PUBLIC-PRIVATE PARTNERSHIPS FOR RESEARCH AND INNOVATION: AN EVALUATION OF THE AUSTRALIAN EXPERIENCE

OECD

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

FOREWORD

A major conclusion of the OECD Growth Study was that governments need to be more responsive to the rapid transformation of innovation processes and related business needs and strategies, and that greater use of public-private partnerships can increase this responsiveness and enhance the efficiency and cost-effectiveness of technology and innovation policy.

In the framework of its follow-up work on *micro-policies for productivity and growth*, the OECD is conducting peer reviews of member countries' public-private partnership (PP/P) programmes for research and innovation. This report examines and assesses PP/P initiatives in Australia, with a special focus on the Cooperative Research Centres (CRC) Program.

It has been prepared by the OECD Secretariat,[1] in co-operation with the Australian Department of Industry, Tourism and Resources, and in consultation with other stakeholders in CRCs. It takes into account the results of a peer review meeting which took place in December 2003 within the OECD Working Party on Technology and Innovation Policy.

It is published on the responsibility of the Secretary-General of the OECD.

1. The OECD project team was led by Jean Guinet, assisted by Byung-Seon Jeong. Andreas Dubs (consultant) assembled and processed most of the information presented in this report.

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EXECUTIVE SUMMARY

Since the early 1990s, the Australian economy is one of the best performers in the OECD area. Structural reforms across a broad front have contributed to this achievement, including science and innovation policy initiatives that have consolidated and broadened the basis for economic growth in the country, by accelerating the transition from a natural resource-based to a knowledge-based economy.

The Australian science and innovation scene is broadly characterized by the following aspects:

- Good overall scientific performance.
- Good skills base - for example, relatively high level of university-level education.
- Strong use of ICT and software by business to achieve technological change.
- Low expenditure on business research and development.
- Continuing government support for science and innovation.
- Weak linkages between public researchers and industry.

In order to increase the level of private sector research and to improve the linkages between the many actors of the innovation system, the Australian government has undertaken a range of policy measures since the 1980s, ranging from measures supporting the research undertaken in industry (e.g. competitive grants, R&D tax concession) and programs encouraging multinational firms to establish a research base in Australia, to measures aimed more directly at the establishment of contacts, interaction, collaboration and partnerships between public sector institution and the private sector. The latter received an increasing priority in the 1990s.

A range of schemes have been introduced with the primary aim to encourage and facilitate public-private partnerships for innovation (PP/P), which together represent about 9% of the total S&T budget. The report briefly described these PP/P schemes in terms of their specific aim, mechanism and size.

By far the most substantial PP/P program in this portfolio is the Cooperative Research Centres (CRC) Program. It has been operating for about 12 years, having been announced in early 1990 and the first selection round launched in October of the same year. The CRC Program has seen the creation of 96 centres since its inception, with some 70 centres currently operating with funding under the Program.

The report takes a closer look at the CRC Program, focusing on issues such as: governance and legal structure; financing; human resources; intellectual property management; evaluation of individual centres and of the program as a whole.

Overall the program has been successfully achieving the four stated objectives - research excellence; effective collaboration; creation of new educational opportunities; and the translation of research outputs into economic, social and environmental benefits to Australia. The report identifies the aspects of the program design and management features that have contributed most to this success, notably:

- The open-ended, long-term commitment by the government;
- The equal emphasis on all four major program objectives (research, collaboration, education, application of outcomes);

- A consistent, transparent and open application and selection process;
- An effective governance structure at the program level and a clear management structure at the centre level; and
- A rigorous monitoring and evaluation process.

Nevertheless, the report asks whether the changes of the economic environment over the past 13 years have been taken fully into account in fine-tuning the program over its life and identifies other challenges for the future, taking into account the findings and recommendations of a recent evaluation commissioned by the administering government department, and focusing on generic issues that may be of interest to other countries.

- *Management of the portfolio of CRCs in the long-term.* The first selection rounds of the program focused on initiating a change in the research culture among actors in the Australian NIS, through mostly bottom-up and science-push initiatives. The more recent selection rounds gave more priority to the commercialisation of research outputs through demand-pulled initiatives, as well as to research topics of public interest. Combining more effectively a niche strategy in emerging fields with the consolidation of comparative advantages in broader sectors, as well as the promotion of innovation in the private sector with the pursuit of public missions, may now require a new balance between "bottom-up" and "top-down" criteria in deciding the areas of research to be funded. The majority of CRCs would not be viable without government financial support in the foreseeable future. Even those which could be self-sustained, on pure economic terms, would find it harder to operate cohesively without the "glue" of CRC Program funds. However, providing different levels of government financial contribution to different types of Centres should be considered. In addition, the conditions for Centres to be allowed to operate as CRCs even when no longer receiving program funding should be clarified.
- *SME participation and internationalisation.* Some observers consider that participation by SMEs in CRCs is often too low. While it is difficult to establish generic criteria, it would be useful to clarify the nature of these concerns and monitor the situation on this issue. To overcome the insufficient capabilities of Australian firms to commercialize domestic scientific outputs, a niche strategy involving key foreign participants and/or start-ups has been highly successful in some fields. The continuing success of some CRCs may now depend almost entirely on their ability to attract foreign partners with key complementary capabilities. Building on globalisation to further increase the efficiency of the CRC program may require a wider definition of national benefits that gives greater weight to the benefits derived indirectly from the internationalisation of CRCs.
- *Complementarity with other S&T programs.* The success of the CRC program will continue to depend on favorable framework conditions for research and innovation that are created by other measures and institutions, including the R&D tax concession. Now that the improvement of science-industry relationships has become a goal, as a primary or secondary objective, of many other policy instruments, it is necessary to determine an efficient division of policy objectives between the CRC program and other relevant schemes and programs managed by the Australian Research Council, notably the Centres of Excellence and the Linkage Projects, and by AusIndustry, notably the R&D Start and Commercialising Emerging Technologies programs.

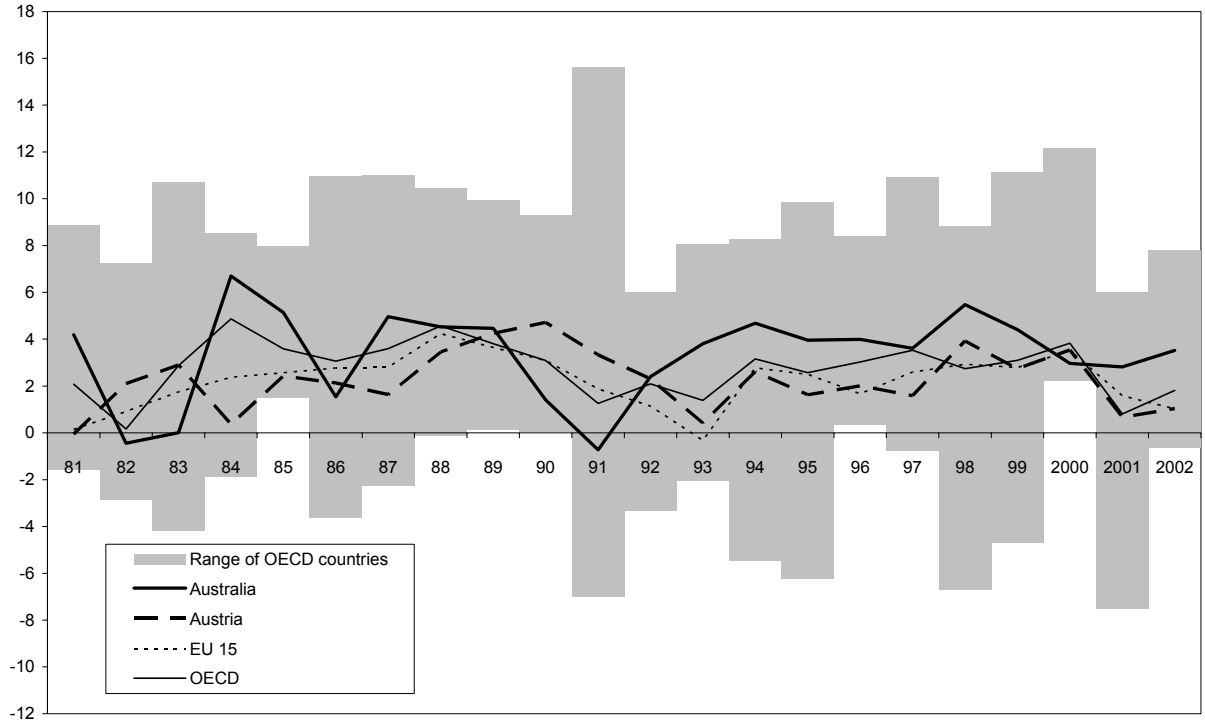
THE ROLE OF PUBLIC-PRIVATE PARTNERSHIPS IN THE AUSTRALIAN INNOVATION POLICY

Introduction

"Dogged pursuit of structural reforms across a very broad front, and prudent macroeconomic policies firmly set in a medium-term framework, have combined to make the Australian economy one of the best performers in the OECD, and also one notably resilient to shocks, both internal and external. Incomes growth has remained brisk, employment is expanding, inflation is under control, and public finances are healthy." (OECD Economic Survey of Australia, 2003). Science and innovation policy initiatives are among the structural reforms that have contributed to this achievement, by consolidating and broadening the basis for economic growth in the country, and thus accelerating its transition from a natural resource-based to a knowledge-based economy.

The OECD Growth Project demonstrated that innovation is a key determinant of sustained growth in productivity, and that improved innovation performance requires more intensive collaboration between the different actors of innovation processes. It acknowledged the remarkable progress made by Australia in this respect, suggesting that good practice policies had been implemented to increase the efficiency of the national innovation system. This report reviews the role of Public-Private Partnerships in the Australian innovation policy, with a special focus on the most emblematic relevant initiative, the Cooperative Research Centres (CRC) Program.

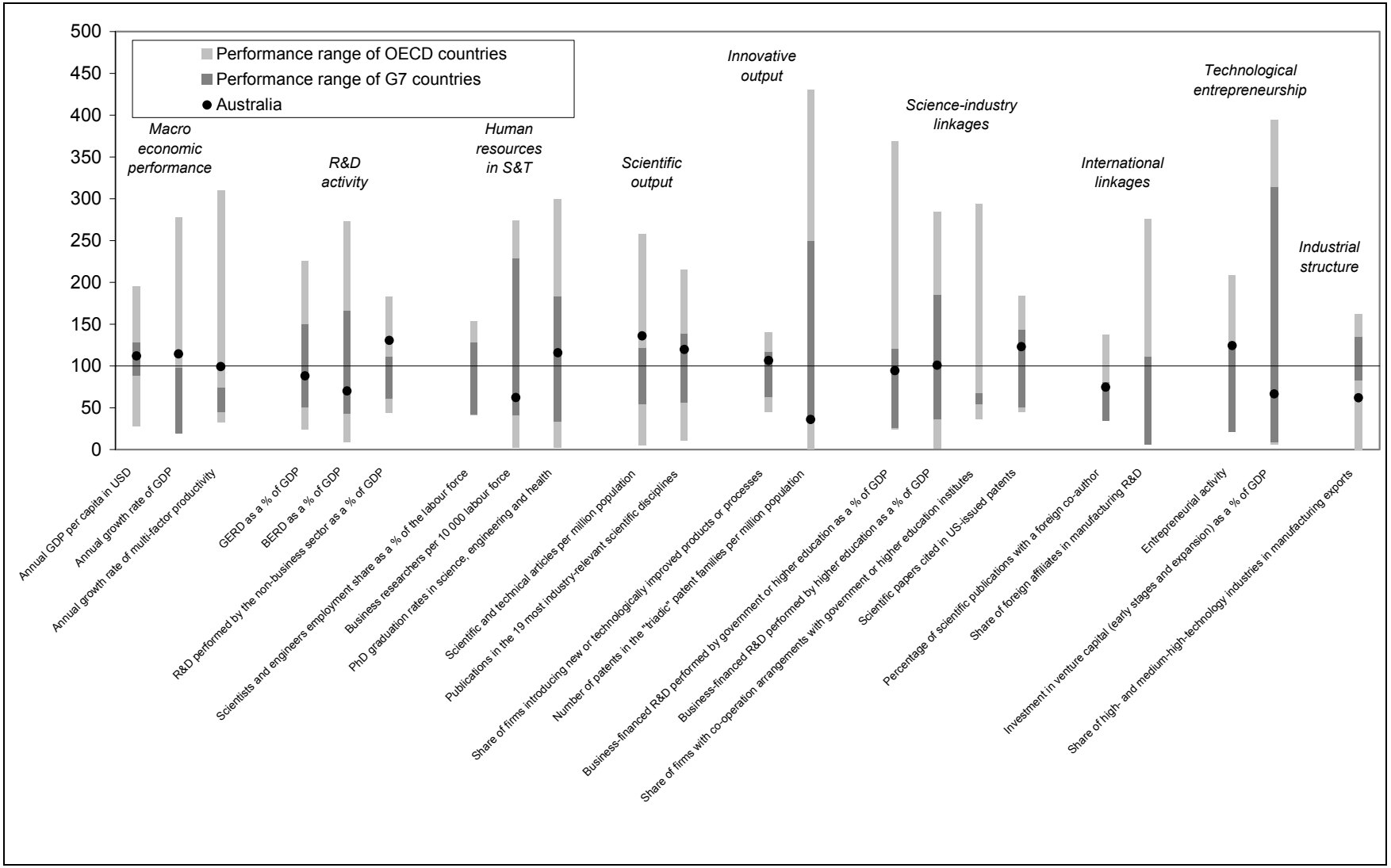
Figure 1. Annual growth rates of GDP



Source: OECD.

