Cooperative Research Centres Association Inc

Cooperative Research Centres – Delivering Innovation for Australia

The Economic Impact of Cooperative Research Centres in Australia

Delivering benefits for Australia

A report for the Cooperative Research Centres Association Inc

By

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Executive Summary

Study context

The Co-operative Research Centres (CRC) Programme has been in continuous operation since its establishment in 1991, with nine funding rounds now having occurred. The CRC Programme represents a key element of the 'applied' research end of the Government's R&D investment portfolio. Over its life, the Commonwealth Government has to date provided cash grants totalling around $2 billion, with approximately $1.65 billion of that money allocated to CRCs formed during the first seven funding rounds of the Programme (with the seventh round CRCs being established in 2001).

Given that the CRC Programme has been in operation for almost fifteen years, it is reasonable to expect that measurable benefits will have been delivered. Notwithstanding the considerable methodological challenges involved in assessing the economic impacts of research and development activity, it is reasonable to consider the scale of these benefits and assess the economic impact of the program in light of the benefits delivered and the resources that have gone into generating these benefits. Such an analysis of *delivered* benefits from CRCs has not been previously conducted – an information gap that this study commissioned by the CRC Association (CRCA) is designed to address.

This study represents, to our knowledge, the first attempt to measure only the quantified and verified (by end users) *delivered* benefits of a major Government R&D funding program in Australia. As such, the economic impact results from this study should not be directly compared to the economic impact estimates and projections that have been conducted for a number of other funding programs. The exclusion of *possible* or *estimated* benefits and the strict application of criteria for the attribution of a benefit to the CRC Programme mean that the results of this study should be viewed as a minimum calculation of the benefits delivered by the CRC Programme rather than as a comprehensive measurement of all the benefits that will *likely* be delivered by the CRC Programme.

The criteria used for assessing quantified and verified impacts from the CRC Programme

In the assessment of the *delivered* economic impact of the CRC Programme that has been conducted in this study, stringent criteria for inclusion of an economic impact within the modelling have been used. To be included:

- a benefit needed to be attributable to the CRC Programme – i.e. the benefit is unlikely to have occurred in the timeframe under consideration in the absence of the program;
- the benefit must have already been delivered (or be commenced but ongoing); and
- the benefits must have been quantified and verified by the end users or beneficiaries of the research.

Given these stringent criteria, the outcomes of the economic impact assessment of the CRC Programme conducted in this study should be viewed as only a partial accounting of the actual benefits delivered by the Programme.

In this study twenty-five key identified sources of delivered and verified benefits from CRCs have been included in the economic impact assessment of the Programme.

Outcomes of the assessment of the delivered economic impact of the CRC Programme

The key step in the economic modelling conducted in this study was to develop realistic *with CRC Programme* and *without CRC Programme* scenarios. In the *without CRC Programme* scenario it is assumed that, other than the Commonwealth CRC grant funds, all the cash and in kind resources allocated to the CRC activities would have been allocated by the funding providers to some alternative R&D activities. Comparison of the *with CRC Programme* scenario with this realistic *without CRC Programme* counterfactual allows the *net* effect of the Commonwealth Government funding for CRCs on Australian economic performance to be identified.

The following findings from the CRC Economic Impact assessment show the economic impacts resulting from the Commonwealth's funding of the CRC Programme over and above the economic impacts that would have been generated had the Commonwealth Government funding for the Programme been directed instead to general government expenditure. These findings therefore show the additional impacts, of the provision between 1992 and 2005 of $1,647 million of Commonwealth Government funding for the first seven rounds of CRCs, on economic performance when compared to the counterfactual situation that the Programme had not been implemented and the money instead allocated across all other areas of government expenditure[1].

The key finding from this modelling is that over the 1992 to 2010 period the Australian economy's overall performance has been considerably enhanced when compared to the performance that would have occurred in the absence of the Commonwealth Government investment in the round one to seven CRCs that was provided between 1992 and 2005.

[1] Funding for round eight and nine CRCs has been excluded from the analysis as these CRCs have not been in operation for long enough to be reasonably expected to have generated any measurably economic outcomes to date.

In 2005 dollars[2], the Commonwealth Government expenditure to date on round one to seven CRCs totals $1.92 billion. The cumulative net impact of the Programme on GDP of $1.14 billion can be compared to this figure to give a sense of the rate of the *measurable* return on the Commonwealth Government's investment in the CRC Programme to date[3]. **For every $1 spent by the Commonwealth Government on the CRC Programme, GDP is cumulatively $0.60 higher than it would have been had that $1 instead been allocated to general Government expenditure**. It should be stressed that due to the stringent criteria used for inclusion of impacts in the economic impact assessment, this represents the *minimum* accounting of the returns from the Programme, with actual returns likely to be significantly higher.

