invest in new, strategically important R&D projects; and
2) creating conditions favourable to attracting major corporations to locate major R&D facilities and activities in Australia that otherwise would be placed elsewhere.

Both kinds of investment are likely to result in significant spillover benefits and contribute to clustering.

Internationally, tax incentives play a critical part in influencing the siting of major new research and development facilities by large companies. Australia must be internationally competitive in the incentives available to influence such important investment decisions. The incentive can be in the form of a tax incentive or an investment attraction package of the type considered for pre-commercial research and development investment proposals by Invest Australia.[80] Some countries offer a tax concession at the 200 per cent rate to attract major research and development projects. It is clear that Invest Australia would need to provide a comparable incentive if Australia is to compete successfully for major research and development projects.

[78] Recommendation 11.

[79] The UK government has introduced changes in the tax treatment of R&D for SMEs (UK Finance Act 2000).

[80] Invest Australia is administered through the Commonwealth Department of Industry, Science and Resources

13 Major Recommendation

1 *The R&D Tax Concession should be modified to provide a cash out option for R&D expenditure for SMEs with a turnover of less than $1 million and R&D investment of less than $1 million based on 130 per cent.*

2 *Significant R&D investment should be encouraged by providing a tax incentive in the order of 200 per cent or an equivalent incentives package for overseas companies to locate R&D facilities in Australia.*

7.4 Connection between ideas and commercialisation

The ARC administered SPIRT program is designed to support collaborative research projects between higher education and industry. Submissions to the Review note the success of this scheme in fostering university-industry relationships. The funding increase proposed for the ARC would significantly add to the value of this program.

Consultations have suggested a need for an additional scheme to assist formation of research teams intending to seek long-term strategic partnerships with industry. SPIRT does target this area, but there are promising researchers who have not yet reached the stage where they can attract the cash or in-kind industry contribution required for dollar-for-dollar funding under SPIRT.

Where universities see a strategic direction and where there are promising researchers, funding should be made available for establishing research capabilities that will attract industry alliances. The proposed Federation Industry Chairs could provide the leadership and direction required for such research capabilities.

7.4.1 Connecting Universities and Industry

It is important that small to medium-sized companies, in particular have the necessary receptors in place to be able to connect effectively to research capabilities. Technology diffusion, acknowledged as a key element in business success, depends fundamentally on the skills of people. Building closer links between the players in the national innovation system and the users of and investors in the system is crucial for a knowledge-based economy. Technology transfer and innovation enables business to be at the cutting-edge of product development and can further stimulate collaborative work with universities. Australian society is the ultimate beneficiary.

Universities will be at the heart of this effort to build the knowledge-based economy by providing a springboard for new business creation in technology intensive areas. In the 1980s, the higher education system went through its first revolution – increased numbers of universities. Universities are now facing a second revolution. It is the potential for universities to play a central role as dynamos of growth[82] in the innovation process and be significant generators of wealth creation and spin off advantages, derived from having a growing community of high growth, innovative companies.

" Australia is reaping a huge return from our national investment in university teaching and research…The BHERT report demonstrates that on the basis of $9 billion direct investment by universities - approximately half of the income for which comes from government - the return to the national economy is over $22 billion…"[81]

[81] Australian Vice-Chancellors' Committee, 'Report shows Huge Return for Nation from Australia's Investment in Universities' - Media Release, 4 August 2000.

[82] UK White Paper, *Excellence and Opportunity - a science and innovation policy for the 21st Century*, Chapter 3, paragraph 4, 2000

"Universities have always played a key role in discovering the new ideas that lead to social and economic progress. But, in the knowledge-based economy we now live in, universities are now literally the ideas factories that will shape our future prosperity."[83]

Commercialisation activity within universities has been increasing over the last few decades. This mirrors university activity in other countries. Business interaction with universities in Australia is at the OECD average and most universities have established links with other research organisations in the innovation system. The culture within Australian universities for commercialisation, however, has not developed to a level that is necessary for knowledge-based industries. Many Australian universities are appreciating their expanded role, demonstrated, for example, by increasing levels of industry sponsorships of research projects and integrating commercialisation success into criteria for appointments and promotions. However, the main driver for success in universities for researchers continues to be the activity of grant seeking and associated publication. This focus must shift if more funding is to be provided through the competitive grants process for research.

Strategy

Universities must introduce strategies to stimulate and facilitate increased transfer of knowledge to business and society

Developing the culture of commercialisation within universities will need the skills and the infrastructure to translate science into products. The challenge for universities is, therefore, to stimulate and facilitate the increased transfer of knowledge to business and society across all sectors of the economy, while improving the quality of teaching and research. The Steinbeis Foundation model may warrant further study for its applicability and feasibility in Australia to create the infrastructure where industry and the SET base can be linked at a business level. The Steinbeis Foundation is a central non-profit statutory body providing a broad range of services commencing with an industry diagnostic - a methodology used to assess the current condition of a firm across a broad spectrum of corporate activities. The Steinbeis model offers a regional network with a set of nodes or Profit Centres that draw on expert advice from research/technology providers. In effect, the primary role of the central body is to work as a brokerage service to individuals or firms by providing them with access to contracted research providers and/or their institutions.[84]

7.4.2 CRC Program

The Cooperative Research Centre (CRC) program was strongly supported in submissions to the Review and in the public consultations. Many universities and GFRAs, either directly or through participation in CRCs and other cooperative efforts, are creating research environments relying upon building networks and collaboration. These important centres are located all over the country, performing research in the locality which best supports them.

[83] *Public Investment in University Research: Reaping the Benefits*, The Prime Minister's Advisory Council on Science and Technology, Canada, 1999

[84] http://www.stw.de/60001.htm

The CRC Program was established in 1990 and by all measures has been shown to be extremely successful. All major reviews of the program have endorsed the success of the CRC program. The major features and achievements of the program have included:

- strong research management through corporate-style Boards for each Centre, setting research policies, strategies and priorities;
- the outcome of cooperative research being greater than the sum of the parts;
- projects being undertaken which would not have started outside a cooperative program;
- exceptional and innovative education programs, specially at the post-graduate level;
- the development of spin-off companies and SMEs to add to Australia's innovation base; and
- successful commercial and public interest outcomes resulting from cooperative research.

Another great strength of the CRC program is that students receive their research training in an end-user-connected environment. As an outcome measure it would be useful to track graduates for a few years after they leave the CRC. CRCs should be encouraged to increase student numbers involved in the CRCs and the type of activity that these students undertake, including a greater role in the management of the CRC. This could include PhD degrees with a significant business component. CRCs would be required to report student involvement in more detail including the tracking of graduates after leaving the CRC.

Many submissions supported the expansion of a number of linkage programs, particularly the CRC program:

> *The investment by the Commonwealth in industry incentive programs is significant. Indeed, it is fairly typical that small, hungry companies are a significant component of a national innovation engine. However, these companies tend to operate on the edge of survival and are in no position to make a significant financial commitment to a CRC for any period, let alone seven years. Thus, there is a range of companies that, if given access to a CRC and its knowledge, would blossom and flourish, yet cannot gain such access because the CRC guidelines effectively require that the associated industry commit significant funds to the CRC.*[85]

Unlike some R&D incentive schemes, the CRC Program demands that a certain level of collaboration and connectivity between players in the innovation system is established prior to an application being made. This is in contrast to other schemes in which contestability of public funding tends to favour competition rather than collaboration. The Review considers that the CRC approach to allocation of public funding delivers significant results in helping to raise awareness of the benefits of collaborative research environments and should be strongly supported.

[85] Australian Geological Survey Organisation submission to the Review.

The Commonwealth Government funds CRCs to address two areas of market failure. First, the more basic end of R&D is not an attractive business proposition because no individual business can fully capture the benefits to warrant paying the full cost the research, including the training of postgraduate students. Second, the establishment of networks and linkages between firms to facilitate collaboration and technology diffusion is again an area where individual businesses cannot capture sufficient benefit to warrant paying the full cost.

The CRC Program does not have a legislative base. It operates as a Commonwealth department program[86] using departmental budget funds. It could now be recognised through continuing the program under its own Act of Parliament to formally become part of Australia's innovation and research network along with the ARC, the NHMRC, and CSIRO, for example. This would add future certainty to the program and recognise the enormous contribution the CRCs have made to date to Australia's knowledge base.

A CRC approaching the end of its term (or a 'renewal' CRC) may well be in the position where it has performed well and delivered outcomes that more than justify the original funding, but is still capable of undertaking further R&D that fully satisfies the main objectives of the program of collaboration, end-user involvement and outcomes that create new business. A different set of participants or end-users may be involved. Such CRCs should be considered on their merits against new proposals and not be automatically excluded.

Spin-off formation is becoming a feature of the CRC program. A recent survey[87] identified 23 spin-off companies from 14 surveyed CRCs. 10 spin-off firms had 20 employees on start up and now employ 540 staff including 40 outsourced/contract researchers. This is an average compound annual growth rate of 357 per cent. Most firms from the survey currently turn over less than $1million, but 74 per cent of the firms commenced operating only in the last three years. Three, however, have a turnover of $10.1-$50 million and one has a current turnover of over $100 million. All report an expectation of strong growth, up to tens of millions of dollars, in the next two to five years.

Many of the submissions emphasised that CRCs should be encouraged to explore ways to further improve access to CRC developed technology by SMEs, for example, through improved access to expert assistance through short term research contracts, or access to CRC research infrastructure. This may be facilitated more easily when a CRC is an incorporated body and in any case, is easier than direct participation in a CRC as a core or supporting participant.

The CRCs should be able to provide services for non-core participants, to run technology clinics and to take equity positions in start-ups, for example.

[86] Commonwealth Department of Industry, Science and Resources

[87] *Report on CRC Spinoffs*, Advance Consulting & Evaluation Pty Ltd, October 2000

There is an opportunity for the CRC program to involve itself more intimately with emerging areas of economic growth or areas singled out in any whole-of-government priority setting process. It may be appropriate to have special rounds for priority areas. This would stimulate internationally competitive, leading edge research in areas critical to Australian economic, environmental and social development.

A further option to help SMEs access CRCs may be to introduce in the guidelines a 'capacity to pay' element in the assessment of the level of industry commitment in a given proposed CRC. The concept would apply both to the quantum of proposed commitment, and to the duration of such commitment.

