WESTERN AUSTRALIAN TECHNOLOGY & INDUSTRY ADVISORY COUNCIL

RESEARCH AND DEVELOPMENT: THE ROLE OF THE STATE GOVERNMENT IN ATTRACTING EXTERNAL FUNDING

MAY 1998

TABLE OF CONTENTS

APPENDICES

FIGURES, BOXES AND TABLES

Executive Summary

Study Context

This study was initiated to "… engender community debate and provide options for the State Government to use its resources to increase the flow of Commonwealth and private sector research and development funds, facilities and personnel into Western Australia to promote economic and industrial growth."

The report examines research and development (R&D) expenditure in Australia. A review of Western Australian R&D identifies areas in which the State has a strong performance and areas where there appears to be under-investment relative to the rest of Australia. Consultations with research organisations provided a framework for evaluating the key criteria that lead to success in attracting external R&D funds while an examination of the role of the State Government enabled options to be proposed on ways in which the Government could increase external investment in R&D activities.

This Executive Summary provides an overview of the report with a list of key recommendations. A more comprehensive list of recommendations is included in Chapter 6.

R&D Expenditure

Expenditure on R&D in Western Australia has been increasing at over 10% per annum for the last ten years. However, expenditure is still low when considered as a proportion of gross domestic product (GDP) or expenditure per head of population in comparison with OECD countries.

Around half of R&D expenditure is carried out by the business sector, a quarter is in higher education institutions with State Government agencies providing 15% and Commonwealth research agencies less than 10%.

The focus of R&D effort in Western Australia is quite different to the rest of Australia. Expenditure is highly concentrated in the mineral and energy resource areas followed by agriculture, the environment and commercial services. Expenditure in the manufacturing and the information and commercial services sectors is low when compared with national levels.

Business R&D

Business R&D has grown dramatically over the past decade and the State now has the third highest ratio to GDP after Victoria and New South Wales. It is the largest R&D sector constituting around half of the R&D investment in the State.

Expenditure in the manufacturing sector comprises just over 40% of total business R&D and is dominated by the metal products category. Metal products expenditure almost certainly includes the Rio Tinto HI-Smelt experimental iron and steel plant at Kwinana and the Alcoa research laboratories. These are large facilities closely related to the companies' mining activities in the State and hence their classification may be misleading.

Fast growing sectors in manufacturing R&D are in electronics, food and beverage, and 'other chemicals'. The State also has a number of significant electronic communication companies.

Mining R&D in Western Australia represented just under 40% of business investment and constituted around half the nation's investment in 1994-95.

The Government has been very supportive of mining R&D including, most recently, the commitment of substantial funding for the establishment of a CSIRO National Centre for Petroleum and Mineral Resources Research at Technology Park.

The third largest business R&D sector (other industries) accounts for only 12% of WA investment. The majority of this went into technical services, much of it again related to the mining industry.

Higher Education Sector R&D

Higher education institutions are the second largest R&D sector expenditure area but the largest employer of R&D staff reflecting the education and training role. Funding is primarily provided by the Federal Government although the largest institution - the University of Western Australia - has substantial funds of its own.

Higher education R&D is just below the State's population share of Australia. The State is well represented in agricultural sciences, general engineering, earth sciences and information, computers and communication technologies. State expenditure is low in the physical and chemical sciences, health and mathematics.

Western Australia has done well in attracting Federal Government-funded Special Research Centres with five located in the State out of 19 nationally. The State has been much less successful with Technology Centres, having only 18 compared with South Australia's 23 and Queensland's 37.

Federal R&D Programs

The State has scored reasonably well with the CRC program having six with headquarters in the State, a significant presence in 15 and some form of participation in 18 out of the total to the end of 1996 of 62. The CRCs with a significant State investment mirror the existing presence of State Government and Commonwealth research agencies, ie the CRCs generally build on existing strengths rather than create new areas of research expertise. Unfortunately, business involvement in CRCs is low with less than ten significant participants in the 15 centres.

There are many areas in which there is no CRC activity in the State despite some apparent relevance to the State economy. The 'tyranny of distance' also appears to be a factor in the small number of CRCs in which there is State involvement which have more than two other States represented. The State is involved in only nine of these compared with 13 for South Australia and 16 for Queensland.

Government Agency R&D

Government expenditure is dominated by the State Government ($97 million) with Commonwealth agencies contributing only half of this amount. State Government expenditure is focused on agriculture through Agriculture WA, the environment through CALM, mineral and energy resources through the Departments of Minerals and Energy, Resources Development and the Office of Energy, and fishing through Fisheries WA.

The lack of federal government research agencies, other than CSIRO, in Western Australia is the major factor behind a low Commonwealth direct R&D contribution. The relocation of key staff and the creation of the CSIRO National Centre for Petroleum and Mineral Resources Research at Technology Park will increase Commonwealth expenditure.

Overseas Funding

Overseas funding for R&D in Western Australia is well below the national average. Funds flowing into the higher education sector are increasing but remain at low levels while the most recent data for business suggests very little overseas funding in this sector in the State. More work is needed to evaluate potential international funding sources for Western Australian R&D and it appears there may be considerable potential which is not being exploited by State organisations.

What the State Government Can Do

The State Government has already provided leadership and direction through its progressive Science and Technology Policy. It is also a strong contributor to R&D through its own departments.

An important role for the Government is to promote the R&D activity already taking place, the wide range of skills available, the high quality infrastructure and the supportive ethos of the State Government.

Increased R&D investment requires the right people given that research is a demanding vocation involving highly skilled and motivated individuals. The 'right' people can either be developed locally or imported. At the local level, education begins in primary school and it has been found in international surveys that Australian children have a high awareness of science issues. Education agencies need to ensure that the school curriculum continues to encourage an interest in research activities in all spheres including science-based disciplines.

Western Australia has a highly skilled and well educated work force. The State has also in the last few years built up a strong core of research workers engaged in business R&D programs. It is important that these skills be retained and developed.

Part of the education and training process is to ensure that research workers are exposed to the latest methodologies and approaches and hence exchanges with overseas research organisations are highly desirable. Similarly, it is a legitimate role of the State Government and research institutions to work together in attracting highly skilled and internationally recognised research workers to the State.

In addition to the right people, the State also needs to have the right infrastructure to attract investors. The Government needs to continually review the infrastructure available for R&D and ways in which it can be improved and expanded. Accommodation and people are the building blocks upon which R&D is built.

Given the dominant role now played by the business sector, the State Government must stress the importance of this sector at all opportunities and argue vigorously for a suitable taxation regime. The Technology Park at Bentley has demonstrated its importance to R&D infrastructure and the Government must continue to plan and support the establishment of suitably located Technology Parks.

With venture capital important for new technology enterprises, the State Government needs to monitor the progress of the Federal Small Business Investment Fund. It should also evaluate 'investment ready' programs to determine whether these would help Western Australian small to medium-sized enterprises access R&D funds.

The Mortimer Inquiry[1] highlighted the plethora of Commonwealth programs which provide assistance to business. The State Government should provide an information exchange on these programs and assistance with application processes. The constant changes in federal programs make the task of tracking these time-consuming and expensive for the business and tertiary sectors.

Western Australia must capitalise on the strength of its mining and petroleum industries by ensuring a high level of R&D investment in this State. The Government can play a role by assisting with the creation of a 'critical mass' of research infrastructure and by ensuring that higher education institutions provide the courses which address industry requirements in this sector. The Government should also consider ways in which the royalty system may be used to encourage R&D investment.

Some universities utilise competitive processes as a means of selecting proposals for external funding. Others provide a more decentralised process with the research vice chancellors providing information but not actively vetting proposals. There appears to be a valuable role at both the university and government level for a process of competitive selection in prioritisation of research objectives. Consideration should be given to restricting State Government support to proposals which have been approved and prioritised by the institution.

---

[1] Going for Growth: Business Programs for Investment, Innovation and Export (Mortimer June 1997)

Western Australia has fairly high expenditure levels in higher education institutions covering a range of disciplines. However, the State is under-represented in a number of categories. Areas of apparent low investment in the State through the ARC should be reviewed with an emphasis on ways of improving grants for research infrastructure and collaborative grants. The State Government, through the Department of Commerce and Trade, can play a role through the provision of incentives to encourage the formation of collaborative groups to bid for ARC projects.

The State Government provides a range of measures which support R&D investment including direct funding support under the CRC and the new Centres of Excellence programs. The State Government has also established an $11 million Medical and Health Research Infrastructure Fund. The State Government should continue to provide funds to assist coordinated research applications from State groups seeking access to federally-funded programs. If the CRC program continues, the State Government needs to consider ways in which local universities and businesses can be encouraged to develop quality collaborative proposals.

Support from the Government in all research areas should be based on a contestable application process with merit assessed by an appropriate evaluation panel. Priority should be given to collaborative projects which either involve a number of tertiary institutions and industry in the team.

Western Australia receives a relatively low level of funding from CSIRO and other Commonwealth research agencies. The State Government needs to work closely with CSIRO to identify opportunities for an expanded CSIRO presence in the State. Given the State's expertise in agriculture, CSIRO would appear to be under-investing in this sector in the State. Opportunities should be examined for joint programs with the existing agencies and CRCs that would justify an increased CSIRO presence in the State.

The State also needs to review its revenue receipts from the individual rural industry R&D corporations and evaluate what needs to be done to attract a greater share of funding from any schemes judged to be deficient in their Western Australian allocation.

The State has substantial and growing sectors in wood and timber products, lightweight ferry boat building, fisheries, viticulture, long distance communications and aquaculture. There appears to be a low level of research in these sectors and consideration needs to be given as to how the level of investment may be increased. The approach adopted by ASTEC in the 2010 Study using foresight groups provides a model by which the investment potential of these industries may be reviewed.

Key Recommendations

The State Government:

1. consider the development of world class minerals and energy research facilities given the strength of these sectors in the State economy;

2. continue to support the creation of a 'critical mass' of infrastructure for collaborative research through the Centres of Excellence program to attract further external funding from the private sector and the Commonwealth;

3. broker and support collaborative R&D arrangements which further enhance Western Australia's national prominence in mining, metal manufacturing, agriculture and electronic communications R&D;

4. continue to provide incentives to attract major science and technology organisations to Western Australia;

5. examine opportunities for international R&D collaboration both as a funding mechanism and as a tool to promote market access to local companies;

6. continue to support collaborative applications from State researchers seeking access to Commonwealth-funded programs for research centres and industry focused R&D projects;

7. monitor the opportunities presented by the extension of the marine economic development zone and the resulting highly diverse marine environment for the location of national and collaborative international marine research centres;
8. consider joint programs that could lead to a greater presence of CSIRO, DSTO and AIMS in the State;
9. argue strongly for an effective Commonwealth R&D taxation incentive scheme;
10. monitor the progress of the Commonwealth Innovation Investment Fund to ensure that venture capital opportunities are available to Western Australia companies;
11. examine 'investor-ready programs' in other States to ascertain their suitability as models for Western Australia;
12. initiate further studies into the nature of business investment in R&D and the policies needed to support further growth in this sector;
13. promote the achievements of Western Australian researchers and research centres to the community;
14. consider the development of a program which identifies emerging research leaders and provides appropriate support to encourage the development of these vital people; and
15. ask the Commonwealth to develop a user-friendly Internet-based register of Commonwealth and relevant international R&D Funding schemes.

1. BACKGROUND TO THIS REPORT

1.1 Introduction

This report was commissioned by the Technology & Industry Advisory Council. The work was carried out by a consulting team headed up by Economics Consulting Services working under the direction of a steering committee, the membership of which is listed in Appendix 1.

The purpose of the study was defined as being "*To engender community debate and provide options for the State Government to use its resources to increase the flow of Commonwealth and private sector research and development funds, facilities and personnel into Western Australia to promote economic and industrial growth*." The full terms of reference are set out in Appendix 2, while a glossary of abbreviations is contained in Appendix 3.

1.2 Context

An earlier report completed by the Technology & Industry Advisory Council (TIAC)[2] provided a rationale for government intervention in research and development (R&D. The justification for government involvement was based on three aspects of the uncertain nature of R&D activity, which may result in too little R&D being performed by the private sector:

- R&D is technically risky and may not be commercially successful;
- the non-core benefits which flow from R&D activity may not be fully appropriated by the company which invests the funds; and
- the size of the initial investment required may present cash flow problems.

The study emphasised a recognition by governments and businesses that technological innovation is a crucial determinant of economic prosperity.

An examination of Commonwealth R&D expenditure per head of population indicates that Western Australia receives a low level of funding from Commonwealth sources. The low level appears to reflect a chronic under-investment in R&D infrastructure in the State. This under-investment in turn acts as an impediment to winning research funds from both the private and public sectors.

[2] R&D and the State's Economic Development: What is the Best Fit? (1994, TIAC)

This study was initiated with the following specific terms of reference:

1. identify key areas of R&D strength in the State which have the potential for becoming centres of research excellence;
2. identify appropriate sources of external funds;
3. identify the key criteria of research centres that succeed in attracting external R&D funds; and
4. provide policy options for the State Government to consider in order to increase Commonwealth and private sector R&D funds, facilities and personnel in the State.

The report has been prepared as a discussion paper on these issues following widespread consultation with research and funding organisations at both the Commonwealth and State Government levels. It examines Commonwealth Government contributions to R&D in Australia and the criteria used by Commonwealth agencies in assessing funding applications (Appendix 4 and Appendix 5). Western Australian R&D is examined in an attempt to identify those areas where the State has a strong R&D performance and areas where there appears to be under-investment relative to the rest of Australia (Chapter 2). The report outlines the structure of the Western Australian economy with an emphasis on the key economic sectors and those experiencing significant growth (Chapter 3). The consultation with research organisations provided a framework for evaluating the key criteria that lead to success in attracting external R&D funds (Chapter 4). Finally, the report considers the role of the State Government and the policy options available to it to increase Commonwealth and private sector investment in R&D activities (Chapter 5).

The report provides very limited information on the medical sector. This sector was covered by a TIAC report released in 1996 (*Medical Research Infrastructure Funding in Western Australia*). That report resulted in the establishment of a Medical and Health Research Council which administers a fund with a total allocation of $11 million over four years.

The report also does not address any issues associated with the absolute level or adequacy of existing R&D programs - that is a subject of considerable complexity on its own.

1.3 Research and Development Defined

Research and development is a very broad concept. *Research* involves the systematic inquiry or investigation into a subject in order to discover facts or principles. Research is essentially the discovery of knowledge and is hence broad ranging through health, social, scientific and technical fields. Research work may be divided into work aimed primarily at the acquisition of knowledge, work aimed to improving quality of life and work aimed at productivity improvement. Research into ancient civilisations, languages and outer space may provide spin-off benefits to other areas but is primarily a knowledge gathering process.

Extensive research into quality of life attributes would include all medical research along with technology research aimed at improving our living environment in areas such as food, water and air quality.

The term '*research and development*' is generally used in a technological context and is primarily concerned with the development of new products or improved processes for existing products. It is essentially science-based. The OECD defines it to be "… *creative work undertaken on a systematic basis in order to increase the stock of knowledge - including knowledge of man, culture, and society - and the use of this knowledge to devise new applications*."

Whilst many people use the term in a 'manufacturing' context, R&D is increasingly moving into the area of service provision. Information technology and computer science may have had their origins in manufacturing processes but are now primarily concerned with improvement in the delivery of services.

TIAC is a Council established by the Minister for Commerce and Trade and it has a primary objective of supporting science and technology research and innovation in the State. The Government's science and technology policy emphasises the role of science in our natural and social environment with technology involving the application of knowledge for the creation of new or improved products, processes or systems.

In the Government Science and Technology Policy discussion paper, research and development is primarily described in an industry context. For example, the policy "… seeks to support firms in their efforts to create profitable enterprises through research and development, the commercialisation of science and the adoption of innovative products and processes."

Given that the definition of R&D incorporates development of *new applications* and that TIAC as a Council is primarily concerned with 'technology' the focus in this report will be on science and technology based research with only limited coverage of the wider areas of social and cultural research. This focus is not intended to deny or overlook the importance of such research work.

As will be apparent in subsequent sections, Commonwealth Government programs have built up considerably in business-oriented R&D investment and hence much of the focus on attracting more Commonwealth funds will need to be directed towards those growing areas of research and development activity.

Technological innovation or intensity in countries is frequently measured using R&D investment as a proportion of gross state product. This measure has shortcomings. Because it focuses almost exclusively on R&D in a particular sector, it fails to take into account the fact that industries often do little R&D themselves but purchase highly R&D-intensive

intermediate and capital inputs from other sectors. R&D intensity indicators are thus typically low although the industries themselves may be technologically sophisticated.

When technological acquisitions are included in the total measure of technological intensity, Australia ranks seventh out of ten OECD countries. Australia's total expenditure ranks it above countries such as Denmark, Canada and Italy although it still falls short of other smaller countries such as the Netherlands, the United Kingdom and France.

2. RESEARCH AND DEVELOPMENT IN WESTERN AUSTRALIA

2.1 Introduction

This chapter examines research and development expenditure in Western Australia with a focus on the relative strengths and weaknesses of the State's R&D base. In particular, the chapter is concerned with R&D capability covering:

- sectors in which research activity is prolific and large in absolute terms (i.e. where there is, or could potentially be, a 'critical mass' of R&D expertise);
- sectors or fields of research which appear to have a competitive advantage in national terms (i.e., where WA's share exceeds an expected level[3]); and
- areas where the State might be under-performing.

The chapter commences with an examination of the way in which R&D is coordinated in the State.

2.2 The Organisation of R&D

2.2.1 Ministerial responsibility

Like the Commonwealth, Ministerial arrangements for science and technology and R&D have changed frequently since the first Minister for Technology was appointed in 1983. At present the Minister for Commerce and Trade is responsible for this portfolio area.

2.2.2 Research agencies and funding organisations

In contrast to the Commonwealth, the State Government does not have dedicated research agencies, whether they be research performers such as CSIRO and ANSTO, or research funders such as the Rural R&D Corporations, NH&MRC or the ARC. Most State Government R&D has been carried out by Government Departments which combine research responsibilities with other functions such as policy development, regulatory activities and client service.

The 1996 *Directory of R&D in Western Australia* lists 15 State Government departments and agencies performing R&D. The larger agencies are Agriculture WA, CALM, and the Departments of Environmental Protection, Fisheries, Minerals and Energy, Land Administration and Main Roads.

---

[3] Determining what is an 'expected' level or share of R&D is not simple. For non-business R&D, an 'expected share' might be the State's share of the national population; for business R&D, the preferred basis would be WA's share of the national industry.

There are also a small number of departments and agencies which provide funds to individuals, companies and the universities for research. For example, the Department of Commerce and Trade provides $1 million per annum for company-based research through the WA Innovation Support Scheme (WAISS), it provides up to $4 million per year to support Centres of Excellence, it has committed $8 million over four years to a Medical and Health Research Infrastructure Fund, and it supplies funds for Technology Park in Bentley. The other main area of State Government sponsored research grant programs is in the minerals and energy area, with support for Renewable Energy from the Alternative Energy Advisory Board (part of the Office of Energy), and for other minerals and energy research through the Minerals and Energy Research Institute of WA (MERIWA). The Department of Resources Development also allocates some research funding to the minerals sector through the Channar Fund.

Finally, there are a very small number of 'dedicated' research groups including sections in the Chemistry Centre (WA) and the State Health Laboratories, which could perhaps be seen as similar in function to the Commonwealth research agencies. In the WA Government system, however, they are connected much more closely to their host departments than their counterparts at Commonwealth level.

2.2.3 Major R&D policy instruments

As is the case at the national level, pluralism in the organisation of R&D has been the norm in Western Australia. There are a number of agencies involved in performing and funding R&D with no identifiable R&D 'budget'. If anything, Western Australia has been even more pluralistic. Until very recently there were no priority setting mechanisms of any kind at the State level, whereas the Commonwealth had increased its coordination and central influence over R&D through the appointment of a Chief Scientist and various advisory and coordinating bodies established in May 1989. The only exception to this in WA was the establishment of the Science Industry and Technology Council (SITCO) in 1983 and its successor, the Technology and Industry Advisory Council (TIAC), in 1987. These advisory councils have influence over the overall directions of research funding but no direct involvement in prioritisation processes.

The Science and Technology Policy issued by the State Government in April 1997 heralded extensive changes to this situation. Two important committees were established: a Ministerial Science and Technology Council comprising Cabinet Ministers with portfolio responsibilities, which include science and technology, and a Coordinating Council on Science and Technology, with membership drawn from the chief executive officers of key R&D performing and funding agencies as well as a university representative and the Chairman of TIAC. These bodies will oversee science and technology activities within the State Government as well as policy measures to promote science and technology more broadly. The Science and Technology Policy included a detailed analysis of measures in the 1997 State Budget related to science and technology and a document is to be released shortly by the

Department of Commerce and Trade which provides a comprehensive overview of R&D and other science and technology-related indicators in WA. The Department of Commerce and Trade has been reorganised and now contains an upgraded Science and Technology Co-ordination Unit.

In summary, although it is too early to evaluate their effectiveness, Western Australia now has one of the most comprehensive set of policies and institutional settings for science and technology of any State Government.

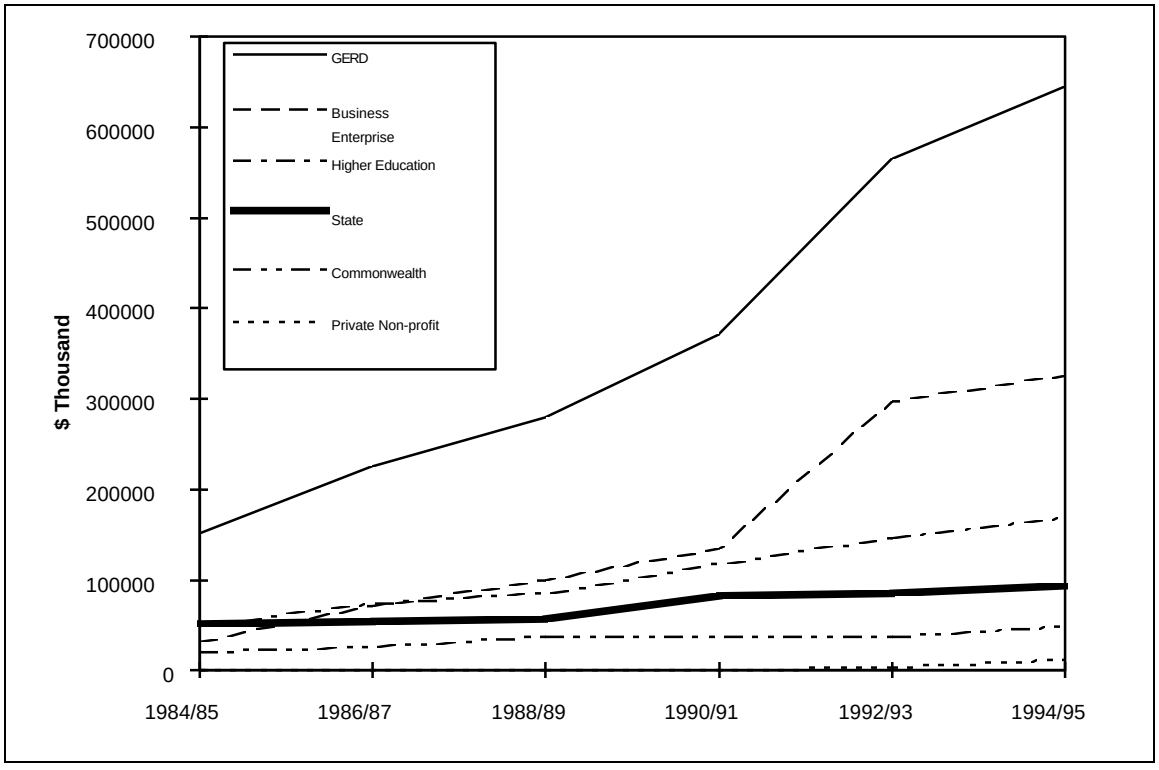
2.3 Western Australia R&D Investment

This section provides detail on the funding and performance of R&D in Western Australia. using statistics collected by the Australian Bureau of Statistics. Unfortunately, with a small number of large firms dominant in some sectors, confidentiality constraints limit the conclusions which can be drawn.

2.3.1 Total Expenditure

Total expenditure on R&D was $665 million in 1994-95. Ten years earlier, in 1984-85, total expenditure was just $151 million (Figure 1). Expressed in constant (1989-90) dollars, expenditure increased from $203 million to $580 million.

Figure 1: R&D Expenditure in WA, Total and by Sector, 1984-85—1994-95



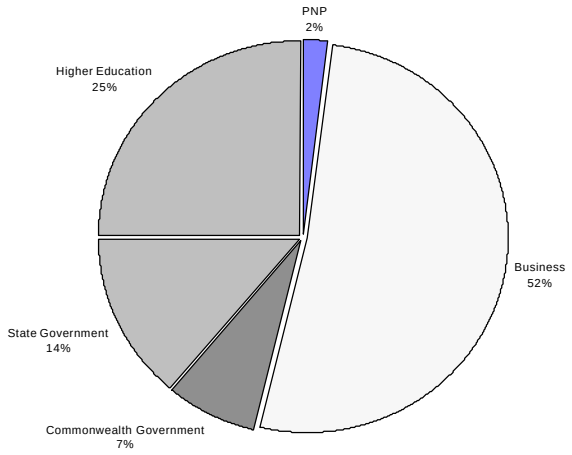
This is an average annual increase of 11%, compared to a 7% increase per year for Australia as a whole. The increase means that the State now accounts for 8.8% of Australia's R&D expenditure compared with only 6.8% in 1990-91. While this is a significant improvement over the last five years, expenditure remains below both the State's share of GDP (10.4%) and population (9.6%).

2.3.2 Distribution of R&D across sectors

Until 1990-91, R&D activity within WA was spread fairly evenly across the three sectors of business enterprises, government, and higher education (Figure 1). From 1990-91, however, this began to change as business expenditure rapidly increased.

By 1994-95, approximately half the R&D in WA was performed in the business sector, a quarter in higher education institutions, 15% in State Government agencies, 7% in Commonwealth agencies and 2% in PNP organisations (Figure 2).

Figure 2: R&D Expenditure in WA by Sector, 1994-95



While all sectors have increased their real expenditure on R&D since 1984-85, business R&D has grown very rapidly while State Government growth slowed (Table 1). There has also been impressive growth in the private non-profit organisation sector, although it remains a very small sector. The reductions in government expenditure can largely be attributed to reduced funding for departments as part of overall budgeting constraints and the reduction in research services provided by agencies like the Chemistry Centre.

Table 1: R&D Expenditure in WA by sector, 1994-95

Sector	Expenditure ($m)	% of Total	% growth p.a. 1984-85-1994-95 (current $)	% growth p.a. 1984-85-1994-95 (constant $)
Business Enterprises	343.8	52	26.4	20.3
Higher Education	167.7	25	13.1	8.9
State Government	95.0	14	6.4	2.4
C'wlth Government	47.6	7	9.6	6.1

Private Non-Profit	10.6	2	29.4	24.6
TOTAL	**664.6**	**100**	**15.6**	**11.4**

2.3.3 Research Intensity in WA

One of the most commonly used comparative measures of R&D performance is the percentage of GDP spent on R&D. Using this measure Western Australia had a ratio of 1.37 compared with 1.61 for Australia as a whole in 1994-95 (Table 2).

Table 2: Expenditure by State/Territory, 1994-5

	R&D ($million)	R&D/GDP (%)	Change since 1981
AUSTRALIA	7,321	1.61	0.61
NSW	2,312	1.47	0.64
Victoria	2,160	1.81	0.73
Queensland	836	1.13	0.41
W.A.	***665***	***1.41***	***0.73***
South Australia	588	1.78	0.54
ACT	507	5.25	-1.13
Tasmania	165	1.70	0.75
NT	72	1.49	1.09

Western Australia doubled its ratio since 1980-81 but still has the second lowest ratio, with only Queensland (at 1.13%) having a lower level (Table 2). The reason for the relatively low ratio in Western Australia becomes clearer when we look at how R&D is distributed.

Western Australia has the third highest level of business expenditure (in terms of percentage of GDP), after NSW and Victoria, and a high level of State Government expenditure (Table 3). The State's higher education sector lags slightly in its R&D expenditure, but the largest deficiency is clearly in Commonwealth expenditure, where Western Australia has the lowest expenditure/GDP of all States and Territories.

Table 3: R&D/GDP by Sector, by State/Territory, 1994-95

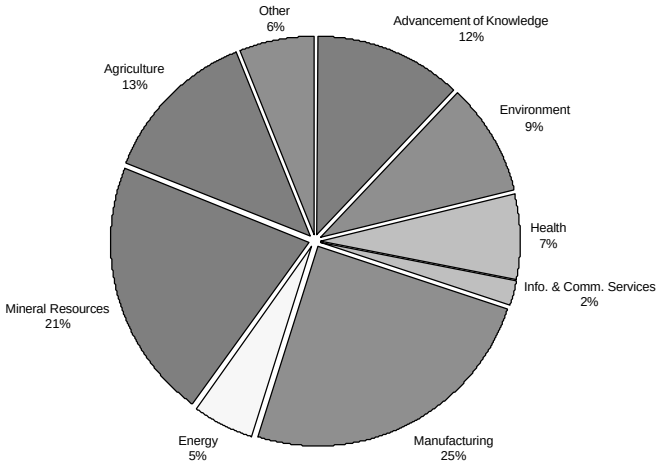
	Total	Business	Higher Education	Common-wealth	State	PNP
OECD	1.94	1.19	----------0.70----------			0.05
AUST.	1.61	0.74	0.40	0.26	0.17	0.03
N.S.W.	1.47	0.79	0.32	0.16	0.16	0.03
VIC.	1.81	1.05	0.33	0.25	0.11	0.07
QLD.	1.13	0.35	0.41	0.14	0.23	0.01
W.A.	***1.41***	***0.73***	***0.35***	***0.10***	***0.20***	***0.02***
S.A.	1.78	0.62	0.39	0.51	0.25	0.01
A.C.T.	5.25	0.27	2.78	2.16	0.04	0.01
TAS.	1.70	0.37	0.51	0.59	0.22	0.01
N.T.	1.49	0.09	0.18	0.69	0.51	0.02

Preliminary results for 1995-96 show that the ratio for business and higher education R&D increased but Western Australia's relative position among the States did not change for either sector.

2.3.4 Socio-Economic Objective

Around half R&D expenditure in Western Australia in 1994-95 went to two Socio-Economic Objectives: mineral and energy resources and manufacturing, with around a quarter each (Figure 3). The most important objectives after those were agriculture, advancement of knowledge, environment and health.

Figure 3: R&D Expenditure in WA by Socio-Economic Objective, 1994-95



R&D in Western Australia is distributed differently from the rest of Australia (Table 4). Areas of R&D concentration in WA - compared to the rest of the nation - were in mineral resources (where R&D spent in WA represented almost half the national total), energy resources, agriculture (i.e. plant and animal production and products), environment and commercial services. Manufacturing R&D in WA was just 7.2% of the national total with information and communication services even lower at 2.7% of the national total.

Table 4: Total R&D Expenditure in Australia and WA by Socio-Economic Objective, 1994-95

Socio-Economic Objective	Australian expenditure (%)	WA expenditure (%)	WA Proportion of Australia (%)
Defence	5.0	0.2	0.4
Economic Development			
Plant - production & primary products	4.8	7.4	13.7**
Animal - production & animal products	4.7	5.6	10.6*
Mineral resources (excl. energy)	4.0	21.0	45.8****
Energy resources	2.7	4.1	13.5**
Energy supply	2.2	0.9	3.5
Manufacturing	29.2	23.7	7.2
Construction	1.3	1.0	7.3
Transport	1.2	0.9	6.8
Information and communication svces	8.1	2.5	2.7
Commercial services	1.2	1.3	9.7*
Economic framework	1.5	1.1	6.6
Total Economic Development	60.9	69.7	10.1
Society			
Health	9.3	7.2	6.9
Educ. & training, Social devt. & community	3.0	2.2	6.3
Total Society	12.3	9.4	6.7
Environment	7.8	8.9	10.0*
Adv. of knowledge	13.9	11.8	7.5
TOTAL	**100.0**	**100.0**	**8.8**

* denotes SEOs where WA has a share of national R&D expenditure above its total average.

Source: ABS

2.3.5 Field of Research

The field of research data for non-business R&D gives an indication of the discipline areas in which research is carried out. Field of research may be directed at a variety of socio-economic objectives. The emphasis in the State is clearly on agricultural sciences (31%), medical and health (17%) and earth sciences (10%) (Table 5). The combined non-business R&D for agricultural, biological and earth sciences in the State is just on half of the total. In the Australian context, the State remains significant in agricultural and earth sciences but surprisingly has a significant share of psychology and accounting and finance expenditure. While medical and health research is a large part of the State's R&D effort, this is true for the rest of the country too, and Western Australia's level of spending in 1994-95 was actually just below the average found elsewhere in Australia. Moreover, the State had quite low shares of national R&D expenditure in quite a number of important fields of research. For example, its share of national R&D spending was 6% or less in physical sciences, chemical sciences, biological sciences, and information, computers and communications technologies.

Table 5: R&D Expenditure by Non-Business Organisations in Australia and WA by Field of Research, 1994-95

Field of Research	Australian expenditure (%)	WA expenditure (%)	WA proportion of Australia (%)
Natural sciences, technology & engineering			
Mathematical sciences	1.7	1.1	5.2
Physical sciences	4.6	1.4	2.5
Chemical sciences	4.6	3.0	5.3
Earth sciences	6.9	10.0	11.7**
Info., computers & communic'ns tech.	7.1	5.2	6.0
Applied S&T	6.6	3.1	3.9
General engineering	6.2	6.3	8.3*
Biological sciences	11.9	8.7	5.9
Agricultural sciences	17.6	30.8	14.2***
Med/health sciences	17.1	16.8	8.0
Total natural sciences, tech. & engineering	84.4	86.4	8.3
Social sciences & humanities			
Accounting & finance	0.6	0.7	9.6*
Economics	2.0	1.8	7.1
Political sciences	0.8	0.7	6.9
Sociology	0.7	0.1	1.7
Law	0.8	0.8	7.7
Psychology	1.1	1.3	10.1**
Education	2.2	2.1	7.7
Other social sciences	3.5	2.7	6.3
Humanities	3.8	3.4	7.3
Total social sciences & humanities	15.6	13.6	7.1
TOTAL	100.0	100.0	8.1

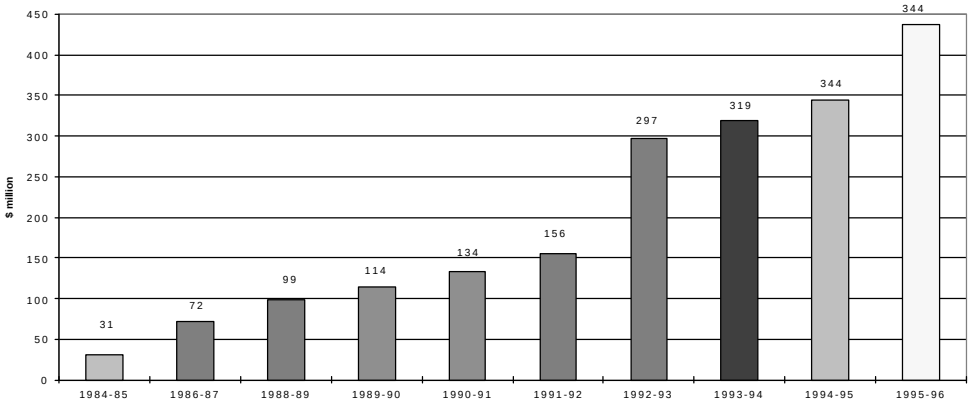
Source: ABS

2.4 Business Enterprises R&D

2.4.1 Overview

Business expenditure on R&D in Western Australia has increased dramatically over the past decade, especially since 1991-92 (Figure 4).