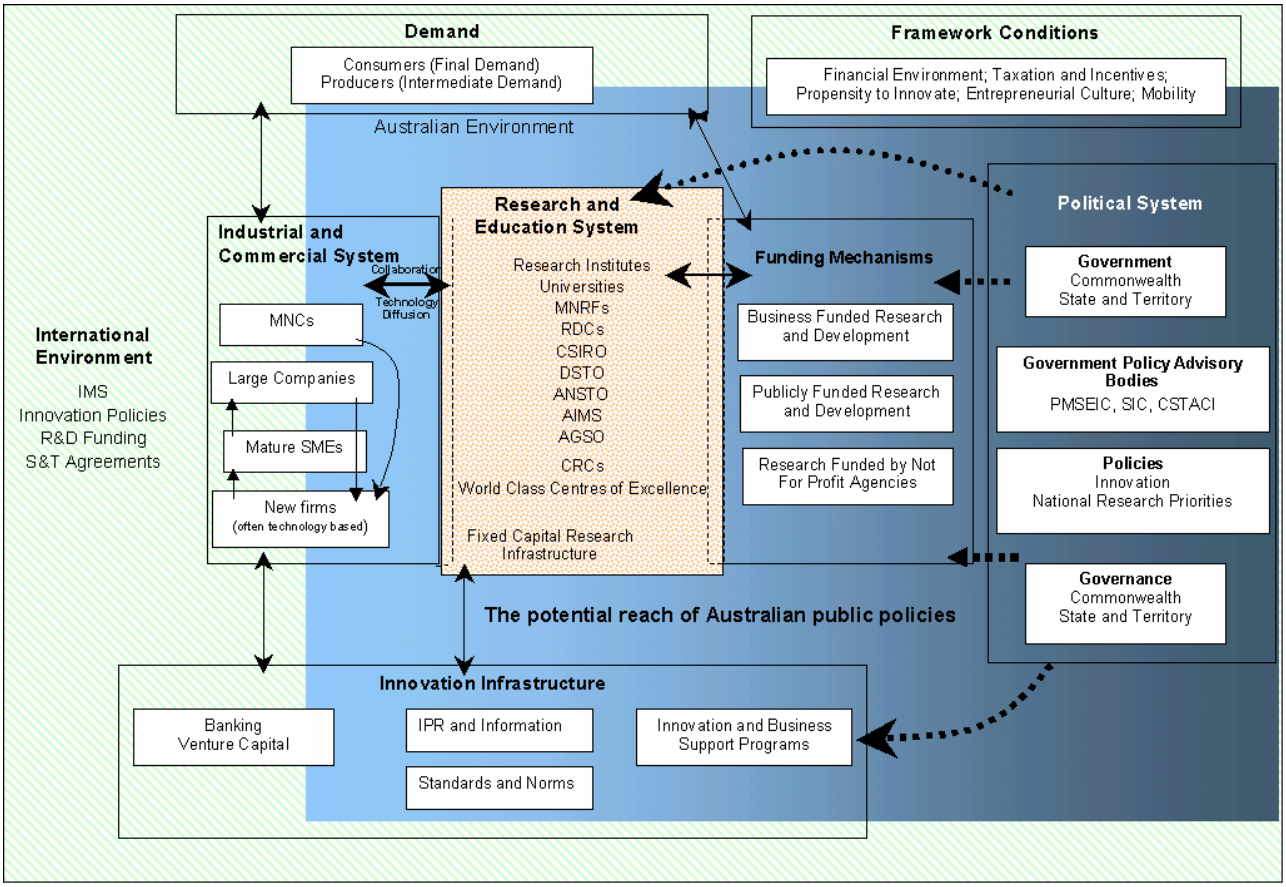
Figure 2. Profiling the Australian innovation system

(2001 or latest year available)



Source: OECD.

Figure 3. Main components of the Australian innovation system



Source: Department of Industry, Tourism and Resources.

Figure 4. Trends in business and non business expenditure on R&D (% GDP)

Source: OECD *Main Science and Technology Indicators* (May 2003), updated by ABS Bulletin 8104.0 (Aug 2003).

The Australian NIS – performance and bottlenecks

In November 2002 the Prime Minister announced a study to map Australia's science and innovation activities across the full range of public and private sectors expected to be completed in late 2003. It will assess innovation performance and provide a summary of strengths and weaknesses of the Australian innovation system, to assist in planning the future strategic direction for government policy. Preliminary results together with other information from international benchmarking (Figure 2 and Table 1) suggest the following.

Areas of strength include:

- Good framework conditions for research and innovation.
- A comparatively large and productive basic research sector.[2]
- Well developed interactions between public research and industry in particular sectors, e.g. mining and agriculture, where Australia enjoys a comparative advantage.
- A good skills base, in terms of education attainment, and the proportion of tertiary graduates.
- A high rate of diffusion and use of ICTs throughout the innovation system.
- A high rate of adoption of overseas technologies, and good capabilities for organizational innovation in large firms.

Areas of weakness include:

- A comparatively low level of research performed by the private sector, including the Australian affiliates of multinational enterprises.
- Insufficient linkages between public and private sector in a number of sectors.
- A still under-developed venture capital market, and a shortage of seed capital to finance the early stage of innovation projects.
- A lack of technology-based entrepreneurship, and insufficient management and entrepreneurial skills to support innovation in small firms.

Table 1. University research financed by industry as a percentage of GDP

	1994	1996	1998	1999	2000
Australia	0.014	0.023	0.023	na	0.020
European Union	0.021	0.024	0.022	0.023	0.024
OECD weighted average	0.022	0.023	0.025	0.025	0.026

Source: Derived from OECD *Main Science and Technology Indicators* (May 2003).

The single most important challenge for Australia has long been the imbalance between the public and the private research effort that made more difficult the correction of other weaknesses in the NIS and the exploitation of strengths. The changing patterns of R&D expenditures are encouraging in this respect.

2. Basic research is carried out by universities, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), medical research institutes, and State-based research bodies specialised in agricultural research. Increased emphasis on competitive and contestable funding arrangements contributes to the quality of research outcomes.

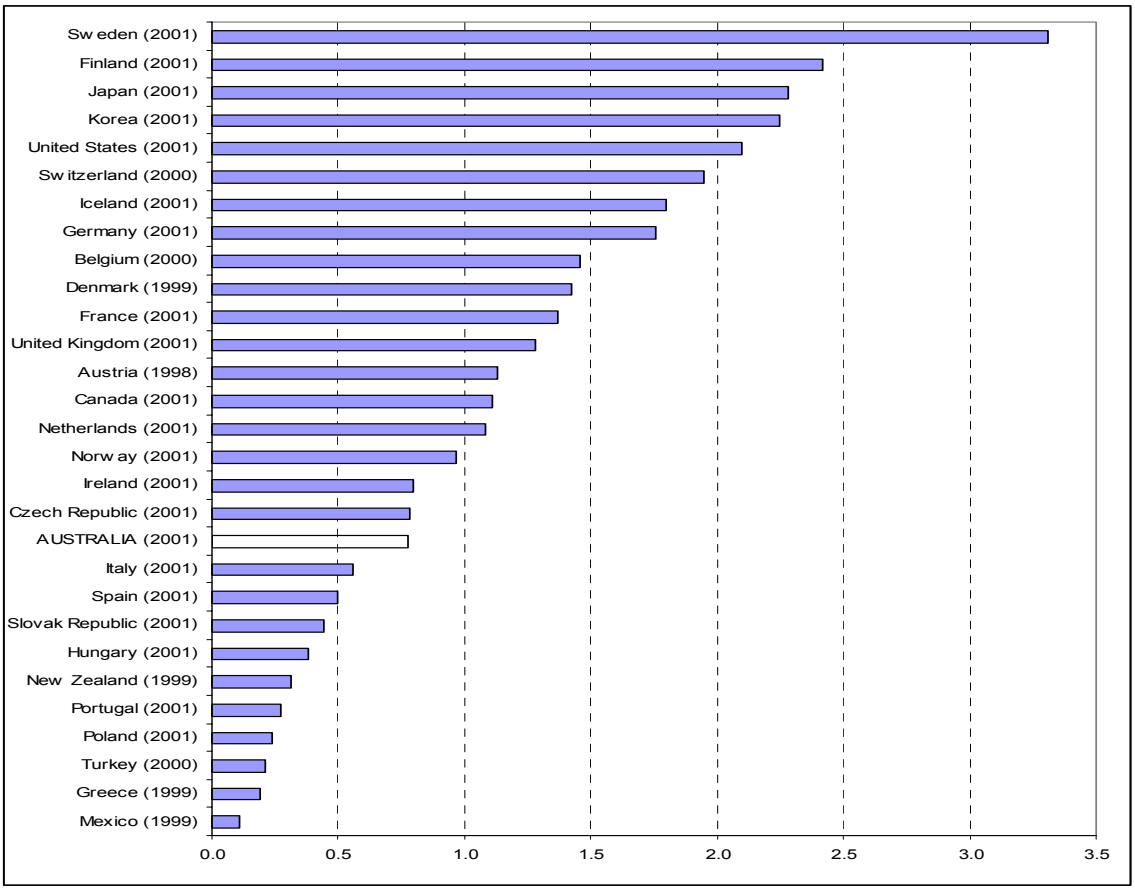
Figure 4 shows that BERD grew fairly consistently from the 1980s till 1996. It then dropped but has recovered in the past two years. Non-BERD has grown from about 0.7% of GDP to about 0.8% over the 20 years to 2000-01. Over the same period, BERD has grown from around 0.25% to 0.73% of GDP, representing an almost ten-fold increase in current dollar BERD and an almost three-fold increase as a percentage of GDP. Business expenditure constitutes 47% of total Australian expenditure on R&D, with 23% by government, 27% by higher education and 3% by private non-profit organisations (Table 2).

Table 2. Australian expenditure on R&D, by sector, 2000-01

Sector of R&D performance	2000-01 AUS$ million	2000-01 % GDP	2001-02 AUD million	2001-02 % GDP
Business enterprises (BERD)	4,917	0.73	5,546	0.78
Federal Government agencies	1,425	0.21	na	
State and Territory agencies	944	0.14	na	
Universities (HERD)	2,775	0.41	na	
Private non-profit organisations	283	0.04	na	
Total R&D expenditure (GERD)	**10.343**	**1.55**	na	

Source: ABS Bulletin 8112.0 (July 2002), updated by ABS Bulletin 8104.0 (Aug 2003).

Figure 5. BERD as a percentage of GDP



Source: OECD *Main Science and Technology Indicators* (May 2003), updated by ABS Bulletin 8104.0 (Aug 2003).

The difference in BERD to GDP ratios between Australia and other OECD countries (Figure 5) reflects a number of factors including differences in industry structure and the relative intensity with which industries typically engage in R&D. Australia, for example, has a relatively small manufacturing sector and a relatively high level of foreign investment but with few multinational companies headquartered in the country. It must be recognised, however, that, although multinationals have in general a greater propensity to conduct R&D in their home markets, 38% of foreign-owned manufacturers in Australia conduct R&D locally compared with only 18% on average in the OECD area.

Some of the industry structure factors that influence the variation in BERD to GDP ratios across countries simply reflect the diversity of comparative advantage. In general, the relative level of national investment in various economic activities will reflect the relative potential of those activities to generate national wealth, and will ultimately determine the structure of the national economy. There is good reason to assume that such relativities will result in a considerable degree of variation across countries. The extent of defence industry activities is another feature that can significantly impact on national levels of BERD. In the United States for example, defence R&D, as a % of GDP, is about 8 times higher than in Australia.

Policy responses: the increasing role of public-private partnerships

Over the past four years Australia has committed to strengthening its science and innovation system as never before. A major focus on science and innovation emerged from a National Innovation Summit convened by the government in 2000, followed by a report by the Chief Scientist entitled *The Chance to Change*, culminating in a $3 billion package *Backing Australia's Ability*, launched in January 2001. This five-year strategy focuses on action around 3 major themes: generating ideas through research; developing ideas into products; and building a highly skilled workforce.

A suite of programs supporting each of these themes were either established or enhanced with the additional funding (see *http://backingaus.innovation.gov.au*). The implementation of science and innovation initiatives is coordinated by a sub-committee of Cabinet, the Science and Innovation Committee chaired by the Prime Minister. The Committee plays an across government role in the development of future innovation policy and initiatives.

Building on this innovation strategy, the government developed a set of National Research Priorities in 2002: An Environmentally Sustainable Australia; Promoting and Maintaining Good Health; Frontier Technologies for Building and Transforming Australian Industries; and Safeguarding Australia.

Public-private partnerships are key tools in implementing these new policy orientations. In recent years, a range of funding bodies have adopted a policy in favour of public-private partnerships, sometimes within existing schemes, in other cases through new initiatives, e.g. the ARC Linkage Grants. Table 3 and Table 4 provide an overview of the major public-private partnership programs and their current annual budgets.

Table 3. Budget for public-private partnership programmes (2002-03)

PP/P programs	AUS$ million
Co-operative Research Centres Program	148.6
Innovation Investment Fund	26.0
Pre-Seed Program	6.0
Rural R&D Corporation	194.4
Australian Research Council (ARC) Linkage Grants and Industry Fellowships	76.7
Total PP/P programs	**451.7**
Total S&T budget	4989.0
Share of PP/P programmes in total S&T budget	9.1 %

Source: Department of Education, Science and Training, Science and Innovation Budget Tables (May 2003) and ARC Linkage-Projects Selection Report and Summary of Recommendations for Funding Commencing in 2002.