A number of options exist to ensure greater flexibility and greater SME access:

- A CRC could be established for a shorter period, for example, four or five years, to address a particular industry need.
- Special consideration could be given to projects that are recommended and strongly supported by States and Territories, or a consortium thereof, in areas of special interest.
- Selection criteria for funding should reflect the experience of CRC applicants. For example, an established CRC allowing for a second round should not be assessed against the same criteria as a CRC applying for first time funding. Application rounds need not be concurrent.
- Other government departments should have an increased role in the funding and selection of CRCs in particular research fields to better reflect national priorities.
- CRCs and spin-offs should have greater access to government R&D incentive programs, via the industry participants. This would include R&D *Start*, COMET and SPIRT.
- CRCs nearing the end of their term and with particular commercialisation goals soon to be realised, could be funded a smaller amount outside the normal selection process to complete their work. This would provide an alternative to the 'renewal' process.
- Industry Associations could become more involved in CRCs to address common problems across industry sectors.
- CRCs which are assessed to be very successful, but still rely on government to address the market failure associated with their research, should have the option of renewal subject to competitive requirements.

The average funding each CRC receives is $2.3 million per year, which differs little from the average funding each CRC received 10 years ago, when the program commenced, of $2 million per year. The Review recommends that in view of the success of the CRC program and its potential for further development, additional funding be provided to significantly expand the CRC program. This will enable the CRCs to:

- develop more flexible operating arrangements and enhance the opportunities for participation by SMEs;
- expand their activities beyond the core set of activities agreed at establishment;
- increase their collaboration with international research networks engaged in cutting-edge research; and;
- tap into a more diverse set of funding sources.

14 Major Recommendation

Expand the CRC program to encourage greater SME access and to facilitate stronger networks between the SET base and industry, nationally and internationally.

Investment: $150 million over five years

7.4.3 Innovation Centres

New business formation around cutting edge technologies is essential for a growing economy. Australia needs to have at least ten times the number of start-up and spin-off companies than it currently creates per year. The universities and GFRAs are slowly increasing their activity in this area, but they will need to give it much greater impetus if they are to be at the heart of the effort to build Australia's knowledge economy. To accelerate this growth, new ways of assisting universities and other research providers must be implemented. A fundamental gap in the system is know-how associated with commercialising research. Australian universities and GFRAs need to enhance their capabilities for knowledge transfer, over and above the services currently provided by the university commercialisation arms, where in many cases there is an acute shortage of suitable personnel.[88]

The additional competitive funding proposed for the ARC, infrastructure and pre-seed capital and the initiatives proposed for assessing intellectual property in ARC grants recommended in this report will generate much more research that is likely to be commercially attractive. The current system in place to take research to market is not operating efficiently enough and cannot convincingly demonstrate that it could cope with increased research activity. A more efficient and effective method of dealing with the results of *The Chance to Change* investment strategy is required. The Review, therefore, proposes that new resources be provided to facilitate connecting researchers with commercial nous to evaluate opportunities and suggest the most appropriate paths for commercialisation, similar to the recent UK experience[89], in the form of around five Innovation Centres. These Innovation Centres might also help to address the less than critical mass seen in

[88] ATTICA Executive submission, 28 October 2000.

[89] UK Science Enterprise Challenge

some of the numerous commercialising arms of the universities. They would bring in the GFRAs and encourage collaboration and consolidation.

Innovation Centres could deal with intellectual property issues, start-up incubator opportunities, networks to venture capital and management of access to CRCs, government incentive schemes and GFRAs. They could also help clarify the funding mechanisms available and provide a coordinated approach to commercialising university-generated research. The Centres would integrate scientific, technological, legal, innovation and management skills, together with a training function to address the acute shortage of people skilled in this area.

These Centres should:

1. advise how to handle intellectual property protection and development in a particular area;
2. advise how to access pre-venture capital funding for incubator-type activities;
3. identify the potential for start-up companies;
4. manage new businesses;
5. identify opportunities for spin-off companies and nurture their establishment;
6. manage reward and incentives schemes for researchers;
7. assist in establishing international collaborative projects;
8. advise how to develop market plans and prototypes;
9. have excellent networks into venture capital, R&D *Start*, BITS, CRCs, RDCs and the GFRAs; and
10. provide commercialisation training.

Another role of the Innovation Centres would be bridging the innovation gap by closely aligning the commercial interests of universities and industry. Individual centres would need a critical mass of expertise, possibly by combining or complementing the resources of several existing commercialising arms/companies, to provide avenues of assistance attractive to more than one higher education institution. Private sector researchers play an important role in developing Australia's innovation capacity and the introduction of new technology. The submission to the Review from Australian Business Limited (ABL) noted the potential for companies to contribute to increased levels of start-up formation and suggested that more knowledge within government and business is required about what factors could stimulate this type of activity. The Review supports ABL's comment that industry associations can play a crucial role in supporting innovation, particularly at a local level.

> *ABL supports greater use of industry associations as brokers between the business community and public sector researchers, in much the same way that ABL and other bodies have developed a role as a 'Business Angel' broker, helping SMEs access finance from high wealth individuals.*[90]

[90] ABL submission to the Review.

Industry associations could help form strategic links between Innovation Centres and their member companies.

Innovation Centres should aspire to international standards of training and advice, addressing all stages of the innovation process. The Commonwealth Government could seek competitive bids to manage them, with successful centres displaying strong elements of collaboration between universities, industry and government.

To stimulate commercially oriented behaviour in the university research community, each Innovation Centre would offer a number of prizes for business plans each year. It is not expected that each university in Australia have its own Innovation Centre, but at least have virtual access to centres located elsewhere. Companies, especially small and medium sized enterprises, will be able to access the information and services provided by the Innovation Centres and each centre would be linked, to facilitate knowledge sharing.

Submissions to the Review and the public consultations have strongly supported the Innovation Centres as a means of enhancing commercialisation prospects for research. Of particular note was the strong endorsement by the John Curtin School of Medical Research[91] which noted that an Innovation Centre which provided services for a number of organisations would provide much needed critical mass in commercialisation services. ISIG has made a complementary recommendation to establish five Innovation Centres as part of a pilot (Recommendation 17). The Review endorses this recommendation and notes that details would be developed during an implementation process.

15 Major Recommendation

Establish a small number of Innovation Centres to provide universities and government-funded research agencies with support in commercialising research.

Investment: $50 million over five years.

7.4.4 Pre-seed Capital

Despite the recent changes in capital gains tax and the increasing availability of venture capital, the Review believes that there is a need to provide funds to enable the further work necessary to take a promising technology to a point where a venture capitalist or investor can make a decision about commercialisation. The recent ARC report on commercialising university research highlighted this ‘innovation progression gap’ in resources available for funding research at the ‘proof of concept’ stage.[92] Submissions to the review from GFRAs also highlighted the need for access to this particular type of funding. Even with the growth in venture capital and the business angel funds (available through high networking individuals and now through Australia’s large banks) there is still a risk adverse approach by venture capital funds because of their judgements about acceptable

[91] A presentation by Professor Judith Whitworth, Director, John Curtin School of Medical Research at the ACT public consultation on *The Chance to Change – a discussion paper*, 27 September 2000.

[92] Australian Research Council, *University Research: Technology Transfer and Commercialisation*, October 1999.

risks and return and a lack of the skill base to adequately assess early stage proposals. Until this skill base is better established, we need a pre-seed fund for bringing research to the venture capital ready stage. The problem is not unique to Australia. Even in the US, it is acknowledged that there is a 'valley of death' between early stage research and venture capital ready research.[93]

Organisations such as CSIRO have demonstrated an ability to form close strategic alliances with industry, and the Review considers that the skills and infrastructure are in place for CSIRO and other government funded research institutions, including CRCs and RDCs to access additional investment from a new capital fund. These funds might be in the form of soft loans. CSIRO's submission notes:

> *Pre-seed funding occurs very early in commercialisation/technology transfer. The earlier the investment, the higher the risk for the investor and the more acute the need for expertise in the technology and intended markets in order to assess the risk (as well as the potential return). This is manifest in venture capital normally investing in a familiar and fairly narrow area, and it happens because specialisation improves the probability of success.*

The Review notes that skilled personnel will be required to operate a pre-seed fund.

ISIG also identified access to pre-seed capital as a major inhibitor for commercialisation of research (Recommendation 19). The Review supports the proposal in ISIG and suggests that the funding requirement is greater than that proposed there, based on the initiatives outlined in this report.

Funding should be allocated on a competitive basis.

16 Major Recommendation

Establish a pre-seed capital fund for universities, Innovation Centres, and government-funded research agencies, such as CSIRO, RDCs and CRCs.

Investment: $75 million over five years

7.5 Intellectual Property and Incentives

A strong intellectual property (IP) regime can stimulate domestic and foreign investment and has the capacity to encourage innovation and further development of new technology.

Traditionally, research providers employed an IP strategy that focused on IP-ownership. This tended be at the expense of in-house development, as well as the creation of an environment in which early stage commercial activity and exploitation of intellectual resources was encouraged. In some situations, licensing IP is the only feasible path to successful commercialisation. An example of this is IP associated with the development of pharmaceuticals. In other cases, however, taking out a provisional patent and licensing to a large corporation generates short

[93] Dr Neal Lane, Assistant to the President for Science and Technology, briefing to the Australian Government, 1 November 2000.

The NHMRC views IP management as, " one of the most critical steps in the translation of research into national wealth."[94]

term income at the expense of a more favourable long-term commercial advantage derived via, for example, equity positions in spin-off companies. We should be endeavouring to hold on to IP long enough to maximise our position, including equity, in any commercial proposition.

The public sector in Australia has traditionally been reluctant to explore the benefits of adopting a more commercial approach to its IP. Furthermore, a uniform policy with regard to IP does not exist at Commonwealth or State/Territory level. This is partly because of perceived conflicts of interest, lack of commercial expertise and acumen and broad issues of legal liability.

Increasingly, however, Australian governments, GFRAs and universities are taking a more commercial approach to using and commercialising IP. For example, the Commonwealth Government recently developed draft guidelines for the management of IP, *Commercialisation of Commonwealth Intellectual Property in the Field of Information Technology*, in an effort to boost the transfer of technology into the private sector where it can be commercialised.[94] There are, in fact, many initiatives in this area, for example, the Western Australian Government's Intellectual Property Guidelines and recent Department of Defence initiatives.