Figure 4: R&D by Business Enterprises in WA, 1984-85 - 1995-6



Source: ABS

Over $437 million was spent in business enterprises in 1995-96, compared to $344 million in 1994-95 and just $134 million in 1990-91. Average annual growth in business expenditure since 1984-85 has been 26%, nearly double that of Australia as a whole. As a result, the State's share of national business enterprise R&D has risen to 10.3%, its highest ever, compared to just 4.4% in 1984-85 and 7.1% in 1990-91.

With the increase in business investment the R&D ratio to GDP has also increased markedly to 0.83 in 1995-96. This is the third highest in Australia after Victoria and NSW although it is still well below the OECD average of 1.19.

2.4.2 Commonwealth Tax Concession for R&D

The large increase in business R&D investment recorded by the ABS is reflected in the number of companies registered for the Commonwealth Government's R&D tax concession, which has been rising steadily since its inception (Table 6).

Table 6: R&D Tax Concession Registrations and Expenditure

Year	Number of registrations		WA/Aust	R&D expenditure ($m)		WA/Aust
	W.A.	Australia	(%)	W.A.	Australia	(%)
1985-86	133	1,837	7.2	0.1	98.4	0.1
1986-87	102	1,411	7.2	31.1	684.1	4.5
1987-88	139	1,953	7.1	44.9	1,044.8	4.3
1988-89	142	2,020	7.0	63.2	1,248.1	5.1
1989-90	170	2,194	7.7	92.0	1,535.0	6.0
1990-91	176	2,347	7.5	126.0	2,073.4	6.1
1991-92	185	2,505	7.4	132.9	2,305.9	5.8
1992-93	181	2,438	7.4	138.1	2,383.1	5.8
1993-94	259	3,158	8.2	198.6	3,207.3	6.2
1994-95	278	3,170	8.8	304.4	3,555.7	8.6
1995-96	480	3,707	12.9	352.7	4,269.9	8.3
TOTAL	2,245	26,740	8.4	1,484.0	22,405.8	6.6

Source: ABS

There has also been an increase in the total amount of concessional R&D expenditure by Western Australian firms registered for the tax concession, and more significantly in their proportion of the national total.

2.4.3 Business Sector Strengths and Weaknesses

The measures used to show where WA was spending 'above the national average' in R&D by socio-economic objective and field of research provide an initial indicator of Western Australia's relative R&D strengths and weaknesses. However, they do not really show whether the State has a distinctively innovative or R&D-intensive capability in a particular sector or field. Given that the State has a different economic structure to the rest of Australia, the existence of high (or low) shares of national R&D in any one sector may only reflect the fact that the State has a higher (or lower) share of that industry sector. We would expect Western Australia to have a high share of the national R&D effort in mining because the State is a large player nationally in the mining industry.

A more useful measure is to compare an industry's share of national R&D with its share of the national industry, whether that is measured by turnover or employment or some other indicator. If an industry sector's R&D:turnover ratio is higher in WA than nationally, then this is at least an initial indication that the State may have a particularly innovative capability in that industry sector.

The following section looks at aggregate measures of R&D activity as a first approximation of those industry sectors where WA may possess a critical mass of R&D capability. It follows this with R&D:turnover ratios in order to determine where the State may be particularly strong (or weak) in competition with other parts of Australia.

2.4.3.1 Critical Mass: Large Performers of R&D in WA, by Industry Sector

Business expenditure can be classified into three main industry sectors depending on the enterprise's predominant activity - mining, manufacturing and other industries [4].

[4] Unfortunately, there are constraints on the coverage of business R&D activities in WA in the ABS data. The small number of firms in some industry sectors raise confidentiality problems and therefore in certain instances R&D data may not be available for some sectors in some years. However, it is possible, through a careful reading of expenditure from previous years and other techniques to 'guesstimate' R&D expenditure levels. In the following discussion, such guesstimates are used for some important sectors, having been checked with officers from the Department of Commerce and Trade.

Table 7: Industry Distribution of Business R&D in WA, 1994-95 and 1995-96

	Expenditure on R&D ($m)		Proportion (%)	
	1994-95	1995-96	1994-95	1995-96
Mining	126	172	36.7	39.3
Manufacturing	138	188	40.2	42.9
Other industries	79	78	23.0	17.8
TOTAL	344	438	100.0	100.0

Source: ABS

R&D expenditure in 1995-96 was almost evenly split between the mining and manufacturing sectors (Table 7). This is quite a different distribution from that in the rest of Australia (Table 8) where manufacturing companies were responsible for about 57% of business R&D compared with only 43% in WA. Mining was, of course, the major difference, with Western Australia's mining sector spending a much larger share of the total R&D in the State (39%).

This was easily the highest share of any State (Queensland is the next highest with 27%, with all other States having less than 10% of business expenditure spent on mining). The 'other industries' sector was correspondingly lower as a share of R&D in Western Australia.

Table 8: Industry Distribution of Business R&D in Australia and WA

	Business R&D Share 1994-95 (%)		Business R&D Share 1995-96 (%)	
	W.A.	Australia	W.A.	Australia
Mining	36.7	7.1	39.3	11.8
Manufacturing	40.2	57.0	42.9	57.3
Other industries	23.0	35.8	17.8	30.9
TOTAL	100.0	100.0	100.0	100.0

Source: ABS

WA was responsible for almost half the mining R&D in Australia in 1994-95, a figure which slipped to around one third in 1995-96, even though it increased as a share of Western Australian business expenditure (i.e. mining R&D increased faster in the rest of Australia in 1995-96). WA's share of manufacturing R&D has been climbing steadily for a number of years and is now at 7.7%. Other industries lag behind to some extent at under 6% (Table 9).

Table 9: WA's Share of National Business R&D by Sector, 1994-95 and 1995-96

	WA/Aust. 1994-95 (%)	WA/Aust. 1995-96 (%)
Mining	47.2	34.3
Manufacturing	7.5	7.7
Other industries	5.6	5.9
Total	10.0	10.3

Source: ABS

Mining R&D is divided into the following industry subdivisions:

- metal ore mining expenditure was around $135 million in 1995-96, or about 78% of all mining R&D in Western Australia;
- services to mining (including exploration) was about $20 million, or 12% of the total. This is significantly more than the $5 million spent in 1994-95; and
- the remaining $17 million (10%) was split between oil and gas extraction and 'other mining' (eg quarrying minerals).

The overwhelming majority of expenditure in the metal ore mining subdivision reflects the dominance in the mining sector of the gold, iron ore, alumina/bauxite and nickel commodities. However, the small proportion in oil and gas extraction (less than 10%) understates the significance of this sector which contributed 30% to the gross value of the resources sector in 1996.

Manufacturing is divided into a larger number of industry subdivisions. Traditionally, the most important subdivision has been metal product manufacturing. Business activities in this subdivision include iron and steel manufacturing, alumina production, smelting, basic metal, structural metal product, fabricated metal product and sheet metal product manufacturing. Although ABS data on this sub-sector has not always been published, the Department of Commerce and Trade has estimated expenditure over the past four years (Table 10).

Table 10: WA Metal Product Manufacturing R&D, 1992-93—1995-96

	Expenditure ($M)	Proportion of Manufacturing R&D (%)
1995-96	51.7	27
1994-95	79.5	57
1993-94	75.3	58
1992-93	101.9	57

Source: DCT

Total metal product manufacturing R&D expenditure over the past four years has halved with an even larger drop in its share of manufacturing R&D. Even so, the State still accounted for about 15% of national R&D expenditure in metal product manufacturing in 1995-96.

There were two other substantial subdivisions in terms of manufacturing business R&D in Western Australia in the past two years. They were:

- electronic and electrical equipment and appliance manufacturing. Businesses in this subdivision spent $17 million on R&D in 1994-95 and $22 million in 1995-96. Most (70%) of this expenditure was in 'electronic equipment manufacturing not elsewhere classified', which includes the manufacture of radio and TV receiving sets, sound reproducing and recording equipment, headphones, hearing aids and electronic components not classified elsewhere; and

- petroleum, coal, chemical and associated product manufacturing businesses. These spent $14 million in 1994-95 and $22 million a year later. In Western Australia, most of this expenditure was in 'other chemical product manufacturing'; there was no expenditure in petroleum refining or coal production R&D.

Three other manufacturing subdivisions are worth noting as well:

- food, beverage and tobacco manufacturing had a huge increase in R&D from $4.5 million in 1994-95 to an estimated $46 million in 1995-96[5];
- motor vehicle, parts and other transport equipment increased its R&D expenditure from $3 million in 1994-95 to almost $11 million in 1995-96. This expenditure would probably include the lightweight ferry shipbuilding industry and the Orbital Engine Company; and
- industrial machinery and equipment R&D rose from $5 million in 1994-95 to $10 million in 1995-96.

The expenditure in the food category appears misleading given the lack of enterprises engaged in this R&D sector. It appears to be due to the construction of a large soft drink manufacturing facility.

The third industry subdivision is that of *Other Industries*. This is made up of wholesale and retail trade, finance and insurance, property and business services, scientific research and other. Expenditure in this subdivision was constant at around $78 million a year. In both years, property and business services accounted for most of this expenditure and for about 12-13% of total business R&D in Western Australia. Around 60% of this sector was for technical services, much of it related to the mining industry (eg surveying, consultant engineering, chemical analysis, testing or assaying services, etc.), with 25% being for computer services.

Over the past ten years, annual growth in R&D has been around 58% for metal ore mining, 29% for petroleum, coal, chemical and associated product manufacturing, 22% for machinery and equipment manufacturing, and 17.5% for business services.

---

[5] This subdivision was classified as 'n.p.' in the ABS 1995/96 published data, but the estimate of $46 million is a fairly reliable one given that the only other 'n.p.' in this subdivision is for 'overseas' R&D. Assigning a fairly small amount for overseas expenditure thus leaves around $46m for expenditure in WA. This large increase also helps to explain the increase in manufacturing R&D from $138m to $188m between 1994/95 and 1995/96.

2.4.3.2 Innovation Grants

Another indicator of 'critical mass' in R&D comes from an analysis of the recipients of WAISS grants.

Just under half the recipients were in business services, with the other half mainly in machinery and equipment manufacturing (Table 11). Interestingly, only one company in metal product manufacturing was successful, although it is by far the largest R&D performing sector in the State (other than mining). This may be because firms in this sector are large enough not to need R&D assistance from the State Government.

Table 11: WAISS Grants 1993-1997 by ANZSIC Classification

ANZSIC Division		No. WAISS Grants
A.	**Agriculture, Forestry and Fishing**	**2**
04	**Commercial Fishing**	**2**
	Aquaculture	*2*
C.	**Manufacturing**	**21**
24	**Printing, Publishing and Recorded Media**	
	Printing and Services to Printing	*1*
25	**Petroleum, Coal, Chem & Associated Product Manufacturing**	
	Plastic Product Manufacturing	*3*
26	**Non Metallic Mineral Product Manufacturing**	
	Ceramic Manufacturing	*2*
27	**Metal Product Manufacturing**	
	Fabricated Metal Product Manufacturing	*1*
28	**Machinery & Equipment Manufacturing**	
	Other Transport Manufacturing	*2*
	Photographic & Scientific Equipment Manufacturing	*5*
	Electronic Equipment Manufacturing	*3*
	Industrial Machinery and Equipment Manufacturing	*3*
	Electrical Equipment & Appliance Manufacturing	*1*
E.	**Construction**	**1**
42	**Construction Trade Services**	**1**
L.	**Property and Business Services**	**23**
78	**Business Services**	
	Scientific Research	5
	Technical Services	*14*
	Computer Services	*3*
	Other Business Services	*1*

Source: DCT

2.4.3.3 Competitive Advantage in R&D, by Sector

Western Australia manufacturing R&D was around 7.7% of national R&D in 1995-96, which is quite a deal lower than the State's share of Australia's population or GDP. However, as noted, these are not necessarily the most appropriate comparisons. For example, in 1994-95,

Western Australia accounted for 7.7% of Australia's manufacturing sector turnover and employment.

A better measure, therefore, and one way to assess whether WA has any industry sectors with a particular competitive advantage in terms of R&D, is to compare R&D expenditure with industry turnover. This can show the relative R&D intensity of the sector. Using ABS data, the Department of Commerce and Trade has been able to calculate R&D:turnover ratios in two ways: first, by ANZSIC industry code, and second, by product field, for Australia and for Western Australia.

Table 12: Business Enterprise Expenditure on R&D as Proportion of Industry Turnover

Manufacturing (ANZSIC x Industry of Enterprise)	1993-94 WA (%)	1994-95 WA (%)	1994-95 Aust (%)
21 Food, beverage & tobacco manufacturing	.147	.180	.344
22 Textile, clothing, footwear & leather manufacturing	.312	.336	.282
23 Wood & paper product manufacturing	*	.618	.678
24 Printing, publishing & recorded media	.080	.107	.114
25 Petroleum, coal, chemical & associated product manufacturing	.412	.515	1.039
253 Basic chemical manufacturing	.546	.605	1.226
255 Rubber product manufacturing	*	*	.625
256 Plastic product manufacturing	*	*	.457
26 Non-metallic mineral product manufacturing	.270	.345	.510
27 Metal product manufacturing	2.107	2.041	.893
28 Machinery & equipment manufacturing	1.897	1.654	2.640
281 Motor vehicle & part and other transport equipment	.977	.580	1.862
282			
283 Photographic & scientific equipment	3.268	*	7.241
284 Electronic equipment manufacturing	10.379	*	8.101
285 Electrical equipment & appliance manufacturing	.476	*	1.320
284 Electronic & electrical equipment and appliance	5.145	9.246	4.243
285			
286 Industrial machinery and equipment	.716	.697	1.072
29 Other manufacturing	.257	.235	.316
Total Manufacturing	.946	.942	1.007

** Not available*

Source: DCT

Manufacturing in Western Australia in total had an R&D:turnover ratio of 0.942%, which was only just below the national average of 1.007% (Table 12). There were only three industry sectors which had R&D:turnover ratios higher than the national average in 1994-95. These industry sectors were:

- textile, clothing, footwear and leather manufacturing;
- metal product manufacturing; and
- electronic equipment manufacturing.

Of these, textile, clothing and footwear had a very small total R&D expenditure of just over $1 million. The other two sectors were much more substantial R&D spenders. Metal product manufacturing spent just under $80 million, and had an R&D:turnover ratio of more than double the Australian average. Electronic equipment manufacturing R&D was $17 million in 1994-95. Although its R&D:turnover ratio is not available for 1995-96, it is likely that it fell from its 1993-94 figure of 10.379, since the ratio for the combined ANZSIC class fell, and most WA R&D expenditure in these subdivisions is in electronic rather than electrical equipment.

Expenditure by product field (Table 13) appears understated which may be because it is only available according to the head office location of a company. It appears that $102 million (30%) of business R&D undertaken in WA is not included in this data.

Table 13: Business Expenditure on R&D by Product Field and as % of Turnover

Technology	WA Expend.	WA Ind T/Over	R&D as % of Ind T/Over (WA)	R&D Expend (Aust)	Ind T/Over (Aust)	R&D as % of Ind T/Over (Aust)
High						
Electronic equipment	27.73	177.6	16.612	348.95	3,157.6	11.051
Computer hardware	1.94	43.3	4.491	59.95	1,423.7	4.211
Aircraft	0.12	41.5	0.296	11.863	1,316.9	0.901
Medium High						
Other electrical appliances, machinery & equipment	3.12	169.1	1.847	73.997	6,047.5	1.224
Photographic, professional & scientific equipment	0.79	56.4	1.405	75.877	1,698.8	4.467
Medium-Low						
Industrial machinery & equipment	7.08	723.0	0.979	117.043	6,850.7	1.708
Other manufacturing	6.25	614.1	1.018	100.013	5,800.9	1.724
Ships & boats	2.94	236.6	1.242	74.218*	1,376.3	5.393*
Non-metallic mineral product	2.09	1,107.4	0.189	29.087	8,879.1	0.328
Rubber & plastic products	2.23	314.4	0.392	49.383	7,232.3	0.683
Wood, wood products & furniture	0.85	698.2	0.122	26.407	11,287.8	0.234
Low						
Fabricated metal products	1.86	234.9	0.794	102.311	4,633.1	2.208
Food, beverages & tobacco	4.68	2,810.6	0.166	121.48	41,114.9	0.295

Source: DCT

Western Australia business R&D:turnover ratios were above the national average in two 'high technology' products (electronic equipment and computer hardware) and one 'medium-high technology' product (other electrical appliances, machinery and equipment), although they are quite small product fields in terms of industry turnover with only $390 million between them (Table 13).

In the sectors where Australian R&D is weakest, Western Australia is even further down the scale (wood products, non-metallic, rubber and plastics and aircraft). Two areas raise interesting questions. Western Australia has a reasonable and healthy wood, wood products and furniture industry and an expanding boat building sector. In both, R&D is not only very low as a proportion of turnover, but well below the national average.

Estimates from the Department of Commerce and Trade put the national R&D:turnover ratio at over 5% for ships and boats, compared to a figure for Western Australia of just 1.2%. Even if the national R&D expenditure for 1994-95 is over-estimated, it is likely that the R&D:turnover ratio is at least 3% (a figure estimated by DIST for 1993-94), which is still well above the ratio for Western Australia's shipbuilding industry.

This might reflect one of two things: either that the shipbuilding industry in the State is 'under-performing' (or under-reporting) in terms of R&D, or that the industry in this State is divided between a small number of very innovative (and high R&D spending) firms and a large number of less innovative companies.

2.4.4 R&D Companies in Western Australia

The Directory of Research and Development in Western Australia, produced by the Department of Commerce and Trade lists 489 companies for 1996. The Directory is compiled by mail-out and is not compulsory or legislation-based. There are some concerns that this may be resulting in missed companies and inaccurate reporting. A broad approach to the definition of research has been adopted as one way of overcoming these limitations. This means a substantial number of consulting firms are included whose primary role is provision of services for local clients in areas such as geoscience, mine mapping, environmental studies and computer programming.

The 489 companies listed in 1996 employed 2,426 people identified as research staff for an average of five staff per firm. For 1995-96, the ABS estimated R&D expenditure in the State by business at $437 million. This represents around $0.9 million per company in the Directory or $180,000 per employee. The average per employee appears high suggesting that there was a major component of capital expenditure in the ABS estimate or that the Directory under-estimates the number of staff involved in business sector R&D. If a staff cost of $100,000 per R&D employee is used as a proxy, then the statistics suggest that there was capital expenditure, in excess of normal staff costs, of at least $194 million or alternatively a total R&D employment in WA of at least 4,370 staff (1.8 times the number listed in the Directory). Clearly more work needs to be done to understand the statistical data.

The distribution of R&D effort across the business sector varies greatly. Of the 489 firms listed, the two largest employ 17% of the staff with the five largest companies employing 25%. The top 23 companies employ just over 40% of the R&D staff but make up only 5% of the number of firms. The top 23 firms are listed in Box 1. Two firms engaged primarily in the

provision of consulting services (one financial software and one environmental) have been omitted.

The largest company, by far, is the Orbital Engine Company with 282 research staff. Two other companies, the OKA Motor Company and Gemco, work in the transport area (road and rail respectively) bringing employees in this area of R&D to around 322 (13% of the total).

The largest R&D sector, however, is in the electronics area (primarily communications). This sector includes seven firms out of the top 20 employing 352 staff (14%).

Mining-related research includes seven companies with a total employment of 208 (8%).

Box 1: Large R&D Companies in Western Australia

Company	Research focus	Research Staff
Orbital Energy Company	Motor engines	282
ERG Group	Electronics	142
Rio Tinto	Mineral processing	72
Stanilite Electronics	Electronic communications	65
Delta West	Pharmaceuticals	56
ALCOA	Mineral processing	53
QPSX	Electronic communications	40
Scitec	Electronic communications	40
Intellect Australia	Electronic communications	25
Peters and Brownes Group	Food processing	25
GEMCO	Transport engineering	22
AAP Information Services	Electronic data	20
Nautronix	Electronic communications	20
RGC Mineral Sands	Mineral processing	20
Maptek	Mining software	18
OKA Motor Company	Motor vehicles	18
Biotech	Biotechnology	17
CCK Treasury	Financial software	16
Bunnings	Timber	15
Australian Meat Technology	Food processing	15
TI-West	Mineral processing	15
Swan Portland	Mineral processing	15
WMC Resources	Mineral processing	15
TOTAL		**1,026**

Companies with large private sector research laboratories are an asset to more than just their own company. They can potentially provide a source of expertise to universities and supplier companies in their region, as well as being an employment destination for local graduates. The branch plant nature of the Western Australia economy and its lack of large, indigenous, value-added companies has traditionally meant that there has been a lack of large scale company laboratories in this State.

However, this is beginning to change. Perth is now the location for a number of quite large firms with a substantial R&D presence. The most important of these include the Orbital

Engine Corporation, ERG, QPSX, Delta West, Intellect Australia, and Rio Tinto's Advanced Technology Development Centre at Technology Park. The extent to which these companies are interlinked with local companies and universities is not clear. Recent research by the Institute for Science and Technology Policy at Murdoch University has indicated that at least one of the above-named companies has fairly weak links with local researchers, and gets many of its research staff from outside the State due to a lack of appropriately trained graduates in the local universities. More recently, Rio Tinto has halved the staff numbers at its Technology Park premises, and QPSX is also reducing the scale of its operations..

2.4.5 Business R&D Statistics

The picture of R&D provided by the Directory and by the Australian Bureau of Statistics is both complementary and contradictory. Both reveal the importance of the mining sector with the Directory suggesting the ABS statistics may under-state the importance of this sector given that two of the largest private research facilities listed in the Directory (Rio Tinto's HI-Smelt operation and ALCOA's research laboratories) are almost certainly classified as metal manufacturing by the ABS whereas they it would be equally valid to classify them as mining related.

The Directory also highlights the number of substantial electronic research companies whereas this segment is less apparent in the ABS statistics. The presence of three large R&D companies in the motor vehicle/transport sector is also not picked up clearly in the ABS figures where this sector is credited with only $11 million in R&D. The Orbital Engine company alone with 282 research staff almost certainly exceeds this investment level.

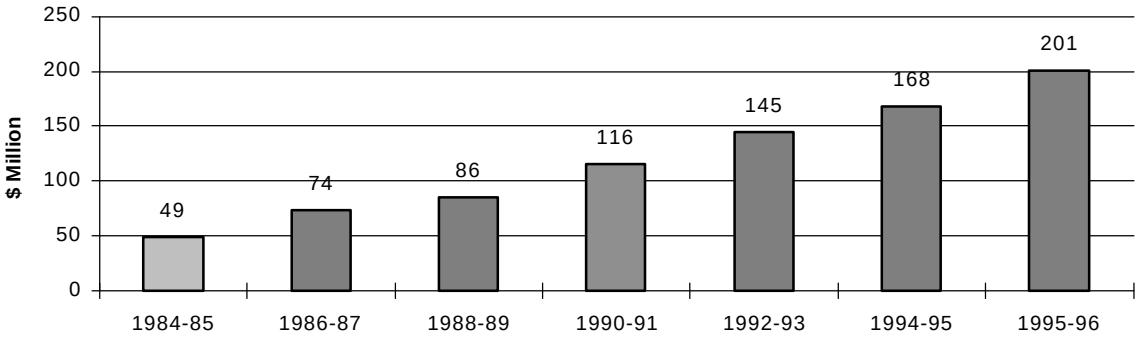
A surprising inclusion in the ABS figures for 1995/96 is food at $46 million compared with only $4.5 million in the previous year. Only twenty companies are listed in the Directory with any food research and only four have more than seven staff. The total research staff numbers of 78 would be unlikely to account for more than $10 million, leaving a large component of the ABS statistic unexplained by any details in the Directory. It appears that two companies account for most of the expenditure and it is questionable as to whether all expenditure is research.

2.5 Higher Education R&D

2.5.1 Overview

Total expenditure on R&D in the higher education sector in Western Australia in 1995 was just over $200 million. This was a substantial increase on earlier years bringing the State share to 9.8% of national R&D expenditure, compared with 9.2% a year earlier and 8.8% in 1990 (Figure 5).

Figure 5: R&D in Higher Education Institutions in WA, 1984-1995



Expenditure was concentrated on the advancement of knowledge and health socio-economic objectives with plant and animal production, environmental research, mineral and energy resources, and (for 1995) education and training also significant (Table 14). There were some differences between the two years, with health R&D in particular growing rapidly while plant and animal production R&D declined in absolute as well as relative terms.

Table 14: Higher Education R&D in WA by Socio-Economic Objective, 1994 and 1995 ($M)

Objective	1994	1995
Advancement of knowledge	71.2	75.4
Health	25.7	37.7
Plant & Animal production	20.7	16.5
Mineral & energy resources	10.5	15.1
Environment	11.4	16.4
Education & training	6.7	13.1

Source: ABS

Higher education R&D was above national concentrations in mineral and energy resources, agriculture, construction and the environment and construction (Table 15). The large increases in health, economic framework and education and training R&D in 1995 also saw these areas move above the State's share of national higher education research. The State had relatively low shares of the national R&D effort in the advancement of knowledge (i.e. basic research) and in manufacturing, and quite low shares in information and communication services.

Table 15: Shares of Higher Education R&D by Socio-Economic Objective, 1994 and 1995 (%)

Socio-Economic Objective	WA Expenditure (%)		Proportion of Aust (%)	
	1994	1995	1994	1995
Agriculture	12.3	8.2	22.2	15.4
Mineral resources	4.9	5.5	32.1	33.1
Energy resources	1.3	2.0	18.7	30.5
Manufacturing	3.4	3.1	7.5	6.5
Construction	2.0	2.1	11.9	16.8
Info & comm. services	0.7	0.7	3.0	4.2
Econ framework	3.4	3.8	7.9	10.7
Health	15.3	18.8	8.4	10.6
Educ., training & social devt.	6.0	8.7	7.1	12.0
Environment	6.8	8.2	9.4	11.3
Adv. of knowledge	42.5	37.6	8.1	7.8
Other	1.4	1.3	6.7	6.7
TOTAL	100.0	100.0	9.2	9.8

Source: ABS

In terms of the field of research, higher education R&D has been concentrated on social sciences and humanities, medical and health sciences, agricultural sciences, biological sciences and general engineering (Table 16).

In terms of the national scene, WA is well represented in agricultural sciences, general engineering, earth sciences, and information, computers and communication technologies.

Table 16: Higher Education R&D by Field of Research, 1994 and 1995 (%)

Field of Research	WA Expenditure (%)		Proportion of Australia (%)	
	1994	1995	1994	1995
Mathematics	1.4	1.8	5.2	6.4
Physical sciences	2.5	2.6	4.8	5.5
Chemical sciences	3.4	3.6	5.9	7.4
Earth sciences	5.9	5.7	11.3	11.7
Info, computers & communic'ns	5.7	5.9	10.3	11.3
Applied S&T	3.9	4.7	9.7	11.6
General engineering	10.2	7.8	13.0	11.7
Biological sciences	10.5	10.5	8.2	8.7
Agricultural sciences	12.6	8.6	19.3	14.0
Medical/health sciences	20.3	24.1	9.0	10.7
Social sciences & humanities	23.5	24.5	7.6	8.9
TOTAL	100.0	100.0	9.2	9.8

Source: ABS

A large increase in medical R&D saw it increase its share of the national R&D effort from 9% to 10.7%. The relatively good performance in information, computers and communication technologies seems to be at odds with the State's low level of information and communication services R&D calculated on an socio-economic basis. One explanation for this apparent anomaly may be that higher education researchers in the information

technology area are performing their research for other industry sectors (such as mining and energy) rather than for the information technology sector per se.

2.5.2 Australian Research Council (ARC) Schemes

While the ABS R&D data provide quantitative information it is also possible to get a more qualitative understanding of the strengths and weaknesses of Higher Education R&D from an analysis of the Australian Research Council (ARC) grants and schemes. In particular, the ARC's competitive grant schemes indicate how Western Australia's researchers compare with their counterparts elsewhere in the country.

The ARC administers several competitive grant schemes; the most significant being the Large Grants, the Collaborative Grants, the Research Fellowships, and the Research Infrastructure Grants.

For the analysis below, it is useful to remember that Western Australia's share of Australian higher education R&D expenditure was 9.2% in 1994 and 9.8% in 1995.

2.5.2.1 Large Grants

ARC Large Grants are often seen as the most important and prestigious grants in the higher education sector, and there is fierce competition to win them. As a consequence the success rate is normally around 20%.

Table 17: ARC Large Grants, numbers and total funds, 1994-1997

	WA grants (no.)	Proportion (%)	WA grants ($m)	Proportion (5)
1994	48	8.0	2.88	8.9
1995	46	7.0	2.5	7.0
1996	50	7.5	2.4	8.4
1997	42	6.6	na	na
1994-97	186	7.3		

Source: ARC

The statistics suggest the State is below its share based on overall higher education funding and below the population proportion (Table 17). In terms of research field, the largest categories were: social sciences (28% of the total number of Western Australia grants); biological sciences (16%); engineering (9%). However, in terms of how the State compared nationally, the areas with the most competitive advantage were: agricultural sciences (23% of the national grants in the area); applied science and technology (10%); and social sciences (10%).

2.5.2.2 Collaborative Grants

Collaborative grants involving direct collaboration between a university researcher and a company are increasing in importance within the ARC portfolio. They tend to involve more

applied research and are therefore also a significant indicator of research strengths in areas which are 'closer to the market' than most ARC Large Grants.

Table 18: ARC Collaborative Grants, 1994-1997

	WA grants (no.)	Proportion (%)	WA grants ($'000)	Proportion (%)
1994	6	7.1	262	4.2
1995	9	9.2	580	8.0
1996	10	9.2	907	11.7
1997	12	6.0	na	na
1994-97	37	7.5		

Source: ARC

Distribution of collaborative grants by fields of research is quite different from the ARC large grants (Table 18). Of the 22 grants to Western Australia projects in 1996-7, by far the highest proportion (9, or 41%) were in the social sciences, with the next highest being in earth sciences and agriculture with 3 each, or 13.6%. Nationally, however, the stronger areas were mathematics (1 of 5, or 20%), humanities, (1 of 6, or 16.7%), earth sciences (3 of 19, or 15.8%), agriculture (3/22, or 13.6%), social sciences (9/81, or 11.1%) and biological sciences (2/19, or 10.5%). Western Australia received no grants at all in physical sciences, applied science and technology, engineering, or medical and health sciences (which is different from the NHMRC grants).

2.5.2.3 Research Fellowships

Research Fellowships include support for established academics as well as for younger postdoctoral students.

Table 19: ARC Research Fellowships, numbers granted, 1994-1997

	WA fellows (no.)	Proportion (%)
1994	4	4.0
1995	6	7.1
1996	4	4.0
1997	12	10.7
1994-97	23	5.8

Source: ARC

The State appears to have under-performed in attracting ARC fellowships although the situation for 1997 was far higher than the previous three years (Table 19).

Examination of the fields of research of the research fellows show that 5 of the 16 research fellows in 1996-97 were in earth sciences, with another 4 in physical sciences (Table 19). These two areas also were best represented within Australia; earth sciences fellows from Western Australia comprised 23.8% of the national total, and physical science fellows were 21.6%. The two engineering fellows represented 17.1% of the Australian fellows in that field of research.

2.5.2.4 Summary: Competitive Grants by Field of Research

For the combined three schemes (large grants, collaborative grants and fellowships), Western Australia shows a concentration in social sciences, biological and earth sciences (Table 20). Within the national context social sciences and earth sciences receive a strong proportion along with the agricultural field. The State did poorly in the medical/health and chemical fields. A more complete understanding of the health area would require an evaluation of NHMRC funding which was outside the scope of this study.

Table 20: ARC Competitive Grants (No.)
By Field of Research, 1996-1997

F.O.R.	WA	% OF W.A.	AUSTRALIA	% OF AUST.	WA/AUST (%)	
Mathematics	6.4	4.9	83.5	4.6	7.6	
Physical	10.7	8.3	107.5	5.9	10.0	*
Chemical	5.0	3.9	141	7.7	3.5	
Earth	14.1	10.9	128.2	7.0	11.0	**
Information	7.3	5.7	126.8	7.0	5.8	
Applied S&T	6.4	4.9	119.4	6.6	5.3	
Engineering	11.0	8.5	184.7	10.1	6.0	
Biological	17.6	13.6	318	17.5	5.5	
Agricultural	7.0	5.4	40.9	2.2	17.1	***
Med./health	0.5	0.4	52.9	2.9	0.9	
Soc. Science	34.8	27.0	362.9	19.9	9.6	**
Humanities	8.4	6.5	154.6	8.5	5.4	
TOTAL	129	100.0	1820.4	100.0	7.1	

* Indicates Western Australian share above average

Source: ARC

There is clearly some scope for improving Western Australia's share of large and collaborative grants. The State Government could play a role by providing support for collaborative proposals.

2.5.2.5 Research Scholarships

PhD students are an important R&D indicator, as they represent future researchers. Between 1993 and 1995, 386 students received Australian Postgraduate Awards to study at Western Australia universities. The State's share of these awards was consistently around 9%. However, there were marked differences between subjects. These are significant, because student choices may well indicate areas of research strength, or at least the perception of strength.

Table 21: Research Scholarships Awarded in WA, by Field of Research, 1993-95

Field of Research	No. of Awards 1993-95	Proportion (%)	WA Proportion of Aust (%)
Maths	12	3.1	5.9
Physics	10	2.6	5.6
Chemistry	18	4.7	10.2
Earth	17	4.4	11.2
Info Tech	25	6.5	11.1
Applied S & T	2	0.5	4.2
Engineering	40	10.4	10.5
Biological	45	11.7	8.5
Agriculture	7	1.8	7.3
Medical/Health	35	9.1	10.0
Social Science	90	23.3	9.4
Humanities	84	21.8	9.1
TOTAL	386	100.0	9.1

Source: ARC

Western Australia has a large number of PhD scholarship students in the social sciences, humanities, biological sciences, engineering and medicine/health (Table 21). However, as a percentage of the national total, our relative strengths appear to lie with Earth Sciences, Information Technology, Engineering, Chemistry, Medicine/Health and Social Sciences. Interestingly, Biological Sciences and Agriculture are not as well represented as might be expected. The State also appears to have been fairly weak at attracting PhD students in the physical sciences, mathematics and applied science during these years.

Another PhD scheme run by the ARC is the APA (Industry) scholarships. These scholarships allow postgraduate research students to undertake industry-based research and aim to build long-term relationships between industry and higher education institutions. The industry partner must provide a minimum of $10,000 (of which $5,000 must be in cash) per year. Western Australia's record in attracting APA(I) scholarships is set out in Table 22 below.