Table 4. Public-private partnership programmes in Australia

Instrument	Description	Period
CRC Program	The Co-operative Research Centres program is focused on longer term collaborative research to advance industry and business development through the transfer of knowledge, including contribution to commercialisation. Funding is a combination of public and private sources.	1990 to present
Innovation Investment Fund (IIF)	The Innovation Investment Fund was established to provide small, high-technology companies with access to equity capital for improving the commercialisation outcomes of Australia's R&D. Funding is a combination of both public and private sector sources. Of the 61 companies IIF has funded, the majority are commercialising Internet, information or life science technologies.	1998 to present
PreSeed Fund	The Pre-Seed fund is an equity based program managed by private fund managers to encourage business development from public early stage research of universities and public research agencies. Funding is a combination of public and private sector sources.	2002 to present
ARC Linkage Grants	The Australian Research Council provides funding for medium term strategic research to promote alliances between higher education institutions and industry, including funding for industry fellowships and infrastructure.	1999 to present
Rural Research and Development Corporations (RRDCs)	RRDCs represent a partnership between government, including Public Research Organisations (e.g. CSIRO) and rural industries, characterised by a mix of long-term and short-term projects to advance the uptake of knowledge to industry and build capacity. Sectoral industry participants are closely involved in projects, and short-term projects often involve smaller industry players. RRDCs contract research projects to external R&D providers, including rural-focused CRCs and are also important core participants in a number of rural CRCs.	1990 to present

Source: Department of Industry, Tourism and Resources.

EXAMINATION OF THE COOPERATIVE RESEARCH CENTRES (CRC) PROGRAM

This second section of the paper examines the experience with CRCs, focusing on the following main issues:

- Role and purpose: Are partnerships central to the overall research approach of the country? Are they encouraging research which might not otherwise be conducted?
- Participants: Do research partnerships have competitive processes for selecting diversified participants? Do partnerships include small firms and/or foreign companies?
- Financing: Are the partnerships contributing to cost-sharing and leveraging of private funds?
- Management: What are the governance arrangements for partnerships? Have specific institutions or centres been established to conduct joint research?
- Intellectual property rights: What are the provisions for intellectual property rights for the results of joint research?
- Evaluation: Are partnerships regularly subject to evaluation? What are the procedures and criteria? What have been the results?

The CRC Program was announced in early 1990 and the first 120 applications were received in October 1990. The 15 successful proposals of this initial round were announced in March 1991. Over a further seven selection rounds, held in 1991, 1992 and subsequently every two years, a further 130 CRC proposals were approved, including 39 applications from established CRCs that were reaching the end of the funding period.

Each CRC is a long-term collaborative venture involving research performing organisations, such as universities or public research institutes, and research users, such as industry. In some of the "public good" CRCs, the research user is the relevant public sector organisation or government department and does not include the private sector. Thus, while most CRCs are true public/private partnerships, some are partnerships between the public research performer and the public research user.

On average, a CRC is formed for an initial period of 7 years, has cash resources of AUS$4.6m and total resources (cash and non-cash - also known as 'in-kind') of AUS$12m per annum available, involves 15 organisations as core participants and some 52 professional full time equivalent (FTE) staff and 10 non-professional FTE staff. However, each of these parameters varies within a substantial range. The CRC Program was designed to accommodate a broad spectrum of initiatives tailored to the needs and characteristics of the particular field of endeavour and this is clearly reflected in the diversity of CRCs in terms of size, focus, number of participants and organisational structure.

In the 2003 evaluation of the CRC Program undertaken by an external consultant, Howard Partners, on behalf of the Department of Education, Science and Training, the following statement was made to characterise the CRC Program:

"The CRC Programme is primarily an industrial research programme that supports industry and business development across a broad range of sectors, including agriculture, fishing and forestry, information and communications, mining, manufacturing, energy, health care, water services, transport and construction. The Programme also delivers outcomes in relation to resource sustainability, particularly in the context of the conservation, repair and replenishment of the nation's "natural capital" and the maintenance of biodiversity. In addition, the Programme supports social outcomes through the promotion of public and environmental health."

Role and purpose: Which gap do CRCs fill within the Australian NIS?

A range of programs have in the past and at present focussed on the need to improve the economic and social benefits flowing from the extensive public research effort on the one hand and to increase the level of R&D within the private sector on the other hand. The CRC Program was devised to address primarily the former but also the latter issue. In addition, it was aimed at creating synergistic benefits through better coordination and collaboration of a diverse range of researchers in the same or complementary fields of research.

The outstanding difference of the CRC Program compared with any of the other programs with similar aims in the Australian context is:

- The size of the financial commitment by the government (of the order of 150 million AUS$);
- The long term nature of this commitment (since 1990 and ongoing); and
- The requirement of all core participants in a CRC to commit to the collaborative venture for a substantial length of time, typically 7 years.

Box 1. The objectives of the CRC Program

The Government objectives for the CRC Program are to enhance:

O The contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development;

O The transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia;

O The value to Australia of graduate researchers; and

O Collaboration among researchers, between researchers and industry or other users, and to improve efficiency in the use of intellectual and other research resources.

The CRC Program seeks to achieve these objectives by supporting applications to establish CRCs which bring together researchers and research groups from universities, government research laboratories (Federal, State and Territory), and the private sector, into long term cooperative relationships. These CRCs create strengthened research networks, and provide areas of research concentration, ensuring that national resources are used more efficiently.

Source: CRC Program - Guidelines for Applicants, 2002 Selection Round.

The CRC Program is seen as fulfilling an important role within the Australian national innovation system as it is aimed at:

- Collaboration between researchers and research users;
- Education of graduate researchers in an outcome oriented context;
- Excellence in long-term strategic research; and
- The transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia.

CRCs are selected on a competitive basis against a range of criteria (see Box 2) namely to bring together different research groups of international calibre engaged in the same or complementary fields of research and linking these research groups closely with those who may apply the research outcomes through commercialisation or any other means. This latter group is generally referred to as the research user. All fields of physical and life sciences are eligible and there are very few limitations to the type of organisations that may participate in a CRC. Any proposal for a CRC must be submitted jointly by all participating organisations, which must include at least a university and a research user, which typically is industry.

The CRC Program thus builds on the strengths of the public sector research in Australia while encouraging long-term links with research users. The program also creates new opportunities for PhD students to work within these strategic research projects.

How CRCs are selected and established

Every two years, proposals for funding under the program are called. Centres that are already funded under the program have the possibility to seek additional funds for new research programs and those within one to two years of the end of their current contract period may seek additional funding beyond the current funding period. Proposals must be submitted by all parties that propose to make contributions to a Centre. The commitments by participants must be at least at the same level as the funding sought from the Australian Government under the program. On average, it is about three times the level of program funding being sought, i.e. CRC program funds represent one quarter of the total resources available to a CRC. Proposals are generally for a period of seven years.

All proposals received by the due date are assessed against the selection criteria. The evaluation involves:

- Two external technical expert advisory panels, one for physical sciences and one for life sciences with some proposals being considered by both;
- National and international referees; and
- The CRC Committee.

The assessment conclusions are presented by the expert panel chairs to the CRC Committee. The Committee recommends the proposals to be funded and the funding level to the Minister for Science who decides on the offers to be made and any specific conditions to be attached to the funding offer. Briefly the assessment and selection process is as follows:

- Expert Panels decide on referees for each application unless an application clearly fails to meet the basic eligibility criteria. Generally two Australian and two international experts are approached, with proposals in similar fields being reviewed by at least one common referee who is asked to provide some comparative evaluation of the proposals in addition to the assessment against the selection criteria. The referees are ideally people who can comment not only on the scientific value of the proposal and the standing of key researchers, but equally on the likely value of research outcomes and the quality of the collaborative arrangements being proposed.
- Referees are asked to provide to the extent possible an assessment of the proposal against the full range of selection criteria.
- The Expert Panels then consider the proposals together with the referees' comments and decide on a short-list of proposals to be considered in more detail.
- The proponents of proposals selected for further consideration are interviewed by several members of the Expert Panels. This face-to-face meeting with the key players in a proposal is seen as the most important step and interviews generally take five to six hours.

Box 2. CRC selection criteria

Objectives of the CRC

1. The proposed CRC has well defined objectives that address a specific community and/or industry need.

2. The proposed outcomes of the CRC will make a significant contribution to Australia's sustainable economic and social development.

Quality and relevance of the research program

3. The proposed research program is of high quality and is well defined, with clear outputs that are achievable over the life of the CRC. The outputs are relevant to the stated objectives under selection criterion 1.

Strategy for utilisation and commercialisation of research outputs

4. The proposed CRC has a well structured, feasible and practicable strategy for the commercialisation, technology transfer or utilisation of the research outputs to achieve the proposed outcomes identified under selection criterion 2. The strategy should specifically address SME involvement in the CRC through direct or indirect participation and through involvement in the application of research outputs through commercialisation, technology transfer or utilisation, including where appropriate the spin-off of new SME companies. Milestones should be identified as a basis for performance monitoring.

Education and training

5. The proposed CRC has a well developed graduate education and training program oriented to research user and industry needs. The education and training program will demonstrably enhance the employment prospects and the value of the graduates of the program in the industry and user environment.

Collaborative arrangements

6. The collaborative arrangements reflect a strong commitment by participants to build links between the research groups and organisations, and between research groups and user and industry participants. The collaborative arrangements will integrate and enhance the CRCs research and educational programs. The proposed CRC is required to address the issue of international linkages and indicate how proposed linkages would contribute to the objectives of the CRC.

Box 2. CRC selection criteria *(continued)*

Resources and budget

7. The budgeted resources, cash and in-kind support, including time allocation of key personnel, from all participants clearly demonstrate their commitment to the CRC and is adequate to support the proposed research and education programs.

Management structure

8. The proposed CRC has an effective management structure, including financial, operational and research management arrangements, to ensure that the objectives of the CRC are realised.

Performance evaluation

9. The proposed CRC has a performance monitoring and evaluation strategy appropriate for the internal assessment of research and education programs, and for commercialisation, technology transfer or utilisation. The strategy will also meet the reporting requirements of the Australian Government.

Source: CRC Program – Guidelines for Applicants 2002 Selection Round.

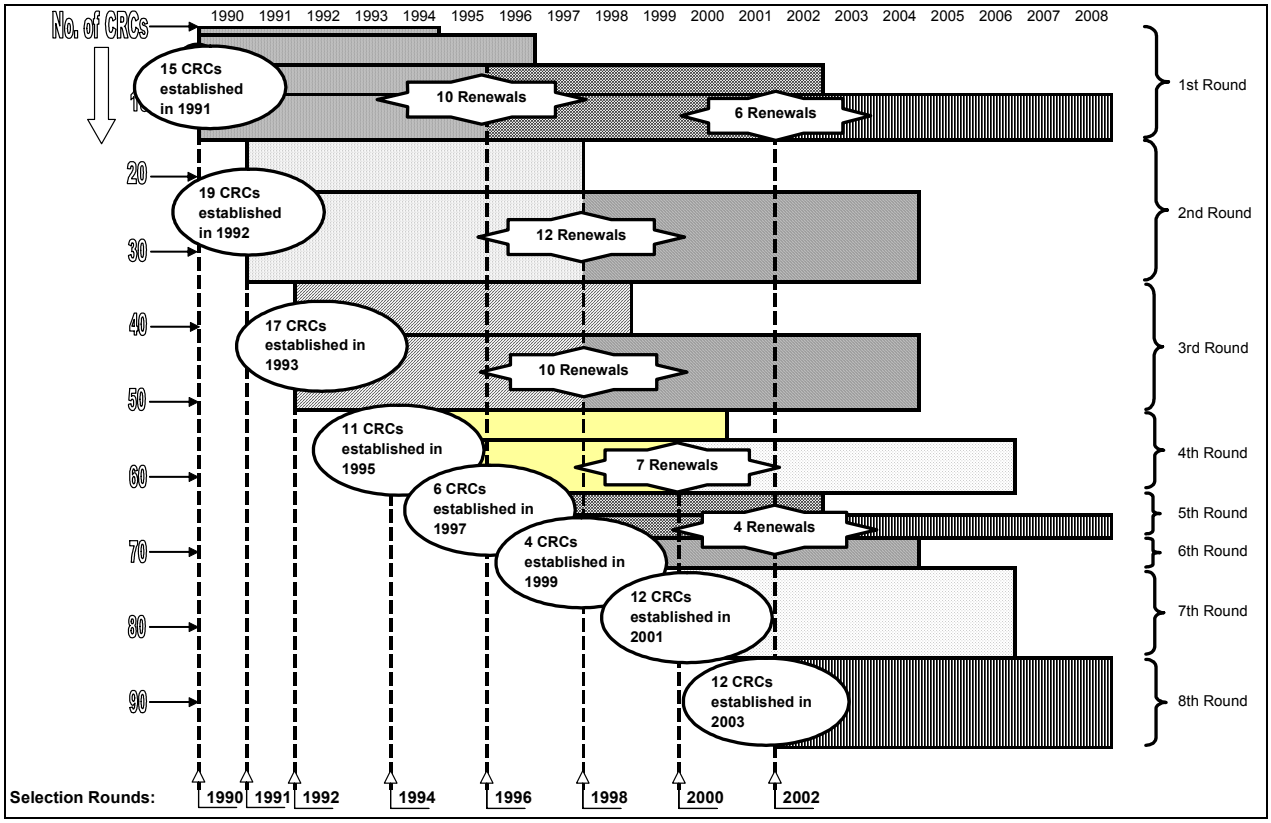
In effect the process of partner-partner linkage that occurs during development of CRC proposals — and the careful consideration of the proposals and participants by expert panels — permits or hastens the identification of likely areas of Australian research strength that have not necessarily been previously identified or widely known. The Program enhances these and aims to turn them to greater national advantage through the provision of seed funding.

The investment by individual applicants during the preparation of the proposal is substantial and has at times been raised as a concern. The possibility of a two stage application process has sometimes been suggested, most recently in the 2003 evaluation by Howard and Partners. On the positive side, one notes that the success rate over the most recent three selection rounds was on average 45%, a rate well above many other competitive schemes for R&D.