Internationally, the US Government has attempted to remove barriers to the commercialisation of research in universities the Bayh-Dole Act (1980). The UK Government is currently following two general strategies:

- creating a climate for enterprise in all UK universities, and
- establishing a balanced set of incentives to encourage publicly-funded researchers to exploit the results of their work and ensure they receive proper recognition for doing so.[95]

The recent Australian review of health and medical research pointed out the need to create an environment encouraging researchers to exploit and commercialise their ideas. Providing incentives for researchers could involve consideration of IP ownership and more flexible working conditions. Offering such incentives is seen as the best means of achieving a more significant contribution to economic growth and wealth creation.

The National Health and Medical Research Council (NHMRC) recently released draft guidelines on management and commercialisation of IP generated by NHMRC-funded research.[96] The document aims to ensure that researchers have access to good practices for the identification, protection and management of IP. This will maximise the benefits and returns on public investment in health and medical research through increased exploitation and commercialisation activities in research institutions. Institutions, rather than individual researchers, will be required to declare their adherence to the guidelines.

The ARC should consider adopting a similar approach to IP management. Likewise, Australian universities should be exploring ways to provide the right incentives for researchers via good IP management policies.

[94] Department of Communications, Information Technology and the Arts, 13 June 2000

[95] *Good Practice for Public Sector Research Establishments on Staff Incentives and the Management of Conflicts of Interest*, UK Department of Trade and Industry, July 2000

[96] NHMRC, *Draft Guidelines for Intellectual Property Management and Commercialisation for Health and Medical Research*, 2000.

17 Major Recommendation

1. *Universities and government-funded research agencies review opportunities for researchers to better share in the benefits of commercialisation.*
2. *Universities and government-funded research agencies adopt a more strategic approach to the management of intellectual property.*

7.6 Better information for business innovation

The array of publicly-funded programs and incentives designed to encourage business innovation is often confusing and can dissuade the private sector from attempting to access them in the first place. A number of submissions to the Review highlighted this issue as an inhibitor for increasing innovative activity in the private sector. The creation of a 'One Stop Shop' for business R&D incentives would be an effective information source for business, and increase awareness and access to such incentives. A coordinated, whole-of-government approach is necessary to promote this initiative.

R&D *Start*, through AusIndustry, should be the primary delivery agency for the dissemination of information to business on the full range of government assistance for R&D. It would also act as the central point of access for current and potential clients, including organisations that intend to access the tertiary research sector.

The ARC, universities, GFRAs and CRCs also need to coordinate their supply of business information.

The Review supports ISIG's recommendation on this issue (Recommendation 14), which suggests that a nationally integrated, internet based, single point of access be created for business to apply for support and obtain advice on which government programs best meet their needs. This could be expanded by also covering information on Australia's R&D expertise in publicly-funded institutions.

Strategy

Create a 'One Stop Shop' for business R&D incentives and R&D information.

Chapter eight

Chapter eight

Accountability

8.1 Measuring Investment Outcomes

Much of what is proposed by this Review involves outlays of a high order. The expected outcomes more than justify the outlays. The Review takes a strong position, however, that outcomes must be observed and measured, on appropriate time scales, to justify ongoing payment of the proposed outlays.

The community has a right to know where its money is being invested and what outcomes are being achieved. Accountability requires clear relationships to be established between investment in the SET base and desired outcomes. In keeping with the theme of Investment in People and Culture proposed in this Review, a well-informed community will be in a stronger position to appreciate the links between the SET base, the quality of life, living standards and economic growth. While improvements in these parameters are tangible, they may not be readily measurable in the short term.

There are, however, a number of indicators that can be used in the near term to measure direct outputs from investment in the SET base. Table 8.1 below outlines an approach for measuring the returns of some key aspects of the three themes of investment, People and Culture, Ideas and Commercialisation.

Table 8.1

Targets to measure success of investment in SET base

Theme	Goal	Measure	Example Target
Culture	Education	Number of SET graduates	Employment of SET graduates increases in industry. Skill shortages in ICT industries are reduced over five years. More SET teachers entering the workforce
Culture	Investment Attraction	Number/size of investments in research related facilities attracted to Australia	5 additional investments in research related facilities by 2005; rising to 10 by 2010
Ideas	Skills	Number of 'star' researchers	High quality overseas researchers and Australian educated researchers come to Australia to pursue research careers
Ideas	IP Creation	Patents	Level of patent activity normalised for research funding levels
Ideas	Fundamental Science	Bibliometrics	Relative citation impact ranking to put Australia in top 10 countries in 6 research fields. Increased visibility in key journals
Commercialisation	Spin-offs	Number of businesses created	Approach world best practice for spin-off creation from research institutes of 8-10 per year per US$100 million research budget
Commercialisation	Economic Benefits	Jobs created by spin-offs. Jobs created from investment in research-related facilities	Determine target new jobs in research-based spin-offs and foreign direct investment in research-related facilities in light of review outcomes

Ultimately, the measure of success in our investment outcomes is the value placed on it by the community but quantifiable outcomes are crucial. The Review does not propose that the new investment in the SET base should continue without demonstrating a required level of performance.

18 Major Recommendation

Any additional funding for the SET base should be closely linked to measurable performance indicators.

The Review notes that ISIG proposes the establishment of an ABS Expert Panel to provide ongoing strategic guidance on innovation data collection and reporting. This could be a good starting point for the development of SET base performance measures.

Appropriate metrics should be constructed to recognise the lead times associated with registering benefits from the investment in the SET base. Many of the benefits involved will only show themselves in a longer time frame. Performance indicators could be developed during implementation and monitored to ensure that they will reflect a true picture of returns.

Table 8.2 notes and comments on some of the expected outcomes and possible means of measurement of our investment.

Table 8.2

Expected outcomes from increased investment in the SET base – metrics

Expected outcomes	Possible Metric	Comment
Stronger patenting performance.	Measure the number of patents received or pending over time.	The recent Narin Report — Inventing Our Future, the link between Australian patenting and basic science — demonstrates the critical nexus between publicly-funded research and the development of new technologies in Australia. Throughout the document, a variety of 'patent type' measures are discussed, including the number of Australian patents and Australian scientific research cited in all Australian-invented US patents.
Stronger commercialisation performance reflected in the creation of spin-off companies to levels closer to those in the US and UK.	Measure the number of spin-offs from research institutions in Australia — for example, the number of spin-offs per $100 million research budget per year for universities, the CSIRO and other GFRAs.	World's best practice for spin-offs from research institutions is of the order of 8 to 10 spin-offs per year per US$100 million research budget. The current rate of spin-offs from CSIRO research is five per year on a research budget of about US$450 million, while for universities it is estimated to be 0.5 per year. It is important to note that increasing the number of spin-offs is not the end of the story; it is also a matter of achieving maximum value from spin-offs.
Stronger performance in terms of the up-take of technological innovations developed elsewhere in the world.	Possible measure is payment for overseas held patents.	
Australia is expected to become a more attractive country to locate research-based investment to the world's leading companies.	Measure the level of investment by multinational companies in research-based facilities and activities in Australia.	According to the OECD's Globalisation of Industrial R&D: Policy Issues: • Foreign subsidiaries are now responsible for 12 percent of total manufacturing R&D investments in OECD countries; • A study of 32 international pharmaceutical and electronics companies shows that the number of new foreign affiliate laboratories tripled in the 1985-95 period compared with the previous decade.
Deliver new health care therapies, new solutions to new environmental challenges, such as dryland salinity and climate change, and new approaches to the management of Australia's natural resources.	There is the need to develop metrics for these outcomes.	
Improve Australia's performance as an exporter of high-tech manufacturing goods and services.	The export performance of Australia's manufacturing and service exports over time.	
Retention of Australia's brightest and best researchers, while also being able to attract and retain leading researchers.	Measure the flow of 'star' researchers to and from Australia.	The Wills Report considered the migration of scientists and academics between 1983-93 and did not observe a 'brain drain'. Anecdotal evidence to the Review, however, indicates that while more researchers enter Australia than leave, it is our best and brightest that leave seeking better opportunities and rewards for their skill in higher quality research environments. The Report is concerned that we will also lose tomorrow's stars in the face of increasingly strong international demand.[97]

[97] The Wills Report, *The Virtuous Cycle — Working Together for Health and Medical Research, Health and Medical Research Strategic Review*, 1999, p.4.

Chapter nine

Chapter nine

Conclusion: The Implementation Plan

9.1 Summary of the Investment strategy

The strength of Australia's SET base will attract many new companies and skilled people to our shores, adding to Australia's knowledge stocks and our ability to contribute to world knowledge. It is the Commonwealth Government's primary responsibility to act now to realise this blueprint for Australia's economic, social and environmental future.

Table 9.1

Theme	People and Culture	Ideas	Commercialisation
University students	Recommendation 1 (P53)		
Career paths for researchers:			
1) Postdoctoral Fellowships	Recommendation 2 (P55)		
2) Federation Industry Chairs	Recommendation 3 (P55)		
3) R&D *Start* Graduate	Recommendation 4 (P56)		
SET awareness	Recommendation 5 (P58)		
Research priorities		Recommendation 6 (P61)	
Excellence in research		Recommendation 7 (P65)	
Leading edge infrastructure		Recommendation 8 (P66)	
Information Infrastructure		Recommendation 9 (P68)	
Major Research Facilities		Recommendation 10 (P69)	
GFRAs		Recommendation 11 (P75)	
Linking public sector research performers		Recommendation 12 (P78)	
Tax incentives for SMEs, R&D investment attraction			Recommendation 13 (P87)
Connecting universities and industry			
1) CRC program			Recommendation 14 (P92)
2) Innovation Centres			Recommendation 15 (P94)
3) Pre-seed capital			Recommendation 16 (P95)
Intellectual Property and Incentives			Recommendation 17 (P97)
Measuring the return on investment	Recommendation 18 (P100)	Recommendation 18 (P100)	Recommendation 18 (P100)
Implementation Group	Recommendation 19 (P105)	Recommendation 19 (P105)	Recommendation 19 (P105)

9.2 Implementation Plan

Due to the integrated nature of the proposals and in order to ensure maximum effectiveness of investment, detailed planning is necessary for implementation of the changes in Australia's SET base proposed in this Review. For example, the proposals to double ARC research grants, encourage commercialisation of research and provide incentives for R&D are all closely related in their impact and should be developed in a consistent fashion. An implementation plan is also required to specify the detailed arrangements necessary for the execution of measures described in general terms by this Review, such as the setting of priorities.