WA has had only moderate success in securing APA(I) awards.

Table 22: Australian Postgraduate Awards (Industry), 1994-997

	WA recipients (no.)	Proportion (%)
1994	14	11.2
1995	4	3.2
1996	11	7.3
1997	9	4.4
1994-97	38	6.3

Source: ARC

2.5.2.6 Research Infrastructure

There are two main sources of ARC infrastructure funds. The first is a block grant based on a set formula, in which Western Australia does fairly well, averaging between 9.5% and 11.2% of total funds between 1994 and 1996, probably in recognition of the particular needs of the universities in this State (a growing population, Murdoch's new campus at Rockingham, etc.). The more academically relevant source of infrastructure is the Research Infrastructure (Equipment and Facilities) Grants, which are awarded on a competitive basis (these were called 'Mechanism C' grants before 1995).

Table 23: ARC Competitive Research Infrastructure Grants, 1994-1997

Year	Grants (No.)	Proportion of National Total	Grants ($ million)	Proportion of National Total
1994	5	13.5	1.215	7.6
1995	4	6.7	0.510	3.4
1996	7	10.4	0.950	5.1
1997	9	11.0	1.550	8.0
TOTAL	25	10.2	4.225	6.2

Source: ARC

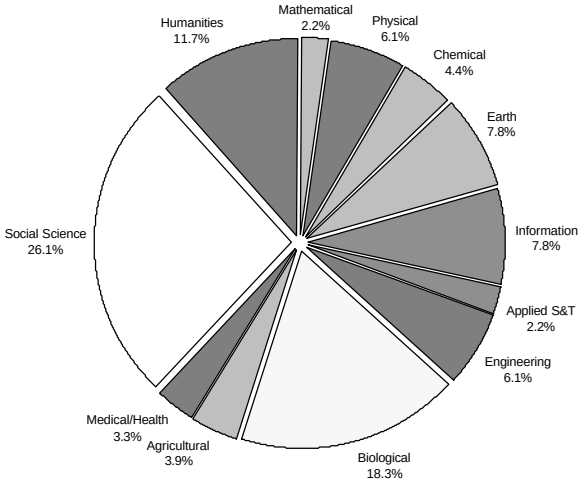
Despite an improvement in 1997, the State appears to be falling behind to some extent in winning support for large infrastructure grants from the ARC, although it is well represented in the number of grants (Table 23). This may reflect the lack of national facilities in the State.

2.5.2.7 Small Grants

Block funds for ARC small grants are distributed to universities based on a formula related to previous performance in obtaining Large Grants as well as a base grant. Academic staff then compete within their universities for the grants. The amount distributed to Western Australian universities each year has been around $2 million for the past 4 years, which represented around 7.7% of the national total. Around 140 grants were given each year.

An analysis of the distribution of these funds on a field of research basis was undertaken for all grants held in 1997 (including those carried forward from previous years) to provide an indication of the research interests and strengths of academics within Western Australian universities (Figure 6).

Figure 6: ARC Small Grants from WA by Field of Research, 1997



Around a quarter (47) of the 180 grants were in social science, 33 (18%) in biological science and 21 (12%) in humanities. The number of grants given in Western Australia represented 7.8% of the national total fields of research in which WA had above that percentage of grants included agricultural science (12.1% of the national total), information technology (11.1%), social science (10.5%), earth science (9.0%) and biological science (8.2%). the state had quite small shares of the national total in mathematical science (3.1%), chemical science (3.9%), applied science (4.3%) and medical/health (4.9%).

2.6 Research Centres

There are three competitive Commonwealth-funded schemes which support research centres. The Special Research Centres and the Key Centres of Teaching and Research, are administered through the ARC. The third, the Cooperative Research Centres (CRCs) are administered through the Department of Industry, Science and Tourism.

2.6.1 Special Research Centres and Key Centres of Teaching and Research

There are 19 Special Research Centres being funded in 1997 at a cost of $14.5 million. Western Australia has five of these with four at the University of Western Australia and the fifth at Murdoch University.

- Advanced Minerals and Materials Processing (since 1991).
- Environmental Fluid Dynamics (since 1991).
- Offshore Foundation Systems (since 1997).
- Tectonics Research (since 1997).
- Social and Economic Change in East and Southeast Asia (since 1991) - Murdoch University.

There were 15 Key Centres being funded in 1997 at a total cost of about $4 million. There are none in WA, as the two centres at UWA and Curtin reached the end of their funding cycle in 1996.

2.6.2 Cooperative Research Centres (CRCs)

CRCs are the most significant research initiative by the Commonwealth Government in recent years. There are now 68 CRCs nationally. Those with WA participation are listed in Box 2.

Box 2: CRCs with WA Participation

With WA Headquarters

Information and Telecommunications Technology

1. CRC for Broadband Telecommunications and Networking
   WA Participants: Curtin University; Edith Cowan University; UWA; Australian Telecommunications Research Institute; ERG Electronics Ltd

Mining and Energy

2. A J Parker CRC for Hydrometallurgy
   WA Participants: Murdoch University; Curtin University; AMIRA; CSIRO Division of Minerals; WA Dept of Minerals & Energy
3. Australian Geodynamics CRC
   WA Participants: CSIRO Division of Exploration and Mining
   Other Participants: Victorian Institute of Earth and Planetary Sciences; Australian Geological Survey Organisation; Digital Equipment Corp.
4. CRC for Landscape Evolution and Mineral Exploration
   WA Participants: CSIRO Division of Exploration and Mining
   Other Participants: ANU; University of Canberra; AGSO
5. Australian CRC for Renewable Energy
   WA Participants: Murdoch University; Curtin University; PowerSearch Ltd; Western Power Corp.; Westwind Turbines; ZBB Australia Ltd
   Other Participants: NTU, ANU, QUT, UTS, several companies and utilities

Agriculture and Rural Based Manufacturing

6. CRC for Legumes in Mediterranean Agriculture
   WA Participants: UWA; Murdoch University CSIRO; Agriculture WA

With WA Nodes

Manufacturing Technology

7. Australian Maritime Engineering CRC
   HQ: Launceston (Tas.); Nodes in Melbourne, Sydney, Perth
   WA Participant: Curtin University

Mining and Energy

8. CRC for Australian Mineral Exploration Technologies
   HQ: Sydney; Nodes in Perth
   WA Participants: Curtin University; Geological Survey of WA; AMIRA; CSIRO Division of Exploration and Mining; World Geoscience Corp.
9. Australian Petroleum CRC
   HQ: Melbourne. Nodes in Sydney, Adelaide and Perth
   WA Participants: Curtin University

Agriculture and Rural Based Manufacturing

10. CRC for Premium Quality Wool
    HQ: Armadale (NSW). Nodes in Sydney, Perth, Geelong, Adelaide
    WA Participants: UWA; Agriculture WA
11. CRC for Temperate Hardwood Forestry
    HQ: Hobart. Nodes in Launceston, Burnie, Morwell (Vic), Manjimup
    WA Participant: Bunnings Treefarms
12. CRC for Molecular Plant Breeding
    HQ: Adelaide. Nodes in Sydney, Perth
    WA Participant: UWA

Environment

13. CRC for Biological Control of Vertebrate Pest Populations
    HQ: Canberra. Node in Perth
    WA Participants: CALM; Agriculture WA
14. CRC for the Sustainable Development of Tropical Savannas
    HQ: Darwin. Nodes in Townsville, Kununurra
    WA Participants: CALM, Agriculture WA
15. CRC for Conservation and Management of Marsupials
    HQ: Sydney. Nodes in Newcastle, Auckland, Brisbane, Perth
    WA Participants: Perth Zoo
16. CRC for Sustainable Tourism
    HQ: Gold Coast (Qld). Nodes in Brisbane, Darwin, Townsville, Perth, NSW
    WA Participants: Murdoch University

Other WA Participation (no WA node)

Agriculture WA:
CRC for Quality Wheat Products and Processes (HQ: Sydney)
CRC for Weed Management Systems (HQ: Adelaide)
Water Corporation of WA:
CRC for Water Quality and Treatment (HQ: Adelaide)

The distribution of CRCs by Field of Research (FOR) in Australia and within Australia (for those with a WA node) is shown in Table 24.

The FORs of the Western Australian CRCs show a strong presence in mining and energy, agriculture and environment, although interestingly, the State is the lead participant in only one agriculture-related CRC and does not lead any environmental CRC. Not surprisingly, the State has a weak presence in manufacturing, but possibly more surprising is the fact that the State has no participation at all in any medical or health related CRC and only one IT-related CRC.

Table 24: WA Participation in CRCs by Field of Research, 1997

Field of Research	WA lead (no.)	WA lead (%)	WA particip. (no.)	WA particip. (%)	WA total particip. (% WA)	Australia All CRCs (no.)	Australia All CRCs (%)
Manuf.	0	0	1	11.1	6.2	9	13.2
IT	1	12.5	1	12.5	6.2	8	11.8
Min/En	4	40.0	6	60.0	37.5	10	14.7
Agric	1	5.9	4	23.5	25.0	17	25.0
Env	0	0	4	28.6	25.0	14	20.6
Med	0	0	0	0	0	10	14.7
TOTAL	6	8.8	16	22.1	100.0	68	100.0

Source: DIST

The distribution of CRCs with Western Australian participation is heavily influenced by the State's public sector research capabilities. Analysis of Box 2 shows that five of the six CRCs based in Western Australia have strong local CSIRO involvement; a number of State Government departments (in particular Agriculture WA and CALM) are also involved in at least four centres with Western Australia nodes (and Agriculture WA is involved in a further two CRCs). Only six Western Australian companies are directly involved in CRCs although other companies are represented in two more through AMIRA, and QPSX is connected with the Broadband Telecommunications CRC. Overall there are less than ten companies involved

in the 16 CRCs which have a significant Western Australian presence. Three are relatively small companies involved in the newly established Renewable Energy CRC. It will be important to ensure either that the CRCs are instrumental in assisting participating companies to grow substantially, or else to promote strong linkages and diffusion of research results to local companies if the State is to get the full benefit of the CRC program and its investment in it.

This impression of relatively low business involvement in WA CRCs is reinforced by Table 25, which shows the distribution of CRC funds by participants by State.

Table 25: Contributions to CRCs by Participants and Program Funds for the Full Contract Period (5-7 years), as at August 1997

	Uni's	CSIRO	Other C'wlth	State Govt	Ind.	Others	CRC Prog.	TOTAL
W.A. ($M)	85	46	19	28	36	2	83	298
Aust. ($M)	867	549	178	362	641	124	1,103	3,824
% of WA Total	28.5	15.5	6.2	9.2	12.1	0.7	27.8	100.0
% of Aus. Total	22.7	14.4	4.7	9.5	16.8	3.2	28.8	100.0

Table 26 needs to be read with some caution, as it allocates funds for each CRC to the State in which the headquarters is located. Obviously, for CRCs with more than one node (which form the majority of CRCs), this is not a correct assumption. Nevertheless, the Table does show that for those CRCs in which Western Australia is the lead location, industry is committed to providing only $36 million over the life of the CRCs. This is around 12% of total funds, compared to a national average of almost 17%. 'Other' organisations are also very low contributors - this reflects the lack of medical-based CRCs in Western Australia. Interestingly, Western Australia has a higher relative contribution from the university sector and from Commonwealth agencies (including CSIRO) - the two sectors which are relatively low overall performers of R&D in Western Australia.

Given the relative lack of industry funds in the Western Australian CRCs, it will be important to ensure either that the CRCs are instrumental in assisting those participating companies to grow substantially, or else to promote strong linkages and diffusion of research results to local companies if the State is to get the full benefit of the CRC program and its investment in it.

Western Australia is the lead location in six CRCs, and has a node in nine others. It also participates in three other CRCs with no local node. Western Australia has a slightly greater tendency than SA and Qld to have more narrowly focused CRCs in terms of their geographical and institutional spread (Table 26).

Table 26: Number of Participating States in CRCs, WA, SA and Qld

State	Total CRCs	Number of participating States in each CRC					
		1	%	2	%	>2	%
WA	15	3	20.0	3	20.0	9	60.0
SA	17	2	11.8	2	11.8	13	76.5
Qld	24	4	16.7	4	16.7	16	66.7

This Table shows that Western Australia was more likely to be involved in Western Australian-only CRCs (three CRCs, or 19% of all CRCs in which the State is involved) and is least likely to be a participant in CRCs with a broader national coverage (i.e. those with more than two participants). Again, this may reflect the public sector's dominance of Western Australian involvement in the CRCs. While this is only one indicator, it does suggest that perhaps local researchers and companies are not as well networked nationally as they might be.

There are several CRCs, for example, which have a large number of participants across two or three States in fields of research which might be thought to be of relevance to Western Australia, but in which there are no local players at all, including:

- tropical pests;
- cattle/beef production;
- aquaculture;
- viticulture;
- waste management and control;
- sustainable tourism;
- Aboriginal and tropical health; and
- research data network.

While there might be explanations for Western Australia's absence from each of these CRCs, the general picture is not as promising as might be thought from the relatively high Western Australian participation rate in CRCs overall.

The Government has a role to play in helping R&D institutions identify external funding sources and some financial assistance with application processes has been beneficial for Cooperative Research Centres.

The Government needs to consider ways in which local universities, businesses and departments can be encouraged to greater participation in Cooperative Research Centres. Some form of bonus payments for collaborative efforts should be considered.

2.6.3 Technology Centres

Another indicator of R&D capability is the number and range of research and technology centres. There has been a growing number of such centres in Australian universities over the

past few years. Centres are able to market themselves better to industry and other clients, and also help pool research facilities and resources (human and financial) across departmental and institutional lines. The annual *Scitech Technology Directory* produces a list of centres; Table 27 below gives the distribution of centres by State and Territory. This list includes ARC Key Centres in Teaching and Research and ARC Special Research Centres, but excludes CRCs.

Table 27: Distribution of Technology Centres by State, 1997

State	Centres
NSW	53
Victoria	54
Queensland	37
S.A.	23
W.A.	18
A.C.T.	9
Tasmania	5
N.T.	1
TOTAL	200

Eight of the Western Australia centres are at UWA, with four each at Murdoch and Curtin Universities. The other two are the Leeuwin Centre for Earth Sensing Technologies and the Materials Institute of WA. While not an exhaustive list, this Table suggests that the State does not have a large stock of technology centres compared to other States. In particular the State number is low when compared with Queensland and South Australia.

2.7 Government R&D

Total R&D expenditure in government organisations in Western Australia was almost $143 million in 1994-95. About two thirds of this was spent in State government organisations, with the remaining third being spent in Commonwealth organisations (predominantly CSIRO).

The R&D in State government organisations represented 15% of all R&D spent in Western Australia. The proportion of total R&D performed by the State Government has declined substantially since 1984-85, when its share of total R&D was about one third.

Only $48 million, or 2.4%,, of Commonwealth government organisations' R&D was spent in Western Australia in 1994-95, which is an even smaller percentage than in 1984-85.

Spending on R&D in State Government organisations increased by an average of 2.4% per year in constant prices in the ten years between 1984-85 and 1994-95, compared to Commonwealth spending which increased by just over 6% per annum in real terms over the same period. This was the opposite of the national trend, where State Government spending increased by around 6% and Commonwealth spending by only 1%.

The relocation of the CSIRO National Centre for Petroleum and Minerals Resources Research to Western Australia is expected to boost the Commonwealth's R&D performance in this State significantly.

State Government expenditure was strongly focused on agriculture, the environment and the mineral and energy resources (Table 28). The actual fields of research reflected this emphasis with agricultural research taking just over half of the total followed by earth sciences with 15%.

The lack of a broad range of Commonwealth R&D agencies means that WA has quite a small share of health and other R&D in the government sector.

Table 28: Government Expenditure by Socio-Economic Objective, 1994-95

Socio-Economic Objective	Expenditure ($m)	Proportion (%)	WA/Aust (%)
Plant & animal production and primary products	61.0	42.8	11.3
Mineral and energy resources	19.9	14.0	15.6
Health	9.4	6.6	4.5
Environment	36.5	25.6	9.9
Other	15.8	11.0	2.2
TOTAL	142.6	100.0	7.3

2.8 Private, Non-Profit R&D

Victoria and NSW dominate the private, non-profit area of R&D in Australia, with $79 million and $44 million respectively out of a total expenditure of $144 million in 1994-95. Almost 80% of this sector's R&D is spent on health research, in institutes such as the Walter and Eliza Hall Institute, the Florey Institute and the Lions Eye Institute in Western Australia.

Western Australia has the third highest expenditure of the States after Victoria and NSW, with $10.6 million. This figure has been rising rapidly, and now represents 7.3% of the national total, compared to just 1.5% in 1990-91. Over 90% of the private, non-profit funds went to health R&D in 1994-95.

2.9 Conclusion

The Western Australian government has endorsed support for R&D through its Science and Technology Policy. Coordination of programs under this policy will be the responsibility of a Ministerial Council and a high level officer coordinating committee. The policy provides a structure for R&D in Western Australia which is at the forefront of State Government approaches to R&D in Australia.

R&D expenditure in Western Australia has been increasing at over 10% per annum for the last ten years. However, expenditure remains low both in terms of the proportion of gross domestic product and population relative to other States and Territories.

Around half of the R&D expenditure is now carried out by the business sector. A quarter of expenditure takes place in higher education institutions with the State Government contributing 15% and the Commonwealth less than 10%.

R&D in Western Australia has quite different objectives to the rest of Australia. Effort is highly concentrated in the mineral and energy resources areas followed by agriculture, the environment and commercial services. R&D in manufacturing and the information and commercial services sectors are low when compared with national effort.

Business R&D has shown dramatic growth over the past decade and the State now has the third highest ratio to GDP after Victoria and New South Wales. Business investment has almost certainly increased as a consequence of the Commonwealth taxation concession and taxation arrangements will continue to play a key role in determining investment levels. There are nearly 500 companies listed by the Department of Commerce and Trade as employing research staff in Western Australia. The industry is, however, dominated by the larger companies with only 8% of the firms employing over 50% of the research staff.

Manufacturing R&D comprises just over 40% of total business R&D and is dominated by metal product manufacturing (55%). Even though expenditure has been declining over the last four years, the State still accounts for around 15% of the national total in this field. Metal product manufacturing almost certainly includes the Rio Tinto HI-Smelt experimental iron and steel plant at Kwinana and the ALCOA research laboratories. These are large research investments which are closely related to the companies' mining activities in the State. Rio Tinto is one of Australia's 10 largest business R&D investors with investments in Western Australia at Kwinana and Technology Park. Unfortunately, as part of a world-wide rationalisation of R&D, the Technology Park facility operated by CRA is being significantly scaled back and research expenditure at HI-Smelt will also decline as the facility is fully evaluated.

Some R&D expenditure by Rio Tinto and BHP is linked to their obligations under State Agreement Acts which require considerable effort into development of further processing opportunities for iron ore in this State.

To ensure long term benefits to the Western Australian community from resource development, the Government should consider ways in which the royalty system may be used to encourage R&D investment. A positive approach involving royalty incentives as a trade-off for R&D investment appears worthwhile.

Fast growing sectors in manufacturing R&D are in 'electronics', 'food, beverage and tobaccos' and 'other chemicals'. The State has a number of significant electronic communication R&D companies. This reflects the growing importance of such R&D which is demonstrated by the inclusion in Australia's top 10 R&D investment companies of four associated with telecommunications. Unfortunately, none of the four has a significant R&D

presence in Western Australia although the State has developed electronic communication expertise and given the demands for remote, long distance telecommunications the State has a suitable environment and demand for such services. The largest twenty companies investing in R&D in the State include six with electronic communications expertise (ERG, Scitech, Intellect Australia, Nautronix, QPSX and Stanilite). The State also has a number of university and CRC groups involved in electronics and every effort must be made to build on this expertise.

The State Government can play a part in maintaining a favourable environment by stressing the importance of the business sector to the Commonwealth Government at all opportunities.

A number of business surveys have emphasised the importance of the taxation deduction level for R&D. There is evidence business investment has declined since the write-off was reduced from 150% to 125%. While the original level may have been exploited the State Government should urge the Federal Government to restore the deduction level through an effective scheme.

Mining R&D in Western Australia represented 39% of business investment and constituted around half the nation's investment in 1994-95. This investment reflects the importance of the resources sector in the State economy. Mining investment increased in 1995/96 but the State proportion of national investment slipped to a third from about half in the previous year. Mining R&D was dominated by expenditure in the metal ore mining segment with smaller investments in other sectors such as petroleum.

The Government has been supportive of mining R&D through MERIWA, the Department of Minerals and Energy, the Mineral Processing Laboratory and the Department of Resources Development. Support has also been given to some of the mining-related CRCs and university research groups. The Government has also provided substantial funding for the relocation to Western Australia of the CSIRO National Centre for Petroleum and Minerals Resources Research.

CSIRO has also been a strong contributor to mining R&D with minerals and mining exploration divisions represented in the State. The relocation of the petroleum division to Western Australia will further enhance this contribution.

Western Australia must capitalise on the strength of its mining and petroleum industries by ensuring a high level of R&D investment in this State. The Government can play a role by assisting with the creation of a 'critical mass' of research infrastructure in the State and by ensuring that higher education institutions provide the courses which address industry requirements in this sector.

The third business R&D sector (other industries) accounts for about 12% of WA investment. The majority of this went into technical services, much of it again related to the mining industry.

When compared with industry turnover, business R&D investment in WA was higher than the national average for three sectors. One sector had a very low level of aggregate expenditure leaving metal products and electronic equipment manufacturing as two sectors in which the State appears to have a significant R&D capacity compared with other States. In both sectors, the State proportion of R&D was more than double the national average. While the State has a low relative strength in all other sectors, two stand out. The wood and wood products and boat building sector have low R&D investments despite the importance of these sectors in the State economy. The recent State Government announcement of plans for a Marine Industry Technology Park at Jervoise Bay demonstrates its commitment to this sector.

Higher education R&D is just below the State's population share of Australia with the State's relative importance being greatest in the mineral and energy, construction and agriculture areas. The State is well represented in agricultural sciences, general engineering, earth sciences and information, computers and communication technologies. State expenditure in higher education R&D is particularly low compared with the rest of Australia in the physical and chemical sciences and mathematics.

Analysis of ARC funding shows the State to be doing well in attracting funds for agriculture and earth sciences. The State has also attracted ARC support for the physical and social sciences but has received much less relative support for health and chemistry areas. Western Australia has done well in attracting ARC-funded special research centres with five located in the State out of 19 nationally.

The State has been less successful with the CRC program providing the lead agency for only six although State organisations has a significant presence in 15 (22%) and some form of participation in 18 out of the total of 62 at the end of 1996.

Involvement in the CRCs reflects the government sector research emphasis with local CSIRO divisions and State Government departments actively involved. Agriculture WA (6), CSIRO (5) and CALM (2) are all involved with more than one CRC. Curtin University is involved with six, Murdoch three, the University of WA three and Edith Cowan one. Business involvement in WA CRCs is low with less than ten significant participants in the 15 centres.

There are many areas in which the State has no CRC involvement despite some apparent relevance including the health centres. The 'tyranny of distance' appears to reflect itself in the small number of CRCs involving more than two States in which WA is represented. The State is involved in only nine of these compared with 13 for South Australia and 16 for Queensland.

The Government needs to consider ways in which local universities, businesses and departments can be encouraged to greater participation. Some form of bonus payments for collaborative efforts should be considered.

Western Australia is also under-represented nationally in the number of technology centres located in the State's universities. The State total of 18 (9%) is significantly less than South Australia (23) and Queensland (37).

Government expenditure on R&D in Western Australia is dominated by the State Government ($97 million) with Commonwealth agencies contributing $48 million. State Government expenditure is strongly focused on agriculture through Agriculture WA, the environment through CALM and mineral and energy resources through the Departments of Minerals and Energy, Resources Development and the Office of Energy. The State needs to constantly review its revenue receipts from the individual rural industry R&D corporations and evaluate what needs to be done to attract a greater share of funding from any schemes judged to be deficient in their Western Australian allocation. Recent negotiations with the Grains Research and Development Corporation have identified ways of overcoming their concerns regarding investment in Western Australia leading to commitments to increased funding.

The lack of federal government research agencies, other than CSIRO, in Western Australia is the major factor behind the relatively low Commonwealth direct R&D contribution. The relocation of the CSIRO National Centre for Petroleum and Mineral Resources Research to Western Australia will increase Commonwealth expenditure.

Despite the length of its coastline and the offshore maritime zone, Western Australia does not have a substantial research effort in marine sciences. Consideration needs to be given to the adequacy of the research work and the potential for more collaborative national research projects in the State.

3. THE WESTERN AUSTRALIAN ECONOMY

3.1 Introduction

This chapter describes the structure of the Western Australian economy from a financial and an employment perspective. Gross State Product (GSP) at factor cost is used by the Western Australian Government to describe the State economy as a background to development of the State's annual budget. The Australian Bureau of Statistics measures GSP in 19 categories, thus providing a uniform classification for comparison between Australian States and Western Australia. GSP may be considered simplistically as the contribution by a sector in the economy to the total financial value of output in the economy.

3.2 Industry Mix

Western Australia, like most developed Western countries, has a complex and highly inter-related economy. The ABS classification indicates that mining is by far the largest sector when measured using GSP at factor cost (Table 29). Mining provided over 18% of the GSP in 1995-96. Mining was more than 75% larger than the next sector, manufacturing, and more than double the size of the third sector (construction). Only mining and manufacturing sectors exceed 10% of GSP with the other 17 sectors providing between 1% and 8% of GSP.

Table 29: Gross State Product at Factor Cost, 1995-96

Sector	Western Australia ($m)	Western Australia (%)	Australia (%)
Mining	7,094	18	5
Manufacturing	4,194	10	15
Construction	3,518	8	7
Property and business services	3,644	8	9
Ownership of dwellings	3,329	7	10
Retail trade	3,124	7	8
Wholesale trade	2,439	6	6
Health and community services	2,835	6	6
Agriculture, forestry and fishing	2,052	6	4
Transport and storage	2,112	4	5
Education	1,809	4	5
Electricity, gas and water	1,161	3	3
Communication	1,130	3	3
Government administration and defence	1,227	3	4
Accommodation, cafes and restaurants	747	2	2
Finance and insurance	919	2	4
Personal and other services	1,052	2	2
General government	839	2	2
Cultural and recreation services	607	1	2
TOTAL	46,886	100	100

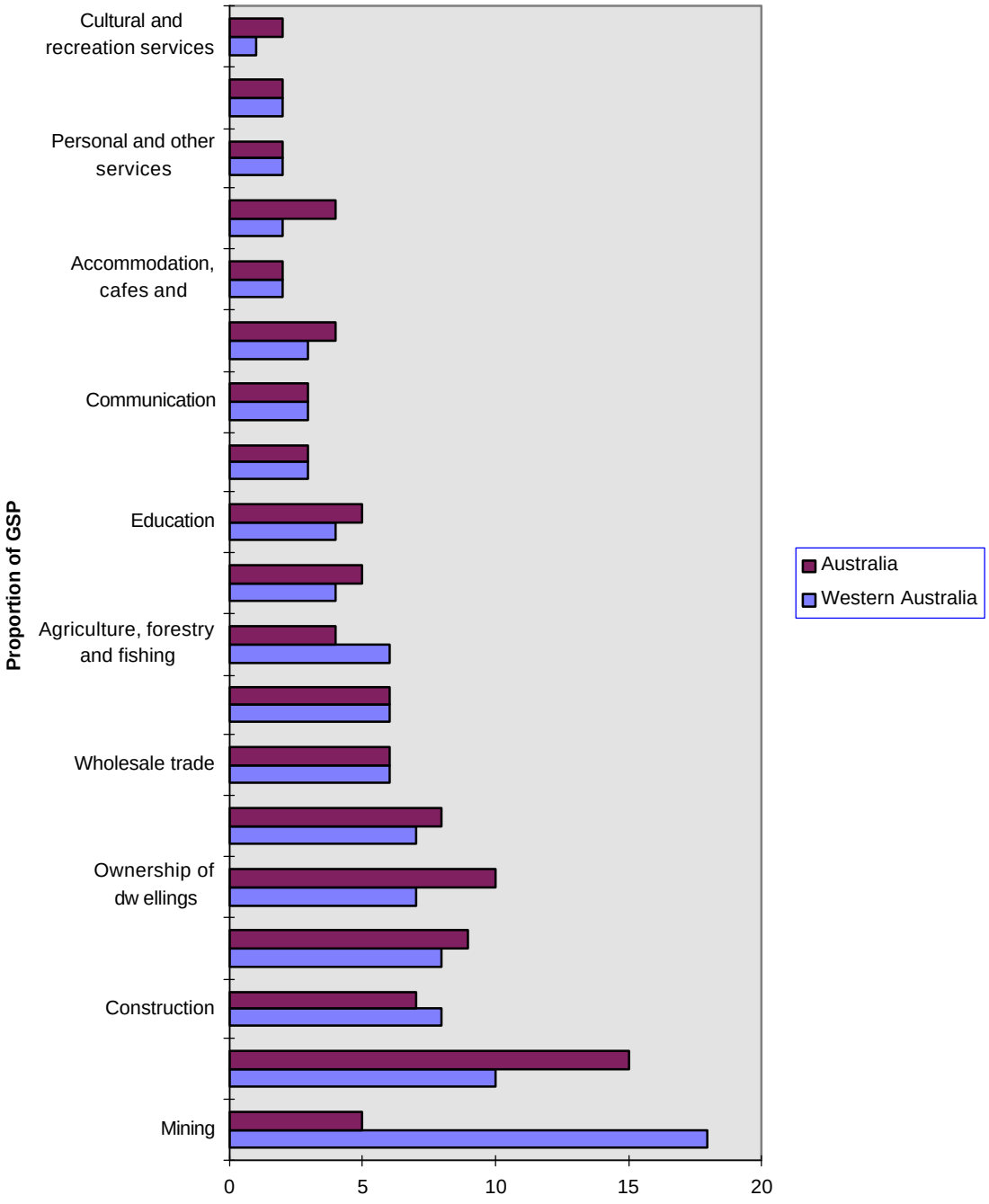
Source: ABS

If expenditure on dwellings is combined with the construction sector, then these two commodities would constitute around 15% of GSP. Activity within this sector would then include dwelling construction renovations and improvements as well as non-residential building construction including engineering works, roads, highways and other capital works. The traditional mainstay of the Western Australian economy — agriculture, forestry and fishing — has declined slowly in importance and now provides around 6% of GSP to the economy.

When compared with the national economy, Western Australia has a far larger mining sector and a smaller manufacturing base (Figure 7). Mining constitutes more than three times the amount of turnover in the Western Australian economy compared with the national economy, while manufacturing is approximately 50% more important in the national economy than it is in Western Australia (Western Australia is Series 1).

Most other sectors provide very similar contributions to the Western Australian and national economies. Some small but significant differences relate to the ownership of dwellings, agriculture, forestry and fishing and the finance and insurance sector. Finance and insurance is under-represented in the Western Australian economy while agriculture, forestry and fishing is more dominant in the Western Australian economy than it is at the national level. Ownership of dwellings provides a lower level of expenditure in Western Australia than Australia as a whole.

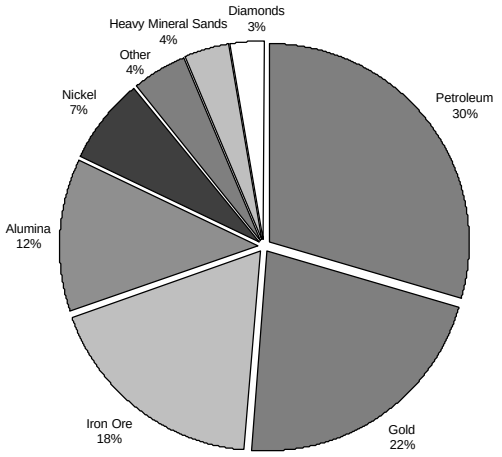
Figure 7: The Western Australian and Australian Economies



Source: ABS

Measured in terms of the gross value of production, the primary production of petroleum is by far the largest single sector in the resources sector of Western Australia (Figure 8). Gold and iron ore rank next in importance followed by bauxite/alumina, nickel and diamonds. In the manufacturing sector, metal product manufacturing dominates the Western Australian economy with alumina production and steel metal working.

Figure 8: Resource Sector Value of Production, 1996

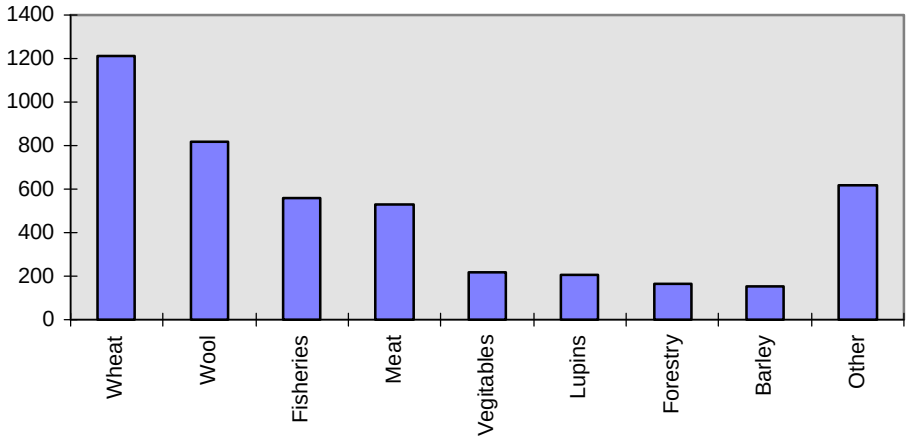


Machinery and equipment manufacturing is also important while the last five years has seen a dramatic increase in the production of lightweight fast ferries based on aluminium construction methods. The State's ship building industry now accounts for around 70% of Australia's marine vessel exports. Petroleum products and chemicals manufacture and food and beverages both make up around 20% of the industry share of turnover (Treasury Budget Paper No. 3).

Activity in the construction sector varies considerably between years. The three major sectors are dwelling construction, non-residential buildings and primarily engineering construction including roads, ports and transport infrastructure. In recent years, dwelling construction has fluctuated significantly as has office construction. Substantial increases in road expenditure have boosted the engineering side along with construction of major resource projects such as the BHP DRI project at Port Hedland.

The agriculture, forestry and fishing sector is dominated by the production of cereals and wool (Figure 9). Significant increases have occurred in recent years in pearling activities and increases are forecast in forestry operations from plantation activities.

Figure 9: Value of Agriculture, Forestry and Fisheries Sector, 1994-95 ($m)



3.3 Growth Sectors

Strong growth in production over recent years has enabled Western Australia to maintain its position as one of the world's leading producers of gold, iron ore and alumina. Petroleum expansion has occurred with the development of new projects and expansion of the North West Shelf project. Significant further growth is anticipated in the petroleum sector while nickel production is also undergoing a significant growth phase.

Metal product manufacturing and the manufacture of machinery and equipment is estimated to increase substantially in 1996-97 (Treasury Budget Paper No. 3). This growth has been supported by the continued expansion of Western Australia's ship building industry based around lightweight ferries. The major contributors to growth over the past decade have been transport equipment, pharmaceutical and medical products, chemicals, telecommunication equipment and general and specialised machinery (primarily for the mining industry).