Building up of the portfolio of CRCs

Figure 6 illustrates how a total of 96 different CRCs were selected over a time span of 12 years. As can be seen, CRCs selected in the first five rounds have already reached the stage where phasing out of CRC funding or alternatively renewal of funding had to be decided. Of the first fifteen CRCs, originally established in mid 1991, 10 were renewed for a further period during the 1996 selection round, and of these, six were renewed for a third term in the context of the 2002 selection round.

Figure 6. The eight selection rounds since the inception of the Program and the corresponding funding periods



Note: Oval symbols designate the original funding decisions; star shapes designate the renewal of contracts.

Of the 68 CRCs that reached the end of their initial funding period, 43 CRCs (or 63%) obtained a further period of funding. Of the 10 CRCs that have already completed the second period of funding, six Centres (or 60%) were selected for a third funding period, which will mean a total operation of 19 years.

An important variable that will influence greatly the nature of the CRCs in the longer term is the proportion of CRCs that gain funding support under the program for a second, third or even fourth period. It is an issue that so far has to our knowledge not been addressed in an explicit way, although past experience in six distinct selection rounds would suggest a renewal rate of the order of 60%.

Becoming self-funded: reality or fiction?

There was always a desire to encourage CRCs to develop strategies which would allow them to become independent of the financial support provided by the CRC Program. At the same time, it was recognized that some CRCs, because of the field of research and the substantial public benefit aspect may never reach such a state.

Others with a committed and satisfied industry participation may, however, position themselves such that their commercial partners provide the increased funding to allow continuation of the cooperative venture beyond the CRC Program support. Alternatively, some CRCs may be able to generate sufficient cash flow from early licensing or other commercial activities to substitute for the CRC Program funds, at least to a sufficient degree to ensure continued operation.

Box 3. Path to self-funding: the example of the CRC for Tissue Growth and Repair

Selected in the first round of CRCs, this centre was established in 1991 and, following a successful renewal application in 1997, continued to be supported under the CRC Program for a second term until 2002. The CRC TGR functioned as an unincorporated joint venture but was set up with a strong commercial focus and a strategy to become self-funding.

An important part of its commercial strategy consisted in setting up a separate company GroPep independent from the CRC but with shareholdings identical to the contributions to the CRC made by the various organisations, i.e. a strong link through the common stakeholders. In mid 2001, a further company TGR BioSciences Pty Ltd was set up. It was to become the new entity through which the activities of the CRC were to continue beyond its formal status and funding as CRC.

The CRC unwound in June 2002. Four of the CRC shareholders have taken an equity position in TGR BioSciences by committing to the new company their royalty returns from CRC IP commercialisation, together with some additional cash injections and staff secondments. Two additional foundation shareholders are also contributing cash and in kind services in return for equity, so that the shareholding at December 2002 was held by six organisations holding between 6 and 25 % of the total capital each. These shareholders have committed themselves for an initial period until June 30, 2005. By the end of 2002, TGR expanded to 15 employed staff and was supported by over 25 scientists from the shareholders. Through a licensing agreement, the company had its first skin care product launched in 2001.

The CRC's director and now managing director of TGR BioSciences cites the following key steps to self-sufficiency:

- Early planning for self-sufficiency.
- Strategy for capital growth of GroPep, the commercial agent of the CRC.
- Accumulation of cash surpluses over the initial 10 years by retaining earnings.
- Establishing a vehicle for continued operation, TGR BioSciences Pty Ltd, well before CRC funding ceased.

Two other aspects are also worth highlighting. First, all parties were committed to the strategy and agreed to leave the intellectual property rights with the joint venture and to reinvest any earnings in the joint venture. Second, at each step rights, responsibilities and commitments were clear to all parties concerned and were kept simple and streamlined. Nevertheless, the structure was such that it allowed the easy entry and exit of partners at key points, while ensuring that partner organisations made longer term commitments and thus allowed sufficient time for the new entity to establish itself.

There is no clear evidence that significant revenue from commercialisation activities has occurred, and there are only very few examples of CRCs reaching self-sufficiency, with the CRC for Tissue Growth and Repair being one of the CRCs that continued operation successfully beyond the CRC funding period. Box 3 gives a glimpse of the history of this Centre. Some key steps to self-sufficiency are mentioned in this summary. Most CRCs have sought repeat funding, for seven or more additional years.

Participants

While there are few basic requirements regarding participants, there has to be at least one university and one research user. The term 'research user' refers in many cases to industrial enterprises but in some CRCs particularly in the area of the environment it may be public utilities or government organisations that are identified as those who will apply the outcomes of the research to be undertaken. The appropriate number of participants is very much influenced by the field of research and the industry sector; however it is not the intention of the CRC Program to establish research centres for the benefit of single companies. A further relevant consideration is that CRCs with a small number of participants, while often more easily managed, are more vulnerable to any financial difficulty or change in priority by partner organisations.

Figure 7. Participating organisations by type

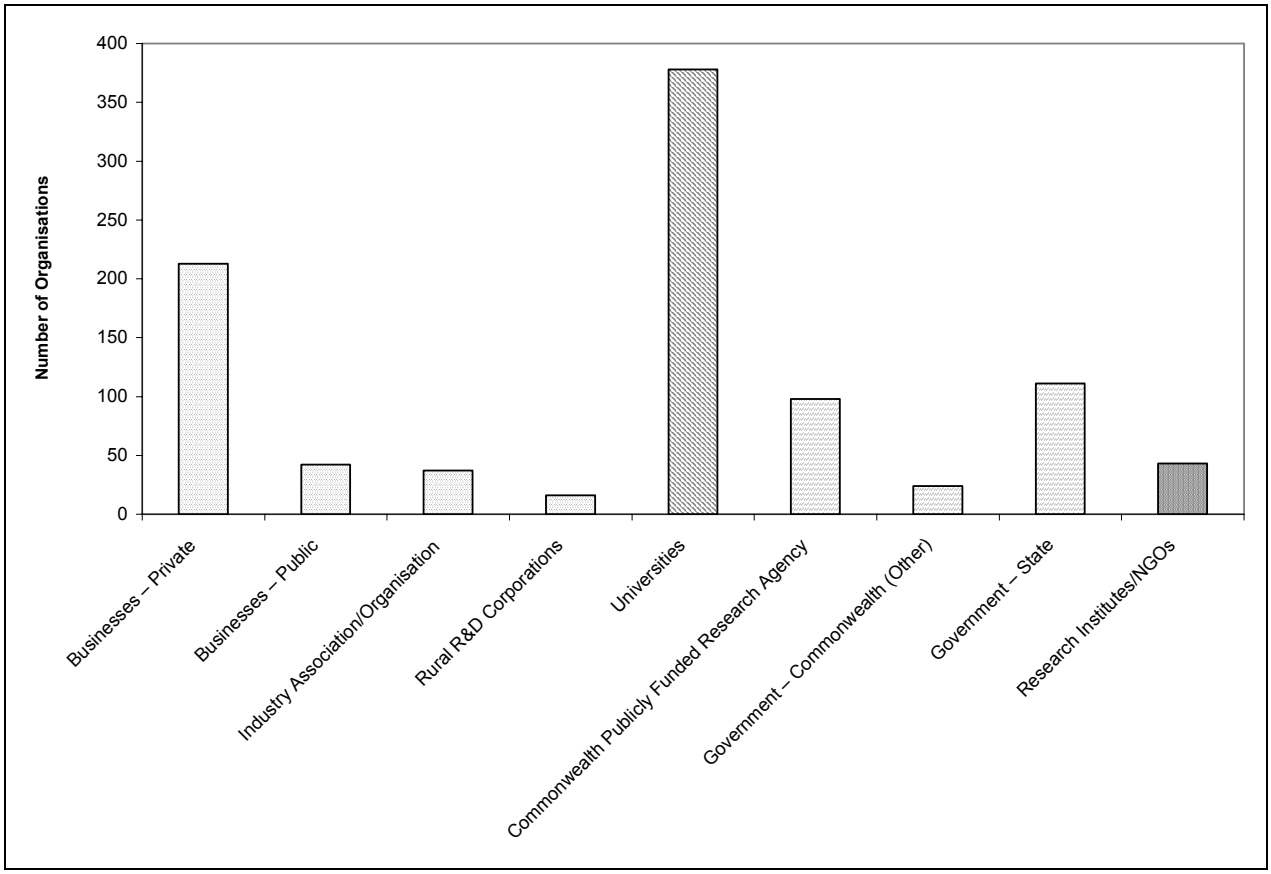
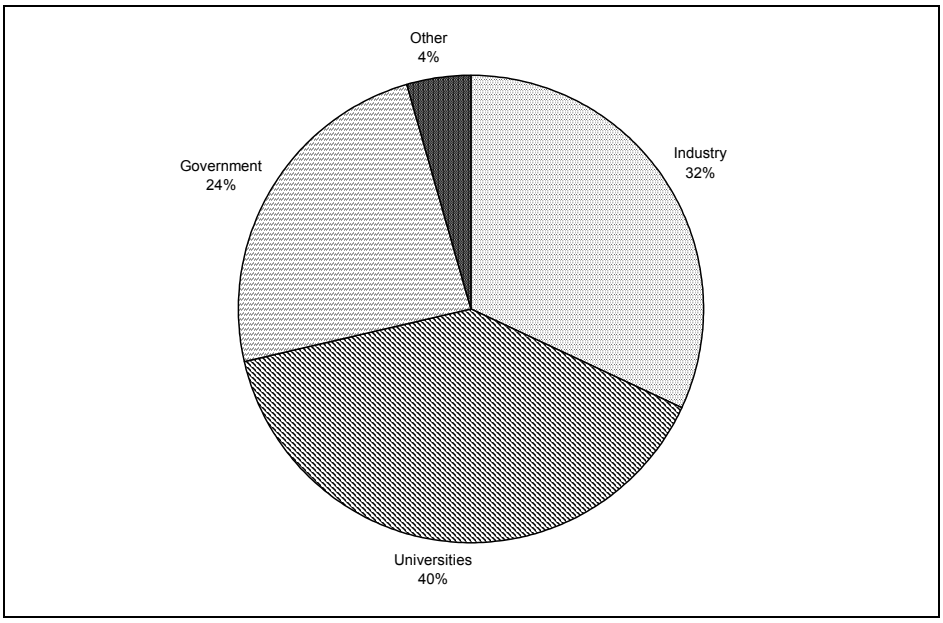


Figure 8. Core participating organisations by type



Note: There are on average about 15 core participants in a CRC. Each university is counted as one participant irrespective of the number of different departments involved while each division of CSIRO is counted as a separate participant.

Selection of themes and participants

As mentioned above, when funding under the Program is being sought, the research programs to be undertaken by the proposed Centre and the initial set of projects to be tackled under each of the research programs must be presented in the submission. The process of developing these programs and setting priorities in terms of the projects to be undertaken is an important collaborative effort and can take many months. Often applicants comment that this process was in itself useful in creating closer collaboration between the organisations involved even if the ultimate funding decision is negative.

The term 'research program' is used in this context for each of the typically four to six research themes likely to remain for the duration of the contract period, while projects are the sub-elements of these programs, often proposed for periods of two to four years. One of the expectations of the CRC Committee is that proposals demonstrate involvement by a range of organisations in each program and where possible at the individual project level.

Of course the nature of research is such that projects and even programs will change or will be abandoned and replaced by more promising work. This process is in no way hindered by the program and the governing body of each CRC (generally referred to as the board) has the responsibility to manage this process in such a way as to ensure that the work of the CRC is in line with the overall aims of the centre and the objectives of the CRC Program.

CRCs are expected to allocate all available resources to the programs and projects in such a manner as to optimise the outcome in terms of the CRC Program objectives. Thus they are not to function like an internal granting scheme nor should they allocate program funding on the basis of the resources provided by participant. Allocation must be based on what is best for the CRC and its objectives.

Participation of SMEs

In the latest selection round, the Minister stated in his foreword to the guidelines that the government wished to see opportunities for SMEs to participate enhanced:

> *"One of the strengths of the CRC Program has been its flexibility in the range of participants and operating structure of each individual CRC. I would like applicants to think innovatively about how they can better involve the many SMEs that make up an integral part of Australia's industrial structure. It is important that Centres develop linkages with SMEs to facilitate technology transfer. I would also expect to see an increase in SME spin-offs coming out of the Program in the future."*

The guidelines for the latest selection round suggests that *"CRCs should note the various approaches that have been successful, such as using industry associates programs, having industry associations as core participants, using agricultural and other extension services, using CRCs as demonstrator sites, SME sponsorship of postgraduate students and assisting SME employees to work in a CRC on temporary secondment Flexibility should be provided for SMEs to join and exit the proposed CRC through associate programs, where such participation would provide a strategic advantage for SMEs".*

The main barriers to participation by SMEs are:

- The relatively high input in senior management resources required from applicants/core participants;
- The expectation of core participants to commit resources for a long period, often seven years; and
- The difficulty of giving SMEs enough influence when mixing small and large players in a co-operative venture.

Those CRCs which have been successful in attracting SMEs have generally lowered these entry barriers by creating mechanisms which allowed easy and inexpensive access to the CRC through, for example, industry associates programs. Typically, such programs allow SMEs to become associated with a CRC at a nominal cost which then provides them preferential access to information about the research outcomes and sometimes also access to the researchers. Annual or more frequent industry briefings may also be a feature of such interactions.

The approach by CRCs that serve an industry dominated by many smaller organisations, typically found in the agricultural research fields, through participation of the relevant industry association or industry R&D association (for example the relevant Rural R&D Corporation) is a convenient and effective way of building on the existing management and funding infrastructure of the research users.

The most difficult situation is when a CRC has already a number of core industry participants which have made the long-term commitment that is crucial to the successful selection as a CRC. In such a CRC the industry core participants may understandably be reluctant to facilitate access to SMEs which are often competitors. SMEs, on the other hand, may feel that any contribution that they make will be absorbed by the CRC without them having an adequate say over the strategic direction of the research.