The experience with the review of health and medical research in Australia showed the value of proposing a detailed and robust implementation plan to carry forward the report's recommendations. At the heart of the Wills Report implementation plan was a two tiered coordination process for the first 18 months of implementation which comprised,

> *An 'Ownership Group', consisting of the respective Ministers for DHAC, DETYA and DISR, would receive reports on implementation progress from an Implementation Committee, approve proposed courses of action, and help facilitate change. The Implementation Committee would be responsible for coordinating actions by the organisations outlined above and for executing tasks delegated to it by the Ownership Group.*[98]

We see merit in proposing an appropriately robust implementation plan, along the lines of that proposed by the Wills Report, in order to ensure the smooth and coordinated application of this Review's final recommendations.

It is envisaged that a Science Capability Implementation Group, established as a working group of PMSEIC, chaired by the Chief Scientist, could perform the following functions:

- monitor progress by the ARC in implementing the competitive grants and related infrastructure recommendations;
- oversee the establishment of the MRF Program;
- further develop the elements of the recommendation on access to information and national site licences;
- establish and oversee the process of competitive bidding for the Innovation Centres;
- oversee the approach to the CRCs designed to expand their functions, increase their flexibility and allow them to be nodes in relevant international research collaboration programs;
- ensure the highest degree of integration in the implementation of the Review's recommendations, including the development of international connections in research;

[98] The Wills Report, *The Virtuous Cycle — Working Together for Health and Medical Research, Health and Medical Research Strategic Review*, 1999, p.207.

- examine further initiatives in the area of science awareness proposed by contributors to the Review; and,
- make initial recommendations on priorities and how they might be implemented.

The Science Capability Implementation Group would report to PMSEIC on progress with the implementation of the Review's recommendations.

19 Major Recommendation

A Science Capability Implementation Group be established to implement the recommendations endorsed by Government.

Abbreviations

Abbreviations

AIMS	Australian Institute of Marine Science
ANSTO	Australian Nuclear Science and Technology Organisation
ARC	Australian Research Council
ATTICA	Australasian Tertiary Institutions Commercial Companies Association Incorporated
BITS	Building on Information Technology Strengths
CGT	Capital Gains Tax
CIVs	Collective Investment Vehicles
COMET	Commercialising Emerging Technologies
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DETYA	Department of Education, Training and Youth Affairs
DHAC	Department of Health and Aged Care
DISR	Department of Industry, Science and Resources
GDP	Gross Domestic Product
GFRA	Government funded research agency
HECS	Higher Education Contribution Scheme
ICT	Information and communications technologies
IIF	Innovation Investment Fund
IP	Intellectual Property
IPO	Initial Public Offering
IR&D	Industry Research and Development
ISIG	Innovation Summit Implementation Group
MRF	Major research facility
NESLI	National Electronic Site Licensing Initiative
NHMRC	National Health and Medical Research Council
NIH	National Institutes of Health
NIS	National Innovation System
NSF	National Science Foundation
OECD	Organisation for Economic Co-operation and Development
PDF	Pooled-Development Fund
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
RIBG	Research Infrastructure Block Grants
R&D	Research and Development
RDC	Rural Research and Development Corporation
Review	Australian Science Capability Review
SET	Science, Engineering and Technology
SME	Small and Medium-sized Enterprise
SPIRT	Strategic Partnerships with Industry — Research and Training Scheme
TEKES	National Technology Agency (Finland)
UK	United Kingdom
US	United States of America

Appendix A

Appendix A

AUSTRALIAN SCIENCE CAPABILITY REVIEW

TERMS OF REFERENCE

Australia's science base consists of the research and research training undertaken in higher education institutions and government laboratories together with the research capacities of the private sector, and the structures and mechanisms by which such activities and institutions are directed, funded and evaluated.

The strength of the science base, and its links to users and industry are key determinants of the success of Australia's innovation efforts. It is vital that Australia's science base is operating efficiently by producing outcomes which are linked to the needs of users as well as advancing the knowledge of the community.

The Australian Science Capability Review is designed to complement the Government's other initiatives in this area, such as the emphasis on an innovative, ideas-based economy and the February 2000 National Innovation Summit.

The Chief Scientist will conduct a capability review of Australia's science base, including basic and applied science, engineering and technology, with the following terms of reference:

Terms of Reference

To examine and report on:

1. The current state of Australia's science base, including an analysis of its effectiveness and of the costs and benefits to the community and business.

2. Mechanisms for funding and other support for the science base which will help ensure that resources most effectively meet the needs and opportunities.

3. The required characteristics of the science base if it is to support the development of leading edge industry in Australia.

4. The contribution the science base should make to economic development, particularly in contributing to the innovative, ideas-based economy. The review should not only report on the technical outputs of the science base, but also on the production of skills well suited to the next generation of ideas-based industries.

The review process will involve wide consultation to ensure that interested parties can express their views and to explain the review's findings upon its completion.

Appendix B

Summary of Strategies

People and Culture

- Lifelong learning must become a key strategy for education providers and employees
- Inspire students to study SET-based subjects
- Reward excellent SET teachers
- Specialist intensive training for teachers
- Opportunities for SET graduates already in the workforce to enter the teaching system
- Institutions and researchers take more of an active role in promoting science and technology awareness
- A new social contract between science and society must be created
- More communication between researchers and the public, including schools

Ideas

- RDCs to have greater responsibility for infrastructure.
- That a national measurement institute be established to consolidate chemical, physical, biological and legal metrology into one organisation.
- Recognise the importance of international collaboration between universities, GFRAs and industry

Commercialisation

- Double COMET funding over five years
- Modify R&D *Start* to encourage SME participation
- Universities must introduce strategies to stimulate and facilitate increased transfer of knowledge to business and society

Create a ‘One Stop Shop’ for business R&D incentives

Appendix C

Appendix C

National Innovation Summit Recommendations

The February 2000 National Innovation Summit generated a number of recommendations on ways to improve Australia's innovative capacity. The majority of these recommendations have been addressed by the Innovation Summit Implementation Group in its report *Innovation - Unlocking the Future*. A small number of recommendations were referred to the Chief Scientist for response through the Australian Science Capability Review.

Recommendation 4

Signal Priority of innovation by enhancing the Chief Scientist's role.

It would be inappropriate for the Chief Scientist to comment on this recommendation. The Chief Scientist's Strategic Advisers on the Australian Science Capability Review have in various ways indicated the significance of the Chief Scientist role.

Recommendation 5

The Chief Scientist to conduct a substantive whole of government strategic review of innovation related activities and skills.

A review would best be conducted in the context of the evaluation of the Innovation Action Plan.

Recommendation 115

Maintain and strengthen the research base. Identify broad priority areas. Create a passion for world class scientific outcomes by emulating the sports model.

The recommendations of the Australian Science Capability Review are designed to strengthen Australia's research base. The Chief Scientist is proposing as part of the review that the Prime Minister's Science Engineering and Innovation Council take a greater role in informing government about research priorities. This will involve the presentation of an annual report based on data collected through the Science and Technology Budget Statement on Australia's pattern of research investment. Gaps will be identified by PMSEIC and referred to the government for consideration.

Recommendation 118

Re-balance R&D disciplines in the public sector system.

The Australian Science Capability Review notes that there are well established priority setting mechanisms in a number of publicly funded research institutions, including CSIRO. The proposal (see above) for an enhanced role for PMSEIC will increase the government's ability to respond quickly to the changing needs of emerging industries and society.

Recommendation 120

Policies for the establishment of major national facilities should be reviewed and clear guidelines should be developed for their support, based on:

- their need as a national facility being clearly justified
- their utility to industry being identified and promoted, including industry access to the associated research and training activities
- there being feasible strategies in place to support their ongoing operation and capital costs, and
- consideration being given to the location of these facilities to encourage linkages with clusters and technology parks.

Consideration should also be given to extending the concept to major industry initiatives, beyond research per se.

The Chief Scientist has proposed the establishment of a major national research facilities program to assist in the development of clustering activity by industry and research performers. This will involve up to 50 per cent funding by the Commonwealth government for the establishment of a facility and the rest from contributions by State/Territory governments, industry and public research institutions. The selection process will be competitive.

Recommendation 121

Create a permanent budget item for MNRFs and include incentives for industry.

The Review considers that major national research facilities are vital and has recommended accordingly, see Major Recommendation 10.