With favourable seasonal conditions the gross value of agricultural production is likely to be maintained but could decline slightly reflecting lower prices for wheat and wool. A record wheat crop of 7.5 million tonnes is anticipated in Western Australia in 1997, valued at nearly $1,200 million (Australian Wheat Board).

3.4 Employment

Employment in the Western Australian economy is dominated by the retail trade sector which includes accommodation services, cafés and restaurants (Table 30). Education, health and community services is the next largest sector, followed by finance, insurance, property and business services. Essentially, therefore, services to the general population make up just under 50% of total employment while primary and secondary services including manufacturing and agriculture, forestry and fishing make up only 16% of the total. The mining sector is a capital-intensive and not labour-intensive industry and directly employs a very small proportion of the employee numbers (less than 5%).

Table 30: Employment in Western Australia

	Western Australia						Australia	
Industry Division	**1980**		**1988**		**1995**		**1995**	
	'000	**%**	**'000**	**%**	**'000**	**%**	**'000**	**%**
Retail trade	77.4	14.0	103.9	15.1	158.1	19.1	1,608.0	19.4
Education, health and community services	100.7	18.2	117.1	17.0	134.7	16.3	1,342.0	16.2
Finance, insurance, property, business services	44.2	8.0	73.2	10.6	112.1	13.6	1,112.0	13.4
Manufacturing	69.9	12.6	84.0	12.2	85.9	10.4	1,111.0	13.4
Construction	47.3	8.5	55.1	8.0	68.5	8.3	600.0	7.2
Personal, cultural and recreational services	39.3	7.1	49.2	7.1	55.0	6.7	503.0	6.1
Agriculture, forestry and fishing	51	9.2%	61.0	8.9	51.0	6.2	422.0	5.1
Other	124.2	22.4	145.7	21.1	161.1	19.5	1,590.0	19.2
TOTAL ALL INDUSTRIES	554.0	100.0	689.2	100.0	826.4	100.0	8,288.0	100.0

Source: ABS - Labour Force

The Western Australian economy has a similar employment distribution to Australia as a whole with the possible exception of the manufacturing sector where employment numbers in Western Australia make a smaller contribution to the total.

3.4.1 Employment Trends

Over the 15 year period from 1980 to 1995, the number of people employed in Western Australia increased by around 50% with the increase over the last seven years approximately 20%. The numbers engaged in all sectors increased with the exception of the agriculture, forestry and fishing sector which saw an increase in numbers to 1988 and then a decline back to 1980 levels by 1995. In 1980, the largest single sector comprised the community services including health and education and while this sector was still important in 1995, it had been replaced as the largest employment group by the retail trade sector. Employment in the retail trade sector had increased by over 100% while employment in the finance, insurance, property and business services sector had also increased by a massive 150%.

In terms of the contribution by each sector to total employment, over the 15 year period to 1995, ten sectors saw a small decline in their relative importance while three sectors — government, retail trade and the finance and business services saw significant increases in their relative importance. Business, property, insurance and finance services now comprise the third largest sector with a growth rate approximating 10% per annum.

The mining sector of the economy is notably absent from employment statistics. This sector is capital-intensive rather than labour-intensive and provides direct employment for less than 5% of the labour force. This statistic is a little misleading; however, since the mining sector produces substantial flow-on benefits with many of the other sectors providing employment through services to those engaged in mining and petroleum activities.

3.5 Conclusions

In terms of contribution to the financial wealth of the State the large sectors in Western Australia are mining and petroleum, metal manufacturing, and the building and construction industry. However, in employment terms, the largest sectors are the retail trade, education, health, and community services followed by finance, property and business services. The increasing dominance of the services sector follows similar trends in OECD countries.

The relationship between R&D investment and these two ways of viewing the economy (value and employment) are complex. In terms of a financial framework there appears to be a close relationship in Western Australia between investment and financial strength suggesting both some market pull by industry and possibly some market push by research organisations. An employment framework is complicated by a global push for productivity improvement with the greatest potential gains in the high employment sectors. The adoption of new technology has probably been greatest in the health, banking and general finance sectors.

While the services sector has been a very significant research 'adopter', it does not appear to have created a strong R&D presence in the State. This reflects OECD findings. The OECD has concluded that "Service industries are the major users of technology.

Despite the increasing share of R&D carried out in the services sector, innovations are developed primarily in a cluster of high-technology manufacturing industries. Service industries are the acquirers of technologically sophisticated machinery and equipment. In general, the supply of technology is more concentrated than demand: a relatively small number of industries account for most R&D expenditures while the use of R&D diffuses broadly across many industries."

The State is unlikely to become a key player in computing hardware but given the size and population of the State, has a need for efficient long distance telecommunications. These are important to service all sectors of the economy.

4. SUCCESS FACTORS IN R&D FUNDING

4.1 Introduction

To investigate levels of investment in research and development in Western Australia and to explore the State Government's potential role in increasing the level of contribution from these sources, senior staff from 35 research organisations were interviewed (Box 3). A standard questionnaire was used in the interview process (Appendix 6). In addition to these interviews leading workers in R&D facilitation were also interviewed with their comments included in the sections on potential roles for the government. The contact list for the study is included in Appendix 7.

Box 3: Organisation Consultations

Centre of Intelligent Information Processing Systems	
University of Western Australia Geomechanics Group	
Key Centre of Strategic Mineral Deposits	
Centre for Oil and Gas Engineering	
Centre for Advanced Mineral and Materials Processing	
Centre for Renewable Energy Systems, Technology of Australia	
Australian Telecommunications Research Institute	
Key Centre for Science and Maths Education Centre	
Centre for Petroleum and Environmental Organic Geochemistry	
Institute for Science and Technology Policy	
Asia Research Centre on Social, Political and Economic Change	
State Agricultural Biotechnology Centre	
Australian Centre for Geodynamics	
Centre for Water Research	
CRC for Premium Quality Wool	
CRC for Legumes in Mediterranean Agriculture	
Australian Maritime Engineering CRC Ltd	
Australian Petroleum CRC	
CRC for Australian Mineral Exploration	
CRC for Broadband Telecommunications and Networking	
AJ Parker Centre for Cooperative Research in Hydrometallurgy	
Australian CRC for Renewable Energy	
Centre for Cooperative Research for Biological Control of Vertebrate Pest Populations	
CRC for Quality Wheat Products and Processes	
CRC for Sustainable Development of Tropical Savanna	
CRC for Weed Management Systems	
Groundwater Studies	
CRC for Landscape Evolution and Mineral Exploration	
CRC for Conservation and Management of Marsupials	
Agriculture Western Australia:	Plant Research and Development
	Animal research and Development
	Technology Transfer and Communication Services
CSIRO:	Centre for Mediterranean Agriculture Board
	Division of Exploration and Mining
	Division of Plant Industry
Department of Fisheries:	Research Division
Department of Minerals and Energy:	Mineral Processing Laboratory
Perth Zoological Gardens:	Threatened Species Research Centre
Lions Eye Institute	

4.2 Research Organisations Consulted

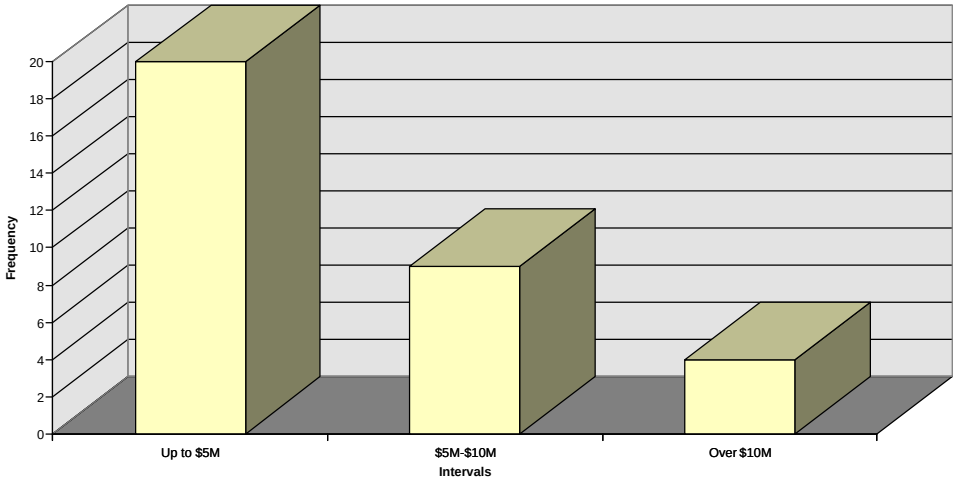
Forty one research organisations were approached for information on their R&D programs with 35 participating in a structured interview (Box 3). Five formed part of State government Departments with three Divisions of CSIRO, and one private, not for profit organisation. The remaining 26 formed part of research organisations or centres based at universities. Three of the CRCs have only a small part of the effort based in Western Australia with the major part of the program centred on an Eastern States university. In terms of their industry focus, the largest single category by far is food and beverages which includes the agricultural research organisations.

4.2.1 Financial Details

The total level of funding from all sources for the organisations interviewed is estimated at $270 million. Annual budgets ranged from $0.5 million to $70 million, the average being $8.4 million. However this figure is not particularly meaningful given that budget amounts vary significantly from centre to centre. For this reason it is useful to examine total funding or budget size using broad intervals.

The majority of research centres (42%) had research budgets of between $1 million and $5 million.

Figure 10: Centre Budgets ($m)



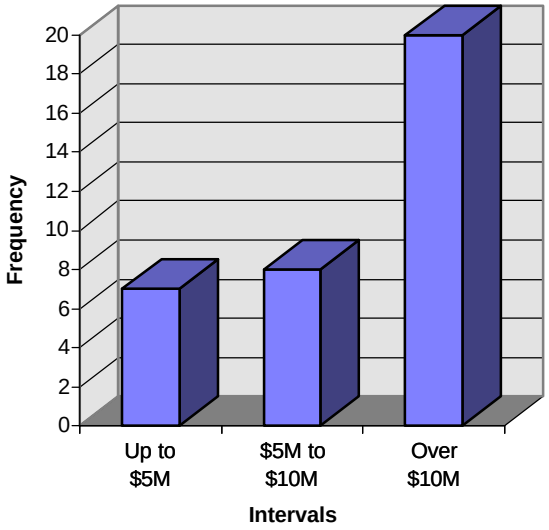
Just over one quarter have research budgets from $5 million to $10 million and a quarter have budgets of less than $1 million. One centre has a budget of $10 million to $15 million, one centre has a budget of $36.5 million and two centres have budgets of between $40 million and $90 million.

Three of the four centres with the highest budgets (in excess of $10 million) operate in the 'food, beverage and fibre' industry. These are all in the agricultural research field. Similarly, of the eight research centres with moderate centre budgets ($5 million to $10 million), half operate in the agriculture sector. Of the seven centres with low budgets (up to $1 million) there is no pattern between the industry and research area.

4.2.2 Funding Availability

Respondents were asked to estimate total funding available in their area of R&D. Almost 60% said it was over $10 million while 23% said there were funds between $5 million and $10 million and 20% considered there to be available funds of less than $5 million (Figure 11).

Figure 11: Total Funds Available in Area of R&D (State and Federal)



Funding availability in both the 'Food, Beverage and Fibre' and 'Information, Technology and Communication' research areas were estimated by a majority of respondents to be in excess of $10 million. However over one third of respondents in these industries indicated that funding available may only be in the range of $5 million to $10 million suggesting either that they operate in a part of the industry with lower funding or they are not aware of all funding opportunities.

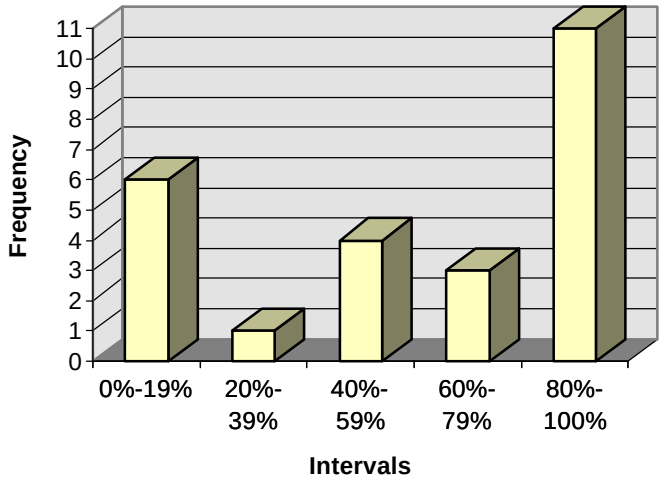
In the 'Oil, Gas, Mining and Chemical Industries' 87% of all respondents believe that there is substantial research funding available.

In 'Education and Commercial Business Services' industries the results indicate that there are funds in the $5 million to $10 million range available. In the 'Health, Environment and International Science' category the size of available funds is difficult to establish with the only two respondents having quite different perceptions of this issue.

4.2.3 Funding Success

With respect to funding success , 11 (44%) judged their success rate in funding applications to be high at between 80% and 100% while almost 30% felt they had a moderate success rate of between 40% and 80% (Figure 12). This suggests that around three in four of the research organisations interviewed had a better than 40% success rate in funding applications. Compared with the 20% rate frequently quoted for ARC funding, this group of organisations interviewed appears to be particularly successful in obtaining funds.

Figure 12: Funding Success



Despite a moderate level of success overall, a significant number interviewed rated their success at less than 20% and hence there still appears to be potential to increase the funding success of a number of research and development organisations.

In the most prevalent industry - 'Food, Beverage and Fibre' - the majority of respondents (60%) have a funding success rate below 60%. Agricultural R&D has sophisticated funding mechanisms and a history of national competition for grants. The level of funding success may thus reflect the competition for grants as much as any lack of skill in gaining funds. It could also suggest applications need to be improved providing potential for a higher success rate.

In the next most significant industry, 'Oil, Gas, Mining and Chemical', half the research centres consider they have around a 90% success rate, while 33% have below 20% success. There appears, therefore, to be potential to increase the success rate for some centres working in this industry while others are already successful.

In the 'Health, Environment and International Science' category one centre is achieving a very high success rate and the other less so.

4.2.4 Rating of Success in Attracting External Funds from Various Sources

To further investigate funding success, organisations were asked to rank their success against different sources of funding. Sources included the parent organisation (generally a university or State Government department), State Government in general, Federal Government or private sector. Success was rated on a scale from poor to above average.

In the majority of cases (60%), success in obtaining funding from the parent organisation was rated as 'above average' while in 30% of cases it was rated as 'average' (Table 31). Only three of the respondents had 'below average' success in obtaining funding from the parent organisation. With 90% of the organisations claiming average or above average success in obtaining funds from a parent organisation the sample of organisations enjoy strong support from that parent.

Table 31: Success in Attracting External Funding (number)

	Above Average	Average	Below Average	Poor	Have Not Tried	Total
Parent	16	8	3	0	0	27
State	8	13	4	2	5	32
Federal	18	12	3	1	1	35
Private	12	13	5	2	2	34

In rating their success in acquiring funds from the State Government the majority felt they were 'average' although 25% rated considered they were 'above average'.

In rating the rate of success of acquiring funds from Federal Government sources, the majority of respondents (51%) felt they were 'above average' with 34% 'average' and 9% 'below average'.

Success in attracting funding from private companies was nearly always rated as average, 'above average' or a small number 'below average'.

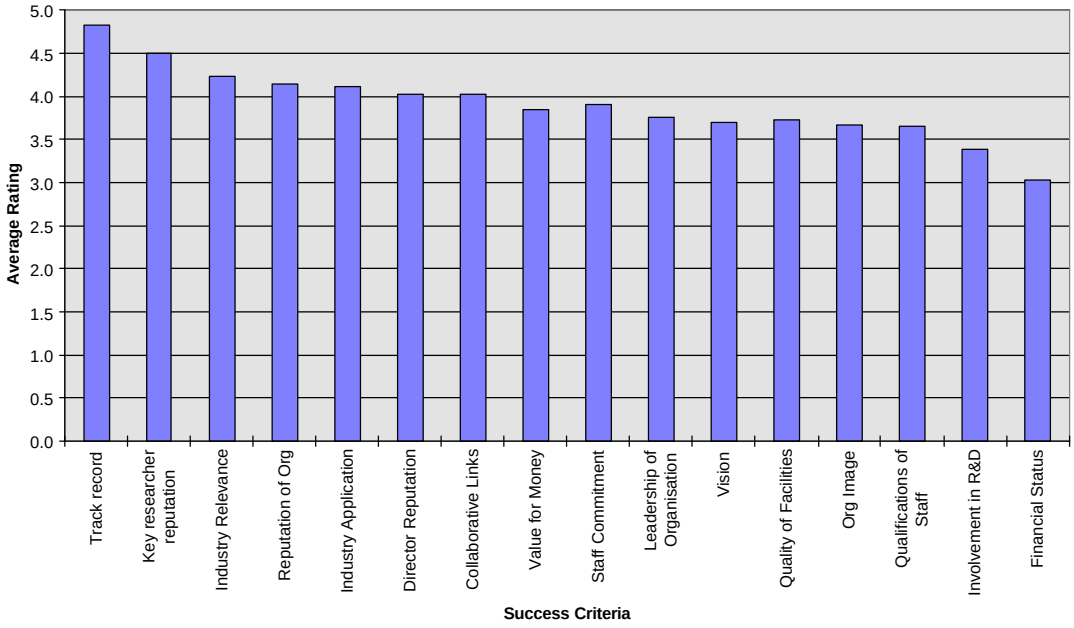
Reflecting the nature of the respondents (funded research organisations) a majority felt success was above average in obtaining funds from any source although they felt they were particularly successful in obtaining federal and private funds. This bias is understandable given that many were federally funded CRCs. The least successful source of funds was the State Government. This suggests less awareness of sources or confidence in sourcing State Government funds.

4.2.5 Criteria for Attracting External Research Funds

To obtain an indication of the criteria people in successfully funded organisations see as important for gaining funds, respondents were asked to consider 16 factors and to rank these individually on a scale of 1 to 5, where 1 was 'not important' and 5 was 'very important'.

Fourteen of the 16 criteria had an average score of more than 3.5 out of a possible 5 with the financial status of organisations ranking the lowest at 3.0 (Figure 13). Six criteria had an average score of 4 or more with the next nine ranking between 3.5 and 4. All factors are thus seen as being more important than the mid point in the range.

Figure 13: Criteria for Attracting Funds



Track record in research and development was rated as most important with an average rating of 4.8. The reputation of the principal researcher was rated as the second most important with an average rating of 4.5. When combined with the sixth ranked criteria (*reputation of director*) it is apparent that track record and reputation are of paramount importance. It is hardly surprising that proven performance is a key criteria in attracting research funds. What is more relevant in the current research funding climate is that industry relevance and application rank third and fifth in importance. What it means, however, is that new centres will find it difficult, in a competitive funding environment, to get established without attracting leadership or key research workers with the appropriate skills and reputation.

The second most important group of factors are those related to industry with industry relevance and application ranking third and fifth. Given that industry appears to favour shorter term applied research, the importance of the relevance to industry suggests there is an incentive for centres to focus on medium term projects as opposed to long term research.

4.2.6 Characteristics of the Industry Sector Served by Research Centres

Respondents were asked to rate five characteristics of the industry sector on a five point scale. The characteristics were: potential growth, recent growth, potential research project funding,

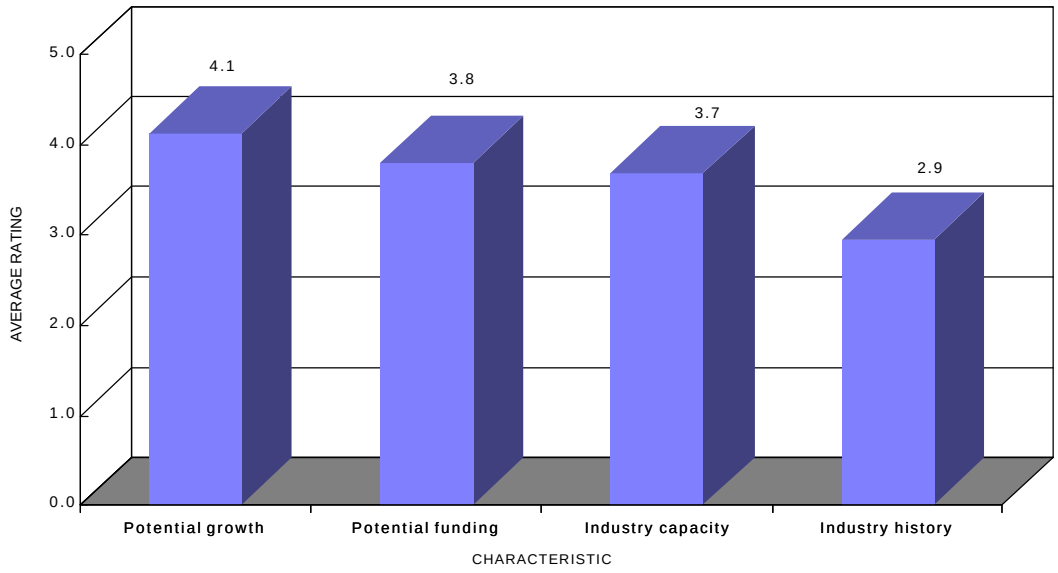
industry capacity to fund research and industry history of funding. where a rating of 1 was 'weak' and 5 'strong'.

Table 32: Industry Characteristics

		IT & Comm (%)	Food, Bev & Fibre (%)	Oil, Gas, etc (%)	Educ & Comm (%)	Marine Def, etc (%)	Health, Env, etc (%)
Recent Growth	Strong	67	73	50	33	100	83
	Ave	33	27	50	33	0	17
	Weak	0	0	0	33	0	0
Potential Growth	Strong	100	73	63	33	100	100
	Avg	0	8	25	33	0	0
	Weak	0	9	12	33	0	0
Potential Funding	Strong	33	82	88	33	0	50
	Avg	67	18	0	33	100	50
	Weak	0	0	12	33	0	0
Industry Capacity	Strong	0	73	88	33		67
	Avg	67	8	12	0	0	0
	Weak	33	9	0	67	0	33
Funding History	Strong	33	55	63	0	0	0
	Avg	33	36	12	33	0	67
	Weak	33	9	25	67	100	33

Potential growth on average was seen to be moderately strong with an average rating of 4 and *recent growth* was rated slightly lower at an average of 3.7 (Figure 14). Potential research project funding was also 3.7 and industry capacity to fund research received an average rating of 3.6, these characteristics of respondents' respective industries were viewed as being above average. Industry history of funding on the other hand received a relatively low rating of 2.9. The general questions revealed that there is optimism about industry growth but less confidence about the potential for research project funding. There is a general perception that industry is not a key source for funding and that researchers need to largely rely on government sources. To an extent, this perception may be influenced by low support from industry in the past and the strong relationship of industry funding to well defined projects, where industry sets the guidelines for the research project.

Figure 14: Industry Sector Characteristics



The responses suggests that industries exhibiting strong recent growth are 'Food, Beverage and Fibre', 'Health, Environment and International Science' and 'Information, Technology and Communication'. Enterprises operating in these industry sectors were perceived to be of average or above average in their capacity to fund research and development activities.

Industries exhibiting strong potential growth have been identified as 'Information, Technology and Communication', 'Food, Beverage and Fibre' and 'Health, Environment and International Science' and 'Oil, Gas, Mining and Chemical Industries'. Enterprises in these industry sectors are also likely to be able to fund research and activities in the future.

In terms of potential for research project funding, 'Food, Beverage and Fibre', 'Oil, Gas, Mining and Chemical Industries' are seen to have strong potential for research funding. Other industries exhibiting strong potential growth such as 'Information, Technology and Communication' and 'Health, Environment and International Science' are also likely to have potential to make available and/or attract research funding. The two sectors seen as having average or weak capacity to fund research (education and commerce, marine and defence) must be viewed with some caution given the very small sample numbers in these sectors.

The results indicate strong industry capacity to fund research in the 'Food, Beverage and Fibre', 'Oil, Gas, Mining and Chemical Industries' and 'Health, Environment and International Science' areas.

Results pertaining to industry funding history reveal that the 'Food, Beverage and Fibre' and 'Oil, Gas, Mining and Chemical Industries' are viewed as having had a history of average to strong funding.

4.2.7 Reasons for the Present Level of Funding

Respondents were asked to identify the reasons for their success in raising funds. The first broad success factor involves having a *commercial orientation.* Reasons given include*:*

- having an industry focus;
- delivering research outcomes on time; and
- providing value for money from research.

One respondent summed this up by attributing the funding success of the research centre to the "calibre and breadth of research staff, the ability to see the industry perspective, good ideas, excellent research which is relevant, research skills and expertise and excellent world class facilities."

A second factor identified by a large number of respondents was *leadership and vision*. Success in attracting research funds was often attributed to the centre Director. One respondent pointed to the "Director's tenacity and long term application", another to a "strong, long term vision and commitment to the centre. These include the way to do research, spending money on quality equipment and ensuring that facilities present well, an enthusiastic team and having a high profile in the university."

Having a *track record* in research and development is important, with the reputation of key researchers being a factor which was often stated as a reason for success.

Success and the *ability to build on success* was seen to be an important factor. As one respondent said "...[we] started with ARC funding and planned for development and marketed our services well."

Being in a *strong industry* also appears to lead to greater success when it comes to attracting research funds. The level of support and representation from industry is also seen to be a reason for success. On this point if there is strong industry application for the research outcome then support from industry is likely to be relatively high. One respondent attributed their success in attracting research funds to "having strong collaboration with industry and with international agencies such as AUSAID and the United Nations". The importance of the industry or research area to the State or to Australia is thus influencing funding success. Similarly being in a *growth industry* or growth research area also helps.

4.2.8 Obstacles to Attracting Research Funds

One factor consistently identified as an obstacle to research funding is the *level of research infrastructure*. One respondent said "limited research infrastructure inhibits further growth in project activities."

Respondents identified a number of specific obstacles relating to *inadequate resourcing* including: the need for an assured income stream to run the centres; need for better facilities; and the inability to recruit and retain key staff given, among other things, an inability to offer competitive salaries. A major obstacle was identified as the substantial *time and effort required to apply for funding*. Access to specialist skills such as a business manager was seen by a number of respondents as a way of overcoming this obstacle.

Another factor related to l*ow levels of contribution from industry*. Two components were identified, first the limiting of expenditure on research and development and second the preference for supporting short to medium term applied research rather than longer term research. One respondent said "industry focuses on short term applied research, hence there is a move towards shorter term contracts; it becomes more like consulting than research." Long term funding may also be compromised where industry members are large. In the petroleum industry, for example: "industry partners have research laboratories overseas, hence it's difficult to extract dollars for long term projects in this State."

The *industry or research area* and its relative priority ranking for funding affect the level of funding. For example, one respondent perceived there to be a "lack of base funding in particular areas of research, for example, Geophysics. A suggestion was to rely on taxation — for example the French Institute of Petroleum is funded by the petrol tax ... providing base income." Low industry growth or being in a depressed industry was also seen to reduce the capacity to attract research funds.

Another obstacle to more diverse funding was seen to be *CRC status* predominantly because these Centres are precluded from applying for ARC grants. One respondent said "as a CRC, the Centre is not supposed to seek other (university) grants." On the issue of access to Commonwealth funds, one respondent notes as an obstacle "[the] reducing of funds available for research and development from the Commonwealth Government."

Other obstacles identified included *location* and the lack of regular contact with funding decision makers. Being removed from funding sources on the east coast was seen to be problematic. One respondent attributes the lack of funding to "low profile research and lack of promotion of WA research in the east coast."

A number of other factors identified as obstacles pertain to the *review and reporting process*. The methods of review of research applications was seen to be inappropriate by a number of respondents, accountability requirements when funded and sectoral interests and political manoeuvring by those applying for funding and those reviewing applications were also mentioned by a small number of respondents.

4.2.9 State Government Assistance

One of the most important roles for the State Government was identified as *facilitating seed funding for research*. New research initiatives are unlikely to be adequately funded from other sources and State Government support in the early stages can ensure that such research proceeds. Once established, centres can apply for alternative funding. On the ability of new centres to attract external funding, one respondent said "it's very important to have a reputation and track record, so external organisations need to provide support early in the centre's life so that they can later attract funding from elsewhere.

Another respondent said "…our Institute was a success, all due to the State Government setting it up. It was only $1.2 million over 4 years but the seed funding was essential. There have been great flow-ons from that investment."

A number of respondents referred to the State Government developing *incentive schemes* for attracting external funding. A common suggestion involved the State Government calculating State research funding for individual centres using an appropriate 'matching ratio' to external funding secured. One respondent said "[the] State Government can help a centre to develop an international market, this could be done as dollar for dollar incentives to get research funding."

A recurring response pertained to the State Government *assisting with identifying external funding.* Respondents faced imperfect knowledge and time constraints and as a result often failed in identify and applying for available Commonwealth and industry funding. A significant number of respondents indicated that the State Government could provide an information service on funds availability. One respondent suggested that the State Government "provide a central clearing house for all public and private agencies to show what funding is available and all specific projects to be tendered for from any source (local, Australian or from overseas). Perhaps on Internet."

Other responses related to the State Government providing *assistance with applications and the securing of available funds.* A number of respondents indicated a need for additional State Government assistance in the funds application process by way of cash and in-kind contributions. One respondent's statement communicated the view of many "applying for funding is time consuming, it's a full time job." Another said "the State Government has a role to play in assisting organisations to understand what is required to gain various funds." Another respondent pointed out "we need funds for a commercially oriented business manager for liaison with industry and with Government."

Regarding enhancing the success rate of Western Australian applications for external funding one respondent said "[State Government] could make it a precondition of support that applicants must pass through a State panel with significant expertise to ensure that the requirements of the application are understood and secondly to ensure that the application is

of a standard to warrant sending in." Similarly another commented that "...an external review process would be very helpful and would have a positive effect on results".

Another important State Government role was identified as providing underwriting support for applications for external funding. One respondent said "State government assistance and underwriting are big factors in getting a message to Canberra."

A number of respondents called for *assistance in commercialising research findings or in identifying and approaching user groups* . One respondent said "The state government needs to recognise that in most cases markets are overseas and hence R&D groups will choose to locate near the marketing organisations unless there is some incentive to remain in WA."

It appears that there are two areas of influence for the State Government. The first is determining how to best allocate State Government funds and the second is influencing the allocation of external funds. On the first point responses indicate a need to review the criteria for State funding. In addition to the above mentioned, suggestions include targeting priority research areas for the State, continued provision of infrastructure financing and support funding to maintain continuity for established centres. One respondent suggested "funding to finance high technology equipment needed for research". Other suggestions included removing funding restrictions and linking allocations to research outcomes. A number of respondents pointed to the State Government identifying the public good of government investment and using this as a criteria. For example, a respondent said that "the State Government must have a clear view of private and public good issues."

Regarding who allocates the funding, one respondent said "there is a need for an expert committee to make funding decisions the committee should be sector based and allocations should be arms length". Another respondent saw a need for a "… workable and transparent method for allocating government funds. The State could fund a research performance scheme to appraise the allocation of funds. This approach is used at Curtin and by the Commonwealth Government to allocate their research budget and by DEETYA in distributing funds to universities."

Regarding influencing the allocation of alternate funding (i.e. from the Commonwealth, other States and industry) a targeted approach has been suggested. The criteria is seen to include priority research activities for the State and equity issues. On the latter point one respondent states that the State Government "[is] to ensure that there is equity in the distribution of national research funds, for example, where a State-based activity generates [national] income, funds need to be redirected to the State." Additional considerations suggested by respondents included "the leveraging of Commonwealth funding with State funds."

The maintenance of *high standards of research* in Western Australian is seen as essential to attracting funding from external sources. One respondent would like to see the State Government "develop a proactive process to facilitate science movement across the country."

State Government assistance in forging international linkages is also seen as important, because there is a symbiotic outcome. Access to international researchers introduces new technology for both parties and funding from overseas sources is likely to follow given the increased competitiveness of our science and the attractiveness to overseas user groups.

One respondent states that support is needed "to maintain international collaboration to keep our science base to the fore." Another respondent is of the view that "research centres around queen bee experts, they attract all the worker bees. To get more ARC [funding] we need to attract and allow in international standard research workers." Another respondent would like to see "State government fund international workshops in WA provided they are well targeted and related to what is applicable to the State."

The majority of respondents identified quality research staff as a key factor contributing to their success in attracting research funding. State Government support for attracting, developing and retaining quality researchers was seen as being of importance. One respondent states "our major asset is people; they need to be highly skilled and trained" and "… funding is needed over three to four years so that PhD students can work on the projects proposed".

Other State Government initiatives to stimulate research and development were identified. One respondent suggests "a higher level of tax concession for research and development and the establishment of a discrete fund in different areas of science through a levy." Other State Government initiatives included establishing and supporting research centres. One comment was "provide a positive and supportive approach to proactively attracting funds perhaps through the establishment of Scientific Institutes", and "establish recognisable centres of excellence to attract high calibre researchers. This can be done by spending money on infrastructure and giving people ongoing support. Build teams to focus on relevant problems and expect innovation."

In addition one respondent states "provide core funds to support core staff. Better pay, better staff management systems and performance rewards" while another suggested "being proactive in facilitating strategic amalgamations of research institutions."

With regard to ongoing State Government support there were calls for less "administrative interference and control." Another respondent was in favour of a "less rigorous and tedious processes for applying for funds and reporting. The process is time consuming and parties may be discouraged from applying for the Department of Commerce and Trade funding for this reason."

Other suggestions for State Government support include the following: “Having a clear view of its policy on research and development and conveying it to industry and research organisations,” “the creation of a Science and Technology Ministry,” “helping to elevate the public profile of research”, “providing access to intellectual property providers at a price scientists can afford”, “reduce political interference in research”, “ helping to better market centres”; other comments pertained to providing security for researchers and allowing “organisations to stabilise within set budgets and staff numbers.”

One industry has a dedicated officer who regularly communicates with all potential funding sources and energetically interacts with both research organisations and the industry. He appears able to support the attraction of significantly more funding to Western Australia than achieved by the other States, with a return of better than 4 to 1 for Western Australian funds invested by the State government and industry. The role of this person has been referred to by some as a ‘ferret’, and the application of such a person or role to other industries was welcomed during some interviews.

4.2.10 State Government’s Contribution to Directing Research Funding to Research and Development Organisations

When asked to rate the State Government’s contribution to supporting or directing research funding to Western Australia, respondents were divided on their ratings. The average rating for both the *degree of support* and *the nature of support* was a below average score i.e. less than a mean score of 3.

On the degree of support, 27% of respondents rated the State Government contribution as average. However, 30% rated it as good to excellent compared to 42% who indicated that it was below average to poor.

Overall, these results suggest some disappointment with the State Government’s contribution to supporting or directing research funding in these terms. The views suggest either a lack of success in dealing with the State Government, a lack of funds for these areas of research or a lack of appreciation of the role played by the State Government.

4.3 Conclusions

The R&D organisations surveyed in this study suggested that on average there was approximately $10 million in funding for their area of research work. The industry having the largest research funds potentially available appears to be the ‘Oil, Gas, Mining and Chemical’ industry classification.

The organisations interviewed appear to have a fairly high success rate in obtaining funds for R&D work. Most suggest there are adequate potential funds with the limitations being the effort required to obtain them, a lack of infrastructure to attract funders and keen competition.