The 2003 program evaluation found that SMEs, while encouraged to participate in CRCs find it generally difficult to do so given the long-term commitments expected of core participants. It suggests increased flexibility and active encouragement to improve this situation. This seems to already have happened and it remains to be seen whether CRCs can foster the participation of SMEs more effectively in the future.

Given the above considerations, it may be necessary to do more than encourage CRCs to work with SMEs. Any specific incentives or targets would have to be set for each CRC separately since the circumstances are too different to allow a general rule to be applied to all CRCs.

Role of post-graduate students

One of the objectives of the CRC Program is to offer the opportunity for graduate students to undertake their research in the context of a major collaborative venture involving not only top researchers but also research users. It is argued that such an experience will form individuals better able to work in a collaborative team and more focussed on ultimate outcomes sought by research users. These are characteristics which are seen as valuable within the context of an effective national innovation system.

The CRC Program has performed extremely well in this area. The number of graduate students has increased steadily. Eight per cent of all PhD students in natural sciences and engineering now graduating in Australia have undertaken their research within a CRC. These students are thus more attuned to the demands of outcome-oriented research programs and collaborative and interdisciplinary projects. They are also more aware of the issues related to intellectual property rights and effective technology transfer to industry. This is an achievement that should not be underestimated since it also ensures an effective skill and technology transfer as well as having a multiplier effect on the culture change supported by the CRC Program.

As indicated elsewhere, research students working in a CRC also substantially enhance the corporate culture of CRCs in that they are often the only ones who have no competing organisational allegiances.

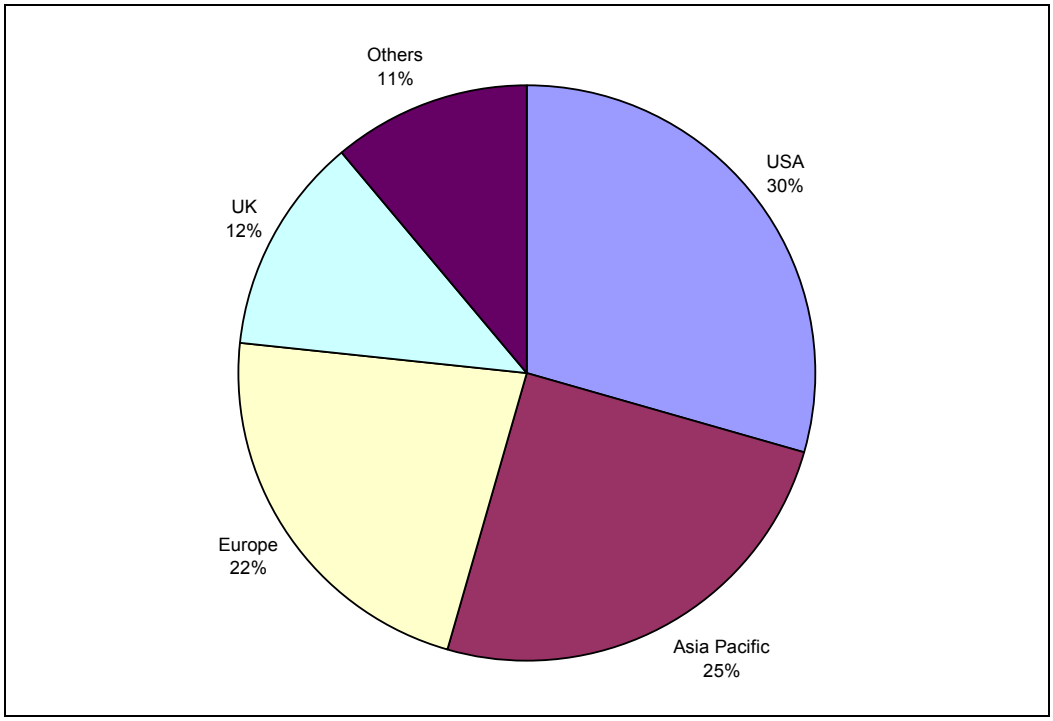
Participation of foreign companies and public research organisations

To increase collaboration with international research networks is an explicit selection criterion of the CRC Program. In fact, this aspect was one of the explicit reasons for the increased funding allocated in 2001. The 2003 evaluation noted that reporting on this aspect is not well defined and seems to be restricted to listings of collaborations in annual reports and the yearly Management Data Questionnaire.

From these sources, one can gather that some 935 international collaborations took place in 2001-2002, a substantial increase from 508 collaborations only four years previously. However, the actual scope of this aspect of CRCs' activities can only be gleaned from examples collated and published by the CRC Association and ranges from research collaborations with universities and research institutes, over student and researcher exchange programs to joint development and commercialisation activities.

International collaboration with overseas firms is limited, mainly because such collaboration is generally undertaken through the Australian subsidiaries. Direct collaboration with a foreign firm would normally be undertaken through separate agreements involving either all or some of the CRC participants. The level of such activities is not known but would have to take account of the fact that CRCs must seek to optimise the benefits flowing to Australia.

Figure 9. CRC international collaborations (number) by region, 1997-98 to 2001-02



Financing

Financing of the seven-year ventures that most CRCs are is secured through two separate contracts covering the total period and setting out the contributions to be made by the CRC Program and the other parties (in the Australian Government Agreement) and detailing the contributions to be made by each individual participating organisation (in the Centre Agreement).

There is no minimum contribution per participant stipulated by the Program, but from the point of view of each participant a reasonable stake in the overall venture is needed to ensure that adequate influence, control and benefits are gained and to justify the overhead involved in becoming a participant in such a cooperative venture. On the other hand, the major contributors to a CRC will want to ensure that their interests are not diluted by participants making minimal contributions and gaining dis-proportionate rights. This mechanism seems to work quite well except perhaps in the case of SMEs which is discussed above.

The overall figures in terms of type of funding source show that the CRC Program achieves a substantial leveraging of its funds with funding from participants being on average equal to three times the CRC Program funding. While this signifies that collaborative research of the type undertaken in CRCs represents a substantial part of R&D undertaken in Australia (about 10%), it also should be acknowledged that by diluting the CRC Program funds there may be a danger of losing some of the flexibility and agility of CRCs because often the Australian Government funds represent the bulk of cash resources available to CRCs, with other contributions being mainly "in-kind".

Two thirds of all resources are provided by the CRC Program, universities, CSIRO and other Australian Government organisations. Only one quarter of the resources is provided by industry and other non-government sources. It would be easy to conclude that funding is too much dominated by public sources but it must be recognised that the CRC Program funds substantial public interest activities, including in the areas of the environment, health and safety as well as in terms of its educational objectives.

Figure 10. Resource contributions by type of participant, July 1991 to June 2002

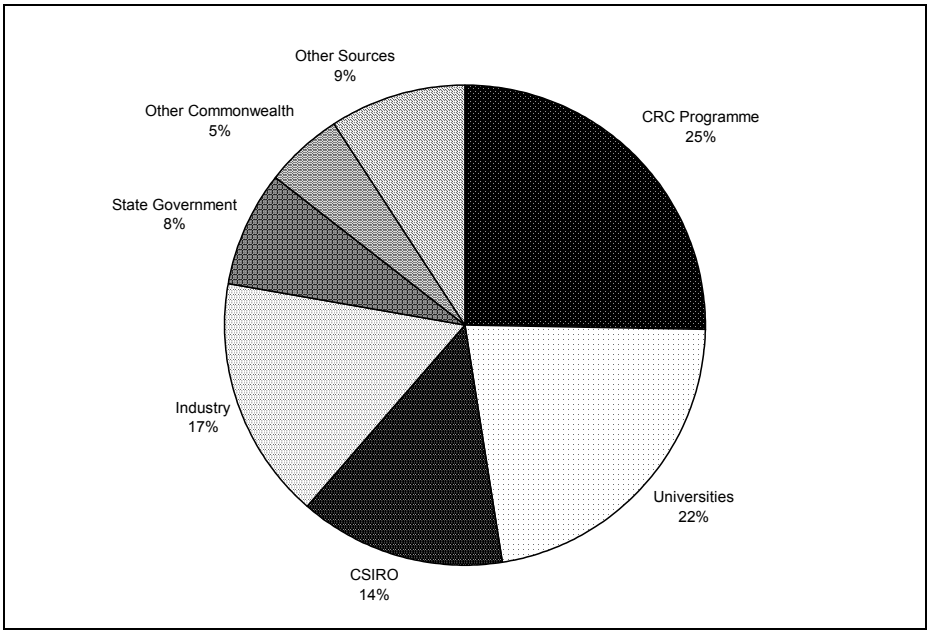


Figure 11. Cash and in-kind resource contributions, July 1991 to June 2002

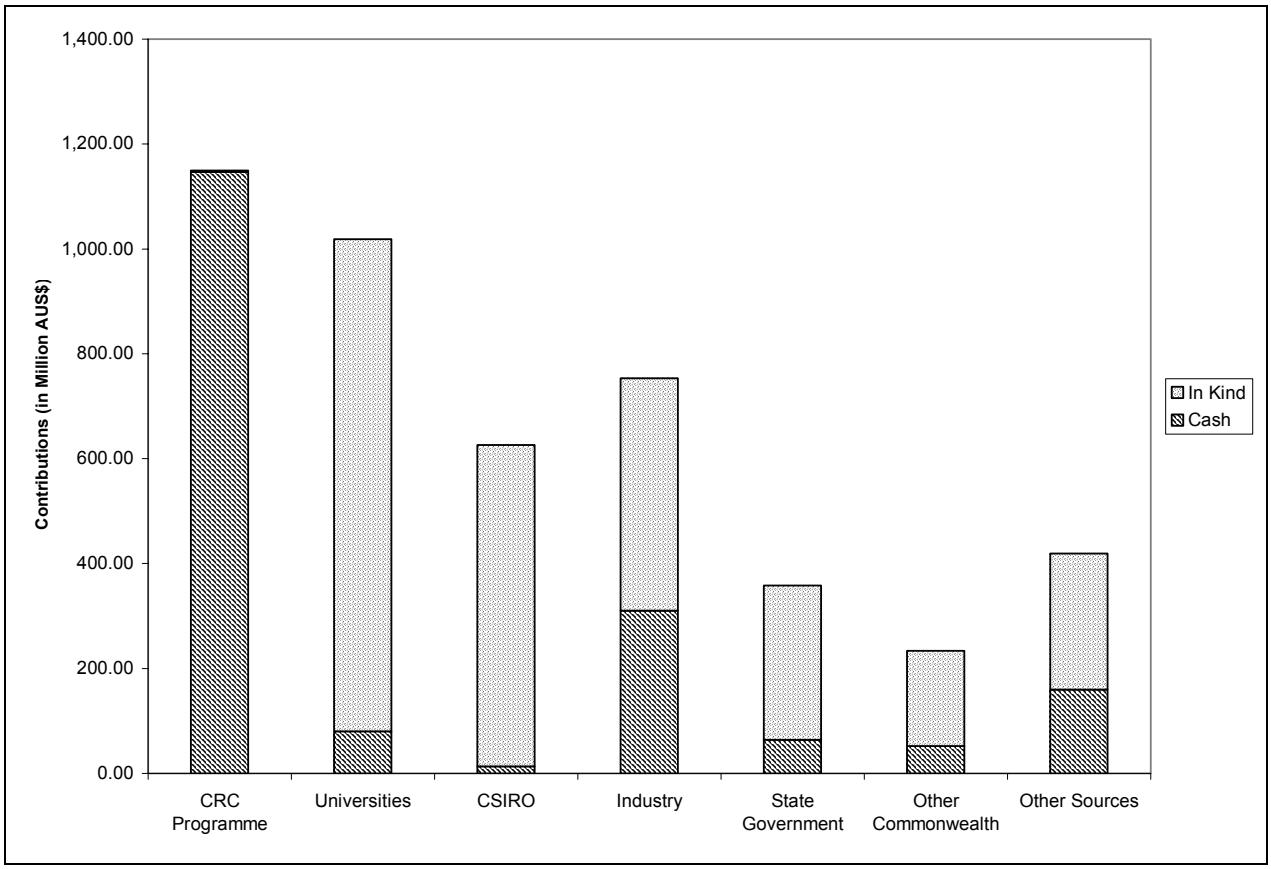


Table 5 shows the CRC Program expenditure (Australian Government funding) side-by-side with total Australian R&D expenditure and its component expenditures by universities, government and business. In this comparison, the CRC funding represents less than 2.5% of the overall R&D expenditure. It would be wrong, however, to conclude from this a similarly limited impact, for the following reasons:

- In some areas, its financial importance is much greater, for example almost 9% in the field of environmental management.
- CRC funds have a greater impact than their proportion suggests because they are new funds providing substantial flexibility.
- CRC Program funding represents only a quarter of resources available to CRCs and therefore a total of 10% of all R&D expenditure in Australia is incurred by CRCs.

Table 5. CRC expenditure in relation to total Australian R&D expenditure, 2000-2001

Socio-economic objective	Higher education and Non-Profit Institute R&D expenditure	Government expenditure on R&D	Business expenditure on R&D	**TOTAL expenditure on R&D**	CRC expenditure
	$m	$m	$m	**$m**	*$'m*
Economic Development					
Animal Production and Animal Primary Products	64.6	297.8	55.4	**417.8**	*10.5*
Plant Production and Plant Primary Products	108.6	392.5	46.8	**547.9**	*37.2*
Mineral Resources (excluding energy)	42.1	81.9	317.2	**441.2**	*20.6*
Energy Resources	32.4	65.3	103.6	**201.3**	*9.8*
Energy Supply	31.1	28.3	121.8	**181.2**	*10.0*
Manufacturing	143.5	232.8	1,947.0	**2,323.2**	*45.2*
Construction	54.2	33.2	59.9	**147.4**	*0.9*
Transport	22.8	20.3	80.6	**123.7**	*0.7*
Information and Communication Services	127.7	53.0	1,368.7	**1,549.4**	*29.3*
Economic Framework	131.1	158.7	7.8	**297.6**	*4.4*
Commercial Services & Tourism	40.4	11.4	211.0	**262.9**	*0*
	800.7	1,375.0	4,317.8	**6,493.6**	*168.8*
Environment					
Environmental Management	135.0	380.9	62.0	**577.9**	*50.7*
Environmental Policy Frameworks	12.7	50.2	25.4	**88.3**	*0*
Society					
Health	1001.2	213.0	276.0	**1,490.2**	*25.1*
Advancement of Knowledge	692.2	33.8	6.5	**732.5**	*7.2*
Other	397.7	315.4	155.8	**868.9**	*0*
Total	**3057.8**	**2,368.4**	**4825.3**	**10,251.4**	***251.9***

Source: ABS Bulletin 8112.0 (July 2002) and data provided by the CRC Program (DEST).