Appendix D

Appendix D

INITIAL SUBMISSIONS TO THE REVIEW

Submission Name

Antarctic Science Advisory Committee, Australia's National Committee on Antarctic Research, Australian Antarctic Division of Environment Australia and Cooperative Research Centre for the Antarctic and Southern Ocean Environment, Joint Submission

Australia & New Zealand Association for the Advancement of Science

Australia & New Zealand Industrial and Applied Mathematics

Australian Academy of Science

Australian Academy of Science, National Committee for Physics

Australian Academy of Technological Sciences & Engineering

Australian Academy of Technological Sciences and Engineering (Supplementary Submission)

Australian Academy of the Humanities

Australian Coal Association Research Program

Australian Council of Deans of Science

Australian Council of Engineering Deans

Australian Earthquake Engineering Society

Australian Fisheries Management Authority

Australian Geological Survey Organisation

Australian Geoscience Council

Australian Industry Research Group

Australian Institute of Marine Sciences

Australian Institute of Biology

Australian Institute of Mining and Metallurgy

Australian Mathematical Science Council

Australian National Seismic Imaging Resource

Australian National University

Australian Nuclear Science & Technology Organisation

Australian Petroleum Cooperative Research Centre

Australian Research Council

Australian Science Network Pty Ltd

Australian Vice-Chancellors' Committee

Bureau of Meteorology

C S R Limited

Charles Sturt University

Coalition for Innovation in Scholarly Communication

Coalition for Innovation in Scholarly Communication (Supplementary Submission)

Cochlear Limited

Commonwealth Department of Agriculture, Fisheries and Forestry - Australia

Cooperative Research Centre for Aboriginal & Tropical Health

Cooperative Research Centre for Catchment Hydrology

Cooperative Research Centre for Food Industry Innovation

Cooperative Research Centre for Hydrometallurgy
Cooperative Research Centre for Satellite Systems
Cooperative Research Centre for Tropical Rainforest Ecology and Management
Cooperative Research Centre for Water Quality and Treatment
Cooperative Research Centre for Welded Structures
Cooperative Research Centres Association
Cooperative Research Centres Committee
Council of Australian Postgraduate Associations
Council of Australian University Librarians
CSIRO
CSIRO Information, Manufacturing and Service Industries
CSIRO Staff Association
Deakin University, Faculty of Science & Technology
Deans of Science Group, Griffith University
Deans of Science & Engineering, University of Technology Sydney
Edwards, Dr S A
Environment Institute of Australia
Environmental Research Information Construction Pty Ltd
European Union, Delegation of the European Commission to Australia and New Zealand
Faculty of Science and Engineering, University of Tasmania
Federation of Australian Scientific and Technological Societies
Ferguson, Dr Ian
Geological Society of Australia
Glaxo Wellcome Australia Ltd
Group of Eight Universities
Institution of Engineers, Australia
James Cook University
Kelleher AO, Mr Graeme
La Trobe University
Lamb, Ms Belinda
Lambeck, Professor Kurt
Macquarie University
Murdoch University
National Association of Forest Industries Limited
National Association of Testing Authorities,
Australia National Centre for Epidemiology & Population Health,
Australian National University
National Tertiary Education Union
Natural Resources & Environment, Department of Victoria
Northern Territory Office of Communications, Science and Advanced Technology
Orica Limited
Parsonage, Mr Craig
Parums, Mr Robert
Queensland Department of Natural Resources
Queensland Health Scientific Services

Queensland State Government
Research Committee of the National Health and Medical Research Council
Research School of Earth Scientists, Australian National University
Rice, Michael
Royal Melbourne Institute of Technology University
Rural Research and Development Chairs Committee, on behalf of The Rural Research and Development Corporations
Sleigh, Professor Merilyn
Southcorp Limited
Swinburne University of Technology
Tasmanian State Government
Telstra Corporation Limited
The Australian Museum
The Australian Veterinary Association Ltd
The Broken Hill Proprietary Company Limited
University of Adelaide
University of Melbourne
University of New England
University of New South Wales
University of Newcastle
University of Newcastle, Faculty of Science
University of South Australia
University of Sydney, College of Sciences and Technology and Faculty of Science
University of Tasmania
University of Western Australia
University of Western Australia, Department of Mathematics and Statistics
Victoria University of Technology
Walter, Dr David Evans
WMC Resources Ltd

There were 11 confidential submissions

Appendix E

Appendix E

SUBMISSIONS ON THE CHANCE TO CHANCE - A DISCUSSION PAPER[99]

Organisation

Academic Board of Adelaide University
Adelaide University
Adelaide University, Faculty of Science
AMRAD Corporation
Australasian Institute of Mining and Metallurgy
Australasian Society of Clinical and Experimental Pharmacologists and Toxicologists
Australian Academy of Science
Australian Academy of Sciences, National Committee for Biochemistry and Molecular Biology
Australian Academy of the Humanities
Australian Association of Mathematics Teachers Inc
Australian Business Limited
Australian Council of Engineering Deans
Australian Council of National Trusts
Australian Geoscience Council
Australian Industrial Research Group
Australian Information Economy Advisory Council
Australian Institute of Geoscientists
Australian Institute of Marine Science
Australian Institute of Physics
Australian Library and Information Association
Australian Mathematical Sciences Council
Australian Mathematical Society
Australian Museum
Australian National Seismic Imaging Resource
Australian National Training Authority
Australian National University
Australian Nuclear Science and Technology Organisation
Australian Psychological Society, Division of Research & Teaching
Australian Science Technology Heritage Centre
Australian Society for Biophysics
Australian Society for Parasitology
Central Queensland University
Child Health Research Institute Inc
Coalition for Innovation in Scholarly Communication
Collins Group
Committee of Deans of Australian Medical Schools
Council of Australian State Libraries
Council of Australian University Librarians

[99] The overwhelming majority number of submissions were highly supportive of the report.

CRC Association Inc
CRC for Black Coal Utilisation
CRC for Catchment Hydrology
CRC for Cattle and Beef Quality
CRC for Coastal Zone Estuary & Waterway Management
CRC for Freshwater Ecology
CRC for Tissue Growth and Repair
CSIRO
CSIRO Staff Association
Environmental Research and Information Consortium Pty Ltd
Ericsson Australia
FASTS
Flinders University, Flinders Medical Research Institute
Genetics Society of Australia
Geological Society of Australia
Graeme Kelleher & Associates Pty Ltd
Grains Research and Development Corporation
Group of Eight Universities
H-Net, the International On-Line Network for the Humanities and Social Sciences
Institution of Engineers Australia
IP Branch, Attorney-General's Department (Cwth)
James Cook University
Macquarie University
Mathematics Education Research Group of Australasia
Minerals Council of Australia, Minerals Tertiary Education Council
Monash University, Faculty of Medicine
National Committee for Psychology
National Library of Australia
National Tertiary Education Unit
Professional Historians Association of NSW
Queensland Government
Queensland Innovation Council
Queensland Manufacturing Institute Limited
Queensland Department of Primary Industries
Questacon: The National Science and Technology Centre
Royal Australian Chemical Institute
Royal Australian Chemical Institute, Queensland Branch
Royal Australian Chemical Institute, Tasmanian Branch
Science Industry Australia
Society of Australian Systematic Biologists
University of Canberra, Division of Science and Design
University of New South Wales, School of Geology
University of Newcastle, Faculty of Science and Mathematics
University of Queensland, Advanced Computational Modelling Centre
University of Queensland, Department of Physiology & Pharmacology
University of Queensland, Faculty of Biological & Chemical Sciences

University of Queensland, Faculty of Biological & Chemical Sciences
University of Queensland, Faculty of Health Sciences
University of Sydney, Faculty of Science
University of Tasmania
University of Tasmania, School of Mathematics and Physics
University of Technology, Sydney
University of Western Australia
University of Western Australia, Faculty of Medicine and Dentistry
Victorian Council for Knowledge, Innovation, Science and Engineering
Victorian Government Agencies with Science, Technology and Innovation responsibilities
Victorian Innovation Centre
Western Australian Institute for Medical Research Inc

Individuals

Aitkin, Professor Murray, Department of Statistics, University of Newcastle
Anderson, Joseph, Department of Physics, University of Queensland
Anscomb, Robin
Atrens, Associate Professor Andrej, Department of Mining, Minerals & Materials Engineering, University of Queensland
Baker, Dr Joe, Chief Scientist (Queensland)
Barnard, Associate Professor Ross, Faculty of Biological & Chemical Sciences, University of Queensland
Barry, Dr John, Centre for Microscopy & Microanalysis , University of Queensland
Bedson Jack, Dixson Library, University of New England
Bertram, Associate Professor Chris, Graduate School of Biomedical Engineering, University of New South Wales
Brabham, Gary
Breit, Dr Samuel, Centre for Immunology, St Vincent's Hospital & University of New South Wales
Brisco, Dr Michael, Department of Haematology & Genetic Pathology, Flinders University
Browning, John
Bubb, Dr William, Department of Biochemistry, University of Sydney
Bull, Melissa, Faculty of Social and Behavioural Studies, University of Queensland
Burgess, Dr Antony, Director, Ludwig Institute of Cancer Research
Byrne, Dr Kerry, School of Mechanical & Manufacturing Engineering, The University of New South Wales
Campbell, Dianne, University of Ballarat
Catcheside, Professor David, School of Biological Sciences, Flinders University
Chalmers, Dr Ainsley, Department of Haematology & Genetic Pathology, Flinders Medical Centre
Clark, Mike
Clarke, Professor Adrienne et al, findings & recommendations from a series of workshops convened by Professor Clarke, the Lieutenant-Governor of Victoria and Co-Deputy Chair of the Victorian Government's Knowledge, Innovation, Science and Engineering Council
Critchley, A/Professor Christa, Department of Botany, University of Queensland
Connor, John, School of History, Australian Defence Force Academy

Curby, Pauline
Curlewis, Dr Jon, Department of Physiology & Pharmacology, University of Queensland
Dawson, Alan
Day, Professor Richard, Faculty of Medicine, St Vincent's Hospital and University of New South Wales
Dayhew, Miriam
de Crespigny, Dr Charlotte, School o f Nursing & Midwifery, Flinders University
de Jersey, Professor John, Department of Biochemistry, University of Queensland
Deane, Professor Elizabeth, Division of Environmental and Life Sciences, Macquarie University
Deverall, Professor Brian, University of Sydney
Dickson, Dr Kerry, Victoria University
Doley, David, Department of Botany, University of Queensland
Drennan, Associate Professor John, Centre for Microscopy & Microanalysis, University of Queensland
Duane, Leonie
Factor, Dr June
Foger, Dr Karl, General Manager, Technology Development, Ceramic Fuel Cells Ltd
Ford, Associate Professor Robin, School of Mechanical & Manufacturing Engineering, University of New South Wales
Frost, Associate Professor Richard, School of Mechanical & Manufacturing Engineering, University of New South Wales
Fuerst, Dr John A, Department of Microbiology & Parasitology, University of Queensland
Gani, Joe, School of Mathematical Sciences, Australian National University
Garson, Associate Professor Mary, Chemistry Department, University of Queensland
Geoghegan, Dr Noel, Department of Early Childhood, University of Southern Queensland
Gibbs, Professor Adrian, Molecular Genetics Group, John Curtin School of Medical Research
Gibson, Dr Lisanne, Australian Key Centre for Cultural & Media Policy, Griffith University
Glenn, Professor Andrew, Pro-Vice Chancellor (Research), University of Tasmania
Goulter, Professor Ian, Deputy Vice Chancellor (Higher Education), Swinburne University of Technology
Graham, John
Green, Dr Michael, Department of Engineering, Australian National University
Grigg, Professor Gordon, Professor of Zoology, The University of Queensland
Grigg, Professor T, Acting Vice Chancellor, University of Queensland
Grun, Professor Rainier, Research School of Earth Sciences, The Australian National University
Gunter, Associate Professor Maxwell, School of Physical Sciences and Engineering, Chemistry, University of New England
Haddad, Professor Paul, Dean, Faculty of Science & Engineering, University of Tasmania
Hall, Professor Peter, Centre for Mathematics and its Applications, The Australian National University
Hartley, Bruce
Hawes, Anne, Environment, Materials and Consumer, Standards Australia
Hawkins, Professor Clifford