Success in winning funds varies widely between organisations. This may reflect the attitude of senior staff to application processes as much as the level of funds available with, for example, research leaders only putting in the effort when the probability of success is high. Many points raised suggest, perhaps not surprisingly, that 'success breeds success'.

Despite the apparent success of the groups, there appears to be the potential to increase the funding success rate, especially in the most prevalent industry, 'Food, Beverage and Fibre'.

Across all industries on average research centres are likely to be most successful in acquiring funding from their parent organisation. This almost certainly reflects the important role played by universities and State Government Departments in supporting their own research, with the Commonwealth government the most significant external funding organisation.

Research track record, the reputation of the principal researcher and industry relevance of the research were identified as the most important criteria determining whether a centre attracts funding.

A number of industries have been identified as having experienced recent growth or as being on the way to exhibiting growth ('Food, Beverage and Fibre', 'Health, Environment and International Science' and 'Information, Technology and Communication', 'Oil, Gas, Mining and Chemical Industries'). It is expected that research centres operating in these industries may be able to access funds with greater ease. In addition, three research areas ('Food, Beverage and Fibre', 'Oil, Gas, Mining and Chemical Industries' and 'Health, Environment and International Science') have been identified where industry appears to have strong capacity to fund research. Success in acquiring funds is seen to be due to:

- a commercial orientation;
- leadership and vision;
- having a track record;
- success and the ability to build on success;
- being in a strong industry; and
- working in a growth industry.

Obstacles to attracting funding included:

- low levels of infrastructure;
- inadequate resourcing;
- the time and effort required to apply for funding;
- low levels of contribution from industry;
- the industry or research area;

- location; and
- review and reporting processes.

Possible State Government assistance to attract external funding included:

- providing seed funding;
- incentive schemes;
- assisting with identifying external funding;
- assistance with nationally funded scheme applications;
- assistance with commercialisation of research findings and identification of user groups;
- promotion of high standards of research; and
- attracting and developing quality researchers.

5. THE ROLE OF THE STATE GOVERNMENT

5.1 Introduction

This chapter examines the theoretical and constitutional roles of the State Government. It then examines the potential roles the State could play in attracting additional private sector or Commonwealth funding to the State. The work draws on a range of recent reviews and the consultation with research organisations.

5.2 The Theory

Around the globe, the state is in the spotlight. Far-reaching developments in the global economy have us revisiting basic questions about government — what its role should be, what it can and cannot do, and how best to do it (*The State in a Changing World,* World Bank, 1997).

Technological change has opened new opportunities for unbundling services and allowing a larger role for markets. These changes have meant new and different roles for government - no longer a sole provider but as facilitator and regulator. Five fundamental tasks lie at the core of every government's mission, without which sustainable, shared, poverty-reducing development is impossible:

- establishing a foundation of law;
- maintaining a non-distortionary policy environment including macro-economic stability;
- investing in basic social services and infrastructure;
- protecting the vulnerable; and
- protecting the environment.

The balance between these roles is determined by the philosophical aspirations of a government and the constraints imposed by its constitution and legal structures.

The Australian Constitution is now over 100 years old and provides only limited guidance on a modern role for government and the respective roles of the Federal and State legislatures. This lack of enthusiasm has in part contributed to the gradual centralisation of power in Canberra.

Part of the centralisation process which has also occurred in other Western countries has been due to the prevailing economic philosophies and particularly the perceived role of the State in

macroeconomic management. Industry policies and the rise of the 'welfare state' have also been contributors[6].

The 'drift' has created a need for a review of the role of the States - this is demonstrated by the current calls in Australia for a review of the financial imbalance between the States and the Federal Government over taxation and spending responsibilities.

Public finance theory uses three categories to describe the role of government in an economy: stabilisation, allocation and distribution functions. The *stabilisation* function deals with those activities which are usually the preserve of macroeconomics, such as maintaining desired levels of economic growth, unemployment, and fiscal and monetary stability. The *allocation* function deals with those activities in which it is believed, on practical or theoretical grounds, that government may allocate resources more efficiently than markets. The *distribution* function deals with the social welfare implications of the way in which governments and markets distribute income.

Stabilisation functions rely on management of financial transactions and hence can only be effectively undertaken by the level of government with powers over currency arrangements. This function needs to be carried out at the highest level of government.

Allocation functions are required where the operation of the open market is not perceived to provide the desired distribution of goods and services. The so-called market failure typically occurs where the private sector is unwilling to provide goods or services or they are most effectively provided under monopoly conditions. In either case, government intervention is justified on the grounds that a more equitable distribution will occur.

The role of government in allocation is under review, with recent emphasis being towards a reduced role for government typified by such expressions as "the government's role is to steer not row".

The micro-economic reform agenda is focused on improving market performance. Responsibility for this is being shared between all levels of government, as demonstrated by the National Competition Principles Agreement.

The distributive function involves a reallocation of resources on the assumption that the market operates but produces less desirable outcomes than socially acceptable. The most obvious method of redistribution is through the income taxation system and through varied rates of indirect taxation. These are distributed through various welfare mechanisms, mostly income support schemes for the poor, the old, the ill, the handicapped, and so on. Other

---

[6] (Rutherford, A. Australian Federation 2001, unpublished paper)

goods and services are also heavily subsidised to ensure a 'fair' distribution - health care, transport and communications, electricity and gas, housing, and so on.

There is, once again, a fairly strong and widespread belief among scholars that the distributive (or redistributive) function is best left to the national level.

5.3 The Practice

The evolution of the Australian Federation and the nation's geography have combined to create States of vastly different economic structures with a large fiscal imbalance between the State and Territory Governments and the Commonwealth government. The lack of agreed theories on the framework for the establishment of a sound theoretical structure for a federation has itself almost certainly contributed to this outcome.

The State's geography means it is isolated from both world population centres and also from the great majority of the nation's population. The tyranny of distance, even with efficient electronic communication systems, means it is more difficult to be a key part of political and economic decision making processes.

The evolution of financial powers in the Federation means that, although Western Australia has a strong economy and for some years has been a net contributor to the nation's coffers, a large proportion of the funding for government activity in the State comes through the Federal Government. This is particularly applicable to services such as tertiary education and research services which are predominantly funded by or through Federal Government agencies.

Western Australia, along with all other States and Territories, is in competition for Federal research and education funds. The State must also compete with the other States to attract business investment. While the primary emphasis should be on encouraging research and development investment by companies already engaged in commerce in the State, there are significant benefits from attracting new investment.

This report has been commissioned to examine the Government's role in attracting additional Commonwealth and private sector R&D investment into the State. The following section outlines a range of roles with an examination of each.

5.4 Potential Government Roles

The issues for government in a free market economy is to find the mix of policies and programs which constitute a productive and acceptable compromise between leaving a market to evolve through its own operations and intervening to change the market allocation process. The following sections cover a range of possibilities. They are loosely ranked from a minimalist role in providing support and direction through to an active participatory role in the provision of actual research services.

5.4.1 Build a Research and Innovation Culture

It is individuals who provide the ideas and creativity for research and development activities, although governments play a key part in forming the environment in which they work. Community support for research is an important prerequisite in building a culture supportive of research, development and innovation activities. Democratically elected governments will not provide funds for research activities without electoral support.

The Western Australian Government has limited resources but has the capacity to use these to leverage increased research and development activities. Substantial funding for R&D flows direct to research organisations from Commonwealth Government programs and Commonwealth agencies. Very substantial business investment also occurs directly in R&D activity in which the Government only plays a small role.

The Western Australian Government has provided leadership and direction in the science and technology area with the release of its Science and Technology Policy. The discussion paper which preceded this policy set down concepts and proposals supportive of increased science and technology activity and investment in Western Australia. The research field, however, is wider than science and technology programs and consideration needs to be given to a wider policy which encompasses the range of research activities. As the financial analysis has demonstrated, Western Australia also has strengths in social research fields.

The creation of a ministerial science and technology council and a coordination committee involving chief executive officers from government agencies involved in science and technology activities is a significant step towards the development of integrated programs in Western Australia.

Western Australia has many successful research organisations. The State's successes need to be promoted both to increase community understanding and support for research activities and to provide examples to interstate and overseas investors of Western Australian capability. Part of the promotion exercise should involve an annual audit of research activity in Western Australia.

The Department of Commerce and Trade is addressing this requirement and has compiled comprehensive statistics on R&D activity in the State. These statistics need to be supplemented with case studies of successful institutions to demonstrate to the wider community and investors the activities and changes taking place.

Creating the right culture involves clear direction and long term planning by government. The science and technology policy represents a sound beginning for a clear government policy. Long term plans for the development of this sector can now be established based upon this policy. The State Government science and technology policy has been through an extensive development and public consultation process and is rightly viewed by the Government as a

working document and not a static policy. The Minister responsible for science and technology issues, the Deputy Premier, has sought public participation in the development and ongoing review of policy.

With community support the next step is to attract the right people and the right numbers into research and development activities.

5.4.2 The Right People

Research is a demanding vocation requiring highly skilled and motivated individuals. Education begins in primary school and it has been found in international surveys that Australian children have a high awareness of science issues. The Government's science and technology policy includes a range of strategies to ensure that science curriculum for schools stimulate an interest in science-based topics at both the primary and secondary level. Consideration needs to be given as to whether the curriculum is encouraging an interest in research activities in all spheres including science-based disciplines. The excellent facilities at Scitech in Perth have provided an interactive experience in science and technology issues for many primary school children

Increased provision be made for the professional development of teachers of science, mathematics and technology with ongoing support through centres such as the Curtin key centre for science and maths education.

Western Australia has attracted a large number of overseas students, particularly at the tertiary education level. The State's excellence in education has been a major attraction and the students provide excellent opportunities for future cooperation and investment links with South East Asian countries.

The survey of successful R&D organisations in Western Australia clearly demonstrated the importance of a strong research leadership in the success of these organisations. A performance track record can be developed over time and it is important that research organisations develop and foster internal expertise. It is also important that research workers are exposed to the latest methodologies and approaches and hence exchanges with overseas research organisations are highly desirable.

The attraction of highly skilled and international standard research workers to the State is a desirable objective of both government and research organisations. The exchange of research workers between public sector research organisations and universities and the private sector is supported by the Government's science and technology policy.

Western Australia has a highly skilled and well educated work force. The State has also in the last few years built up a strong core of research workers engaged in business R&D programs. It is important that these skills be retained and developed. Incremental increases in the

numbers already engaged in R&D activities may be a more easily attained objective of increasing R&D funding than the attraction of new funds from outside the State.

In addition to the right people, the State also needs to have the right infrastructure to attract R&D funding.

5.4.3 The Right Infrastructure

Research infrastructure comprises land, buildings, major equipment purchases and provision of administrative and support services. Quality infrastructure is a major attraction for interstate and overseas investment. With a wide range of research organisations including CSIRO, universities and State Government departments, Western Australia has substantial R&D infrastructure. Agriculture Western Australia, for example, has a large investment in research infrastructure at the South Perth and regional sites. Much of this infrastructure is now in need of upgrading and substantial funds will need to be set aside in future years to achieve this.

The Western Australian government has been a large contributor to R&D infrastructure through its own Departments and agencies, universities, the Cooperative Research Centres and Technology Park.

The State Government has provided support in the establishment of the cooperative research centres both in the application process and in infrastructure investment.

The Commonwealth system of university funding through ARC tends to separate infrastructure and project costs potentially leading to under-investment in infrastructure. A number of leading research groups interviewed at the University of Western Australia in particular emphasised the lack of available accommodation as a constraint on their expansion. A number of Commonwealth Government programs provide support for R&D but the grants available do not always include allowance for infrastructure costs. The rapid expansion in programs at the University of Western Australia and the age of some of the existing infrastructure also means that there will be significant future demands for infrastructure expenditure. Some of the other universities have also sought funds for the establishment of technology precincts.

The Western Australian science and technology policy discussion paper recognises the importance of infrastructure and the important role that had been played by the endowment land for the University of Western Australia. The discussion paper recommends the establishment of endowments for the non-endowed universities along with the provision of land endowments for construction of science and technology facilities. Mention is also made of a possible marine research facility at Jervoise Bay in Cockburn Sound.

The government Science and Technology Policy also provides funds for a centre of excellence program which may enable the construction of infrastructure.

The Technology Park at Bentley is a vital component in the State's research infrastructure with around 60 organisations located on that site. The success of this site has led to numerous requests for further technology parks in metropolitan and regional areas of Western Australia and the science and technology discussion paper recommends that the State continue to plan for and support their establishment.

One of the important prerequisites for research and development is a modern communications system. Western Australia generally enjoys a high standard in electronic communications, with services in the metropolitan area of a world standard. Proposed upgrades to fibre cable links with South East Asia will provide even better facilities than at present. The Select Committee on Science and Technology in 1994 recommended that the State commit to the provision of information technology infrastructure. The explosion in the use of the Internet since that report was compiled and the substantial investment by research organisations and government organisations in Internet communications systems has probably meant that the need for a State Government policy on electronic communication is possibly less urgent. The select committee also raised the possibility of government investment in a super-computer to attract specialised research applications.

With respect to business investment, concern has been raised in recent years by a number of organisations regarding the difficulty of accessing venture capital for business innovation activities. The senate committee on science and technology recommended that the State Government stimulate the private sector venture capital industry by investment in an accredited fund. The Commonwealth has recently announced the establishment of a small business innovation fund (SBIF) to help small technology companies access equity finance. SBIF will provide $130 million, thus creating a potential pool of $195 million for use Australia-wide. The proposal is to establish six investment funds, each with capitalisation in the range from $30 million-$50 million. These funds will be managed by private sector fund managers with funds being restricted to investment in small technology companies. Rather than duplicate the operation of such a fund, the Victorian Government has established an 'investment-ready' program. This program, which is targeted at small to medium enterprises, helps to prepare them to take advantage of the Commonwealth's R&D support programs. To help attract R&D funds into the business sector, consideration of such an initiative appears warranted.

5.4.4 The Right Processes

A more proactive role for government involves establishing the right processes both for investment in its own R&D programs and to encourage the development of programs in Western Australia which will attract Commonwealth funding. Government roles range from information through to priority setting.

5.4.4.1 Information

The Mortimer Inquiry[7] highlighted the plethora of Commonwealth programs which provide assistance to the business community. Many of the 70 programs provide support for innovation and R&D activities. When combined with the range of grants available through the university ARC system it is clear that there are many potential avenues for research funding. The State Government can play a valuable role in providing information on both State and Commonwealth programs covering the university and business sector. While this information is available from the Commonwealth Government, a number of the research organisations interviewed during the consultation process emphasised the time and effort needed to keep up to date with the range of programs and grant conditions. The universities generally have senior positions responsible for research coordination, with these officers providing valuable assistance in grant application processes. There does not appear to be a similar centralised capacity for Western Australian business to access federal programs and this is a role which the Department of Commerce and Trade could valuably undertake. The State Government has provided information to assist with applications to the CRC scheme. A review of participants in the CRC process conducted on behalf of the Department of Commerce and Trade has demonstrated the value of this information role.

5.4.4.2 Competition and Coordination

Competition between research groups for funding is an important catalyst in improving the quality of research applications. However, there are circumstances under which competition can be counter-productive. Experience with the CRC program in Western Australia has shown that some grants have not been successful because of the similarity of competing proposals. A combined proposal may have been more successful than a number of smaller, overlapping proposals.

Some universities utilise competitive processes as a means of selecting proposals for Commonwealth funding. Others, such as the University of Western Australia, provide a more decentralised process with the research vice chancellors providing information but not actively vetting proposals. There appears to be a valuable role at both the university and government level for a process of competitive selection in prioritisation of research objectives.

5.4.4.3 Facilitation

The State Government can provide funds to facilitate research and development. Funding may range from assistance with grant applications through to investment in infrastructure. The Western Australian Government provides a range of support mechanisms for R&D. The

[7] Going for Growth: Business Programs for Investment, Innovation and Export (Mortimer June 1997)

most recent assistance has been provided through the Department of Commerce and Trade for applicants wishing to access the Commonwealth CRC program.

In addition to information provided by departmental officers, a number of seminars have been conducted, a visiting consultant from Canberra has provided advice to applicants and mock interviews have been conducted for applicants. The Department has also provided grants to assist in the preparation of applications and the State Funding Advisory Committee has provided infrastructure support where benefits to Western Australia can be demonstrated. Approximately $5 million has been committed to the Western Australian-based CRCs through this program.

The Government also provides a range of other programs including direct funding to the University of Western Australia Centre on (Geoscience). The State also contributes $750,000 per annum to MERIWA. This Institute primarily funds projects jointly with industry but there are some 'public good' projects funded totally by MERIWA.

A recent example of a substantial commitment by the State Government to R&D is the grant to CSIRO for the relocation of the National Centre for Petroleum and Mineral Resources to Technology Park.

As this report has identified in a number of areas, Western Australia receives less funding from CSIRO than would be suggested by its proportion of the national population and a lower proportion of some university funding schemes. The Western Australian Government needs to work closely with CSIRO to identify opportunities in this State for an expanded CSIRO presence. Given the State's expertise in agriculture and resources, CSIRO would appear to be under-investing in agriculture in the State. Opportunities should be examined for joint programs with the existing agencies and CRCs that would justify an increased CSIRO presence in the State.

5.4.4.4 Direct State Investment

The Western Australian Government is a major investor in its own R&D activities. The largest funding flows into agriculture, forestry and fisheries with funding also into environmental and health areas. These investments address areas of market failure where under-investment by the privates sector has occurred in primary resource R&D. Agriculture WA, in particular has been an active participant in federally-funded rural industry R&D programs and plays an active role in a number of CRCs.

Given the State's obvious expertise in the primary resource sector, the Government should continue to build on this with leveraged funding to attract more Commonwealth and rural research funds into Western Australia. Agriculture WA has recently completed a review of one of its key activities and this may lead to an increase in funding by the Grains Research

and Development Corporation. Similar reviews by the agency may target other areas for increased investment from national agricultural programs.

The Western Australian Government has a valuable role to play in providing seed funding to encourage an expansion of Commonwealth programs in the State. The grant funding for CSIRO to assist with relocation is one such case.

Other areas in which increased Commonwealth expenditure in the State appear justified are in defence and marine science. These areas of research justify more detailed consideration.

5.5 Appropriability

Business looks to invest in projects which provide innovation and technological advantages for the firm. Investments need to be repaid and hence issues which affect return on investments are critical to business decision making. While the Western Australian Government has little control over taxation arrangements, it does have responsibility for elements of property rights which affect the extent to which new products and processes can be protected.

While the Federal Government has responsibility for patents and copyright provisions, the Western Australian Government does have some control over the intellectual property developed in its own agencies. The State's Science and Technology policy recognises the importance of commercialising public service intellectual property. The State Government has recently developed a policy which allows agencies to retain some of the benefits for commercialising intellectual property thus acting as a catalyst to encourage commercialisation.

6. RECOMMENDATIONS

The following recommendations have been developed from this study. They include a reference to the page on which the recommendation was developed. The Key Recommendations are summarised in the Executive Summary at the beginning of this report.

1. The Government provide support for any collaborative proposals by the universities which seek large ARC grants. The emphasis to be on achieving a critical mass of expertise (page 28).

2. Areas of apparent low-investment in the State through the ARC be reviewed with an emphasis on ways of improving grants for research infrastructure and collaborative grants. Assistance with increasing the State's success in gaining collaborative grants should include an industry listing of companies willing to provide support in selected areas (page 28).

3. The Government has a role to play in helping R&D institutions identify external funding sources and some financial assistance with application processes has been beneficial for Cooperative Research Centres (page 35).

4. The Government needs to consider ways in which local universities, businesses and departments can be encouraged to greater participation in Cooperative Research Centres. Some form of bonus payments for collaborative efforts should be considered (page 35).

5. ***Key Recommendation 1:*** *Given the strength of the minerals and energy sector in the Western Australian economy, the State Government give consideration to the development of world class minerals and energy research facilities.* To ensure long term benefits to the Western Australian community from resource development, the Government should consider ways in which the royalty system may be used to encourage R&D investment. A positive approach involving royalty incentives as a trade-off for R&D investment appears worthwhile (page 38).

6. The State has developed electronic communication expertise appropriate to the need for remote, long distance telecommunications. Every effort must be made to build on this expertise (page 38).

7. ***Key Recommendation 2:*** *The State Government use its Centres of Excellence program to continue to support the creation of a 'critical mass' of infrastructure for collaborative research to attract further external funding from the private sector and the Commonwealth.*

8. ***Key Recommendation 3:*** *The State Government should broker and support collaborative R&D arrangements which attract funds into those fields where the State has achieved national prominence including mining, metal manufacturing, agriculture and electronic communications* (page 40).

9. The State Government can play a part in maintaining a favourable environment by stressing the importance of the business sector to the Commonwealth Government at all opportunities (page 39).

10. Consideration needs to be given to the lack of State participation in many Eastern States based CRC's including health related organisations (page 40).

11. The State has substantial and growing sectors in wood and timber products, lightweight ferry boat building, fisheries, viticulture, long distance communications and aquaculture. At present there appears to be a low level of research in these sectors and consideration needs to be given as to how the level of investment may be increased. The recent State Government announcement of plans for a Marine Industry Technology Park at Jervoise Bay demonstrates its commitment to this sector (page 40).The ASTEC 2010 foresight groups approach provides a model by which the R&D investment potential of all these industries may be reviewed (pages 38 and 49).

12. ***Key Recommendation 4:*** *The State Government continue to provide incentives to attract major science and technology organisations to the State in priority areas identified in the State science and technology plan*. Additional support should be available for collaborative ventures, particularly those which offer the potential for development of a 'critical mass' in research expertise. Collaborative joint ventures between industry and government, including higher education institutions, should be promoted (page 61).

13. ***Key Recommendation 5:*** *The State Government examine opportunities for international R&D collaboration both as a funding mechanism and as a tool to promote market access to Western Australian companies* (page 63).

14. ***Key Recommendation 6:*** *The State Government continue to provide funds to assist collaborative research applications from State groups seeking access to federally funded programs*. Assistance should be prioritised through a contestable application process with merit assessed by an appropriate evaluation panel (page 61).

15. ***Key Recommendation 7:*** *The State Government monitor the obligations and opportunities presented by the extension of the marine economic development zone with a view to leveraging the requirements of managing the State's diverse marine environments for the location of national and collaborative international marine research centres* (page 41).

16. The State review its revenue receipts from the individual rural industry R&D corporations and evaluate what needs to be done to attract a greater share of funding from any schemes judged to be deficient in their Western Australian allocation. Recent negotiations with the Grains Research and Development Corporation have identified ways of overcoming their concerns regarding investment in Western Australia (page 75).

17. ***Key Recommendation 8:*** The State Government seek opportunities for an expanded role in Western Australia for Australian Institute of Marine Science and Defence Science and Technology Organisation funding (page 76). *Given the small presence of Commonwealth research agencies in Western Australia, the State Government should consider joint programs and collaborative opportunities that lead to a greater presence of CSIRO, DSTO and AIMS*.

18. The State Government examine the potential for Western Australian R&D groups to carry out contract research on behalf of the Defence, Science & Technology Organisation. A foresight group to identify possible opportunities may be worthwhile (page 76, Appendix 4 page 18).

19. ***Key Recommendation 9:*** *Western Australia argue strongly for an effective Commonwealth R&D taxation incentive scheme. The State recommend to the Commonwealth restoration of an effective 150% taxation deduction or a combined concession/rebate scheme* (page 39).

20. ***Key Recommendation 10:*** *The Department of Commerce and Trade monitor the progress of the Commonwealth's Innovation Investment Fund to ensure that venture capital opportunities are available to enterprises in Western Australia* (page 73).

21. ***Key Recommendation 11:*** *The State Government examine investor-ready programs to ascertain their suitability for Western Australian companies*. The aim would be to assist them in preparing for commercialisation of new products (page 73).

22. The State Government continue its support for primary and secondary science education programs with support for curriculum development and organisations such as Scitech (page 71).

23. Use sister-State relationships to foster Western Australian R&D capability through memorandum of understanding approaches (pages 63 and 71).

24. ***Key Recommendation 12:*** Statistics suggest that business is the largest investor in R&D and it is the fastest growing sector. However, there is contradictory information and more work is needed to identify and quantify the R&D work being carried out. *The State Government should initiate further studies into the nature of this investment and the policies needed to support further growth* (pages 23 and 38, Appendix 4 page 26).

25. ***Key Recommendation 13:*** *The State Government promote the State's R&D expertise and the diversity of education and R&D opportunities in the State* (page 70).

26. The State Government use its report of R&D activity in the State for promotion of research capability (page 70).

27. ***Key Recommendation 14:*** Strong leadership is fundamental to the success of a research group in attracting and retaining funds. Such leadership needs to be both developed locally and 'imported' as appropriate. *The State Government should consider ways in which research staff with the potential for such leadership can be identified and supported* (page 71).

28. Increased provision be made for the professional development of teachers of science, mathematics and technology with ongoing support through centres such as the Curtin key centre for science and maths education (page 71).

29. The State Government initiate further high level discussions with the CSIRO board to identify opportunities for a greater CSIRO presence in Western Australia, particularly in those areas where the State has demonstrated expertise (page 75).

30. ***Key Recommendation 15:*** *The State Government ask the Commonwealth Government to develop and provide a user-friendly Internet-based register of Commonwealth and relevant international R&D Funding schemes*. The initial emphasis should be on business assistance programs with a higher education sector register developed after discussions with those institutions to identify requirements (page 61).

31. Given the State's strength in agriculture and fisheries, CSIRO would appear to be under-investing in these industries in the State. Opportunities should be examined for joint programs with the existing agencies and CRCs that would justify an increased CSIRO presence in the State (page 75).

32. Mechanisms to improve the Western Australian share of ARC funds will be dependent on the individual program but could include support for further university membership on federal allocation panels (Appendix 4 page 27 and Appendix 5 page 3).

33. The Western Australian Government and higher education sector need to be fully aware of the way in which ARC funding formulae operate and should actively contribute to the development of ARC policies and funding formulae (Appendix 5 page 3).

Appendix 1:
Steering Committee Membership

Dr Lesley Borowitzka (Chairman)

Dr Mike Carroll (TIAC member)

Ms Leslie Chalmers (TIAC member)

Professor John Maloney (TIAC member)

Mr Lloyd Zampatti (TIAC member)

Dr Sue Meek (Department of Commerce and Trade member)

Dr John Barker (Department of Commerce and Trade member)

Earl White (TIAC Executive Officer)

Work on this study was completed by Murray Meaton from Economics Consulting Services, Dr Michael Taylor from ACiL Economics & Policy, Dr John Phillimore from the Institute for Science and Technology Policy, Dr Doug McGhie and Nigel Goodall.

Appendix 2:
Study Terms of Reference

Project Title:

"Research and Development: The Role of the State Government in Attracting External Funding"

Purpose:

To engender community debate and provide options for the State Government to use its resources to increase the flow of Commonwealth and Private Sector R&D Funds, Facilities and Personnel into Western Australia to promote economic and industrial growth.

Terms of Reference:

In relation to the generation of economic and industry development benefits to the State:

1. Identify key areas of R&D strengths in the State which have the potential of becoming centres of research excellence.

2. Identify appropriate sources of external R&D Funds.

3. Identify the key criteria of research centres that succeed in attracting external R&D Funds.

4. Provide policy options for the State Government to consider in order to increase Commonwealth and Private Sector R&D Funds, Facilities and Personnel in the State.

Appendix 3: Glossary

ABS	Australian Bureau of Statistics
AIMS	Australian Institute of Marine Science
ANSTO	Australian Nuclear Science and Technology Organisation
ANZSIC	Australian, New Zealand Standard Industry Classification
APA	Australian Postgraduate Awards
ARC	Australian Research Council
ASTEC	Australian Science & Technology Council
BERD	Business Expenditure on R&D
BHP DRI	BHP's Direct Reduced Iron project
CCST	Coordination Committee on Science and Technology
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific & Industrial Research Organisation
DEETYA	Department of Education, Employment and Training and Youth Affairs
DIST	Department of Science, Industry & Tourism
DPIE	Department of Primary Industries & Energy
DSTO	Defence Science and Technology Organisation
ERDC	Energy R&D Corporation
FOR	Field of Research
GDP	Gross Domestic Product
GIRD	Grants for Industry R&D scheme
GRDC	Grains Research and Development Corporation
GSP	Gross State Product
GVP	Gross Value of Production
HERD	Higher Education R&D
IIF	Innovation Investment Fund
IR&D Board	Industrial Research and Development Board
LRGs	Large Research Grants
MERIWA	Minerals & Energy Research Institute of WA
MNRF	Major National Research Facilities program
NH&MRC	National Health and Medical Research Council
NHT	Natural Heritage Trust
OECD	Organisation for Economic Cooperation and Development

GLOSSARY

(cont)

PMSEC	Prime Minister's Science & Engineering Council
PNP	Private Non-Profit organisation
R&D	Research and development
REIP	Renewable Energy Industry Program
RGC	Research Grants Committee
RIBG	Research Infrastructure Blocks Grant Program
RIEF	Research Infrastructure (Equipment & Facilities) Scheme
RQ	Research Quantum
RTC	Research Training Component
SBIF	Small Business Innovation Fund
SEO	Socio-Economic Objective
SITCO	Science Industry & Technology Council
SME	Small to Medium-sized Enterprises
SPIN	Sponsored Programs Information Network
TIAC	Technology & Industry Advisory Council
WAISS	WA Innovation Support Scheme

Appendix 4:
Research and Development in Australia

Appendix 4:
Research and Development in Australia

Contents

PAGE

RESEARCH AND DEVELOPMENT IN AUSTRALIA

Introduction

This appendix provides an overview of R&D in Australia. It includes sections on funding levels, human resources, political processes and Commonwealth Government and industry investments. The location of R&D investment in Australia provides a perspective on Western Australian involvement in this sector.

The overview of Australian R&D included in this appendix provides the context within which Western Australian R&D is reviewed. Given the fairly frequent changes in Commonwealth programs for R&D support, material in this appendix may become quickly outdated. Particular attention should be given to the R&D Start Program which is a major source of funding and an area where changes to program operations may be ongoing.

International Context

From the early 1970s to the early 1990s, research and development expenditures for the OECD countries as a whole grew steadily and faster than gross domestic product (GDP). The intensity when measured as the ratio of R&D expenditures to GDP peaked in the early 1990s and R&D expenditures declined in absolute terms in the middle of the recession of the early 1990s[1].

In OECD countries, more than half of all R&D expenditures are financed by industry and two thirds of all R&D investment is performed in the business sector. R&D tends to be concentrated in a few high technology manufacturing industries such as computers, semi-conductors and aerospace[1]. These industries typically account for between 40% and 60% of all business sector R&D effort. When their products are sold to other sectors as production inputs or are sold directly for domestic consumption or export, the technology of the upstream industry is embedded in their products. R&D expenditure in the services sector accounts for an increasing share of total business sector R&D. This trend is particularly apparent in Australia, Canada and the United States where up to 40% of R&D is now performed by the non-manufacturing sector. A significant proportion of this increase may be due to the way in which R&D is measured and a change in the way business operates. With increasing specialisation and contracting out by firms, many consulting and sub-contractors now perform research activities which would previously have been carried out within a manufacturing

[1] Technology and Industrial Performance (OECD 1996)

organisation. However, R&D is increasing in IT areas such as entertainment and information exchange with database and communication systems now major areas of research effort.

Australian Overview

Australia has a different pattern of R&D expenditure to many other countries in the OECD group. Firstly, the communication equipment and semi-conductor industries which are the first or second R&D sector in most countries are not included in the top five efforts in Australia. Aerospace, chemicals and computers are also absent with these again featuring prominently in the top group for other countries.

Australia's top group includes:

- motor vehicles - 19%;
- electrical machinery and electrical equipment - 17.5%;
- pharmaceuticals - 8%;
- ferrous metals - 8%;
- food, beverage and tobacco - 6%.

Gross R&D Expenditure

Gross expenditure on R&D in Australia as measured by the Australian Bureau of Statistics now totals $7,321 million (Table 1).

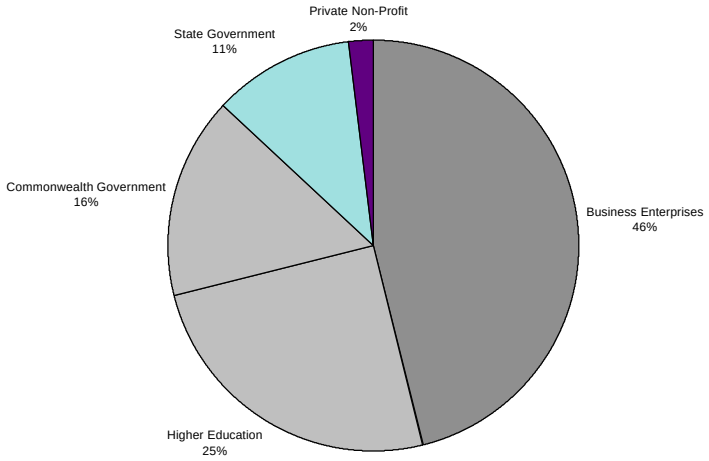
Table 1: Australia's Expenditure on R&D, by Sector of Performance, 1990-91 to 1994-95

	1990-91			1991-92			1992-93			1993-94			1994-95		
Sector of performance	$m	%GDP	% real annual increase	$m	%GDP	% real annual increase	$m	%GDP	% real annual increase	$m	%GDP	% real annual increase	$m	%GDP	% real annual increase
Business	2100	0.55	0.6	2360	0.61	9.9	2855	0.70	17.4	3069	0.72	5.0	3383	0.74	9.6
private	1896	0.50	0.5	2144	0.55	10.5	2610	0.64	18	2836	0.66	6.0	3051	0.67	6.8
public	204	0.05	2.0	216	0.06	3.8	245	0.06	11.4	233	0.05	-5.8	332	0.07	43.7
Government	1704	0.45	6.6	na	na		1819	0.45	-0.9	na	na		1965	0.43	2.7
Cwlth	1034	0.27	4.0	na	na		1151	0.28	0.6	na	na		1178	0.26	0.0
State	670	0.18	11.0	na	na		668	0.16	-3.3	na	na		786	0.17	7.3
Higher educ.	1333	0.35	6.1	na	na		1695	0.43	10.7	na	na		1830	0.41	1.3
Priv non prof.	85	0.02	18.8	na	na		101	0.02	5.0	na	na		144	0.03	18.7
TOTAL	5222	1.38	4.5	na	na		6470	1.59	8.2	na	na		7321	1.61	4.6

Source: DIST based on ABS data

About 46% of Australia's R&D expenditure, corresponding to 0.74% of GDP, was undertaken within business enterprises in that year. The other principal R&D sectors include higher education institutions with 25% of R&D, Commonwealth Government agencies with 16% and State Governments with 11% (Figure 1).