Organisation, governance and management

The issue of the type of legal arrangement that a CRC should adopt has been discussed from the outset and has created some substantial problems in cases where participating organisations had opposing views. The issue is still one of concern, as is demonstrated in the recent evaluation. The two essential options are: to incorporate the CRC as a separate legal entity, generally limited by guarantee and tax exempt, or to set the CRC up as an unincorporated joint venture, with one of the organisations, often one of the universities, acting as the agent of the CRC, providing the administrative infrastructure and acting as employer of CRC appointees.

The Australian Government indicated in 2002 that an incorporated structure was preferred but a majority of CRCs have chosen the unincorporated joint venture route, with sometimes an incorporated entity to act as commercial agent and holder of intellectual property. The 2003 evaluation recommends that "the Department of Education, Science and Training explore the feasibility of legislation for CRCs to be established with a specific status. The objective would be to resolve uncertainties and complexities in corporate and taxation status and provide a sound basis for a public-private research partnership". Given the substantial experience gathered in terms of the likely issues, barriers and objectives when selecting a legal structure, it may well be opportune to explore such an option, particularly since the issue has remained of high priority but unresolved for over a decade.

Each CRC is given substantial flexibility in its organisation, governance and management. However, there are a few basic principles which have been identified over the years as best practice and which are now required to be implemented by all CRCs, for example: all CRCs are expected to be managed by a CEO with overall responsibility; each CRC has a board of directors representing core participants as well as other stakeholders and chaired by an independent industry representative; and, researchers are responsible to the CRC and its management even though they are often employed by one of the organisations participating in the CRC. Therefore, while CRCs are not geographically collocated research groups, calling them virtual centres would be misleading in that each CRC is expected to establish a strong corporate identity with substantial responsibilities and powers vested in the CEO, the Centre Management Team and the Board.

Each CRC is a collaborative venture of a multitude of organisations. Generally CRCs are also geographically dispersed, across the breadth of the continent. For this reason, the most common structure is one of a network of nodes of research, located in some of the existing laboratories. Facilities are often upgraded and some research groups who were located in different laboratories within the same town may collocate. A global collocation of all resources is neither possible nor desirable: it would be far too costly, and many workers in CRCs retain teaching, research or other duties outside the CRC with their "home" organisation. More importantly, the networked arrangement ensures that the CRC approach has a much greater impact on the organisations involved: the CRC mode of operation is found within each of the cooperating organisations and demonstrates and promotes the collaborative approach beyond the groups and individuals directly involved in CRCs.

All CRCs have more than one geographical location and are constituted by a staff employed by its participant organisations as well as the CRC itself (in the cases where the CRC is incorporated and thus able to employ its own staff). However, in all cases the majority of staff is not directly employed by the CRC and a minority of all staff work exclusively for the CRC.

The management system used in CRCs could best be described as a matrix with research issues being dealt with through the research program management hierarchy of the CRC and personnel matters through the staff home organisation, i.e. his or her employer. The fact that a majority of researchers work a certain percentage of their time in CRC research programs and the remaining time in duties

related to their employing institution (e.g. teaching, other research projects, management tasks within their employing organisation) adds an additional complexity compounded by the fact that specific laboratories, office space and other infrastructure often belong to one of the participant and not the CRC so that an additional grey area exists. This may appear rather complex but the reality seems to be that where there is goodwill, trust and a clear understanding and acceptance of these arrangements, the implementation is not overly difficult. For the arrangement to work, however, it is important that all participants see the CRC to benefit them and their organisation in an adequate way.

Box 4. Example of a CRC: Australian Cotton CRC

Research locations

Armidale (NSW), Narrabri (NSW), Broome (WA), Geelong (VIC), Dalby (QLD), Darwin (NT), Katherine (NT), Kununurra (WA), Richmond (QLD), Sydney (NSW), Canberra (ACT)

Core participants

Industry: Cotton Research and Development Corporation; Cotton Seed Distributors Limited; Queensland Cotton Corp Limited; Western Agricultural Industries.

University: The University of New England; The University of Sydney.

Australian Government: CSIRO, Plant Industry, Entomology, Sustainable Ecosystems, Textile and Fibre Technology.

State: NSW Department of Agriculture; Queensland Department of Primary Industries; Western Australian, Department of Agriculture; Northern Territory Department of Primary Industry and Fisheries.

Research focus

To enhance the development and growth of the Australian cotton industry through the application of collaborative research, education, and sustainable farming systems which are environmentally responsible, enhance reliability of production, and increase market competitiveness. To be achieved by:

- Undertaking research on farming systems suitable for potential new cropping regions in northern Australia;
- Developing innovative technologies for crop management, which provide biological solutions to pest and disease management;
- Undertaking research on sustainable farming systems which optimise the use of natural resources and minimize environmental impact;
- Developing and commercialising new approaches for processing of cotton yarn and fabric; and
- Providing a coordinated, national extension service for cotton as well as outstanding educational opportunities for new research and extension staff, and training for industry participants.

Areas of research expertise

Integrated management of insect pests, weeds and disease ecology, field evaluation of transgenic technologies, biocontrol, bioremediation, chemical attractants, diagnostics, biodiversity and vegetation management, plant pathology, irrigation science and water use efficiency, soil structure, microbiology and chemistry, agronomy, crop nutrition and soil management, modelling, fabric bleaching and dyeing processes, education, technology transfer and community consultation.

Personnel involved in Centre: Postgraduate students: 22
Full-time equivalent research staff: 54

Funding details

CRC Program Funding per annum: AUD 2.0 million; total over the grant period: AUD 13.4 million.

Total resources available to CRC: AUD 12.6 million per annum and AUD 84.1 million over grant period.

Centre established: 1 July 1999 **Round No:** 6 **Grant period:** 7 years **Incorporated:** No

Further information: see http://www.cotton.crc.org.au/

Intellectual property rights (IPRs)

One of the objectives of the CRC Program is the "transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia". It is obvious that intellectual property rights are frequently of great importance, with the possible exception of those centres with an exclusively public interest nature.

However, the circumstances of each centre are so different that no attempt is currently made at establishing general rules for all centres beyond that each centre must ensure that IPRs are protected and dealt with in such a way as to maximise the outcomes in terms of the objectives of the CRC Program and that rights to IPRs and/or benefits flowing from them are equitably shared between the members of the CRC taking into account the relative contributions made by each party.

The Australian Government, through the CRC Program, contributes funds but does not claim any share in the IPRs generated by CRCs. It is the contribution by the participants that determines each organisation's stake in the research outcomes. The preferred approach is for all participants to share in all IPRs even though some organisations may only be interested and directly contribute to some of the research programs. This preferred approach ensures that CRCs allocate Program funds and to some extent their own resources in such a way as to overall maximise the outcomes rather than individual participants seeking to channel CRC Program funds into "their" research programs.

Public research organisations are encouraged to commercialise research outcomes to the benefit of Australia and any financial gain flowing from such activities remains with the research organisation. In the case of CRCs, this general rule also applies. Participants may of course agree to reinvest any such financial return into the CRC activities. This allows the CRC to grow and/or to become less dependent from public funds.

Each Centre Agreement, i.e. the agreement subsidiary to the main agreement with the Australian Government, must establish the rules governing IPRs in sufficient detail and in such a manner as to satisfy the government that benefits will be maximised under the specific circumstances.

As a general rule, the Centre Agreement must ensure that pre-existing IPRs are made available to the CRC free of charge for research purposes and that participants who own such IPRs agree to make them available on normal commercial terms if they are required for the commercialisation of CRC developed IPRs. IPRs developed in the course of the research by the CRC belongs to the CRC and in the case of CRCs which are not legal entities in their own right (i.e. unincorporated joint ventures) the IPRs are held by one of the public sector partners on behalf of the CRC participants. Each participant organisation has a financial interest in the IPRs proportional to its overall contribution to the CRC. The exact basis is determined by the Centre Agreement.

Evaluation

The CRC Program was established at the time when program evaluation became a prominent concern. In this context, the Program was devised in such a way as to facilitate the ongoing monitoring and evaluation of both individual centres and the program as a whole.

The contractually defined aspects of program architecture that address this concern are:

- Milestones for each research program.
- Contractually defined resource contributions by all parties to the CRC.
- Contractually defined performance indicators, chosen by the Centres to address their main objectives while ensuring that each of the four program objectives are addressed by a small but representative number of carefully selected indicators.
- Standard reporting and review schedules.
- Quarterly cash reporting using simple one page proforma.
- Annual reporting of progress against milestones and standard financial reporting (annual report).
- Annual reporting of a uniform set of statistical measures addressing inputs, outputs as well as outcomes.
- Appointment of a Visitor (often recently retired manager or researcher with no prior connections with the CRC participants) whose role it is to serve as a link between the CRC Committee and the CRC.
- A visit after one year of operation to discuss progress with and issues related to the establishment of each new CRC, and formal reviews after two and five years of a CRC's operation by a panel appointed by the CRC Committee.

Individual CRCs

Each Centre is formally evaluated in terms of its progress against the milestones of its agreement as well as more generally against the objectives of the CRC Program. The evaluations take place after two and five years and serve to provide feedback to centres to ensure the government's expectations are being met and as input to any future application for an extension or a renewal of funding.

Each CRC must produce a public annual report in a common format and covering a set list of data, including audited financial information. CRCs generally include information going well beyond this basic requirement, making the annual report a useful promotional tool for centres. These annual reports are important inputs into the two and five year reviews and provide the basis for the program administration to ensure that the agreement is adhered to and resource commitments are being met.

CRC Program

The CRC Program as a whole has also attracted close attention and has been subjected to external reviews in 1995, 1997 and 2003, with the second review focusing specifically on opportunities for greater commercialisation and self funding of CRCs.

The Program was just five years old, counting from the first announcement, and the first centres had just been reviewed after three years of operation, when the first review of the program took place in 1995. Of course, it was too early to evaluate any actual achievements in terms of ultimate outcomes and the review was thus focussing more on whether progress was being made in the right direction and whether the administrative and management systems were adequate and made some recommendations reinforcing the original intent. The overall finding of the review was that *"the major success of the CRC Program [was] in producing a culture change in Australian research and education activity in support of research and development and especially in interaction with industry and other research users"*.

A second independent review was undertaken in 1997, focussing on the issue of effective commercialisation and increased independence of CRCs from the CRC Program funds. One of the conclusions was that *"one of the most important benefits of the Programme is already evident in the changed attitudes and perspectives in industry and research organizations"*. The review also recommended a number of actions which were focussing the CRCs more clearly on achieving the program objectives. The review concluded that CRC Program funds played an essential role as *"glue that unites the participants"*. It took the view that independence from CRC Program funding was unlikely to be achieved by many CRCs and that there will remain a need for the CRC Program to continue funding some existing and some new CRCs. A greater emphasis on the services sector was also recommended.

The third review was an evaluation by a private consultant Howard and Partners on behalf of the administrating department and was published in August 2003. It analysed in great detail the available information, particularly the Management Data Questionnaire database and the public documentation, complemented by interviews, written submissions and a structured telephone survey.

The program evaluation resulted in a total of 30 recommendations ranging from administrative changes to more substantial modifications to the program. Of interest in the context of this report is the view that the program should be focussed more clearly towards economic and social outcomes and, to achieve this, applications should be formulated in terms of investment proposals focussing on the ultimate outcomes and how they will be achieved.[3] In line with this emphasis, the evaluation recommends improved reporting of outcomes, noting that while the Management Data Questionnaire database provides solid and useful information on inputs and outputs, it is weak in its ability to reflect the ultimate economic and social outcomes.

The Howard and Partners evaluation identifies three quite distinct trajectories in the evolution of the CRC Program, and which have relevance for its ongoing development in the national science, industrial research and innovation system, namely:

- CRCs that operate as national benefit research centres (Category 1) – with a strong focus on resource sustainability, including maintenance of biodiversity, environmental health and national disaster research.
- CRCs as industrial research collaborations (Category 2) – which have a strong focus on cross industry performance improvement. This type of CRC has thrived in mature, commodity-based industries concerned with productivity, product quality and international competitiveness.
- CRCs as business development centres (Category 3) – which have a strong focus on research commercialisation in individual companies. These CRCs aim mainly to create new businesses based on the research undertaken.

The 2003 Evaluation argues that the paths to adoption, application and use of research outcomes are different in these three models and that therefore the processes for selection, approval, funding, monitoring and reporting should be adapted to differing needs and requirements. For an outline of the differences between these three models, refer to the Table 6, sourced from the Howard and Partners evaluation report.