Heddle, Dr R J, Department of Immunology, Allergy and Arthritis, Flinders Medical Centre

Hidi, Peter and Sangster, David, University of Sydney

Hogg, Dr Michael, Glaister, Dr John, Humphreys, Dr Michael, University of Queensland

Holmes, Professor Roger, Vice Chancellor & President, University of Newcastle

Home, Professor Rod, Department of History and Philosophy of Science, University of Melbourne

Hudman, Dr Frank, CRC for Waste Management and Pollution Control

Hunt, Dr Peter, CSIRO

Hynes, Professor Michael, Department of Genetics, University of Melbourne

Irvine, Rod, Research Fellow, Adelaide University

Jackson, Professor Frank, Director, Institute for Advanced Studies, the Australian National University

Jago, Associate Professor Jim, Applied Geology, University of South Australia

Jones, Dr Malcolm, Senior Research Fellow, University of Queensland

Kagi, Dr Robert, Professor of Applied Chemistry, Curtin University

Kavanagh, Helen, National Women's Officer, CAPA

Kearney, Professor Robert, School of Resource, Environmental & Heritage Sciences, University of Canberra

Kefford, Bruce, Executive Director, Agriculture, Victorian Department of Natural Resources and Environment

Key, Associate Professor Brian, Department of Anatomical Sciences, University of Queensland

Kozlowski, Wesley,

Laird, Associate Professor Philip, School of Mathematics and Applied Statistics, University of Wollongong

Lavina, Dr Aviva, School of Chemistry, University of Sydney

Lay, Professor Peter, School of Chemistry, University of Sydney

Lee, Joanna, Department of Botany, University of Queensland

Lennox, Dr Paul

Lim, Professor Edward, Monash University

Lindoy, Professor L, Division of Inorganic Chemistry, University of Sydney

Lister, Andrew, Executive Dean, Faculty of Engineering, Physical Sciences and Architecture, University of Queensland

Londey, Dr Peter, Military History Section, the Australian War Memorial

Marinova, Dr Dora, Institute for Sustainability and Technology Policy, Murdoch University

Martin, Jennifer, Institute for Molecular Bioscience, University of Queensland

Martinez-Coll, Dr Alfredo, Biomedical Consulting Services

Martyr, Dr Philippa, Tasmanian School of Nursing, University of Tasmania

McCallum, Dr Hamish, Department of Zoology & Entomology, University of Queensland

McCann, Joy, University of Canberra

McCormack, Terri, Consultant Historian

McCulloch, Professor Peter, Physics Department, University of Tasmania

McDougall, Dr David, School of Engineering and Mathematics, Edith Cowan University

McEwan, Dr Angus

McKee, Professor Don, Sir James Foots, Institute of Mineral Resources, University of Queensland

McKinlay, John, Information Services, James Cook University
McKitrick, Dr Douglas, Department of Medicine, Flinders Medical Centre
McKnight, Dr David, Faculty of Humanities & Social Sciences, University of Technology, Sydney
McLachlan, Professor Elspeth, Prince of Wales Medical Institute, University of New South Wales
McLeod Malcolm, School of Chemistry, University of Sydney
Metcalf, Jennifer, Econnect Communication
Milbourne, Professor Ross, Pro-Vice Chancellor (Research), University of New South Wales
Molloy, Fran
Moo, Michelle
Moon, Professor Tony
Moore, Alan, Equities Analyst, SunCorp Metway Investment Management Ltd
Morgan, Dr Gary, Western Australian Museum
Morley, Professor AA, Department of Haematology & Genetic Pathology, Flinders Medical, Centre
Napier-Munn, Dr T J, Julius Kruttschnitt Mineral Research Centre, University of Queensland
Nelson, Cynthia
Nield, Blair, Molecular Prospecting Unit, Macquarie University
Noller, Professor Barry, National Centre for Environmental Toxicology
Norton, Professor Geoff, Centre for Pest Information, Technology and Transfer, University of Queensland
O'Brien, Professor Fergus, Software Engineering Research Centre, RMIT University
Pfeil, Helen, Research School of Social Sciences, the Australian National University
Platt, Martin
Possingham, Professor Hugh, Department of Zoology & Mathematics, University of Queensland
Postdoctoral and postgraduate researchers, Department of Zoology and Entomology, The University of Queensland
Power, Dr John, Department of Human Physiology, Flinders University
Prociv, Associate Professor Paul, Department of Microbiology & Parasitology, University of Queensland
Quartly, Professor Marian, School of Historical Studies, Monash University
Ralph, Peter
Redden, Robert, Department of Primary Industries, Queensland
Reid, Professor James, Chair, Academic Senate, University of Tasmania
Rose, Professor Reuben, Dean, Faculty of Veterinarian Science, University of Sydney
Schultz, Dr Carolyn, CRC for Bioproducts
Scott, Associate Professor Jim, Division of Agronomy & Soil Science, University of New England
Secomb, Nicole, Consultant Historian
Sims, Associate Professor Neil, Department of Medical Biochemistry, Flinders University
Slatyer, Professor Ralph
Sly, Dr Lindsay, Department of Microbiology & Parasitology, University of Queensland

Smith, Professor Geoff, Centre of Materials Technology, University of Technology, Sydney
Smith, Dr Ross, Department of Biochemistry, University of Queensland
Smith, Sean, Department of Chemistry, University of Queensland
Smyth, David, Department of Biological Sciences, Monash University
Somogyi, Associate Professor Andrew, Department of Clinical & Experimental Pharmacology, University of Adelaide
Stalker, Emeritus Professor R J, Department of Mechanical Engineering, University of Queensland
Staudte, Associate Professor Robert, Department of Statistical Science, LaTrobe University
Steane, Dr Dorothy, CRC for Sustainable Production Forestry
Stecher, Gabriel, Stecheng Consultant Engineers
Steel, Professor David, School of Mathematics & Applied Statistics, University of Wollongong
Sutherland, Professor Colin, Faculty of Science & Technology, University of New South Wales
Sykes, Pamela, Flinders University and Medical Centre
Tate, Professor Tony, Division of Science and Engineering, Murdoch University
Tenhumberg, Dr Brigitte, Department of Zoology & Entomology, University of Queensland
Thomas, Professor A W, Chair, National Committee for Physics, Australian Academy of Science
Trainor, Luke
Trinder, Emeritus Professor John, President, International Society for Photogrammetry & Remote Sensing, University of New South Wales
Tyre, Dr Drew, Department of Zoology & Entomology, University of Queensland
Uwins, Dr Philippa, Centre for Microscopy & Microanalysis, University of Queensland
Wakefield, Professor Denis, School of Pathology, University of New South Wales
Walter, Dr Gimme, Department of Zoology & Entomology, University of Queensland
Waters, Kate
Weiss, Associate Professor Anthony, Molecular Biotechnology Program, University of Sydney
Whitehead, Derek, Swinburne University of Technology
Whittington, Dr Ian, Department of Microbiology & Parasitology, University of Queensland
Williams, Dr P John, Edith Cowan University
Wolf, Dr Karl, Wolf's Geological Consultants
Woods, Dr Peter, Hydrogeologist, PPK Environment & Infrastructure Pty Ltd
Wright, Josephine, Department of Anthropology, the Australian National University
Wyndham, Dr Diana
Young, Dr Linda, Cultural Heritage Management, University of Canberra
Zhao, Dr Ming, Telstra Research Laboratories
Ziino, Bart, History Department, University of Melbourne

There were 12 Confidential submissions.

Appendix F

Appendix F

Letters of Support on The Chance to Change

Abraham, Mark, Research School of Chemistry, The Australian National University
Alexander, Professor Christine, School of English, University of New South Wales
Anderson, Rebecca, Department of Anatomy and Histology, Flinders University
Andrews, Peter, Co-Director, Institute for Molecular Bioscience, University of Queensland
Australian Council of Deans of Science
Bacskay, Dr George, School of Chemistry, University of Sydney
Baddeley, Professor Adrian, Head, Department of Mathematics & Statistics, University of Western Australia
Barker, Emeritus Professor JSF, School of Rural Science & Natural Resources, University of New England
Ben-Nissan, Associate Professor B, Department of Chemistry, Materials & Forensic Science, University of Technology, Sydney
Bevitt, Joseph, University of Sydney
Blake, Dr Alastair, Executive Dean, Adelaide University
Booth, David, Department of Environmental Sciences, University of Technology, Sydney
Bray, Professor Igor, School of Chemistry, Physics & Earth Sciences, Flinders University
Burton, Dr Michael, School of Physics, University of New South Wales
Byrne, Professor Kerry P, Head, School of Medical and Manufacturing Engineering, University of New South Wales
Campbell, Professor Gordon R, Director of Research and Postgraduate Studies, Faculty of Biological and Chemical Sciences, University of Queensland
Caprarelli, Dr Graziella, Senior Lecturer, Igneous Petrology and Geochemistry, Department of Environmental Sciences, University of Technology, Sydney
Carlson, Roderick, Senior Geologist
Carroll, Bernie, Department of Biochemistry and School of Land and Food Sciences, University of Queensland
Cartwright, Dr Ian, Groundwater and Crustal Fluid Flow, Department of Earth Sciences, Monash University
Chilcott, Dr Terry, Department of Biophysics, School of Physics, University of New South Wales
Clarke, Ms A, Faculty of Science and Technology, University of New South Wales
Clarke, Ron, School of Chemistry, University of Sydney
Close, Professor Don, Executive Dean, Faculty of Science and Engineering, James Cook University
Cockbain, Tony, Hon Editor, Australian Journal of Earth Sciences
Coney, Dr Jeffrey, Senior Lecturer in Physiology, Murdoch University
Coyle, Meaghan, University of Technology, Sydney
Craig, Professor Ashley, Department of Health Science, University of Technology, Sydney
Cram, Ed, University of Sydney
Crossley, Merlin, Department of Biochemistry, University of Sydney
Crozier, Professor Ross H, Professor for Evolutionary Genetics, School of Tropical Biology, James Cook University
Crumbie, Dr Robyn L, Department of Chemistry, University of Western Sydney - Macarthur