Figure 1: Gross Expenditure on R&D in Australia, 1994-95 (%)

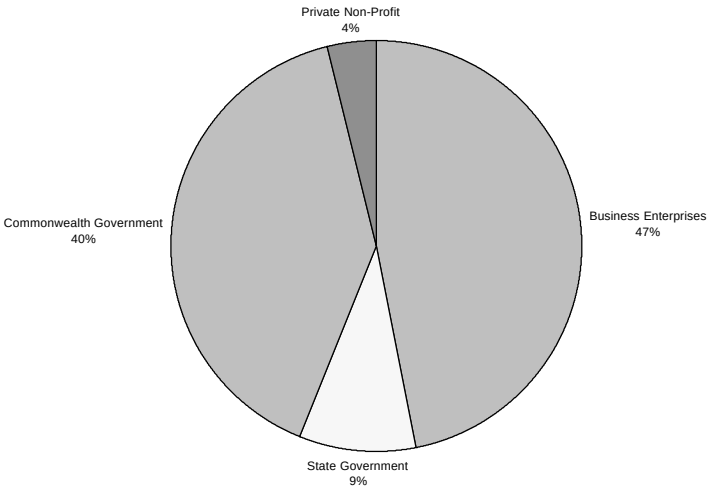


Sources of Funds

Although the Commonwealth Government does not provide a large direct investment in R&D, it is a major source of funds, providing funds to both the higher education sector and business sector though assistance programs of various types (Figure 2). The actual expenditure on R&D is still dominated by the private sector but the Commonwealth provides 40% of the funds for R&D in Australia.

Over the last seven years investment by the business sector has grown significantly with the Commonwealth Government proportion declining.

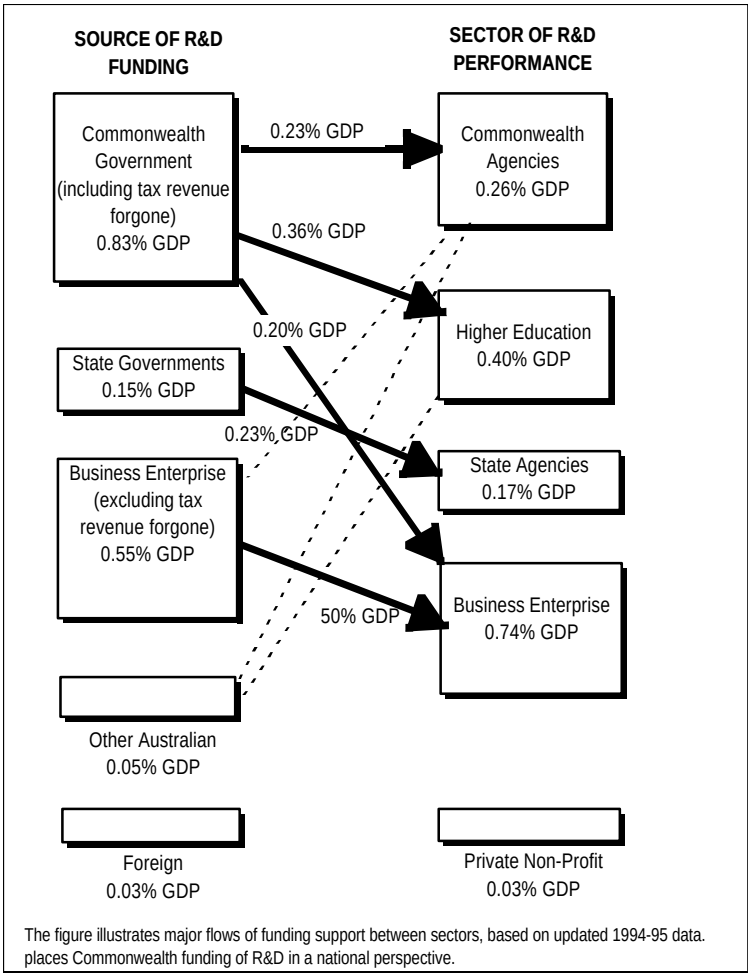
Figure 2: Source of R&D Funds 1994-95 (%)



As a funding source, the Commonwealth Government provides about 40% of R&D funds directly, and has provided another 12% through the indirect means of the R&D tax concession. Derived from ABS survey data, Figure 3 provides a schematic picture of the

Commonwealth's activity in the national R&D context and its relative size and interactions compared with other elements of the system.

Figure 3: Commonwealth R&D Support in a National Perspective



Source: DIST

Thus, of the 0.74% of GDP performed by business enterprises, 0.55% was provided by those enterprises themselves (excluding tax revenue forgone). The balance of funding for R&D performed by business enterprises (0.20% of GDP) was provided by the Commonwealth. As a first approximation, State Government funds went to State agencies.

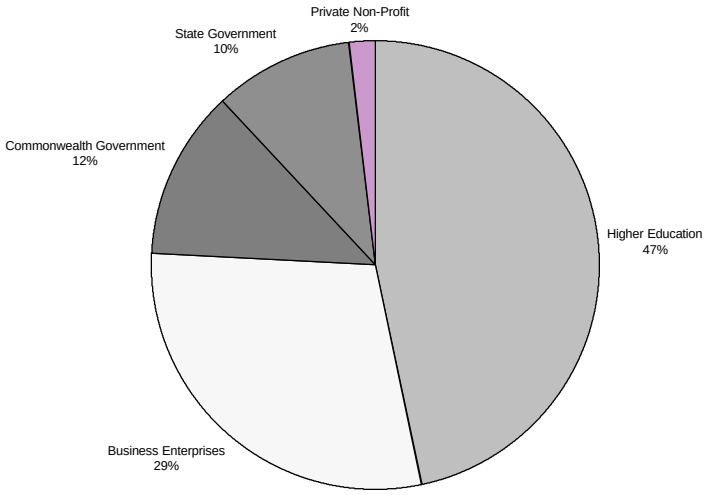
Human Resources invested in R&D

Another way of looking at R&D investment is to examine employment in the sector. Given the high proportion of research in Australia done in universities and the employment of postgraduate students at low income levels the human resources devoted to R&D provides a quite different perspective to this sector than does investment levels (Figure 4).

Human resources devoted to R&D have climbed steadily for the last seven years to 86,162 in 1994-95. Higher education accounts for 40,096 (47%) with business enterprises 25,239 (29%)

and general government 19,134 (22%) (Figure 4). Private non-profit is growing quickly but only constitutes 2% of the total. Human resources have been increasing in all sectors except the government sector which has seen a decline over the last five years.

Figure 4: Human Resources Devoted to Research and Development, 1994-95 (person years)

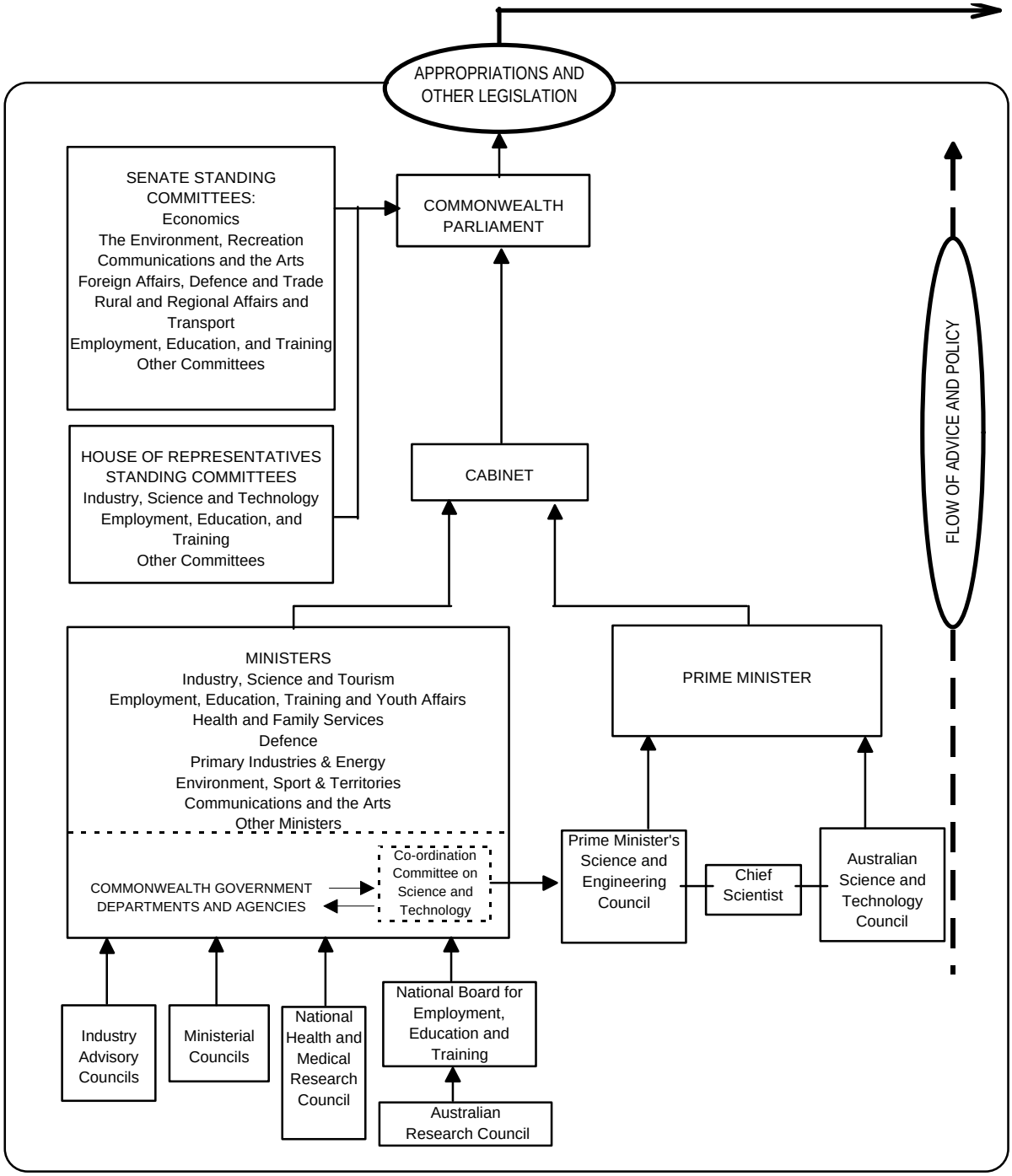


The Organisation of R&D

As in all advanced countries, research and development in Australia is pluralistic. This philosophy is built on the premise that the linkages between science and technology and other activities *within* sectors are stronger than linkages *between* R&D activities in unrelated sectors. Typical sectors are agriculture, mining and manufacturing. The pluralism approach results in each sector determining its own R&D priorities in competition with priorities for non-R&D activities. This 'customer/contractor' principle is aimed at encouraging the development of market forces between the customers (who provide the funds) and the research performers.

The outcome of R&D pluralism is illustrated by the main channels of R&D advice (Figure 5) and the flow of funds (Figure 6).

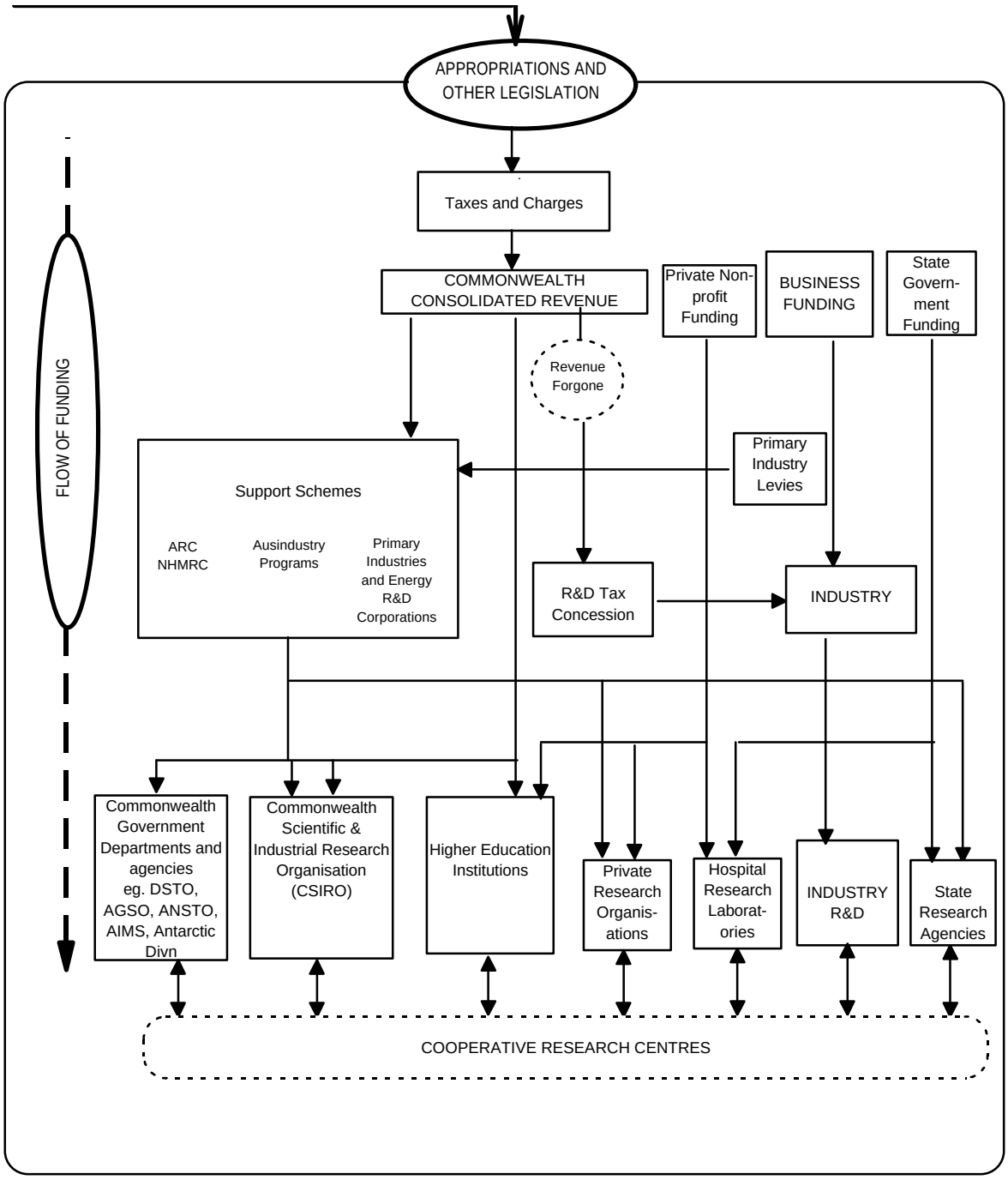
Figure 5: Main Channels of Advice for Policy Formulation in Science and Technology



Note: The figure is indicative of major bodies and principal channels for the flow of policy advice leading to parliamentary and Cabinet decisions on science and technology issues. It is only illustrative. Of course, there are a host of influential forces, including professional organisations and other non-government groups, and there are many cross-links and productive interactions between them. Medical research has been included for completeness.

Source: DIST, Science and Technology Budget Statement 1997-98.

Figure 6: Flow of Funding Support for R&D



Note: The figure illustrates the main channels of funding to R&D performers. Funds originate primarily with the taxpayer and private business. The Commonwealth Government is the major funding source. For simplicity, minor funding flows are omitted.
Medical research has been included for completeness.

Source: DIST, Science and Technology Budget Statement 1997-98.

The peak level advisory arrangements that have been developed to guide priority setting and decision making are:

- *Prime Minister's Science and Engineering Council (PMSEC):* PMSEC is a high level discussion forum in which the Prime Minister and other ministers with interests in science and technology hear expert presentations on current issues of national importance involving science and technology, and engage in discussion on these issues with leaders from industry and the science, technology and engineering communities.

- *Australian Science and Technology Council (ASTEC):* ASTEC provides the Government with carefully considered advice and recommendations, based on policy research and analysis and extensive consultation. ASTEC deals principally with issues where government decisions have to be based on a full examination of all relevant facts. ASTEC's advice represents the outcome of deliberation by experts, both on the Council and co-opted to ASTEC working parties.

- *Chief Scientist:* the Chief Scientist provides advice to the Prime Minister and the Minister for Science and Technology on such matters affecting science, technology and engineering as the Prime Minister or the Minister request, and on other issues to which science and technology are relevant. The Chief Scientist chairs ASTEC.

Combination of the positions of Chief Scientist and ASTEC Chairman aims to ensure that the Government's sources of advice on science and technology are well coordinated, that the work of ASTEC is linked closely with that of PMSEC and that both address the most urgent needs of government.

To complement the advisory arrangements discussed above, there are also needs to promote consultation within the system and needs for mechanisms that will effect coordination between different parts, when that is needed. In this regard, the Coordination Committee on Science and Technology (CCST) exists to complement the work of the Prime Minister's Science and Engineering Council by bringing together heads of agencies and senior representatives of departments with an interest in science and technology to share information about their programs and policies and to address common problems and opportunities.

Commonwealth Government Funding

The Department of Science, Industry and Tourism (DIST) estimates that the Commonwealth will provide over $3,550 million in funding support for major programs of science and innovation in 1997-98 (Table 2). Just under 45% of this will be provided through the higher education sector (predominantly universities) with 20% through CSIRO and the Defence, Science & Technology Organisation (DSTO) (Figure 7).

Figure 7: Commonwealth Support for Science and Innovation ($million)

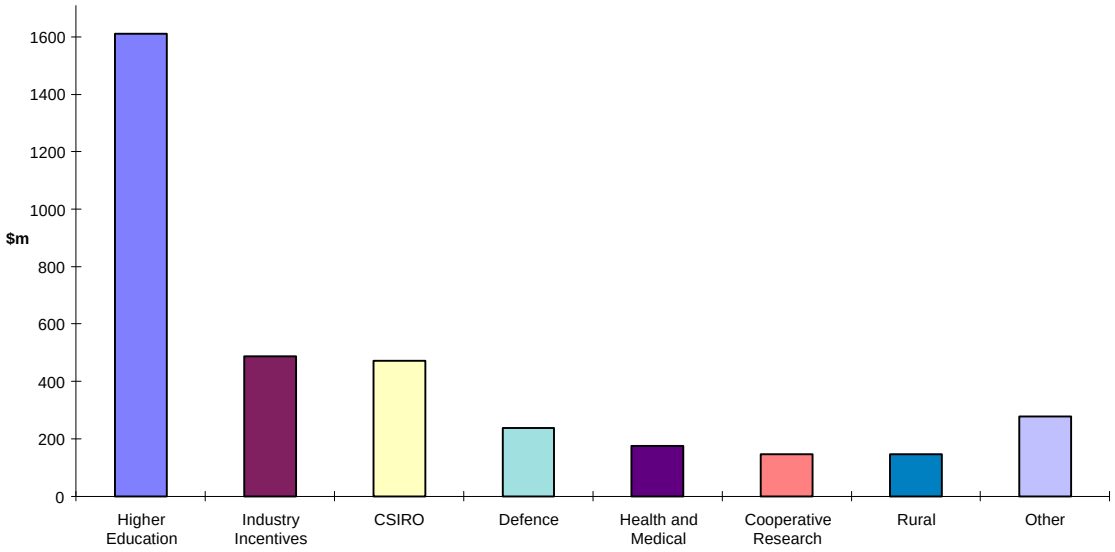


Table 2: Commonwealth Support for Major Programs of Science and Innovation

	1996-97 $m est	1997-98 $m est	Real change
Targeted Higher Education R&D[1]	396.2	427.0	+5%
Other higher education R&D	1,175.8	1,182.4	-2%
Cooperative Research Centres	141.9	146.2	0%
Industry R&D incentives[2]	492.6	486.9	-4%
Rural R&D	135.8	145.4	+4%
NH&MRC	150.3	156.4	+2%
Other Health R&D	13.7	19.4	+38%
Other R&D Grants[3]	13.4	16.8	+23%
CSIRO[4]	439.1	472.9	+5%
DSTO[5]	266.9	237.8	-13%
Other R&D Agencies	282.0	259.3	-10%
TOTAL	3,508	3,551	-1.3%

NOTE Estimated outlays and expenditure are at current prices, the real changes shown are based on constant price estimates.

[1] Represents the total of Budget and HEF Act funding and incorporates funds allocated on the advice of the Australian Research Council (ARC). In 1997-98, $321 million will be allocated on the advice of the ARC.

[2] R&D Start Program plus the estimated effect of revenue forgone via the IR&D tax concession scheme.

[3] Australian Biological Resources Study, Greenhouse research grants, Energy R&D and Australian Road Research Board.

[4] Includes funding through DPIE for the Australian Animal Health Laboratories. In addition to the budget funding shown, CSIRO expects to earn over $268 million from external sources in 1997-98.

[5] These figures include DSTO overheads that are funded through appropriations to other parts of the Defence Portfolio. (See note 1 to Table 4). They also include capital works appropriations principally attributable to DSTO.

Source: DIST

Each of the major programs, except those dealing solely with medical R&D, is described briefly below.

Higher Education R&D

Higher education R&D has two main components for 1997-98:

- university operating grants estimated at $1,182 million; and
- targeted research programs, totalling $427 million.

The research component of the operating grants ($1,182 million) is based on an ABS survey of research expenditure by sources and funds. Within this amount several components can be identified:

- a Research Quantum (RQ): The RQ is an amount within the operating grant which is reallocated to institutions on the basis of research performance. In 1997-98, the RQ will be $219 million;
- the Research Training Component (RTC): The RTC is estimated on the basis of higher degree research student load, weighted in accordance with a relative teaching cost matrix. The RTC is currently estimated to be 10.7% of the operating grant, or $482 million in 1997-98; and
- funding for the schools and centres of Institute of Advanced Studies of The Australian National University: From 1997-98, funding for the John Curtin School of Medical Research will be provided through DEETYA. For 1997-98, the IAS block grant is estimated to be $153 million.

The majority of targeted research funding ($472 million), including research grants, fellowships and centres, is allocated on the advice of the Australian Research Council (ARC) which conducts competitive peer review through its panels and committees. The primary criterion for the awards is the record of researchers and the quality of their proposals, though some weight may be given to other criteria such as national priority areas and links to industry.

The 1997-98 allocation for Research Grants is $128.3 million. The Research Grants program has two components.

- Large Grants Scheme. This supports basic and applied research projects in all disciplines except clinical medicine and dentistry with grants ranging up to more than $250,000 for Special Investigator Awards. The Australian Research Council (ARC) provides advice on the allocation of grants with proposals being selected on a competitive basis by peer review through the ARC's Research Grants Committee and its expert discipline panels.
- Small Grants Scheme. This provides block grants to universities to enable them to offer research grants at less than the minimum value of Large Grants. Eligible

universities receive a base grant of $50,000 with the remaining funds distributed according to a formula that takes into account institutional success in obtaining Large Grants and the distribution of Small Grants in the previous year.

Other targeted research programs include Postgraduate Awards ($84.84 million); Research Fellowships ($27.69 million); Research Centres ($18.45 million); Research Infrastructure ($109.98 million); Collaborative Research Grants ($29.24 million); Overseas Postgraduate Research Scholarships ($15.43 million); Higher Performance Computing and Communications Centres of Expertise Program ($7.3 million); Learned Academies ($1.53 million); Anglo-Australian Telescope Board ($3.5 million); Research Evaluation Programs ($0.66 million); and Advanced Engineering Centres ($1.6 million).

Two types of award with stipend are available under the Postgraduate Awards program, Australian Postgraduate Awards with stipend and Australian Postgraduate Awards (Industry). In addition, 19,900 Equivalent Full-time Student Units (EFTSU) are provided exemption from HECS.

- *Australian Postgraduate Awards (APA).* There are around 4,500 awards provide a stipend of up to $20,180, mainly for students undertaking postgraduate research degrees. The awards with stipend are allocated to institutes on a formula reflecting research student load, research degree completions and comparative research strength measured by the Composite Index.
- *Australian Postgraduate Awards (Industry) (APA(I)).* These awards support higher degree research training for postgraduate students on research projects developed to meet the needs of industry. Each project is sponsored by an industry partner. They are awarded on the recommendation of the ARC. An additional 50 awards will be created in 1998.

The Research Infrastructure (Equipment and Facilities) (RIEF) Scheme is the element of the Research Infrastructure Program (see below) referred to the ARC for advice on the allocation of funds. The Scheme funds relatively large scale initiatives which develop major research infrastructure on a cooperative basis across groups of institutions and with organisations outside the higher education sector. Grants can also be made to individual institutions in cases where cooperative arrangements are impractical or inappropriate. In 1997-98, this element of the Research Infrastructure Program will provide $20.9 million.

The Research Infrastructure Program provides the Commonwealth Government's contribution ($110 million in 1997-98) to research infrastructure in higher education institutions. The Research Infrastructure (Equipment and Facilities) Scheme element of the Program is referred to the ARC and is described above.

The non-referred element is the Research Infrastructure Blocks Grant (RIBG) Program. RIBGs are provided to universities to assist in the development and maintenance of research

infrastructure. Consistent with the program priority of providing infrastructure support for Commonwealth competitive grant schemes, the RIBG is allocated to institutions on the basis of the National Competitive Grants Index (NCGI). This element of the Program will provide $89.1 million in 1997-98.

In the 1996 Higher Education Budget Statement, the Government announced a major review of the broad policy objectives in higher education. A review committee was appointed in January 1997, chaired by Mr Roderick West. The committee is undertaking a broad ranging review of the state of Australia's higher education system. Higher education research policy will be a significant focus of the review.

Cooperative Research Centres

The Cooperative Research Centres (CRC) program provides support for long-term collaboration linking researchers and research users from universities, Commonwealth- and State-funded research organisations and business enterprises. Most CRCs are funded for an initial seven years, with funds from the CRC partners typically at least double those from the Commonwealth.

There are 62 CRCs, with Commonwealth funding estimated at $146m for 1997-98. CRCs are selected on the basis of reports by referees and external assessors, then assessment by an expert panel and the CRC Committee. The CRCs program is administered by DIST.

Commonwealth Incentives for Industry R&D

The Department of Industry, Science and Tourism administers a number of R&D programs.

(i) Strategic Assistance for R&D (R&D Start) program, which was announced in the 1996 Budget and has funding estimated at $68.5 million for 1996-97 and $164.3 million for 1997-98. An additional $556 million is budgeted for the four years to 2001-2. It is a competitive scheme that provides grants or loans to small to all enterprises.

Projects under 'R&D Start' are required to:

- demonstrate a clear commercial focus with high potential rates of return;
- link leading industrial research with management and financial capability;
- demonstrate that the work would not otherwise be undertaken by firms without government support;
- provide net national economic benefits; and
- be performed in Australia.

Funding for up to three years is provided for expenditure of up to 50% of the cost of a project. Round One applications for support under R&D Start were divided into two phases. The first phase results were announced in December 1996, and saw $23.4 million in funding offered to five projects. In the second phase, announced in March 1997, $44 million was offered to 16 projects. Funding of up to $45 million was announced in December 1997 as the third phase.

As part of the March 1997 Small Business Statement, the Prime Minister announced the Small Business Innovation Fund (SBIF), a scheme to help small, technology-based companies gain access to equity finance (venture capital). The Fund was revised in 1997 and repackaged as the Innovation Investment Fund (IIF).

The Fund is an element of the Government's R&D Start Program. It will provide $130 million on a 2:1 basis with private-sector capital, thereby creating potential funding of $195 million. This funding will allow for the creation of up to six early-stage investment funds in the range of $30 million-$50 million. These funds will be managed by private sector fund managers. The funds will be restricted to investing in technology companies with an annual revenue of $4 million or less, averaged over the previous two years. Fund managers were announced in December 1997.

The Government also supports Business Expenditure on R&D (BERD) through the 125% tax concession, which is expected to cost $286m in revenue foregone. Under the tax concession, firms determine the level and direction of R&D. In contrast, R&D Start applicants depend on the discretion of the Industrial Research and Development (IR&D) Board.

(ii) The *Invest Australia* program was established in December 1997 to market Australia as an investment location. It subsumed the Investment Promotion and Facilitation Program (IFP) and has been allocated funding of $28 million.

(iii) The *Technology Support Centres Program* is designed to facilitate the establishment of a national network of Technology Support Centres to improve industry's access to technology and technical advice. The program offers competitive grants in three categories: Network Grants; Technology Demonstration and Awareness Grants; and Feasibility Studies.

(iv) The *AusIndustry Enterprise Improvement Program* is a joint Commonwealth/State program which provides extension services to firms in the traded goods and services sectors to increase internal efficiency and international competitiveness ($32.6m in 1997-98).

(v) The *AusIndustry Enterprise Networking Program* is designed to encourage small to medium-sized enterprises to cooperate with other firms in strategic areas of business to exploit opportunities beyond the reach of the individual firms. Support is available to establish networks, including customer-supplier, innovation and lead firm networks ($8.2m in 1997-98).

(vi) The *Australian Technology Group Limited* (ATG), a technology commercialisation company specialising in investment and management of early stage commercialisation of research outcomes from the public and private sectors.

(vii) The *Pharmaceutical Industry Development Program*, of which the Factor (f) Scheme is a major element, contributes to the development of an internationally competitive pharmaceutical industry in Australia. Under Factor (f), companies can gain increased prices for some of their products listed on the Pharmaceutical Benefits Scheme in return for increased activity in Australia, including new investment, production, research and development. The Factor (f) Scheme will be succeeded by the Pharmaceutical Industry Investment Program.

(viii) The *Telecommunications Industry Development Plans* encourage the licensed telecommunications carriers and key suppliers to undertake strategic investment, R&D and export activities in Australia which are internationally competitive.

(ix) The *Partnerships for Development and Fixed Term Arrangement Programs* encourage international companies in the information technology and telecommunications industries to undertake strategic investment, R&D and export activities in Australia which are integrated into the global marketplace.

(x) The *Renewable Energy Industry Program (REIP)* aims to facilitate the development of a viable internationally competitive Australian renewable energy industry. The program aims to improve the competitiveness of the industry by the development of critical mass and increased access to export markets. Financial assistance is available on a competitive basis for projects which are already technologically proven, yet require assistance with commercialisation and/or market development.

(xi) The Major National Research Facilities (MNRF) Program is directed at keeping Australia at the leading edge of scientific and technological developments. Under the Program, funding is provided for facilities in a range of key scientific fields where the establishment costs are beyond the capacity of any individual Australian institution. These facilities will create centres of capability for pursuing research with state-of-the-art equipment ($16.3m in 1997-98).

Rural R&D

R&D Corporations and Councils were established to:

- attract a higher level of industry expenditure on R&D by providing funding incentives from statutory levies;
- maximise the benefits to both industry and the general community by integrating public and private good R&D;
- achieve effective transfer of technology and a high rate of adoption and commercialisation of research by placing emphasis on the total innovation process;
- cause the research undertaken to operate in a commercial environment relatively free from Government control of their R&D investment while making research managers fully accountable to both industry and Government.

There are currently twelve rural industry R&D Corporations, and one rural industry R&D Council:

- Australian Wool Research and Promotion Organisation;
- Cotton R&D Corporation;
- Dairy R&D Corporation;
- Fisheries R&D Corporation;
- Forest and Wool Products R&D Corporation;
- Grains R&D Corporation;
- Grape and Wine R&D Corporation;
- Horticultural R&D Corporation;
- Meat Research Corporation;
- Pig R&D Corporation;
- Sugar R&D Corporation;
- Tobacco R&D Corporation;
- Dried Fruits R&D Council.

The R&D Corporations and the R&D Council are jointly funded by industry and the Commonwealth, with Commonwealth contributions generally matching on a dollar-for-dollar basis levies (or export charges) up to a maximum of 0.5% of the industry's gross value of production (GVP). Beyond the GVP limit, no Government funds are provided to match levies (or export charges). Exceptions to these arrangements are the Fisheries R&D Corporation which, in addition to appropriation funding of 0.5% GVP, has dollar-for-dollar matching up to 0.25% of GVP, and the Forest and Wood Products R&D Corporation which receives one Commonwealth dollar for every two industry dollars matching up to 0.25% of GVP. Commonwealth Government support to the rural R&D Corporations is estimated at $145 million for 1997-98 (Table 3).

Table 3: Commonwealth Support for R&D Corporations

Organisation	Commonwealth support 1997-98 (est) $m
Wool	13.5
Meat	23.8
Fishing Industry	7.8
Grains	33.0
Horticulture	14.9
Land & Water	10.9
Rural Industries R&D Corporation	10.8
Other rural research	30.6

CSIRO

1997-98 is the first year of a new funding triennium for CSIRO. CSIRO's budget for the new triennium was agreed with the Government at the time of the 1996-97 Budget. There is to be increased allocation of appropriation funds to Marine and Petroleum Sectors, with some reduction of funds for the Building Materials Component of the Infrastructure (Built Environment) sector.

Table 4 shows CSIRO staff numbers by Division by State, as the most accessible representation of the location of CSIRO funding.

Table 4: Staff numbers — CSIRO by division by State at June 1997

	State									
	ACT	**NSW**	**NT**	**OS**	**QLD**	**SA**	**TAS**	**VIC**	**WA**	**Total**
	EFT ratio SUM	EFT ratio SUM	EFT ratio SUM	EFT ratio SUM	EFT ratio SUM	EFT ratio SUM	EFT ratio SUM	EFT ratio SUM	EFT ratio SUM	
Cost Centre										
Animal								248.42		
Animal	1.00	148.17							37.02	
Human		1.00				91.15				
Plant Industry	326.97	48.80			3.83				26.40	
Entomology	236.03	8.40	6.54	1.00	35.82	2.60			8.00	
Wildlife and	161.92	1.00	36.88		23.95				14.00	
Soils	36.74				26.40	88.24			7.00	
Horticulture		4.00	6.00		8.00	35.66		31.36	1.00	
Trop Crops & Pasture					198.78					
Forestry	116.28					15.68	24.43	99.18	17.00	
Food Sci & Tech		96.09			59.86			56.80		
Biometrics Unit		3.58					1.00	2.90		
Biometrics Unit					4.00				5.00	
Coal and Energy		172.49			7.00					
Wool Technology		5.60						248.37		
Fisheries					56.60		128.16		15.22	
Petroleum		26.00						32.36	1.00	
Water	80.01	69.42				19.00			62.00	
Minerals		36.00			21.60			192.28	44.80	
Oceanography							99.49		2.00	
Applied Physics		264.24						10.00		
Information	64.01	28.45						27.18		
Radiophysics		195.19								
Atmospheric							1.00	135.98		
COSSA	16.90									
Biometrics Unit	5.00					2.00				
Floreal Park Site									21.85	
Manufacturing		13.00			26.00	60.60		86.60		
Maths and	6.62	53.73				9.10		17.83	7.00	
Biomolecular		57.64						90.64		
Materials Sci &								137.56		
Trop Animal Producn					125.66					
Building Const &		64.71			5.00			184.71		
Expn Mining	2.00	66.25			90.18				84.29	
Chemicals &		2.00						168.87		
CCMAR									6.88	
Environmental	37.09									
Aust	2.00	106.30								
Publishing								49.25		
INRE Projects	9.20									
Oceanographic RV							9.52			
Executive	51.59	18.00	0.33		2.48	3.74	1.79	11.08		
Corporate	121.24	4.00			2.00	1.00	1.49	39.41	2.00	
TOTAL	1274.60	1494.06	49.75	1.00	697.16	328.77	266.88	1870.78	362.46	6345.46
PERCENTAGE	20%	24%	1%	0%	11%	5%	4%	29%	6%	100%

Source: CSIRO

Other R&D Agencies and Programs

The Defence Science and Technology Organisation is primarily responsible for Australia's research effort in this field. Details of most projects are confidential and hence it is not possible to identify funding levels or location. Western Australia appears to receive very little by way of funding with most going to research groups in Melbourne and Adelaide.