Specifically, over the 1992 to 2010 period, results from the economic impact assessment indicate that[4]:

- Gross Domestic Product (total economic output) is cumulatively (in 2005 dollars) $1,142 million higher than would have occurred had the money spent on the CRC Programme instead gone to general government expenditure (which would have itself contributed to GDP). In 2005, GDP is $143 million higher than it would have been in the absence of the CRC Programme (compared to expenditure on round one to seven CRCs of $113 million in that year).
- Real Consumption (the level of private expenditure on goods and services in 2005 dollars – a good proxy measure for overall economic welfare) is cumulatively $763 million higher than would have occurred had the money spent on the CRC Programme instead gone to general government expenditure (which would have itself contributed to real consumption). In 2005, Real Consumption is $108 million higher than it would have been in the absence of the CRC Programme.
- Real Investment is cumulatively (in 2005 dollars) $417 million higher than would have occurred had the money spent on the CRC Programme instead gone to general government expenditure (which would have itself contributed to real investment). In 2005, Real Investment is $41 million higher than it would have been in the absence of the CRC Programme.
- Commonwealth taxation revenue is cumulatively (in 2005 dollars) $66 million higher than the tax revenue that would have been collected had the money spent on the CRC Programme instead gone to general government expenditure (which would have itself generated tax revenue). In 2005, Tax revenue is $10 million higher than it would have been in the absence of the CRC Programme.

[2] CPI data from the Reserve Bank of Australia is used to convert actual dollars spent in each year to equivalent 2005 dollars. This figure of $1.92 billion is simply the conversion into 2005 dollars of the $1.65 billion of actual dollars distributed to round one to seven CRCs between 1992 and 2005.

[3] The comparison is made to the level of Commonwealth funding as it is assumed in the economic modelling that the other resources invested in the CRCs would have still have been allocated to some other R&D activities in the absence of the CRC Programme. The benefits attributable to the CRC Programme are those benefits assessed as being generated in addition to those that would have occurred in the timeframe under consideration in this study if the CRC Programme had not been funded and if those other contributors to CRCs had instead simply invested the resources in their own R&D activities.

[4] The modelling scenario is run out to 2010 as some of the benefits that have already commenced from the CRC Programme are clearly going to continue to be accrued out to at least 2010. For the purposes of the summary of economic impacts from the CRC Programme, all impacts between 2006 and 2010 have be deflated using a real discount rate of 5 per cent to reflect the fact that future benefits have a lower net present value than current benefits.

When compared to the size of Government funding involved in the Programme, these results indicate that, counting only those measurable delivered benefits that have been able to be quantified, at the very minimum a solid return of 60 cents *additional* GDP is being generated for every $1 allocated by the Commonwealth Government to the CRC Programme (when compared to the alternative that the money was instead allocated to general Government expenditure).

Unquantified impacts from the CRC Programme

The strict set of criteria used for inclusion of CRC impacts in the economic impact assessment of the Programme has resulted in a wide range of observed outcomes from the CRC Programme not being included in the economic impact assessment of the program. The exclusion of these impacts has been due to either difficulties in attribution of benefits or in the quantification and verification of the scale of the impacts. However, the exclusion of these benefits from the economic impact assessment does not mean that significant benefits are not associated with these outcomes of the CRC Programme. It simply means that a number of benefits associated with the Programme are very hard to satisfactorily quantify. A selection of ten cases of delivered but unquantified impacts of the CRC Programme are outlined in this report.

Box ES.1 provides an example of one of the delivered benefits from the CRC Programme that has been excluded from the economic impact assessment due to difficulties in determining the extent to which beneficial outcomes can be attributed to the CRC Programme.

Box ES.1

EXAMPLE OF AN UNQUANTIFIED BENEFICIAL IMPACTS OF THE CRC PROGRAMME

CRC for Cochlear Implant and Hearing Aid Innovation: Contribution to Cochlear Limited's Development

All technology developed by CRC HEAR in the implant field has been licensed directly to Cochlear Limited. Two such examples are the ADRO technology, and the development of the Contour family of electrode arrays. Beginning in the late 1990s, the development of an electrode array that could be safely positioned in close proximity to the neural elements was a critical need in the implant field, and important for the company to maintain its competitive technology advantage. The work conducted by CRC HEAR was critical to this development. The Contour was introduced in the market in 2000, and was an immediate success, and has now been implanted in over 30,000 patients world-wide, more than any other single electrode design in the history of the field. Cochlear Ltd returned sales of $348 million in 2004/05, and royalty income to CRC HEAR has now reached $1 million. The support provided by CRC HEAR has also included training of surgeons, and development of the surgical approach and technique for safe and atraumatic insertion.