Cuthbert, Peter, Department of Biochemistry, University of Sydney
De Bruyn, Dr Hank, Key Centre for Polymer Colloids, University of Sydney
Deane, Janet
Deane, Professor Elizabeth, Head, Division of Environmental and Life Sciences, College of Science and Technology, Macquarie University
Eldridge, Dr Mark, QEII Fellow, Department of Biology, Macquarie University
Elkins, Professor John, Fred and Eleanor Schonell Special Education Research Centre, University of Queensland
Etheridge, Naomi, The Plant Genetic Engineering Laboratory, Department of Botany, University of Queensland
Fernandes, Dr Lynette, Department of Pharmacology, University of Western Australia
Finlay, Professor David, Dean, Faculty of Science and Mathematics, University of Newcastle
Ford, Dr Mike, Senior Lecturer, School of Chemistry, Physics & Earth Science, Flinders University
Gage, Dr Peter W, Professor of Physiology, John Curtin School of Medical Research
Gahan, Associate Professor LR, Department of Chemistry, University of Queensland
Gani, Professor J, School of Mathematical Sciences, The Australian National University
Gilbert, Professor Robert G, Key Centre for Polymer Colloids, University of Sydney
Glenn, Professor Andrew, Pro Vice-Chancellor (Research), University of Tasmania
Goodwin, Peter, University of Sydney
Gray, Dr David, Department of Earth Sciences, Monash University
Green, Dr Michael, Department of Engineering, The Australian National University
Green, Professor David H, Director, Institute of Advanced Studies, Research School of Earth Sciences, The Australian National University
Gregg, Associate Professor Peter, School of Rural Science and Natural Resources, University of New England
Grigg, Professor T, Acting Vice-Chancellor, University of Queensland
Guss, Joseph, University of Sydney
Hains, Dr Peter, Australian Proteome Analysis Facility, Macquarie University
Halder, Greg, Division of Inorganic Chemistry, School of Chemistry, University of Sydney
Hambley, Associate Professor Trevor W, School of Chemistry, University of Sydney
Harding, Associate Professor Margaret, School of Chemistry, University of Sydney
Havenhand, Dr Jon, Acting Head, School of Biological Sciences, Flinders University
Hawkett, Dr Brian, Key Centre for Polymer Colloids, University of Sydney
Hazell, Professor Stuart, Dean, Faculty of Informatics, Science and Technology
Hemsley, Dr Kim, Department of Clinical Pharmacology and Centre for Neuroscience, Flinders University
Heyde, Professor CC, Department of Statistics, Columbia University and The Australian National University
Hocking, Rosalie K, School of Chemistry, University of Sydney
Horsfall, Associate Professor David, School of Medicine, Flinders University and Chief Medical Scientist, Breast Cancer Laboratory, Oncology Unit, Flinders Medical Centre
Hunter, Dr Robert J, School of Chemistry, University of Sydney
Hunter, Luke, School of Chemistry, University of Sydney
Issa, Dr Laura, Muscle Development Unit, Children’s Medical Research Institute
Jones, Adele, School of Chemistry, University of Sydney

Jones, Darren, The Centre for Immunology, St Vincent's Hospital

Jones, Naomi, Department of Chemistry, Materials &b Forensic Science, Faculty of Science, University of Technology, Sydney

Jordan, Kathryn, Department of Biochemistry, University of Sydney

Kepert, Dr Cameron J, School of Chemistry, University of Sydney

Kirk, Janine A, Executive Director, Committee for Melbourne

Knights, Associate Professor Kathie, Department of Clinical Pharmacology, School of Medicine, Flinders University

Kumar, Associate Professor Rakesh K, Department of Pathology, University of New South Wales

Kuss, Dr Bryone J, Department of Haematology and Genetic Pathology, Flinders Medical Centre

Lamb, David, Botany Department, University of Queensland

Langley, Dr David, Department of Biochemistry, University of Sydney

Lawrance, Professor Warren D, Head, School of Chemistry, Physics and Earth Sciences, Flinders University

Leitch, Professor Evan C, Associate Dean - Research, Faculty of Science, University of Technology, Sydney

Lennox, Dr Paul

Lester, Professor RJG, Department of Microbiology and Parasitology, University of Queensland

Li, Dr Zheng Xiang, Deputy Director, Tectonics Special Research Centre, University of Western Australia

Li, Hsiu Lin, School of Chemistry, University of Sydney

Lim, Benjamin, School of Chemistry, University of Sydney

Lister, Professor Andrew M, Executive Dean, Faculty of Engineering, Physical Sciences & Architecture, University of Queensland

Lumbers, Eugenie, University of New South Wales

Luszcz, Professor Mary, School of Psychology, Flinders University

MacGillivray, Professor William, Dean, Faculty of Science, Griffith University

Macinnis, Cate, Department of Environmental Sciences, University of Technology, Sydney

Mackay, Dr Joel, Department of Biochemistry, University of Sydney

Magarey, Dr Anthea, Nutrition Unit, Department of Public Health, Flinders University

Martin, Neil, School of Earth Sciences, University of Tasmania

Matthews, Jacqui, Department of Biology

Maxwell, Dr Graham, Graduate School of Education, University of Queensland

McKenzie, Professor JA, Dean, Faculty of Science, University of Melbourne

McPherson, Ross, Manager, Water Catchments Team, Environment Division, Hornsby Shire Council

Meier, Peter C, College of Traditional Chinese Medicine, University of Technology, Sydney

Mellor, Associate Professor Robert, Chair, Department of Mathematical Sciences, Faculty of Informatics, Science and Technology, University of Western Sydney - Macarthur

Moon, Professor Tony, Faculty of Science, University of Technology, Sydney

Muirhead, Bruce, Director, Community Service & Research Centre, University of Queensland

Neild, Ms Blair, Molecular Prospecting Unit, Environmental and Life Sciences, Department of Biology, Macquarie University

Nurcombe, Associate Professor Vic, Department of Anatomical Sciences, University of Queensland

O'Donoghue, Dr Fergal, Daw Park Repatriation Hospital

Osmond, Professor CB, Research School of Biological Sciences, The Australian National University

Parkinson, Anne

Perkins, Dr Michael, Department of Chemistry, Flinders University

Postgraduate Association of the University of Western Australia

Powell, Natalie, School of Chemistry, University of Sydney

Pratt, Professor Kerry C, Pro Vice-Chancellor (Research), Swinburne University of Technology

Prescott, Stuart, Key Centre for Polymer Colloids, School of Chemistry, University of Sydney

Primmer, Craig, Department of Ecology and Systematics, University of Helsinki, Finland

Raison, Professor Robert L, Immunology Unit, University of Technology, Sydney

Ramadan, Dr Saad, Department of Biochemistry, University of Sydney

Read, Associate Professor Roger, School of Chemistry, University of New South Wales

Read, Justin, School of Chemistry, University of Sydney

Robertson, Gail, Department of Sociology, Anthropology and Archaeology, University of Queensland

Rose, Harley, Department of Crop Sciences, University of Sydney

Rybchyn, Mark, University of Sydney

Saccone, Gino TP

Sant, Dr Morgan, Associate Dean, Undergraduate Science, University of New South Wales

Sellar, Jeffrey, Materials Engineering, Monash University

Separovic, Associate Professor Frances, School of Chemistry, University of Melbourne

Sharma, Shiwani, Department of Ophthalmology, Flinders Medical Centre

Shoubridge, Cheryl, Child Health Research Institute, Women and Children's Hospital, Adelaide

Sloan, Scienta Professor Ian H, School of Mathematics, University of New South Wales

Smith, Dr Raymond E, Director, CRC LEME C/- CSIRO Exploration and Mining

Smith, Professor T, Deputy Vice-Chancellor (Research), La Trobe University

Smyth, David, Department of Biological Sciences, Monash University

Stoddart, Professor Brian, Pro Vice-Chancellor (Research and International), University of New England

Sutherland, Professor C E, Dean, Faculty of Science and Technology, University of New South Wales

Swan, Emeritus Professor J M

Toh, Justin, School of Chemistry, University of Sydney

Tong, Andrew, School of Chemistry, University of Sydney

Tourigny, Dr Sylvie C, Director & Senior Lecturer, Behavioural Studies, University of Queensland

Vaney, Dr David I, Chair, Research Committee, School of Biomedical Sciences, University of Queensland

Vaughan, Dr Geoff, Chair, CRC Committee

Waters, Dr Karen A, Clinical Senior Lecturer, David Read Laboratory, University of Sydney
Watson, Senator John, Tasmania
Wetherall, Bruce, Flinders University
Wheldrake, Professor John, Head of Faculty of Science and Engineering, Flinders University
Widmer-Cooper, School of Chemistry, University of Sydney
Willoughby, John, Flinders University
Wolf, Dr K H, Wolf's Geological Consultants
Wong, Leon, School of Chemistry, University of Sydney
Wormald, Professor Peter John, Head of Otolaryngology, Head and Neck Surgery, University of Adelaide and Flinders University
Xue Kui Ji, School of Chemistry, University of Sydney
Young, Professor DJ, Head, School of Materials Science & Engineering, University of New South Wales
Zhang, Dr Wei, CRC for Bioproducts, Flinders University
Zhou, Xin-Fu, Department of Human Physiology, Flinders University

Appendix G

Appendix G

International Consultations:

Germany

Antje Fahning, Personal Assistant to the Parliamentary State Secretary to the Federal Minister of Education and Research

Professor Ertl, Fritz Haber Institute of the Max Planck Society

Professor Herbert Weber, Director, Fraunhofer Institute, Software and System Technology

Wolf-Michael Catenhusen, Parliamentary State Secretary to the Federal Minister of Education and Research

European Union

Nicholas K Newman, Head of Division RTD.E.3, International Co-operation, Industrialised Countries and Emerging Economies, European Commission Directorate XII, European Commission

Professor Jorma Routti, Former Director - General, European Commission Directorate XII