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3. "*The CRC Programme be clearly positioned as an* "investment" *programme that is expected to deliver outcomes in the form of national economic, social and environmental benefits, the improved competitiveness of Australian industry, and/or the creation and sustaining of viable new technology based businesses."* (Howard and Partners, 2003)

Table 6. Categories of CRC as defined in the 2003 Review (Howard and Partners)

	Category 1	Category 2	Category 3
Mission Orientation	National Economic, Environmental and Social Benefit	Industrial Research Collaboration.	Business Development.
Nature of the Collaboration	Strategic and structured to resolve issues of national economic, environmental and social significance	Transactional. Reflects trend towards distributed systems of knowledge creation	To "commercialise" research through the creation of new business models – in existing or in new enterprises.
Research focus	New discoveries, new knowledge that may have, or the potential to have application over the longer term. Strong science focus.	Application of existing knowledge to develop technologies that have an industrial application. Strong technology focus.	Applications technologies in products that meet an identified or potential customer need. Strong market focus.
Leadership and Direction	Chief Researcher with strong academic research background.	R&D Manager with industrial research background.	Entrepreneurial Manager with experience in starting businesses.
Nature of Benefits	Increased scientific knowledge and intellectual capital and knowledge available for application for national benefit.	Platform technologies available to industry.	Experimental science and/or technology development leading to the development of intellectual property and the transformation into products and processes.
Distribution of Benefits	Broad and general distribution to the economy and society	Technology transfer across industry	New business formation based on ownership of IP assets.
Industry Partners	State natural resource management agencies.	Companies in global markets. Agriculture Departments and Rural RDCs acting for primary producers. Water services authorities.	CRCs. State governments acting as innovation agents. Venture capital investors (including corporate VCs).
Nature of Innovation	Exploratory.	Continuous/incremental.	Disruptive.
Examples	Natural Resource Management CRCs Biodiversity CRCs Public health CRCs	Mining CRCs. Composites, Alloys and Welding CRS Agriculture CRCs. Water Quality & waste management CRCs.	ITC CRCs, Biotechnology CRCs Medical Devices CRCs – Vision and Cochlear.
IP Management	IP important as a basis for marketing and/or adoption and supplementary income	IP less important than complementary assets.	IP a core strategic asset.
Funding and financing requirements	Long-term commitment, but with a strategy for transition.	Medium term - to provide incentive for industry partners to ameliorate developmental risk.	Short term – with opportunities for flow on and scale up
Exit strategy	Permanent Government Programme	Industrial R&D Institute.	New Technology Company.
Organisational characteristics	Stability and continuity.	Complexity in working with multiple stakeholders and interest.	Flexibility and agility.
Constraints on development	Orientation of academic researchers to discovery/ curiosity research; lack of commitment to implementation and adoption.	Shortage of managers credible in science, knowledgeable of IP and with business and commercial skills necessary to attract and meet needs of partners.	Shortage of managers with business and commercial skills necessary to develop technologies into products and sustainable business models.
Rational for government support	Long term economic, environmental and social benefits	Arguments relating to support for industrial research and development.	Arguments related to new business and associated research commercialisation.
Issues to address in current CRC programme	Encourage collaborations that involve long term commitment and potentially high level of resource commitment. Securing community involvement	Ability to resource fewer centres at significantly higher levels than at the moment. Securing long-term industry engagement.	More flexibility in application, assessment and monitoring processes; lower initial levels of funding. Securing venture investment
Major weaknesses	"Mini ARC" granting arrangement.	Research outsourcing; cost shifting. Industry finds difficult to commit for long term.	Difficulty in meeting current selection criteria relating to commercialisation hurdles
Major strengths	Continuity, commitment, stability.	Effective collaboration; economies from collective approach; focus on global competitiveness.	Innovative, agile, flexible.
Distinctiveness	Focus on application of scientific discoveries and user involvement.	Industry/user driven.	Opportunity driven; innovation focus.
Risks	Application driven funding models.	Anti competitive behaviours.	Business failures. Trust failures.

The evaluation report therefore proposes that *"the CRC framework clearly acknowledge the three CRC categories and relate selection criteria, oversight and monitoring arrangement to suit the needs of each. It is also suggested that a common thread through all categories is to see Commonwealth support for CRCs as an "investment" with clear intentions and expectation relating to adoption, application and use".*

It is useful to identify these different types of CRCs and the distinction also provides a basis for comparison between different programs in Australia and elsewhere. It is for this reason that it is reflected in some detail in this paper. However it remains to be considered whether the distinction is sufficiently clear-cut to benefit from specific selection criteria, oversight and monitoring arrangements. The potential danger is that such a distinction will force applicants to select one of the models rather than opting for an appropriate mix, particularly between the industrial research collaboration and the business development centre, which may change over time.

Conclusions: major policy lessons and open questions

The CRC Program has been a pioneering innovative initiative by the Australian government to consolidate and broaden the basis for economic growth in the country, by accelerating the transition from a natural resource-based to a knowledge-based economy. It has proved an inspiring model for subsequent initiatives in several OECD countries. Considering the results of periodic and thorough evaluations and the recent decision by the Australian government to increase its financial contribution by around 50% in *Backing Australia's Ability* (announced in 2001), there seems little doubt that the CRC Program is an example of good practice in the field of public-private partnerships for R&D. It has promoted a gradual "change in the research culture" in both the private and public sectors, leading to an increased collaboration among researchers and the users of research, in many technological fields, and more generally an improved translation of research outputs into economic, social and environmental benefits to Australia. A whole range of aspects have contributed to this success in terms of the program design and management:

- A sound PP/P concept of how to remedy clearly identified systemic failures in the Australian innovation system.
- A large and diversified portfolio of CRCs including all technological areas where there are/were missing or weak links between research performers and research users, as well as actors ready to use the new institutional framework to bridge these gaps.
- Open-ended, long-term commitment by the Government.
- New money, i.e. the funding for the CRC Program was a substantial increase of funding for R&D in Australia which has facilitated the mobilisation of all relevant public actors.
- Inclusion of an educational objective, aiming at producing post-graduate students with greater knowledge and a facility (e.g. in the field of project management) to work with research users.
- Equal emphasis on all four major program objectives: research, collaboration, education, application of outcomes.
- Consistent, transparent and open application and selection process, with clearly stated objectives and criteria. Requirement of applicants to get agreement from all participants prior to the application for funding.
- Requirement for all parties to make a formal, contractual commitment of resources to the CRC for the full contract period (normally seven years).

- Clear management structure providing the CEO with full control and responsibility over all CRC resources, not just the CRC Program funds.
- Requirement of a board representing the stakeholders and chaired by an independent industry/ research user representative.
- Monitoring and review in collaboration with centre management over the life of each CRC, identifying issues early and allowing early remediation of identified issues.
- While accepting and even encouraging diversity to suit the different circumstances, also create some uniformity and cohesion between all CRCs, particularly in terms of public relations and dealing with the Government.
- A deliberate focus on management issues relating to such large ventures involving a substantial number of partner organisations with sometimes competing goals. The CRC Association is playing a particularly valuable role in this context through sharing of information, workshops, etc.

All players will readily agree that despite this positive assessment there have been recurrent difficulties that have generally been overcome through pragmatic approaches. Some of the generic challenges faced by many CRCs include:

- Difficulties stemming from the fact that Centres are a group of individuals who are employed by one organisation and work partially or mostly for another, i.e. the CRC. The additional/new human resources hired using new (CRC Program) funds, including the postgraduate students, are an important exception and are seen by many as providing the glue to keep the cooperation together and effective.
- Differences in IPR policies between partners in a CRC sometimes create problems that can generally be solved if parties are prepared to look at the intended outcome rather than the specific policy solution.
- While initially the question of whether CRCs should be incorporated and thus become an independent legal entity or should be operated as unincorporated joint venture was left wide open, over time a preference for an incorporated option was developed by the CRC Committee and the Australian Government. In terms of ultimate outcomes and the operation of a centre, much the same can be achieved by both approaches. However, it is clear that an incorporated centre will tend to favour a greater focus on the joint, longer-term future and a greater independence in its operation from its many partners. For example, it can independently employ staff, enter into agreements and own patents, while an unincorporated venture needs to create a commercial affiliate to do the same.
- Perhaps a more fundamental difficulty for a program such as the CRC Program which relies on a great many organisations to commit resources and to hand over day-to-day control over these resources to the cooperative venture, is the natural reluctance by managers to forego some of the control over their own resources, particularly at a time when resources available to R&D organisations are not expanding.
- In some quarters, there was also a perception that CRCs benefit from the reputation of established research organisations and that this is a one way street. It is likely that this view was more prevalent, and understandably so, at the beginning of the program. It would appear however that universities, CSIRO and others have been active and successful in ensuring that their contribution and participation in CRCs is noted and acknowledged by all stakeholders and that

the CRCs have now reached a level of recognition in the public arena which in turn benefits the individual participating organisations.

- Some observers consider that participation by SMEs in CRCs is often too low. While it is difficult to establish generic criteria, it would be useful to clarify the nature of these concerns and monitor the situation on this issue.

The overall CRC program has been so far resilient to adverse circumstances, e.g. episodes of budgetary stringency; responsive to new opportunities, e.g. the creation of new CRCs in emerging technologies; and adaptive to the changing needs of actors, including the priorities set by the government. Regarding the latter, CRCs face currently the challenge to increase the participation by SMEs and to develop further their international linkages. Looking ahead, two crucial questions arise:

- How should the portfolio of CRCs be managed in the long-term?
- What are the implications for the CRC program of ongoing changes in other S&T policy areas?

Table 7 summarises the main elements that should be taken into account in answering these questions.

Table 7. Summary of observations and challenges on the CRC Program

Efficiency criteria	Observations	Challenge
Appropriateness *Are CRCs addressing sound and important objectives which can be related to clearly identified market failures?*	• The CRC program uses appropriate tools to remedy a clear weakness of the Australian NIS. • The first selection rounds of the program focused on initiating a change in the research culture among actors in the Australian NIS, through mostly bottom-up and science-push initiatives. The more recent selection rounds gave more priority to the commercialisation of research outputs through demand-pulled initiatives, as well as to research topics of public interest, the so-called "public good CRCs". • Despite progress over the last ten years, private R&D remains at a relatively low level, limiting the scope for industry-driven CRCs. • To overcome the insufficient capabilities of Australian firms to commercialize domestic scientific outputs, a niche strategy involving key foreign participants and/or start-ups has been highly successful in some fields, e.g. "Vision CRC" and "Photonics CRC". • The continuing success of some CRCs may depend almost entirely on their ability to attract foreign partners with key complementary capabilities, e.g. the "Satellite Systems CRC" and the "Composite Materials CRC".	• Promote internationalization and technology-based entrepreneurship by every means. • Adopt a wider definition of national benefits that gives greater weight to the benefits derived indirectly from the internationalisation of CRCs. • Reconsider the selection process to better balance "bottom-up" and "top-down" criteria in deciding the areas of research to be funded, with a view to combining more effectively a niche strategy in emerging fields with the consolidation of comparative advantages in broader sectors.

Table 7. Summary of observations and challenges on the CRC Program *(continued)*

Efficiency criteria	Observations	Challenge
Own efficiency *Are CRCs cost-effective in achieving their stated objectives?*	• There is no simple methodology or metrics to assess the overall economic efficiency of the Program. But accumulated partial evidence from a series of evaluations point to both its cost-effectiveness and its "behavioral additionality", meaning that it induces positive long lasting changes in the behavior of actors that are likely to survive the CRC arrangement. • The sunset clause (7 year contract) contributes to this efficiency, but the majority of CRCs would not be viable without government financial support in the foreseeable future. Even those which could be self-sustained, on pure economic terms, would find it harder to operate cohesively without the "glue" of CRC Program funds. This is particularly true when one considers the current decline in the already small cash contribution from public research organizations, especially CSIRO. • Some CRCs lack critical mass. • The CRC Association plays a useful but still limited role in increasing the Program visibility and in providing a platform for individual CRCs to exchange experiences.	• What proportion of Centres should be able to get funding beyond the initial seven year contract, given the need to achieve critical mass in every CRC? • Provide different levels of government financial contribution to different types of Centres ("National Benefit CRCs", "Industrial Research Collaboration CRCs", and "Business Development CRCs")? • Should Centres be allowed to operate as CRCs even when no longer receiving program funding provided certain conditions are met? • Reinforce the action of the CRC Association to promote the sharing of experiences, the diffusion of good management practices, and the development of standardised management tools?
Superiority *Are CRCs more effective than other policy instruments which would achieve the same goals?*	• Industry considers that the program provides unique benefits. • Some public funding and research organizations, such as the Australian Research Council (ARC) and universities, have more specific views, especially concerning "public good CRCs". • The ARC Centres of Excellence could be seen by part of the scientific community as an alternative approach for supporting "public good CRCs".	• What degree of overlap/competition between different public programs or organisations is acceptable? • How can industry's preference for the CRC program be translated into increased industry involvement in CRCs?

Table 7. Summary of observations and challenges on the CRC Program *(continued)*

Efficiency criteria	Observations	Challenge
Systemic efficiency *How do CRCs interact with other programmes or instruments?*	• The success of the CRC program owes much to the favorable framework conditions for research and innovation created by other measures and institutions, including the R&D tax concession, the ARC support to scientific research and the accumulated expertise of CSIRO. • To increase science-industry relationships has become a goal, as a primary or secondary objective, of many other policy instruments, especially the Linkage Projects and the Centres of Excellence managed by the Australian Research Council. • The CRC program is not an SME policy tool, but contributes to the promotion of innovation in SMEs by involving many of them in research networks. This involvement is an evolutionary process which is specific to each CRC, depending on the technological field and the associated Australian industrial structure. Some CRCs started with SMEs as their main industrial partners and subsequently engaged larger firms to pursue more ambitious goals. Others had spin-offs as one of their main outcomes. A majority of Centres rely on a mix of large and smaller firms. • The CRC program already promotes mission-oriented and multidisciplinary research on socially high priority topics (e.g. environment: e.g. the “Pest Animals CRC” and the “Bush Fires CRC”). In this area, the potential of the program is probably not yet fully exploited. • The CRC program is a federal initiative involving federal public research institutions, but its impact on regional innovation systems is important. The evaluation committee viewed State government support for CRC proposals as an asset. This prompted many States to be very active in the early phase of the CRC Program, but their involvement has not always been maintained.	• Avoid competition for funding between complementary schemes and organisations? • Clarify the respective role of CRCs and new ARC programs? • Avoid too prescriptive and rigid an approach in promoting greater involvement of SMEs in research networks? • Give more priority and devote more resources to multidisciplinary CRCs? • Improve the articulation between the Australian Government and State innovation policies?