Following a two year review, the Australian Nuclear Science and Technology Organisation (ANSTO) has implemented a strategic plan for 1997-2000. Its budget estimate for 1997-98 is $70.4 million. It does not appear as if any of this funding is spent in Western Australia.

The Energy R&D Corporation (ERDC) has a 1997-98 estimated appropriation of $10.2m, with approximately matching industry contributions. In the May 1997 Budget, the Government announced that ERDC would be abolished, with no new contracts to be entered into. It appears possible that some new conduit for energy R&D funding will emerge in the context of global climate change.

Other Commonwealth agencies with significant budgets include the Australian Bureau of Agricultural and Resource Economics and the Australian Geological Survey Organisation. Both organisations are Canberra-based and although the States are beneficiaries of their work, most expenditure is almost certainly incurred in Canberra.

Industry Sector Research and Development

Business expenditure on R&D in 1995-96 was estimated to be $4,243 million at current prices, an increase of 22% over 1994-95. There were large increases of $213 million (74%) in the mining sector and $498 million (26%) in the manufacturing sector. Other industries increased by $42 million (3%). BERD as a percentage of Gross Domestic Product (GDP) was 0.87% for 1995-96. This was the highest level recorded (ABS, Research and Experimental Development, Business Enterprises, 1995-96).

Most R&D expenditure by businesses was directed towards economic development (91%). Of this, 56% was towards manufacturing, 15% towards information and communications services and 10% towards mineral resources excluding energy. Manufacturing and process technologies and engineering (17%), computer software (11%) and mechanical and industrial engineering (10%) were the three most important groups.

Manufacturing industries accounted for the largest proportion of expenditure by enterprise group at $2,430m (57% of total R&D expenditure, Table 5). The largest sections of manufacturing were those involved in electrical and electronic equipment (20% of the manufacturing total), motor vehicles and other transport (17%) and metal products (14%). The second largest enterprise group was business and property services with 14% of total expenditure followed by mining enterprises with 12%.

Table 5: R&D, Industry of Enterprise[a]

ANZSIC code	Industry of enterprise Description	ENTERPRISES 1993-94r no.	1994-95r no.	1995-96 no.	EXPENDITURE ON R&D 1993-94r $m	1994-95r $m	1995-96 $m	HUMAN RESOURCES DEVOTED TO R&D ..... 1993-94r person years	1994-95r person years	1995-96 person years
B	Mining (including services to mining)	86	99	130	330.9	287.3	500.5	840	903	975
	Manufacturing									
21	Food, beverage and tobacco	130	178	193	140.2	141.8	292.6	1156	1132	1319
22	Textile, clothing, footwear and leather	51	62	64	18.0	28.0	21.0	182	211	203
23	Wood and paper product	33	45	36	106.2	79.3	182.1	230	256	258
24	Printing, publishing and recorded media	34	44	51	10.8	15.1	20.3	121	174	197
25	Petroleum, coal, chemical and associated product	305	363	368	272.9	320.1	348	2140	2460	2498
26	Non-metallic mineral product	50	77	87	31.3	45.3	80.3	274	427	376
27	Metal product	182	244	249	301.9	324.1	336.0	1803	2020	2030
281-282	Motor vehicle and part and other transport equipment	124	144	148	269.7	336.5	408.9	1915	2025	2275
283	Photographic and scientific equipment	110	114	119	105.0	126.3	134.0	1008	1128	1253
284-285	Electronic and electrical equipment and appliance	444	444	445	370.7	415.1	480.3	3788	3880	4005
286	Industrial machinery and equipment	251	291	312	78.3	80.8	107.0	852	932	1018
29	Other manufacturing	62	94	97	14.6	19.2	20.5	161	233	218
C	*Total manufacturing*	*1776*	*2100*	*2169*	*1719.6*	*1931.6*	*2429.9*	*13629*	*14876*	*15650*
	Other industries									
F-G	Wholesale and retail trade	266	263	250	229.2	207.4	233.9	1786	1689	1705
K	Finance and insurance	29	36	33	119.1	100.9	113.1	1198	979	1095
77,782-786	Property and business services	584	673	739	449.9	583.3	578.2	4160	4916	4893
781	Scientific research	71	77	83	90.5	118.4	147.4	810	933	917
[b]	Other n.e.c.	109	136	148	180.7	260.7	239.9	1338	1388	1335
D-Q	*Total other industries*	*1059*	*1185*	*1253*	*1069.4*	*1270.6*	*1312.5*	*9292*	*9905*	*9945*
	Total all industries	**2921**	**3384**	**3552**	**3120**	**3489.5**	**4242.9**	**23761**	**25684**	**26570**
	Private sector contribution	2886	3335	3511	2886.7	3153.3	4063.3	21655	23509	24921
	Public sector contribution	35	49	41	233.3	336.3	179.6	2105	2175	1650

[a] Excludes enterprises in ANZSIC Division A.
[b] ANZSIC codes D, E, H-J, M-Q.

Source: ABS

The business sector provided most of the funds (86%) for its own R&D investments with only 6% from Other business enterprises and 2% from the Commonwealth Government (Table 6). The Commonwealth funds through the Grants for Industry R&D scheme (GIRD) were mostly utilised in the manufacturing and business and property services sectors. Other Commonwealth business assistance sources also went into manufacturing with scientific research also a major recipient. Overseas funding contributed $130 million or 3%. In contrast, the scientific research industry provided only 31% of funds itself, with another 30% provided from other businesses and other Australian sources providing 19%.

Industry emphasis was fairly diverse with $712 million (17%) of the expenditure in manufacturing and process technologies and engineering, $466 million (11%) in computer software $415 million (10%) in mechanical and industrial engineering, $349 million (8%) in mining and minerals processing and $75m (2%) in agricultural sciences (Table 7).

Table 6: Source of Funds for Industry R&D[a]

ANZSIC code	Industry of enterprise Description	Total $'000	Own funds $'000	Other business enterprises $'000	GIRD Scheme [b] $'000	Other C'wealth gov't $'000	State and local gov't $'000	Other Aust. [c] $'000	Overseas $'000
B	Mining (including services to mining)	500454	472480	n.p.	-	380	360	497	n.p.
	Manufacturing								
21	Food, beverage and tobacco	292585	285433	4258	1144	n.p.	n.p.	287	-
22	Textile, clothing, footwear and leather	20981	20981	n.p.	-	n.p.	-	-	-
23	Wood and paper product	182123	n.p.	-	-	-	-	n.p.	-
24	Printing, publishing and recorded media	20277	19201	n.p.	135	n.p.	-	590	-
25	Petroleum, coal, chemical and associated product	347951	323781	4280	474	15	n.p.	n.p.	n.p.
26	Non-metallic mineral product	80313	79467	n.p.	n.p.	n.p.	n.p.	-	-
27	Metal product	334979	330128	2879	323	774	n.p.	n.p.	469
281-282	Motor vehicle and part and other transport equipment	408884	380839	n.p.	358	n.p.	87	n.p.	n.p.
283	Photographic and scientific equipment	134045	107408	2337	1324	n.p.	275	3923	n.p.
284-285	Electronic and electrical equipment and appliance	480315	380186	60384	4572	n.p.	n.p.	5547	3665
286	Industrial machinery and equipment	106974	102137	3509	401	n.p.	n.p.	n.p.	n.p.
29	Other manufacturing	20504	19544	243	364	n.p.	n.p.	n.p.	-
C	*Total manufacturing*	*2429933*	*2231158*	*95777*	*9373*	*46179*	*1839*	*14550*	*31057*
	Other industries								
F-G	Wholesale and retail trade	233918	198112	3740	989	1436	-	n.p.	n.p.
K	Finance and insurance	113089	106678	107	n.p.	-	-	n.p.	-
77,782-786	Property and business services	578243	435847	57742	5151	5023	1677	32451	40352
781	Scientific research	147394	46012	44904	n.p.	21908	n.p.	27302	3883
[d]	Other n.e.c.	239885	177957	n.p.	1319	3219	n.p.	1079	n.p.
D-Q	*Total other industries*	*1312530*	*964606*	*n.p.*	*7682*	*31587*	*9352*	*67782*	*n.p.*
	Total all industries	**4242916**	**3668244**	**255251**	**17054**	**78146**	**11551**	**82829**	**129840**
	Private sector contribution	4063286	3498766	253046	n.p.	n.p.	n.p.	81861	n.p.
	Public sector contribution	179630	169478	2206	n.p.	n.p.	n.p.	968	n.p.

[a] Excludes enterprises in ANZSIC Division A.
[b] Grants for Industry R&D Scheme.
[c] Includes Higher Education and Private Non-profit sectors.
[d] ANZSIC codes D, E, H-J, M-Q.

Source: ABS

Table 7: Resources Devoted to R&D, by Field of Research[a]

FIELD OF RESEARCH	Total	TYPE OF EXPENDITURE ..... Capital expenditure	Labour costs [b]	Other current expenditure	Human resources
	$'000	$'000	$'000	$'000	person years
Natural sciences, technologies and engineering					
Mathematical sciences	9820	663	3279	5879	57
Physical sciences	44529	3387	15918	25223	258
Chemical sciences	151946	19047	49260	83639	891
Earth sciences	137822	18757	38177	80889	519
Information systems and technologies	268601	24518	144629	99453	2300
Computer software	466321	32100	263624	170597	4308
Communications technologies	351239	30621	153055	167563	2450
Other information, computers and communication technologies	155365	16688	80015	58663	1295
Manufacturing and process technologies and engineering	712666	105979	177769	428918	3092
Industrial biotechnology and food sciences	191069	33621	62005	95443	1042
Material sciences and technologies	208155	33486	72777	101892	1226
Other applied sciences and technologies	120377	15378	49375	55623	899
Mechanical and industrial engineering	414823	332233	164156	218433	2803
Mining and mineral processing	348720	49038	41150	258532	688
Other general engineering	308588	45429	123405	139753	2274
Biological sciences	72285	4582	25590	42113	423
Agricultural sciences	75121	11066	29752	34303	575
Medical and health sciences	197571	24677	77591	95303	1390
Total natural sciences, technologies and engineering	*4235018*	*501271*	*1571527*	*2162219*	*26488*
Social sciences and humanities					
Social sciences	6902	800	3991	2111	79
Humanities	997	866	104	27	4
Total social sciences and humanities	*7898*	*1666*	*4095*	*2138*	*83*
Total	**4242916**	**502937**	**1575622**	**2164357**	**26570**

[a] Excludes enterprises in ANZSIC Division A.

[b] Includes wages and salaries, overtime allowances, penalty rates, leave loadings, bonuses, commission payments, all paid leave, employer contributions to superannuation and pension schemes, payroll tax, fringe benefits tax, payments to contract staff on the payroll, severence, termination and redundancy payments and workers compensation insurance.

Source: ABS

The emphasis of business investments raises a number of issues with respect to government programs. The correlation between R&D sectors has been addressed by the Bureau of Industry Economics in its 1996 report *Science System — International Benchmarking*.

In most countries, including Australia, there is a low correlation between the distribution by fields of study in business R&D compared to higher education research. This reflects the fact that while business R&D is concentrated in engineering and software, the R&D conducted in universities is mainly concerned with the medical and natural sciences. Engineering and software includes all branches of engineering as well as metallurgy, material science, software development, electronics and other applied R&D work related to information technology and telecommunications. Natural science includes both basic research that is difficult to

commercialise (eg mathematics, particle physics, astrophysics, meteorology and biology) and more applied research (eg applied chemistry, biotechnology, geology and remote sensing) where the commercialisation prospects are stronger.

Table 8: Shares of R&D Expenditure by Broad Discipline

	Agriculture	Medical Science	Natural Science	Eng'g and software	Total
Australia (1992-93)					
Business R&D	0.0	4.2	18.2	77.6	100.0
Higher Education	7.6	27.3	42.4	22.7	100.0
Government agencies	31.9	7.6	30.2	30.4	100.0
HE funded by business	2.3	2.5	2.5	5.7	3.2
OECD unweighted avg					
Business R&D	0.8	6.9	17.7	74.6	100.0
Higher Education	8.2	29.9	35.1	26.8	100.0
Government agencies	23.3	11.1	31.7	33.8	100.0
HE funded by business	3.7	3.6	3.6	7.3	4.4

Source: BIE calculations using OECD (1993a). The total excludes social science.

National Distribution of R&D Investment

This section places broad categories of R&D performed in Western Australia in the context of national expenditure.

The leading States in terms of the location of General Government and Private Non-Profit (PNP) Organisations expenditure on R&D were NSW at $509 million and Victoria at $430 million, accounting for 26% and 22% of total expenditure respectively (Table 9). Next in order were Queensland (14%), SA (13%), the ACT (10%) and WA (7%). The ranking was the same as 1992-93 except for NSW replacing Victoria as the leading State.

The Western Australian government provided 12% of the total State Government contributions ranking the State fourth as an R&D contributor behind NSW, Queensland and Victoria. In contrast, expenditure in the State by the Commonwealth was only 4% of the national total.

Sectors in which the State received high shares of total government and PNP expenditure included commercial services (28%), environmental management (24%), energy resources (19%), social services (17%) and plant industries (13%).

Sectors in which the State incurred very small proportions of government and PNP expenditure included defence (0%), manufacturing (1%), fundamental research into the natural sciences associated with knowledge advancement (2%), social development and community services (2%), energy supplies (2%), information and communication services (3%) and health (4%).

Surprisingly, the State receives only a small share of total government and PNP investment in the minerals sector (12%) and energy (14%).

Economic development was the predominant socio-economic objective (SEO) of R&D expenditure in all States, except for SA, where most expenditure was directed towards Defence, and Tasmania and the Northern Territory where Environment was the major objective.

Table 9: Location of Government and PNP R&D Expenditure, by Socio-economic Objective, 1994-95 ($'000)

		Location of expenditure								
Socio-economic objective	Total	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Other [(a)]
Defence	**223099**	**12666**	**69925**	**420**	**130287**	**14**	**1659**	**-**	**7530**	**597**
Economic development										
Plant - production and primary products	269964	44842	39599	70962	20025	35666	10751	3709	41863	2547
Animal - production and primary products	267955	74209	53236	54485	24875	25356	8561	13807	12120	1305
Mineral resources (excl. energy)	68049	13664	16869	21736	364	8559	22	272	6023	538
Energy Resources	59660	12326	10147	3651	106	11354	3083	4428	4121	10444
Energy supply	27157	17188	6461	449	214	679	-	284	1834	49
Manufacturing	229951	84665	96513	21092	7494	2376	205	819	9164	625
Construction	31109	9012	17246	2010	700	1136	108	9	840	47
Transport	18347	3242	5566	5380	332	1131	30	-	2667	-
Information and Communications services	37269	9681	6757	4295	3495	959	368	93	11473	149
Commercial services	10468	3015	499	623	1684	2899	8	49	1692	-
Economic framework	28027	10769	1492	540	250	1580	24	150	13223	-
Total economic development	**1040955**	**282613**	**254384**	**185223**	**59538**	**91695**	**23159**	**23619**	**105021**	**15704**
Society										
Health	209350	74471	47150	26059	36850	9426	2099	4630	8380	284
Education and training	7429	826	632	1856	911	784	663	797	877	85
Social development and community services	41125	11620	6337	1285	1608	2450	1209	1515	14857	245
Total society	**257904**	**86917**	**54118**	**29200**	**39369**	**12659**	**3971**	**6942**	**24114**	**614**
Environment										
Environmental knowledge	206197	44101	24418	26375	6940	17325	37305	17665	29558	2810
Environmental aspects of economic development	108409	27505	17035	17582	11597	5826	1750	4422	21983	710
Environmental management and other aspects	55212	17500	1428	6427	1609	13355	3328	2083	9072	411
Total environment	**370118**	**89106**	**42881**	**50384**	**20146**	**36506**	**42383**	**24170**	**60613**	**3931**
Advancement of knowledge										
Natural sciences, technologies and engineering	69674	36714	8053	7513	1770	1216	7570	2823	3480	535
Social sciences and humanities	2925	705	430	92	77	499	49	825	233	15
Total advancement of knowledge	**72599**	**37419**	**8483**	**7605**	**1848**	**1715**	**7619**	**3648**	**3713**	**550**
TOTAL	**1964676**	**508719**	**429791**	**272832**	**251187**	**142589**	**78792**	**58379**	**200990**	**21397**
Commonwealth contribution	1178394	258741	294925	102549	167571	47629	56982	33526	197262	19209
State contribution	786282	249978	134866	170283	83616	94961	21810	24852	3728	2188

[(a)] Includes Australian External Territories and overseas.

Source: ABS

The top three States (NSW, Victoria and Queensland) had virtually the same proportions as they had of government and PNP expenditure, i.e. 26%, 22% and 14% respectively. The ACT and WA had significantly higher proportions while SA had a significantly lower proportion.

The leading States in terms of location of higher education R&D expenditure in 1995 were NSW at $553 million and Victoria at $444 million, accounting for 27% and 22% of total expenditure respectively (Table 10). Next in order were Queensland (15%), the ACT (14%), WA (10%), SA (9%), Tasmania (2%) and the Northern Territory (1%). The ranking was the same as in 1994.

Western Australia had high expenditure levels in the natural sciences, social sciences and environmental knowledge followed by the mineral resources and plant industry sectors.

Table 10: Location of Higher Education Expenditure, by Socio-economic Objective

Socio-economic objective	Aust. $'000	NSW [a] $'000	Vic. $'000	Qld $'000	SA $'000	WA $'000	Tas. $'000	NT $'000	ACT [b] $'000
Defence	6502	379	1859	679	1328	239	-	136	1882
Economic development									
Plant - production and primary products	60152	4795	8090	10721	13619	10044	3662	933	8287
Animal - production and primary products	47420	12438	13779	9566	3356	6479	933	639	230
Mineral resources (excl. energy)	33301	5335	3311	7639	2371	11016	2415	-	1214
Energy Resources	13320	3572	341	3726	1437	4067	178	-	-
Energy supply	13287	2377	4229	1868	2024	954	98	359	1378
Manufacturing	95763	32561	26507	16737	8223	6227	934	128	4447
Construction	24792	7345	8267	2785	813	4170	556	-	856
Transport	9260	1913	2895	1537	1010	616	54	3	1233
Information and Communications services	35550	10530	8737	5564	4772	1479	143	23	4291
Commercial services	10594	4275	2969	1572	695	836	21	138	88
Economic framework	70648	*22881*	13942	10887	3132	7542	1510	293	10461
Total economic development	*414088*	*108023*	*93068*	*72602*	*41449*	*53430*	*10505*	*2524*	*32486*
Society									
Total society	*502877*	*114054*	*145612*	*73956*	*52645*	*55118*	*9773*	*3670*	*48049*
Environment									
Environmental knowledge	98192	18749	16074	16380	7794	12388	4561	953	21292
Environmental aspects of economic development	23738	7395	4348	4307	3279	1844	11433	362	1059
Environmental management and other aspects	23280	7207	3246	5235	1975	2160	986	733	1738
Total environment	*145211*	*33351*	*23667*	*25922*	*13048*	*16392*	*6690*	*2049*	*24090*
Advancement of knowledge									
Natural sciences, technologies and engineering	676227	209191	124875	94869	65783	54235	16262	2053	108958
Social sciences and humanities	294191	88314	54939	46040	11981	21191	4119	3792	63814
Total advancement of knowledge	*970418*	*297505*	*179814*	*140909*	*77764*	*75427*	*20381*	*5845*	*172773*
TOTAL	**2039094**	**553312**	**444021**	**314068**	**186234**	**200607**	**47349**	**14224**	**279279**

[a] Includes Australian Catholic University.

Source: ABS

The leading States in terms of business R&D expenditure were NSW at $1,558 million and Victoria at $1,443 million, accounting for 37% and 34% of total expenditure respectively (Table 11). New South Wales' proportion of total R&D remained the same compared with 1994-95 while Victoria's decreased 3%. Queensland increased its share of total R&D from 8% in 1994-95 to 10% in 1995-96.

In Victoria and South Australia, the main industry undertaking R&D was motor vehicle and parts and other transport equipment manufacturing and in Queensland and Western Australia it was mining. The main industry in NSW was property and business services.

Mining enterprises accounted for over 40% of Western Australian expenditure followed by property and business services (12%) and metal products (12%).

Table 11: Location of Business R&D Expenditure by Industry[a] [b]

ANZSIC code	Industry of enterprise Description	Total $'000	NSW $'000	Vic. $'000	Qld $'000	SA. $'000	WA $'000	Other Aust. States and Territories $'000	Overseas $'000
B	Mining (including services to mining)	500454	138834	51337	117912	7083	171702	11152	2434
	Manufacturing								
21	Food, beverage and tobacco	292585	83328	110226	44513	4965	n.p.	2343	n.p.
22	Textile, clothing, footwear and leather	20981	4932	8631	2130	2452	2666	n.p.	n.p.
23	Wood and paper product	182123	37466	n.p.	n.p.	7051	n.p.	n.p.	17
24	Printing, publishing and recorded media	20277	7092	8619	167	325	2855	n.p.	n.p.
25	Petroleum, coal, chemical and associated product	347951	118114	134589	27282	39783	22407	3165	2611
26	Non-metallic mineral product	80313	46307	10187	12952	2216	7745	n.p.	n.p.
27	Metal product	334979	137238	116041	22121	7237	51706	n.p.	n.p.
281-282	Motor vehicle and part and other transport equipment	408884	44188	275286	24882	70829	10878	2312	10510
283	Photographic and scientific equipment	134045	67271	22386	6718	30722	4200	n.p.	n.p.
284-285	Electronic and electrical equipment and appliance	480315	197348	157697	48119	35019	21566	n.p.	n.p.
286	Industrial machinery and equipment	106974	36279	27458	22817	7875	10329	1194	1022
29	Other manufacturing	20504	6985	n.p.	n.p.	449	n.p.	175	62
C	*Total manufacturing*	*2429933*	*786548*	*960621*	*250102*	*179012*	*188160*	*36465*	*29025*
	Other industries								
F-G	Wholesale and retail trade	233918	110695	67521	10530	29545	9529	4913	1184
K	Finance and insurance	113089	68060	40832	n.p.	-	4025	n.p.	-
77,782-786	Property and business services	578243	336284	118900	37597	14873	54251	10595	5745
781	Scientific research	147394	66067	49325	15716	6753	4827	n.p.	n.p.
[c]	Other n.e.c.	239885	51511	154431	n.p.	2324	5182	16188	n.p.
D-Q	*Total other industries*	*1312530*	*632617*	*431008*	*74080*	*53495*	*77813*	*35175*	*8341*
	Total all industries	**4242916**	**1557999**	**1442966**	**442094**	**239590**	**437675**	**82792**	**39800**
	Private sector contribution	4063286	1493374	1354165	438886	238508	431810	66824	39720
	Public sector contribution	179630	64625	88801	3208	1082	5865	15968	80

[a] Location of the expenditure. This may not be the location of the organisation's head office.
[b] Excludes enterprises in ANZSIC Division A.
[c] ANZSIC Codes D, E, H-j, M-Q.

Source: ABS

Table 12: Summary of R&D Funding by Location[1]

	NSW	Vic	Qld	SA	WA	Tas	Totals[2]
Population (m)	6.2	4.6	3.3	1.5	1.8	0.5	18.3
Commonwealth Government ($m)	259	295	103	168	48	57	1,178
Commonwealth Government ($ per capita)	41	64	31	112	26	114	786
State Government ($m)	250	135	170	84	95	22	2,039
State Government ($ per capita)	40	29	52	56	52	44	4,243
Higher Education ($m)	553	444	314	186	201	47	
Higher Education ($ per capita)	89	96	95	124	111	94	
Business ($m)	1,558	1,443	442	240	440	n/a	
Business ($ per capita)	251	313	133	160	244	n/a	
Total ($m)	2,649	2,317	1,029	678	784	n/a	
Total ($ per capita)	422	503	311	452	435	n/a	

Notes:
(1) This compilation involves data from 1994-95 to 1995-96, and is indicative only.
(2) Includes NT and ACT, not shown individually.

An examination of per capita expenditure for all R&D (Table 12)shows:

- Western Australia ($26 per head) clearly receives the least amount of Commonwealth Government expenditure per head of population. At the other end of the scale, South Australia receives $112 per head, attributable in part to the high level of defence R&D in that State;

- Western Australia is at the upper end of the expenditure for funds contributed by the State Government at $52 per head;
- Western Australia has the second largest higher education expenditure at $111 per head;
- Western Australia($244 per head) is on a par with NSW for business investment in R&D, well ahead of South Australia and Queensland;
- overall, Western Australia ranks third, behind Victoria and South Australia, and just ahead of NSW.

Conclusions

The channels of advice and funding mechanisms at the Commonwealth level are diverse and complex. It takes time and effort to maintain an up to date understanding of the process and changes in emphasis. Western Australia is at a disadvantage with its isolation from the Canberra networks i.e. there a 'tyranny of distance' problem.

Commonwealth Government industry policy is in a state of flux, with consideration being given by the Government to reports from Mortimer, Goldsworthy, Stocker, the Industry Commission, the Business Council of Australia, the Metal Trades Industry Association, plus more general political pressures for the Government to be seen to be 'doing something' about unemployment. The outcome of these deliberations will impact on R&D. Western Australia will want to 'get in early', if possible while these decisions are being developed but certainly before specific programs are put in place. Such Western Australia involvement could relate to program design, sectors where Western Australia is strong and/or membership of funding bodies. This report will assist the State Government to approach this process in an informed manner but the timing of this report also creates difficulties in providing firm advice on Federal programs given the strong likelihood of changes to these programs.

The business sector is the largest investor in R&D in Australia and its importance is growing faster than any other sector. A significant influence on the level of investment is the incentives offered by the Commonwealth Government through the taxation system and a range of R&D support programs. Any change to the business investment environment thus has the potential to create a greater change in R&D levels than any other factors. The State Government can play a part in maintaining a favourable environment by stressing the importance of the business sector at all opportunities and by arguing for a suitable taxation write-down level.

While business is the largest investor, the higher education sector is the largest employer of R&D staff which is not surprising given its education and training role.

Commonwealth agencies are the third largest R&D group of investors followed by the State Governments. Although the States are all active in R&D, their overall contribution is relatively modest.

It is a reasonable *prima facie* assumption that the quantum of Commonwealth R&D funding will not increase greatly, if at all. Thus a central question for the present study is how to access more efficiently the funds now available — which may be delivered in different ways, depending on the future directions of industry policy.

The allocation of higher education funding to the universities is done using well developed and complex formula or competitive processes. A key focus in most ARC grant processes is the quality of the research group and the proposal.

The Western Australian Government and higher education sector need to be fully aware of the way in which ARC funding formulae operate and should actively contribute to the development of ARC policies and funding formulae.

The State Government, through the Department of Commerce and Trade, should provide incentives which encourage the formation of collaborative higher education groups to bid for ARC projects.

The Commonwealth funded CRC program has been successful in creating 62 centres with joint university/industry and frequently State Government involvement.

Western Australia receives a fairly small share of Commonwealth R&D funding but has a strong share of higher education funding and business R&D. The State is the lowest per capita recipient of Commonwealth funding evidenced in the low levels of government funding for defence, manufacturing, natural sciences, energy supply, information and communications and health. There are some high government expenditure levels in other sectors which partially offset these.

Appendix 5:
Funding Organisations

Appendix 5:
Funding Organisations

Contents

PAGE

FUNDING ORGANISATIONS

Introduction

This chapter summarises the allocation and selection criteria used by funding providers. It is essentially about the funding principles rather than the funding levels. The emphasis is on Commonwealth Government funding with smaller sections on private sector and overseas funding sources. The processes for selection of R&D projects by the private sector are not generally made public and are hence discussed in terms of rationales rather than specific criteria.

As will have become evident, there are two main approaches taken by government funding bodies:

- the use of standard formulae; and
- various types of selection committees, each using their own criteria.

Commonwealth Government

Formulae Funding

The non-targeted higher education research and development component of university operating grants, at $1,176 million for 1997-98 is by far the largest single component of Commonwealth R&D expenditure, accounting for about one-third of all funds. This non-targeted funding is based on formulae such as:

- the Research Quantum, which is allocated on the basis of research performance;
- the Research Training Component, estimated on the basis of higher degree research student load developed in 1990 in the context of the Relative Funding Model; and
- the Research Infrastructure Block Grants, allocated on the basis of the National Competitive Grants.

The West review of higher education is likely to be relevant to the future of such formulae.

Australian Research Council (ARC)

The ARC is responsible for advice on allocation of funds for about $320 million targeted higher education funding, including research grants, fellowships and centres. Competitive peer review is conducted through its panels and committees. The primary criteria for the awards is the performance record of researchers and the quality of the proposals, though

some weight may be given to other criteria such as national priority areas and links to industry.

During 1996 and 1997, the Department of Education, Employment and Training and Youth Affairs (DEETYA) and the ARC began implementing a more strategically focused evaluation and monitoring program for the Higher Education Targeted Research Program, to extend the scope of previous evaluation work. This approach is intended to improve accountability and produce more strategic, policy oriented information. It involves reviewing the Program to determine how effectively it has fulfilled specific Government objectives for research and research training and the needs and expectations of particular research disciplines and communities.

In the initial phase of the strategy, the Department and the ARC are reviewing targeted support for biological sciences and industry-linked research, with outcomes expected in early 1998.

Against that background, the process and criteria for allocation of Large Research Grants (LRGs) is used as an example below. The processes and criteria for other granting schemes under the aegis of the ARC are broadly similar to those for the LRGs.

The ARC is supported by four advisory committees, which manage the Council's funding programs:

- Research Grants Committee (RGC);
- Research Training and Careers Committee;
- University-Industry Research Collaboration Committee;
- Committee for International and National Collaboration

The work of the RGC is supported by four discipline panels:

- Biological Sciences;
- Engineering, Earth and Applied Sciences;
- Physical, Mathematical and Chemical Sciences;
- Social Sciences and Humanities.

The membership of the ARC, RCG and the four panels is shown below.

ARC
Professor Vicki Sara (Chair)
Professor Anne Edwards (Deputy Chair), Flinders University of SA
Professor Michael Barber, The University of Western Australia
Dr Marlene Bennett, BHP Research Melbourne Laboratories
Professor Margaret Clunies-Ross, The University of Sydney
Dr Peter Harvey, Kodak (Australasia) Pty Ltd

Professor Ross Milbourne, The University of NSW Professor Peter Robinson, University of Wollongong Professor Merilyn Sleigh, Peptide Technology Limited
RGC
Professor Ross Milbourne, UNSW (Chair) Professor Ray Jarvis, Monash University Professor Don Napper, University of Sydney Professor Mary Chan, UNSW Professor Richard Shine, University of Sydney Professor Ian Sloan, UNSW Professor Evan Leitch, UTS Professor Nigel Bond, UWS Professor Caroline McMillen, University of Adelaide

Discipline Panels of the Research Grants Committee	
Engineering, Earth and Applied Sciences ARC Discipline Panel	**Humanities and Social Sciences Discipline Panel**
Prof Raymond Jarvis, Monash University (Chair) Prof Evan Leitch, University of Technology, Sydney Prof John Booker, University of Sydney **A/Prof Mark Bush, University of WA** A/Prof Ross Coventry, James Cook University A/Prof Judy Raper, University of NSW Prof Patrick Kelly, University of Qld Prof Jason Middleton, University of NSW **Prof Antonio Cantoni, Curtin Uni of Technology** Prof Rao Kotagiri, University of Melbourne Prof Ian Nicholls, Monash University Dr Francis Rose, Aeronautical and Maritime Research Laboratory	Prof Nigel Bond, Uni of Western Sydney (Chair) Prof Mary Chan, University of NSW **Prof Patricia Crawford, University of WA** Prof Beryl Hesketh, Macquarie University Prof Peter Hill, University of Melbourne Prof Graham Hugo, University of Adelaide Prof Genevieve Lloyd, University of NSW Prof Geoffrey Parr, University of Tasmania Dr David Frankel, La Trobe University Prof John Goldring, University of Wollongong Prof Rosemary Pringle, Griffith University A/Prof Marian Sawer, University of Canberra Prof Robert Elson, Griffith University Prof Dianne Austin-Broos, University of Sydney Dr Simon Grant, ANU
Physics, Chemistry and Mathematics Discipline Panel	**Biological Sciences Discipline Panel**
Prof Donald Napper, University of Sydney (Chair) Prof Ian Sloan, University of NSW Prof Ian Dance, University of NSW Dr Neville Fletcher, ANU **Prof Ian James, Murdoch University** Prof Paul Haddad, University of Tasmania Prof Ralph Prager, Flinders University of SA **A/Prof Andris Stelbovics, Murdoch University** Prof Hans Bachor, ANU Prof Robert Leckey, La Trobe University	Prof Caroline McMillen, Uni of Adelaide (Chair) Prof Richard Shine, University of Sydney Prof Gregory Barritt, Flinders University of SA Prof Michael Bryden, University of Sydney Prof Peter Dunkley, University of Newcastle Prof Jennifer Graves, La Trobe University Prof Robert Saint, University of Adelaide Prof James Burnell, James Cook University Dr Derek Eamus, Northern territory University Prof Alistar Robertson, Charles Sturt University Prof Michael Hynes, University of Melbourne

Western Australia has one representative on the ARC, none on the RGC (which has six NSW representatives), one on the Engineering Panel, two on the Physics Panel, none on the Biology Panel and one on the Humanities Panel. Western Australia has one representative (the Chair) on the Research Training and Careers Committee, one representative on the University-Industry Research Collaboration Committee, but none on the Committee for International and National Cooperation. Memberships of these committees are listed below.

The Western Australian Government and higher education sector need to be fully aware of the way in which ARC funding formulae operate and should actively contribute to the development of ARC policies and funding formulae.

University-Industry Research Collaboration Committee

(advises on collaborative grants and APA(Industry))

Professor Peter Robinson (Chair), University of Wollongong
Professor Lesley Johnson (Deputy), UTS
Professor Robert Bilger, University of Sydney
Dr William Blevin, Sydney
Dr Megan Clark, WMC, Boston USA
Professor Trevor Grigg, QUT
Dr Don Nicol, Telstra, Sydney
Dr William Jones, Burnie, Tasmania
Professor Ron Sacks-Davies, Melbourne
Professor David Spottiswood, Curtin University
Professor Paul Baumgartner, University of Western Sydney
Dr Claire Baxter, University of Sydney

Research Training and Careers Committee

(responsible for fellowships and policies relating to research careers)

Professor Michael Barber (Chair), UWA
Dr Janet McCalman (Deputy), University of Melbourne
Dr Halina Rubinsztein-Dunlop, University of Queensland
Professor Andrew Lister, University of Queensland
Professor Belinda Probert, RMIT
Professor Richard Russell, Deakin University
Professor Robert Whelan, University of Wollongong
Professor Derek Robinson, ANU
Professor Stephen Cox, University of Newcastle
Professor Philip Kuchel, University of Sydney
A/Professor Colin Hansen, University of Adelaide
Professor Doug McEachern, University of Adelaide
Professor Lesley Rogers, University of New England

Committee for International and National Cooperation

Professor Vicki Sara (Chair), QUT
Professor Lawrence Cram (Deputy), University of Sydney
Professor Gordon Stanley, Higher Education Council, Canberra
Professor Nick Saunders, Flinders University
Professor Ah Chung Tsoi, University of Wollongong

Dr Carolyn Morris, DSTO, Melbourne
Dr Suzanne Golding, University of Queensland
Professor Ross Large, University of Tasmania
Professor Merle Ricklefs, ANU
Professor Margaret Sedgley, University of Adelaide

Commonwealth Tax Concession for R&D

The large increase in business R&D investment recorded by the ABS is reflected in the number of companies registered for the Commonwealth Government's R&D tax concession, which has been rising steadily since its inception (Table 1).