Science Research and Development, European Commission

Spyros Konidaris, Director, European Commission, Directorate - General XIII, Information Society, Telecommunications, Markets, Technologies, Innovation and Exploitation of Research

Michel F Bosco, Head, International Co-operation, The Information Society Technologies Program, Directorate- General XIII, Information Society, European Commission

Finland

Ms Paula Nybergh, Deputy Director General, Ministry of Trade and Industry

Anna-Maija Rautiainen, Adviser, Ministry of Trade and Industry

Antti Joensuu, Deputy Director General, Ministry of Trade and Industry

Veijo Ilmavirta, Director, Otaniemi International Innovation Centre

Jari Romanainen, Executive Director, Strategy, TEKES National Technology Agency

Esko-Olavi Seppälä, Chief Planning Officer, Science and Technology Policy Council

Kimmo Halme, Chief Planning Officer, Science and Technology Policy Council

Ireland

His Excellency, the Hon Bob Halvorsen, Australian Embassador to Ireland

Tom Sinkovits, First Secretary, Australian Embassy,

Mattie McCabe, Principal Officer, Office of Science and Technology, Department of Enterprise, Trade and Employment

John Fallon, Assistant Principal, Office of Science and Technology, Department of Enterprise, Trade and Employment

United Kingdom

Lord Sainsbury, Minister for Science and Innovation, UK Government

Edmund Quilty, Director, Science in Government Directorate, Office of Science and Technology

Ken Hall, Assistant Director, International Science Policy, Office of Science and Technology

Department of Trade and Industry

Dr Richard Lane, Assistant to the Director, Wellcome Trust

Sir Robert May, Chief Scientific Adviser to the UK Government and head of the UK Office of Science and Technology

Dr Jonathon Grant, Head, International Programs, Wellcome Trust

Dr Aldo Geuna, Lecturer, Science and Technology Policy Research, Science Policy Research Unit, University of Sussex

Dr Graham Fagg, Head, Intellectual Property and Industrial Relations, Wellcome Trust

Dr Barry Dexter, Director, Wellcome Trust

Fiona Clouder Richards, Head of International Relations Unit, Business, Innovation and International Group, Biotechnology and Biological Sciences Research Council

Professor Brook, Chairman, Engineering and Physical Sciences Research Council

Canada

Dr Peter Hackett, Director General, National Research Council, Canada, Steacie Institute for Molecular Sciences

David Strangway, President and CEO, Canada Foundation for Innovation

Dr Mark Bisby, Director, Programs, Medical Research Council of Canada

Francis Rolleston, Director, Ethics and International Relations, Medical Research Council of Canada

Alita Perry, Program Administrator, Business Development and Partnerships, Medical Research Council of Canada

Karen Mosher, Executive Director, President's Office, Medical Research Council of Canada

Janet Walden, Director General, Research Partnership Programs, Natural Sciences and Engineering Research Council

Stuart Wilson, Conseiller Principal, National Research Council, Canada

Marie Tobin, Director General, Innovation Policy, Industry Canada

Andrei Sulzenko, Associate Deputy Minister, Industry and Science Policy, Industry Canada

Jean - Claude Gavrel, Director, Networks of Centres of Excellence of Canada

Dr Gilbert Normand, Secretary of State, Science Research and Development Industry Canada

Chummer Farina, Executive Director, Advisory Council on Science and Technology, Industry Canada

Dr Nigel D H Lloyd, Director General, Research Grants and Scholarships, Natural Sciences and Engineering Research Council

Paul Dufour, Ministerial Assistant, Office of the Secretary of State, Science, Research and Development

Michelle Campbell, Senior Policy Analyst, Medical Research Council of Canada

Elizabeth Dixon, Adviser to the Executive, Medical Research Council of Canada

Steve Shugar, Director, Policy and International Relations, Natural Sciences & Engineering Research Council

Dr Thomas Brzustowski, President, Natural Sciences and Engineering Research Council

USA

Congressman F James Sensenbrenner, Chairman of the House Science Committee, US Congress.

Dr Rita Colwell, Director, National Science Foundation

Dr Joseph Bordogna, Deputy Director, National Science Foundation

Representative Vernon Ehlers, Deputy Majority Chair, House Committee on Science

Dr Neal Lane, Director for Science Policy, Office of Science and Technology Policy

Charles Larson, President, Industrial Research Institute Inc.

Dr Andrew M Pope, Director, Division of Health Sciences Policy, Institute of Medicines

The National Academies

Dr Cheryl Shavers, Under Secretary of Commerce for Technology, Department of Commerce

Dr Albert Teich, Director, Science and Policy Programs, American Association for the Advancement of Science

Cathleen Campbell, Director, International Technology Policy and Programs, Technology Administration, Department of Commerce

Appendix H

Appendix H

Public support for The Chance To Change

In the three months that following the released of the Chance to Change, extensive public discussions were held. Many of these discussions were organised by the State and Territory departments and Councils responsible for innovation and related activities and were attended by hundreds including small and medium sized businesses, and larger enterprises. There was uniform support for the recommendations.

The few single exceptions were from members of GFRAs who noted the lack of specific recommendations on GFRAs, a matter well covered in the final review.

As well as the public fora, discussions were also held with various industry associations, universities, peak academic groups and others:

Queensland University of Technology

University of Canberra

Australian Academy of Science

'Fresh Science' (part of Science Week)

Commonwealth, States and Industry Advisory Council on Innovation

Co-operative Research Centres Association

ATTICA Executive

Coalition for Innovation in Scholarly Communication

Business Higher Education Round Table

Prime Minister's Science Engineering and Innovation Council Standing Committee

Australian Vice-Chancellors' Committee

AVCC Deputy and Pro-Vice Chancellors (Research)

Committee for the Economic Development of Australia

Business Council of Australia

Technology Transfer and Innovation 2000

Strategic Industry Research Foundation

Curtin University

International Technology Innovation Symposium

Coordination Committee on Science and Technology

Australian Information Economy Advisory Council

University of NSW

Warren Centre

Royal Society of Victoria

IP Australia seminar series

Australian Council of the Deans of Science

Institute of Public Administration in Australia, Victoria

Australian Research Management Conference

These discussions strongly confirmed the directions recommended by the Review.

Reaction by the States and Territories

The States and Territories work together with the Commonwealth government in the area of innovation and related activities via a Commonwealth, State and Territory Advisory Council on Innovation. Senior officials of the Council held an extraordinary meeting on 13 October 2000 to focus on the opportunities for action over and beyond the recommendations of the Miles and Batterham reports. They agreed that the following key areas warranted cooperative action:

1. Cultural change - leadership is needed such as in QLD's biotechnology campaign
2. Generation of skilled people - society needs to respond rapidly to changing business demands to achieve a flexible workforce
3. Priority setting processes - synergies between the Commonwealth's pluralist support and that targeted by the States are allowing the first advances in IT, health and biotechnology
4. Innovation support programs - cooperative processes across governments add to the capacity of industry to maintain international competitiveness
5. Budget process and timing - limited existing resources achieve greater results through cooperation and early consultation

Council members acknowledged governments alone could not achieve the required outcomes and highlighted the need for a partnership with business and other stakeholders. Their discussions and resolution acknowledged the need for a national approach in the face of intense international competition.

Further Public Comment

It is unusual in Australia for the peak industry bodies , Academe, and the Learned Academies to adopt a unified position. A public letter of support from this group was published in all national newspapers and reads:

"The Chairman of the US Federal Reserve, Mr Alan Greenspan, has said the remarkable run of economic growth in his country appears to have it roots in advances in technology. More recently the head of the World Bank, James Wolfensohn, commented that if Australia hoped to compete in the new world economy it would need to emulate the American example, with greater investment in research and development.

We agree that if Australia is to sustain growth, increase the number of jobs and improve living standards, we have to develop and implement urgently and innovation action plan to underpin growth in existing and emerging industries and be a ‘knowledge-based society’.

Over the past few years, nations such as the United States, Britain, Canada, Japan, Germany and France have significantly increased their levels of national investment in research and development. They have thrown down a challenge to any country that intends to remain among the group of the world's prosperous nations.

In response, smaller countries such as Singapore, Finland, Norway, Sweden, Israel and Denmark have made decisive and successful moves towards more knowledge-based economies. Ireland has revolutionised its economy through educational and research investment, and recently became the world's largest exporter of computer software.

The history of investment in research and development has shown that while quick returns can sometimes be found, more often patience is met with reward by opening windows for ideas to be picked up later.

Fortunately for Australia, two reports commissioned by our Federal Government - from its chief scientist and the Innovation Summit Implementation Group - have outlined some of the actions that need to be taken to ensure our future performance can see us win in the global arena. These important reports propose ways of creating an ideas culture, generating ideas and acting on those ideas.

We have come together to voice our support for the government to take the decisive steps recommended in these reports. These include: improving the incentives for business to invest in research and development; appropriate levels of public investment in competitive research and world-class equipment and facilities; and encouraging better links between researchers and industry, for the economic, social and environmental benefit of Australia. Given long lead times, early action is needed so results can flow soon and we can compete effectively.

All success is hard to sustain, and Australia's will be sustained only if we continue to "punch above our weight" in developing new ideas and new skills. Just as in sport, where we have always known that we cannot rely on greater numbers to compete successfully at the highest level, our effort as innovators and educators must remain above average if we are to compete against the bigger players.

The great populations of America, Europe and Asia will continue to draw massive benefits from reasonable efforts. But Australia's barely reasonable efforts won't be enough.

With the right policy framework and encouragement from government, Australian industry, research and higher education can help deliver the gold medal performance needed to deliver greater prosperity."

This joint statement is by Brian Anderson, president, Australian Academy of Science; Campbell Anderson, President, Business Council of Australia; Tim Besley, President, Australian Academy of Technological Sciences and Engineering; Ian Chubb, President, Australian Vice-Chancellors' Committee; Martin Cole, President, Institution of Engineers, Australia; Stephen Harrison, Chief Executive Officer, Institute of Chartered Accountants in Australia; Bob Herbert, Chief Executive, Australian Industry Group; John Keniry, President, Australian Chamber of Commerce and Industry; Sue Serjeantson, President, Federation of Australian Scientific and Technological Societies; and Roland Williams, President, Business-Higher Education Round Table.