Table 7. Summary of observations and challenges on the CRC Program *(continued)*

Efficiency criteria	Observations	Challenge
Adaptive efficiency *To what extent have results from evaluation influenced CRCs, and how are CRCs flexible in responding to growth opportunities or unpredictable change?*	• The ongoing monitoring and evaluation of both individual centres and the program as a whole have been implemented rigorously. They have fed and accelerated a learning process among all participants through which management could be improved over time. • Some CRCs have demonstrated good ability to adapt to changing circumstances in business (e.g. the "Satellite Systems CRC" had to change its business plan in response to the failure of a major foreign contractor). • Some CRCs are heavily dependant on the inputs from CSIRO, and thus vulnerable to changes in their research strategy. • There is no established mechanism to screen new opportunities and nurture initiatives in areas where potential actors are still dispersed and inexperienced in accessing government support.	• Embed CRCs in broader national and international networks of research in similar or adjacent fields? • Consider using the ARC Linkage Projects as an incubator of future CRCs in emerging fields? • Give more priority to CRCs with high-growth potential in the program budget allocation?

Appendix 1. List of all 71 Cooperative Research Centres currently operating July 2003

	Established	Latest Funding	Round No	Grant Period	Incorporated
	Year	Year		Years	
Manufacturing Technology					
CRC for Advanced Composite Structures	1991	2003	5	7	Yes
CRC for Bioproducts	1992	1999	6	7	No
CRC for CAST Metals Manufacturing (CASTMM)	1993	1999	6	7	No
CRC for Intelligent Manufacturing Systems and Technologies	1993	1999	6	7	Yes
CRC for MicroTechnology	1999	1999	6	7	No
CRC for Polymers	1992	1999	6	7	No
CRC for Welded Structures	1992	1999	6	7	Yes
CRC for Construction Innovation	2001	2001	7	7	No
CRC for Functional Communication Surfaces	2001	2001	7	7	No
CRC for Innovative Wood Manufacturing	2001	2001	7	7	No
CRC for Railway Engineering and Technologies	2001	2001	7	7	No
Information and Communication Technology					
CRC for Satellite Systems	1998	1998	5	7	No
Australian Photonics CRC	1992	1999	6	7	No
Australian Telecommunications CRC	1993	1999	6	7	No
CRC for Enterprise Distributed Systems Technology	1992	1999	6	7	Yes
CRC for Sensor Signal and Information Processing	1992	1999	6	7	No
CRC for Smart Internet Technology	2001	2001	7	7	Yes
CRC for Technology Enabled Capital Markets	2001	2001	7	7	Yes
Mining and Energy					
Australian Petroleum CRC (Greenhouse Gas Technology CRC)	2001	1997	5	7	No
CRC for Mining Technology and Equipment	1991	1997	5	7	Yes
AJ Parker CRC for Hydrometallurgy	1992	1999	6	7	No
CRC for Clean Power from Lignite	1993	1999	6	7	No
CRC for Coal in Sustainable Development	1995	2001	7	7	No
CRC for Landscape Environments and Mineral Exploration	1995	2001	7	7	No
CRC for Predictive Mineral Discovery	2001	2001	7	7	No
Agriculture and Rural Based Manufacturing					
CRC for Sustainable Sugar Production	1995	2003	4	8	No
CRC for Molecular Plant Breeding	1997	2003	5	7	No
CRC for Sustainable Production Forestry	1991	1997	5	7	No
CRC for Sustainable Rice Production	1997	1997	5	7	No

	Established	Latest Funding	Round No	Grant Period	Incorporated
	Year	Year		Years	
Australian Cotton CRC	1993	1999	6	7	No
CRC for the Cattle and Beef Quality	1993	1999	6	7	No
CRC for Tropical Plant Protection	1991	1999	6	7	No
CRC for Viticulture	1992	1999	6	7	No
CRC for Australian Sheep Industry	2001	2001	7	7	No
CRC for Innovative Dairy Products	2001	2001	7	7	No
CRC for Sustainable Aquaculture of Finfish	1993	2001	7	7	No
Innovative Grain Food Products	1995	2003	7	7	Yes
Environment					
CRC for Antarctica and the Southern Ocean	1991	2003	5	7	No
CRC for Sustainable Tourism	1997	2003	5	7	Yes
CRC Environmental Biotechnology	1991	2003	5	7	Yes
CRC for Biological Control of Pest Animals	1992	1999	6	7	No
CRC for Catchment Hydrology	1992	1999	6	7	No
CRC for Coastal Zone, Estuary and Waterway Management	1999	1999	6	7	No
CRC for Freshwater Ecology	1993	1999	6	7	No
CRC for The Great Barrier Reef World Heritage Area	1993	1999	6	7	Yes
CRC for Greenhouse Accounting	1999	1999	6	7	No
CRC for Tropical Rainforest Ecology and Management	1993	1999	6	7	No
CRC for Australian Weed Management	1995	2001	7	7	No
CRC for Plant-based Management of Dryland Salinity	2001	2001	7	7	No
CRC for Tropical Savannas Management	1995	2001	7	7	No
CRC for Water Quality and Treatment	1995	2001	7	7	No
Medical Science and Technology					
CRC for Aboriginal and Tropical Health	1996	2003	5	7	No
CRC for Cellular Growth Factors	1991	1997	5	7	No
CRC for Discovery of Genes for Common Human Diseases	1997	1997	5	7	No
CRC for Eye Research and Technology	1991	2003	5	7	No
CRC for Vaccine Technology	1993	1997	5	7	No
CRC for Asthma	1999	1999	6	7	Yes
CRC for Chronic Inflammatory Diseases	2001	2001	6	7	No
CRC for Cochlear Implant and Hearing Aid Innovation	1991	2001	7	7	No
CRC for Diagnostics	1995	2001	7	7	No

Source: Analysis of CRC Compendium data and MDQ database.
*Note: For some Round 8 CRCs contracts are still to being finalised.

Appendix 2. Examples of CRC successes referred to in CRC publications and promotional material

National Benefit CRCs

CRC for Aboriginal and Tropical Health - Discovered a new rapid test for detecting streptococcal B infections. The test is fast, non-invasive and easy to perform. This is a critical health issue for newborn infants.

CRC for Catchment Hydrology: Developed a short-term detailed forecasting system that enables more accurate predictions to be made of the precise level and location of rainfall during storms. Estimated to save Sydney Water around $20 million over the next 20 years.

CRC for Coastal Zone, Estuary and Waterway Management - Development of a regular comprehensive 'report card' for the Moreton Bay area to more accurately check the environmental health of the area.

CRC for Conservation and Management of Marsupials – Development of a contraceptive vaccine to control populations of possums and wallabies

CRC for the Great Barrier Reef World Heritage Area - Use of computer models to simulate cyclones on the reef to help engineers construct 'smarter' lighter tourist pontoons that minimise environmental impact and the chance of cyclone damage to the reef.

CRC for Weed Management - Successfully engaged the community to overcome an aggressive creeper introduced into Australia 150 years ago that was smothering Australian bushland.

Industrial Research Collaboration CRCs

Australian Telecommunications CRC – Patented a technology for real-time signal transfer over the Internet.

CRC for Advanced Composite Structures - Developed a patented process for the application of a thermoplastic skin to the surface of thermoset composite materials. The process attracted the interest of the major aerospace companies, Boeing and Airbus.

CRC for Clean Power from Lignite - Development of a laser plasma spectrometer; strategies for coal de-watering through Mechanical Thermal Expression.

CRC for Enterprise Distributed Systems Technology – Development of **GuideBeam**, a unique search tool designed to improve information access by helping the user formulate a precise description of their information need.

CRC for Mining Technology and Equipment - BHP Billiton has retrofitted a production dragline at the Peak Downs mine with the CRC's Universal Dig & Dump Technology (UDD). This innovation in open cut mining technology has increased productivity of the dragline by more than 25 percent.

CRC for Molecular Plant Breeding - The CRC's patents represent real innovation in the field of molecular plant breeding in the cereals and pastures areas; the patents are in various stages of certification for licensing, but are expected to deliver substantial commercial returns.

CRC for Quality Wheat – Development of WheatRite®, a test to determine the level of potential weather damage to wheat crops; expectations of sales of $4m by 2004.

CRC for Sensor Signal and Information Processing – Development of surface wave radar for coastal surveillance; development of an ultra wideband low frequency ground penetration radar.

CRC for Sustainable Rice Production – Developed models and software for understanding the movement of water and salt in relation to irrigation farming at both farm and irrigation-district levels.

CRC for Sustainable Sugar Production – Developed decision support models for onfarm water storage to maximise returns from supplementary irrigation.

CRC for Tropical Plant Protection - Contributed to the development of a test for disease in tropical fruits which is expected to save the industry over $21 million a year in managing this problem

CRC for Waste Management and Pollution Control - Development of a method for increasing the solid content of sewage sludge

CRC for Water Quality and Treatment - Developed a method of rapidly distinguishing toxic blue-green algae species from non-toxic species. The CRC has patented a test that uses genetic technology to identify two of the most toxic species within hours. This enables water resource managers to react more quickly to the potential health threats of algal blooms.

Business Development CRCs

Australian Photonics CRC – Creation of companies that: develop, make and sell applications specific optical fibres to component manufacturers; incorporates optical fibres in devices and components; developing optical circuits on a chip; incorporating new products into new wavelength management systems.

CRC for Cochlear Implant and Hearing Aid Innovation - Developed software for the tele-commerce sector that recognises and blocks 'acoustic shrieks' in phone lines. Expectations of earning around $5m a year, including a substantial export market; development of software to allow audiologists to vary the amplification at different frequencies by hearing devices.

CRC for Diagnostic Technologies – Developed and patented a technology (FNC) that allows rapid identification of variants of a specific gene at a molecular level; combination of FNC with gene chip technologies to make possible the speedy analysis of thousands of genes; technology has been acquired by US biotechnology company Affymetrix generating a royalty stream.

CRC for Eye Research and Technology – Developed continuous wear contact lenses. More than 400,000 people in over 40 countries now have contact lenses they can wear continuously for 30 days and nights.

CRC for International Food Manufacture and Packaging Science – Found ways of using plastics manufacturing systems to produce packaging materials that are biodegradable.

CRC for Satellite Systems - Development of the first all-Australian satellite in 30 years.

CRC for Tissue Growth and Repair - Developed Tendotrophin® for the treatment of horse tendon injuries, which is marketed by PrimeGRO Pty Ltd, a CRC start-up company established in 1999. Another CRC start-up is GroPep Ltd which achieved sales of $9.6 million in 2000-01.

CRC for Vaccine Technology- Developing a vaccine against glandular fever to stage of clinical testing. Potential market of 2.5 million vaccinations per annum

Source: Howard Partners, 2003: Evaluation of the CRC Programme, July 2003.

APPENDIX 3.
LIST OF THE PERSONS INTERVIEWED DURING THE OECD MISSION[4]

(13 to 17 October 2003)

Department of Industry, Tourism and Resources

Ms Tricia Berman, General Manager, Innovation Policy
Dr Russell Edwards, General Manager, NSW State Office
Mr David Gallagher, Manager, Innovation Commercialisation
Mr Jared Henry, Assistant Manager, Innovation Commercialisation

Department of Education, Science and Training

Mr Rod Manns, Branch Manager, Science Programmes Branch
Ms Cathy McKay, Manager, Collaborative Research Policy Section

Australian Research Council

Professor Vicki Sara, Executive Chair
Professor Sue Rowley, Executive Director, Humanities and Creative Arts
Professor Lawrence Cram, Executive Director, Physics, Chemistry and Geoscience
Professor Alan Johnson, Executive Director, Biological Sciences and Biotechnology
Professor Ian Petersen, Executive Director, Mathematics, Information and Communication Sciences
Ms Mary Argall, Senior Research Officer

CRC Committee

Dr Geoffrey Vaughan, Chair

CSIRO

Dr Jack Steele, Senior Adviser, Commercialisation

University of New South Wales

Professor Elspeth McLachlan, Pro-Vice-Chancellor (Research)
Professor Colin Sutherland

Australian Chamber of Commerce and Industry (ACCI)

Mr Timothy Reardon, Senior Advisor, Industry Policy

CRC for Waste Management and Pollution Control

Dr David Garman, Executive Director
Mr Geoff Borton, Manager (International)

Australian Photonics CRC

Dr Don Nicol, Chairman of the Board
A/Professor Simon Fleming, Director
Dr Eric Heyde, Senior Vice President, Redfern Photonics Pty Ltd

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4. The OECD review team was composed of Jean Guinet (project leader), Andreas Dubs (consultant), and Byung-Seon Jeong.

Vision CRC (previously known as CRC for Eye Research and Technology)

Professor Brien Holden, Chief Executive, Vision CRC
A/Professor Debbie Sweeney
A/Professor Mark Willcox
Professor Brian Layland
Ms Amanda Davies
Ms Dorothy McDiarmid, Managing Director, CIBA Vision Australia/New Zealand
Dr Meg Evans, CSIRO

CRC for Satellite Systems

Dr Jeff Kingwell, Centre Manager

Pest Animal Control CRC

Dr Allen Kearns, Deputy Chief, CSIRO Sustainable Ecosystems
Mr Chris Buller, Business Manager

CRC for Innovative Dairy Products

Dr Paul Donnelly, CEO

CRC for Advanced Composite Structures

Professor Murray Scott, CEO
Mr John Heathcote, Senior Executive Officer and Company Secretary

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