Table 1: R&D Tax Concession Registrations and Expenditure

	Number of registrations		WA/Aust	R&D expenditure ($m)		WA/Aust
Year	W.A.	Australia	(%)	W.A.	Australia	(%)
1985-86	133	1,837	7.2	0.1	98.4	0.1
1986-87	102	1,411	7.2	31.1	684.1	4.5
1987-88	139	1,953	7.1	44.9	1,044.8	4.3
1988-89	142	2,020	7.0	63.2	1,248.1	5.1
1989-90	170	2,194	7.7	92.0	1,535.0	6.0
1990-91	176	2,347	7.5	126.0	2,073.4	6.1
1991-92	185	2,505	7.4	132.9	2,305.9	5.8
1992-93	181	2,438	7.4	138.1	2,383.1	5.8
1993-94	259	3,158	8.2	198.6	3,207.3	6.2
1994-95	278	3,170	8.8	304.4	3,555.7	8.6
1995-96	480	3,707	12.9	352.7	4,269.9	8.3
TOTAL	2,245	26,740	8.4	1,484.0	22,405.8	6.6

Source: ABS

There has also been an increase in the total amount of concessional R&D expenditure by Western Australian firms registered for the tax concession, and more significantly in their proportion of the national total.

The primary criteria used for the assessment of applications for funding by the ARC are the quality of the proposed research and the quality of the researcher. Consideration is given to the likelihood that the proposed research will lead to a significant conceptual advance, an important discovery or innovation and/or the solution to an important practical problem.

In assessing the quality of the research proposal, the Panel is required to take particular account of:

- the soundness of the planning and methodology;
- the originality of the project;
- the scientific, theoretical or technological merit;
- the capacity of the institution to provide the necessary infrastructure;

- the time and capacity of the researcher(s) to make a serious commitment to the project, i.e. a minimum of 4 days out of 21 working days, to produce the desired outcomes; and
- the scope of the project.

In assessing the quality of the researcher, consideration will be given to the applicant's track record, covering recent research activities and achievements, publications and other outputs, relative to opportunities.

Other criteria used for assessment are:

- ARC Thematic Priority Areas;
- ARC Structural Priorities; and
- the five benefits of research recognised by the ARC.

The thematic priorities for 1998 are:

- citizenship;
- exploration geophysics;
- food science and technology;
- minerals processing science and technology;
- optics; and
- technological change.

In addition the ARC has identified a number of structural priorities arising from the benefits of research identified in its mission statement. These include how the research proposal and its expected outcomes relate to one or more of the benefits of research, which are:

- contributions to the quality of our culture;
- graduates of high quality;
- direct applications of research results;
- increased institutional capacity for consulting, contract research and other service activities;
- international links; and
- early career researchers.

The RGC Panels use a three-stage process:

- an initial culling of applications;
- a request for assessors' reports on all remaining applications; and

- a final selection, taking into account assessors' reports and rejoinders from applicants.

At least five assessors are used, normally only one of which is nominated by the applicants.

Department of Industry, Science and Tourism (DIST) Programs

This Department administers a large number of industry assistance programs. This report concentrates on the three largest.

R&D Start

The four-year R&D Start program provides $500 million for small to medium enterprises (SMEs) to undertake industry research and development (R&D) and related activities. The objectives of R&D Start are to:

- increase the number of private-sector R&D projects with high commercial potential;
- foster greater commercialisation of outcomes from R&D projects;
- foster collaborative R&D and related activities both within industry and between industry and research institutions; and
- increase the level of finance-sector funding of R&D and its commercialisation.

R&D Start has five elements:

- grants for R&D projects undertaken by SMEs to achieve internationally competitive products, processes or services which demonstrate significant commercial potential;
- grants for collaborative R&D projects between research institutions and companies to encourage collaboration on high technical risk projects with substantial national benefits;
- concessional loans, to support small companies in the early commercialisation of technological innovation in goods and services;
- the Innovation Investment Fund (IIF), which aims to stimulate early-stage venture capital for small technology-based companies; and
- grants for graduate-based R&D related projects, to promote new and appropriate linkages between industry and tertiary/research institutions.

The selection criteria for the first **four** of these elements are described below:

Grants for R&D to Small to Medium sized Enterprises (SMEs)

Grants are awarded to companies to support projects which aim to develop internationally competitive products, processes or services with significant commercial potential. Up to 50% of eligible project costs can be funded over a project life of 3 years. Project costs incurred prior to application lodgement are not eligible. SME R&D Grants typically range in size from $50,000 to $5 million.

Companies eligible for the 125% Tax Concession for R&D may be eligible for R&D Grants in SMEs, but a project for which a grant has been awarded will not attract the full benefit under the concession.

Companies that are not tax exempt, that are incorporated in Australia, and had an annual turnover of less than $50 million (including that of related companies) in each of the three previous financial years can apply.

The project must essentially involve research and development, and can also include related product development and related market research activities. It must have clearly identified commercial potential and demonstrate that it could not proceed without R&D Start support.

Research and development is defined as systematic, investigative or experimental activities that:

- involve innovation, technology transfer into Australia or technical risk;
- aim to produce new knowledge or new or improved materials, products, devices, processes or services; and
- are carried out in Australia and its external territories.

Related product development includes work undertaken to improve the performance or reduce the cost of a product, process or service.

Related market research are those activities undertaken directly in support of the project to enhance and/or expand the market research previously undertaken.

Activities involve innovation if they have an appreciable degree of novelty, such as:

- seeking previously undiscovered phenomena, structures or relationships;
- attempting to apply existing knowledge or techniques in a new way; or
- the results are expected to be patentable.

Activities involve technical risk if there is reasonable uncertainty about:

- the results;
- which of several alternatives is technically feasible; or
- whether they will meet a desired technical specification.

The Industry Research and Development Board (IR&D) assess applications on a competitive basis against specified merit criteria:

- Management capabilities of the applicant;
- Commercial potential of the project and the applicant's capacity to exploit that potential;
- Technical strength encompassing technical capabilities, resources of the applicant and the technical soundness of the project;
- National benefits of the project for Australia, including benefits to Australian industry and the wider community; and
- Need for R&D Start funding — the degree to which the project would not proceed satisfactorily without a grant.

All SME R&D Grant applications are assessed against the same merit criteria; however, the standards demanded do vary with the size of the project.

Grants for Collaborative R&D

Grants are awarded to support projects which aim to encourage collaboration between Australian companies and research institutions. Projects may be based on research findings of the institution which it and the company are developing to meet commercial opportunities. Funding is limited to $1 million for up to 50% of eligible project costs over a project life of 3 years. Project costs incurred prior to application lodgement are not eligible.

At least one company (of any size) that is not tax exempt and is incorporated in Australia, together with at least one research institution must be involved. Research institutions can include the CSIRO, universities, tertiary education institutions, government research organisations, Cooperative Research Centres, medical research institutions, and other organisations that, in the opinion of the Board carry out R&D as their main activity.

The selection criteria and process are similar to those for R&D in SMEs. The IR&D Board gives priority to projects where the outcomes have the potential to provide benefits beyond a single company. These benefits may extend to related industries or provide social, economic or environmental benefits to the wider community.

Concessional Loans for the Commercialisation of Technological Innovation

Loans are awarded to small companies to undertake early commercialisation of technological innovation in goods, systems or services. The maximum loan is 50% of eligible project costs.

The loans span a maximum period of six years from the date of issue of the loan agreement. Within the six-year period, the loan draw downs occur within the first three years and then a maximum of three years is available for the repayment of the loan. Loans may be repaid earlier if preferred.

Interest begins to accrue three years from the date of issue of the loan agreement and is at 40% of the Commonwealth Bank Index Rate.

Companies with up to 100 employees can apply. This limit includes employees of related companies within the group. The program is restricted to companies that are unable to adequately fund their commercialisation project through commercial lending sources.

The project must involve the early commercialisation of technological innovations of goods, systems or services. Activities supported include:

- product/process design;
- trial production runs including tooling up costs;
- regulations and standards compliance;
- protection of core intellectual property;
- trial and demonstration activities; and
- product documentation.

Related market research is also eligible where it occurs directly in support of one of the above activities.

The IR&D Board assesses applications on a competitive basis against the following primary merit criteria:

- management capability of the company;
- market need, growth and size — the market potential for the technological innovation that is being commercialised;
- market competitiveness/dynamism — the ease with which the innovation can enter the market;
- technical and production synergy — the level of understanding and capability within the company with regard to commercialising this technological innovation; and

- national benefits — the degree to which the project would benefit Australia, including Australian industry and the wider community.

Innovation Investment Fund

This Fund, also known as the Small Business Investment fund (SBIF), is currently being finalised and formal documentation such as Ministerial Directions and IR&D Board guidelines are not yet available.

The Fund aims to create a self-sustaining Australian early stage, technology-based venture capital market, and to improve the commercialisation outcomes of Australia's strong R&D capabilities. The Fund is to provide $130 million on a 2:1 basis with private-sector capital, thereby creating potential funding of $195 million. The funding will allow for the creation of up to six early-stage investment funds in the range of $30 million to $50 million each.

The funds will be restricted to investing in companies which are commercialising technology, with an annual revenue of $4 million or less, averaged over the past two years, with a maximum of $5 million in any one year. Investments will be in the form of equity — taking a 'stake' in the company and its profits — rather than debt (providing a loan).

Although the IR&D Board itself will determine what is acceptable technology, the following definitions provide some interim guidance of the broad areas in which the IIF funds will operate.

Small new technology-based firms are those which:

- have a strong focus on innovation, technology or knowledge in their products, services or operating systems (i.e. the majority of product lines or sales come from new technology-based products);
- are engaged in commercialising R&D with the prime growth in the firm coming from this commercialisation;
- operate in the traded goods and services sector;
- have a majority of employees (by number) and assets (by value) inside Australia at the time when a licensed fund first invests in or provides finance to them; and
- have an average annual revenue not exceeding $4 million per year over the two years of income prior to a licensed fund investing in them, with revenue not exceeding $5 million in any one of these two years.

Early stage investment includes:

- 'seed' — the period in which the initial concept of a business is being formed, prototypes of the firm's products are being developed, and the management team begins to form;
- 'start-up' — funds are provided for product development, staffing, initial marketing and other start-up costs. The firm has usually been in business for a short time; its management team is substantially in place; and it is setting itself up to sell its product commercially; and
- 'early expansion' — working capital funds to help launch manufacture and sale of the company's first products and services. Typically, the company is not profitable and frequently will still be cash-flow negative.

Technology commercialisation:

- must constitute a substantial change from existing technology available world-wide, i.e. must be 'new to world' technology and not only technology transfer;
- the technology can come from in-house or outside, but must be commercialisation not transfer;
- must be going to sell the developed technology/service or have business sales primarily attributable to new technology;
- large payments (>10%) for core technology or patents will not generally be allowed;
- acquisition of assets useable by other product lines will only be accepted as part of the commercialisation if that is its primary function. It is expected that large assets such as acquisition of real estate etc would be leased by the firm rather than bought; and
- costs must be in commercialising the new technology not rebranding or creating new models.

Businesses that are excluded from the scheme include:

- re-lenders or re-investors;
- passive businesses;
- real estate businesses;
- businesses whose assets are eroding or who are primarily "single purpose" ventures;
- farm purchases; and
- mining operations.

Cooperative Research Centres (CRCs)

In considering CRCs, it should be noted that there are likely to be few additions to the 68 CRCs now in place, although those now in existence may seek extensions beyond the original seven year term. In addition, the Mortimer report was not supportive of CRCs, and hence the Government's reaction to that report will be relevant.

The CRC process is similar to that for the ARC, involving a CRC Committee, Expert Panels and external assessors.

However, the CRC criteria are quite different to those for ARC Large Grants:

A Cooperative Arrangements

1 The degree to which the Centre reflects a real commitment to build links between the participating research groups and organisations, and integrate and enhance their research activities.

2 The commitment of the participants to the Centre, and to the provision of adequate resources for it.

3 The degree to which the Centre incorporates a strategy for developing international linkages with companies and research organisations that could provide substantial benefit to Australia, particularly the potential for commercial application of Australian research.

B Research and Researchers

4 The quality of the proposed research program, taking into account:

- whether outcomes have been identified and are achievable;
- its feasibility as presented;
- the significance of the research and the likelihood of important advances.

5 The research capabilities of the Director and key researchers, and their commitment to the Centre in terms of their time and that of their support staff.

C Application of the Research

6 The realistic potential of the Centre's research program to lead to significant economic or social benefit to Australia.

Degree to which the Centre addresses the needs of a sizeable sector of activity in Australia not adequately covered by existing CRCs.

7 The degree to which key user groups are integrated into the Centre as core participants, and are making substantial commitments of resources.

8 The existence of a well thought out and practical strategy for the utilisation or commercialisation of the research results.

D Education and Training

9 The development of leading innovative education and training activities that meet sectoral needs and enhance the employment prospects of graduates.

10 The extent to which researchers throughout the Centre are involved in education programs, particularly postgraduate programs.

E Management and Budget

11 The adequacy of the resources and budget for the proposed program.

12 The adequacy of the management for the Centre, including the ability of the Director and key researchers to lead and manage research programs on the scale indicated.

R&D Tax Concession

For the purposes of the 125% concession, R&D activities must:

- be systematic, investigative and experimental activities (referred to as core activities) which:
- be carried out mainly in Australia or an external Territory;
- involve innovation or high levels of technical risk;
- contain an appreciable element of novelty;
- involve a technical risk requiring that the probability of obtaining a given technical outcome cannot be known or determined in advance on the basis of current knowledge or experience;
- be carried on for the purpose of acquiring new knowledge (whether or not that knowledge will have a specific practical application) or creating new or improved materials, products, devices, processes or services; and

- involve other activities (referred to as supporting activities) which are directly related to undertaking the above 'core activities'.

Specific eligibility requirements that must be satisfied include:

- the R&D activities must be carried out by or on behalf of the company actually making the claim;
- the results of the R&D must be exploited on normal commercial terms and to the benefit of the Australian economy;
- the R&D activities must contain adequate Australian content; and
- there is an expenditure threshold of $20,000, although this can be waived under some circumstances.

Rural R&D Corporations

The Rural Research and Development Corporations have been established under Commonwealth legislation to collect and provide funds for rural research. The Commonwealth government contributes to the funding of the Corporations but they were established, and rely substantially, on grower contributions by way of levies collected on rural products. The funds are allocated by a grower/government Board with most funds distributed on a competitive, merit-based application process. Stage Government Departments of Agriculture are major fund recipients with Commonwealth agencies such as CSIRO also major research agencies for the Corporations.

Each of the rural R&D corporations has its own priorities and criteria for funds allocation and project selection. The following section uses the largest, the Grains Research & Development Corporation (GRDC), as an example.

The GRDC prepares a Five Year R&D Plan, the latest being for 1997-2002 and an Annual Operating Plan. The former outlines broad GRDC directions, while the latter highlights the annual budget and research program priorities which give effect to the five Year Plan.

The Five Year Plan identifies four Investment Objectives aimed at improving the profitability of grain producers. Annual investment budgets are allocated to each Objective.

1. Meeting Quality Requirements ($24.9m).
2. Increasing Productivity ($20.6m).
3. Protecting and Enhancing the Environment ($18.2m).
4. Delivering Outcomes ($3.8m).

Within that total research budget of $80m, $48m is allocated to continuing R&D, with priorities in four segments:

- National (Australia-wide);
- Northern Region;
- Southern Region; and
- Western Region (including Western Australia).

Each region has its own program objectives; for example these for the Western Region are:

- enhanced understanding of ground water cycles;
- soil structure;
- soil fertility; and
- decision support.

Each region then has research programs with defined priorities.

Natural Heritage Trust

The Natural Heritage Trust (NHT), administered jointly by DEST and DPIE, will be funded via $1,000 million from the part sale of Telstra, plus an additional $100m from appropriations.

The NHT will be used to fund five major capital projects:

- the Murray Darling 2001 project — $163 million;
- the National Vegetation Initiative — $318 million;
- the Coasts and Clean Seas Initiative — $100 million;
- the National Reserve System —$80 million; and
- the National Land and Water Audit — $32 million.

These initiatives will be complemented by programs such as the National Landcare Program, the National Feral Animal Control Strategy, the National Weeds Strategy, the National Wetlands Program and the Farm Forestry Program.

Thus the NHT is different from the R&D funding programs described above, in that:

- it may support R&D but is not an R&D program as such;
- most of the funds will be directed into programs which already exist;

- accordingly, it has no discrete criteria of its own. At the broadest level, allocations are largely political in nature. At the narrowest level, the priorities and criteria will be those of the specific program into which NHT funds are flowing.

CSIRO

The CSIRO is different again; it is largely a performer of R&D rather than a provider of funds. As such, it usually contracts-in, although may contract-out to tertiary institutions for specialist R&D. CSIRO participates in the vast majority of CRCs, usually on the basis of in-kind contributions rather than cash.

CSIRO has undergone many reviews, ranging from its overall role to the specifics of priority setting by individual divisions.

In March 1996, CSIRO commenced implementation of a fundamental reorientation of its management and structure. The new matrix-style approach involves CSIRO-wide planning and resourcing of research along sectoral lines, while the conduct and delivery of research is undertaken by CSIRO's Divisions in accordance with Sector Plans.

A key element of the new approach is the identification of 22 Sectors representative of industries, markets and natural resources of national significance. Planning of CSIRO's participation in each Sector is assisted by an external Sector Advisory Committee which helps CSIRO to identify those points at which our involvement can make the greatest contribution. The Sector Plans form the basis of the CSIRO Strategic Research Plan for the triennium 1997-98 to 1999-2000. Sector Plans are prepared by Divisions operating in each sector.

A second key element of the new approach is the strengthening of CSIRO's Division as the focus of the Organisation's disciplinary skills base and as the key business or operating units of CSIRO. It is therefore appropriate that the CSIRO Operational Plan is presented on a Divisional basis.

CSIRO's strategies for the new triennium are reflected in six themes: Focus; Teamwork and Collaboration; Balance; Excellence; Communication; and Fiscal Responsibility. Each of these is discussed in more detail in the CSIRO Strategic Research Plan 1997-98 to 1999-2000.

Important developments in the external environment which may have a significant impact on CSIRO during 1997/98 include:

- government decisions in response to the "Stocker Review" of Australia's science and technology arrangements;

- government decisions on the provision/outsourcing of information technology requirements by its departments and agencies, and on practices related to competitive neutrality;

- response by the business sector to changes in government policies and programs in support of R&D; and

- initiation of the Natural Heritage Trust.

The performance of CSIRO R&D within WA will largely reflect the existing location of CSIRO research establishments, except where:

- changing priorities redirect funding; and/or

- these establishments are physically relocated, as with CSIRO Petroleum to the Bentley Technology Park in Perth.

Both of these changes are likely to have effects in the medium term and beyond. For the time being, CSIRO staff in WA represent about 6% of all CSIRO staff, equivalent to about $40m per year.

Private Investors

Private investors (and, increasingly, public sector investors) see R&D as a means of innovation and hence enhanced competitiveness. The recent economic literature has much to say about innovation; this is summarised briefly in the following box.

Box 1: Innovations — Highlights

Much better understanding of the processes of innovation has emerged in recent years:

- It suggests the innovation is the dominant factor in economic growth and patterns of world trade.
- It emphasises the importance of studying systems of innovation — innovating firms in the context of the institutions, government policies, competitors, suppliers, customers, value systems, and social and cultural practices which determine their opportunities. Systems need to be understood at the transnational, national, regional and local levels. Policy therefore needs to adopt a holistic approach.
- Consistently innovative firms possess clear business strategies; are open to the adoption of new technologies and work organisation; undertake continuous improvement, creative design and R&D; and are thus better enabled to commercialise new ideas successfully.

Australia at present lacks an adequate centre of intellectual focus for local development of the 'new learning' on innovation and for working through its policy implications.

It is now possible to derive quantitative measures of many aspects of innovation. For Australian manufacturing, three measures show:

- although only one third of firms are innovative, these innovative firms account for 70% of employees, 80% of sales and 85% of exports;
- there is a close association between R&D and other innovation (also supported by other studies); and
- the cost of R&D is on average about one third of that of innovation overall. This probably implies that most business innovation in Australia is incremental rather than radical.

Source: DIST

Clearly, private investors do not have a single set of criteria by which they evaluate potential R&D projects. Each individual firm will take its own approach, although some measures of return on R&D investments, and the related risks, will generally be applied.

International Funding Sources

Overseas sources are often overlooked as potential source of funding for R&D, both for companies and for researchers in higher education. Although they currently provide a small share of funds to Australian researchers, the amount has grown rapidly compared to total funds. In 1986-87, for example, overseas sources provided around 1% of total R&D funds with this doubling by 1994-95.

Table 2: R&D by Source of Funds, Australia

Sector	1992-1993			1994-1995		
	Total ($M)	Overseas ($M)	OS/Total (%)	Total ($M)	Overseas ($M)	OS/Total (%)
Business	2,855	85.8	3.0	3,383	109.9	3.2
C'wlth Govt.	1,151	14.0	1.2	1,178	11.8	1.0
State Govt	668	3.8	0.6	786	3.9	0.5
Higher Education	1,695	10.5	0.6	1,830	18.5	1.0
PNP	101	3.3	3.3	144	3.8	2.6
TOTAL	6,470	117.4	1.8	7,321	147.9	2.0

In 1994-95, Australia received almost $150 million from overseas to support R&D performed in Australia (Table 2). Most of this ($110 million) was spent in business enterprises, where overseas funding comprised just over 3% of all business R&D. The higher education sector has been the sector which has been attracting overseas funding at the fastest rate, almost doubling its overseas income between 1992-93 and 1994-95 (Table 3). Overseas funds for R&D performed by higher education institutions in Australia almost doubled again between 1994 and 1996, from $18 million to over $35 million.

Table 3: Overseas Funds for R&D in Higher Education, Australia

	Total H.E. Funds ($M)	Overseas Funds ($M)	Overseas/Total (%)
1988	1,077	7.2	0.67
1990	1,351	9.3	0.69
1992	1,695	10.5	0.62
1994	1,830	18.5	1.01
1995	2,039	23.1	1.13
1996	na	35.4	na

However, Western Australian higher education institutions have apparently not been sharing in this source of research funds. with overseas funding to WA universities remaining static at just under $1 million in 1995 and 1996 (Table 4). Overseas sources represent a very small percentage of the national funds from overseas.

Table 4: Overseas Funds for R&D in Higher Education, Western Australia ($'000)

	1995	1996
Curtin	26	140
ECU	67	136
Murdoch	221	216
UWA	616	496
WA - TOTAL	*930*	*988*
AUSTRALIA - TOTAL	23,063	35,394
WA as % of Australia	*4.0%*	*2.8%*

It has not been possible to determine the major sources of funds or the fields of research in which they were expended. Sources are likely to include charitable foundations (e.g. Ford, Rockefeller, etc.), international organisations (e.g. World Bank, OECD) and international government research programs.

An extremely useful list of national and international funding sources available to higher education and other researchers is provided by SPIN Australia. (Box 2). An electronic enquiry seeking details on the broad field 'remote sensing' received 14 'hits', mainly from US-based funding programs, most of which appear to have no restrictions in terms of nationality. Restricting the search to 'remote sensing technology' found three possible sources of funding:

- NASA — John C. Stennis Space Center;
- NASA — Kennedy Space Center; and
- NSERC — Visiting Fellowships in Canadian Govt. Labs/Physics & Chemistry

Details of each program, application details, contact names, etc. are given for each program. While not exhaustive, the SPIN database provides information on hundreds of programs and funding sources, by subject, and should be an essential resource for university and business research managers.

Due to confidentiality reasons, the most recent year for which data is available on business R&D in WA which came from overseas sources is 1990-91. This showed that just $660,000 came from overseas out of a total expenditure of $120 million, representing just 0.55% of total expenditure, well below the national average.

Box 2: SPIN Australia Database

SPIN - Sponsored Programs Information Network - is the leading database of funding opportunities world-wide. SPIN Australia is a subset of SPIN International - and consists only of funding opportunities that are available to applicants in Australia. SPIN Australia contains current and comprehensive information on over 2,600 government and private funding opportunities for projects which cross all areas of interest, that are targeted to institutes of higher education.

All of the information on SPIN is obtained directly from the sponsoring agencies to ensure the integrity of the information. Each funding opportunity is updated on SPIN as the sponsoring agency comes out with updated or revised information, which is typically on an annual basis. The funding opportunities on SPIN are extremely comprehensive, providing such information as the Sponsor Name; Contact Person; Complete address/telephone; Deadline dates; Program title; a brief Synopsis outlining the opportunity; plus a detailed description of the sponsor's Objectives (what is funded) and the program's Restrictions (eligibility requirements, award amounts and durations, allowable costs, indirect cost policies, and application information).

SPIN www is available at http://spin.web.unsw.edu.au/

Appendix 6: Questionnaire

Appendix 6: Questionnaire

The Role of the State Government in Attracting Research and Development Funding

Questionnaire

Introduction

Commonwealth research and development expenditure in Western Australia on a per capita basis has been the lowest of all States and Territories in five out of the last six years. This low level of expenditure means a reduced research presence in the State and hence a lower level of research investment by private companies.

The Western Australian government is keen to increase research and development expenditure in the State and is examining options for achieving this. The Technology and Industry Advisory Council (TIAC) has been given approval by the Minister responsible for the science portfolio to carry out this study on the Government's behalf. The results of this study are aimed at assisting the State Government with policies which may help to increase Commonwealth and private sector R&D funds, facilities and personnel in this State.

TIAC has commissioned Economics Consulting Services Pty Ltd (ECS) to assist the Council in reviewing research and development expenditure in the State, evaluate the factors behind organisation success in attracting funds and develop options for State government involvement. The team we have assembled for the study includes Dr Mike Taylor from ACiL Economics and Policy, Dr John Phillimore from the Murdoch Institute for Science and Technology Policy and Dr Doug McGhie from Doug McGhie and Associates.

We would be grateful for your assistance with our study. Our approach involves widespread consultation but the research and development community is a large one and it is not possible, within reasonable financial constraints, to talk to everyone. We have thus developed this questionnaire to help in our evaluation.

We realise you receive many questionnaires of this type and we have thus attempted to make the questions as simple as possible. The price we pay for this is that many complex issues are dealt with in a simplistic manner. Should you wish to follow up on any of the issues in more detail we would be pleased to talk to you. You can contact Dr Doug McGhie on 9447 0515 (or 041 99 88 488) with any further comments or queries.

Thank you for your assistance.

Murray Meaton
Director
Economics Consulting Services Pty Ltd

The Role of the State Government in Attracting Research and Development Funding

The Research Organisation

Q1 Name of Organisation/Centre: _____ _____

_____ _____ _____

Q2 Location: _____ _____ _____

Q3 Industry focus (please tick box):

- ***(a)*** Information Technology and Communication ❑
- ***(b)*** Food, Beverage and Fibre ❑
- ***(c)*** Building, Construction and Basic Materials Manufacturing ❑
- ***(d)*** Oil, Gas, Mining and Chemical Industries ❑
- ***(e)*** Education and Commercial Business Services ❑
- ***(f)*** Marine and Defence Industry Aviation and Transport ❑
- ***(g)*** Health, Environment and International Science ❑

Q4 Contributing organisations:

(1) _____ _____ _____

(2) _____ _____ _____

(3) _____ _____ _____

(4) _____ _____ _____

Q5 Main Focus of Research Effort: _____ _____

_____ _____ _____

_____ _____ _____

Q6 Number of Staff: _____ _____ ___

Q7 Name of Organisation Director: _____ _____

Q8 Brief Research History of Director: _____ _____

Q9 Management History of Director: _____ _____

_____ _____ _____

The Respondent

Q10 Can you indicate your role in the organisation:

(a) Research Centre Director ❑

(b) Researcher ❑

(c) Administrator ❑

(d) Other - please specify _____ _____

Financial Details

Q11 Annual Budget: $ _____ _____ __

Financial Contributors - Parent Organisation _____ %

State Government _____ %

Federal Government _____ %

Private Sector _____ %

Other (please specify) _____ %

1997 $ _____

Q12 What do you estimate are the total State Government funds available from R&D programs relevant to your area: $ _____

Q13 What do you estimate are the total Commonwealth funds available from specific R&D programs relevant to your area: $ _____

Q14 What do you estimate are the total value of Private funds available in identifiable R&D programs relevant to your area: $ _____

Q15 What do you estimate i s the total amount of funds potentially available for application in your areas of R&D focus (State and Federal): $ _____

Q16 Approximately what is the total value of funds applied for by your organisation in:

1996 $ _____

1997 $ _____

Q17 Total Value of Successful Applications:

1996 $ _____

1997 $ _____

Q18 How do you rate the success of your organisation in attracting external funds for R&D?

	Above average	**Average**	**Below Average**	**Poor**	**Have not tried**	**Not applicable**
From your parent organisation						
From the State government						
From Federal government sources						
From private companies						

Organisation Success

Q19 What do you feel are the most important criteria for an organisation to attract external funds for R&D work. Please rate the following:

	Not Important		**Average**		**Very Important**
Circle appropriate number eg	1	2	③	4	5
Track record in R&D	1	2	3	4	5
Length of involvement in R&D	1	2	3	4	5
Reputation or name of organisation	1	2	3	4	5
Organisation Image	1	2	3	4	5
Reputation of Director	1	2	3	4	5
Reputation of principal research worker(s)	1	2	3	4	5
Staff commitment and resolve	1	2	3	4	5
Leadership of organisation	1	2	3	4	5
Organisation vision	1	2	3	4	5
Financial status	1	2	3	4	5
Collaborative links with other participants	1	2	3	4	5
Industry relevance	1	2	3	4	5
Qualifications of staff	1	2	3	4	5
Value for money reputation	1	2	3	4	5
Industry application	1	2	3	4	5
Quality of facilities	1	2	3	4	5

The Industry

Q23 Please rate the characteristics of the industry sector served by your research centre.

	Weak		**Average**		**Strong**
Circle appropriate number eg	1	2	③	4	5
Recent Industry Growth	1	2	3	4	5
Potential Industry Growth	1	2	3	4	5
Potential for Research Project Funding	1	2	3	4	5
Industry capacity to fund research	1	2	3	4	5
Industry history of funding	1	2	3	4	5

Q24 Please describe the main reasons for the present level of success of this research centre in attracting research funds. _____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

Q25 Please describe the main obstacles to this research centre for attracting research funds.

_____ _____ _____

_____ _____ _____

_____ _____ _____

Q26 How would you rate the Western Australian Government's contribution to supporting or directing research funding to Western Australian R&D organisations?

	Poor				**Excellent**
Circle appropriate number eg	1	2	③	4	5
Degree of support	1	2	3	4	5
Nature of support	1	2	3	4	5

Q27 Please describe how the State Government might more effectively assist research and development organisations to attract and use funds.

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

Appendix 7:
Contact List

Institution and Centre	Contact
University of Western Australia	
Centre of Intelligent Information Processing Systems	Prof Yianni Attikiouzel
Geomechanics Group	Prof Mark Randolph
Key Centre of Strategic Mineral Deposits	Prof David Groves, Dr Neal McNaughton
Centre for Oil and Gas Engineering	Prof Beverley Ronalds
Australian Centre for Geodynamics	Dr Graham Price, Mrs Ros Cafagna
Centre for Water Research	Caroline Wood
CRC for Premium Quality Wool	Prof David Lindsay
CRC for Legumes in Mediterranean Agriculture	Dr Clive Francis, Adj. John Hamblin
Centre for Advanced Mineral and Materials Processing	Prof Paul McCormick
Curtin University of Technology	
Centre for Renewable Energy Systems, Technology of Australia	Prof Chem Nayar
Australian Telecommunications Research Institute	Tony Cantoni
Science and Maths Education Centre	Barry Fraser
Centre for Petroleum and Environmental Organic Geochemistry	Bob Kagi
Australian Maritime Engineering CRC Ltd	Kim Klaka
Australian Petroleum CRC	Norm Uren
CRC for Australian Mineral Exploration	Norm Uren
CRC for Broadband Telecommunications and Networking	Antonio Cantoni
Murdoch University	
Institute for Science and Technology Policy	Peter Newman
Asia Research Centre on Social, Political and Economic Change	Richard Robison
State Agricultural Biotechnology Centre	Prof Mike Jones
AJ Parker Centre for Cooperative Research in Hydrometallurgy	Ian Richie
Australian CRC for Renewable Energy	Martin Thomas
CSIRO	
Centre for Mediterranean Agriculture Board	Mike Poole
Division of Exploration and Mining	Bruce Hobbs
Division of Water Resources	C Barber
Division of Plant Industry	Neil Turner
CRC for Landscape Evolution and Mineral Exploration	Raymond Smith
Government Departments	
Department of Commerce and Trade	Dr John Barker, Deanna Fleming
Agriculture Western Australia:	
• Centre for Cooperative Research for Biological Control of Vertebrate Pest Populations	Stuart Wheeler
• CRC for Quality Wheat Products and Processes	Dr Wal Anderson
• CRC for Sustainable Development of Tropical Savanna	John Morrissey
• CRC for Weed Management Systems	Dr David Bowran
• Groundwater Studies	Chris Barber
• Plant Research and Development	Mike Perry
• Animal research and Development	Dr Debby Cousins
• Technology Transfer and Communication Services	Don Burnside

CALM: • CRC for Conservation and Management of Marsupials	Mark Bradley
Department of Fisheries: Research Division	Jim Penn
Department of Minerals and Energy: Mineral Processing Laboratory	Dr Tony Bagshaw
Perth Zoological Gardens: Threatened Species Research Centre	Mark Bradley
Other Organisations	
Lions Eye Institute - Eye Health	Ian Constable
Federal Government	
Department of Industry, Science and Technology	Dr Lou Lombardo
Department of Primary Industries and Energy	Dr John Madden
Department of Education, Employment and Youth Affairs	Ms Helen Dempster

PUBLIC COMMENT
REPLY SHEET

TO: THE EXECUTIVE OFFICER
WESTERN AUSTRALIAN TECHNOLOGY AND INDUSTRY
ADVISORY COUNCIL

SUITE 3, ENTERPRISE UNIT 2,
11 BRODIE HALL DRIVE,
TECHNOLOGY PARK,
BENTLEY 6102

TEL NO: (08) 9470 3666

FAX NO: (08) 9470 3558

FROM: _____

ADDRESS: _____

_____

_____

TEL NO: _____

FAX NO: _____

NUMBER OF PAGES: _____
(Including this cover sheet)

Comments on the Report entitled

RESEARCH AND DEVELOPMENT:

THE ROLE OF THE STATE GOVERNMENT IN ATTRACTING EXTERNAL FUNDING

Closing Date 20 June 1998

(Please tear out and return with your comments)