While it is clear that the CRC has made a positive contribution to the development of Cochlear Ltd, it is not possible to determine the extent to which this contribution is 'over and above' the outcomes that would have occurred in the absence of the CRC Programme. Cochlear Ltd was established prior to the CRC Programme and maintained strong collaborative links to university researchers prior to the establishment of the Programme. If the Programme had not been established it is likely that Cochlear Ltd would have continued to maintain collaborative research linkages (albeit likely at a somewhat lower level) with university researchers. The difficulty associated with determining the additionality of the CRC HEAR's undoubtedly positive contribution to Cochlear Ltd, is the reason why these positive impacts have not been included in the economic impact modelling in this study.

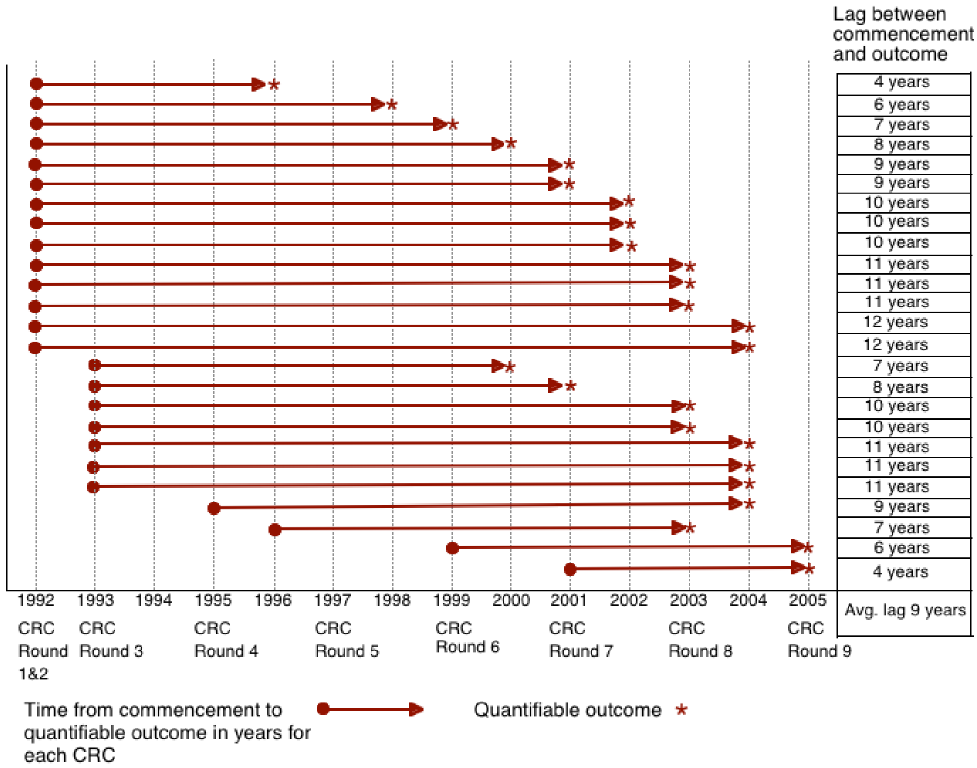
Potential impacts from the CRC Programme

The assessment of outcomes to date from the CRC Programme indicates that the generation of significant measurable economic benefits from research generally takes considerable time.

Of the twenty-five measured economic impacts included in the economic modelling, twenty-two have been generated by CRCs that were in either their second or third terms of operations at the time that the impacts commenced. As shown in Figure ES.1, the average time, between the foundation of a CRC and the commencement of the twenty-five measured economic impacts identified in this study, is nine years.

Figure ES.1

THE TIME LAG BETWEEN THE COMMENCEMENT OF A CRC AND THE ACHIEVEMENT OF A QUANTIFIABLE ECONOMIC IMPACT



Source: Data collected by the CRCA from CRCs

This suggests that the majority of the economic impacts that will eventually be associated with the activities of the CRC Programme to date, have not yet commenced being realised. Supporting this contention is the wide range of prospective economic impacts associated with the CRC Programme that have been identified through the course of this study – a selection of twelve of which are outlined in this report.

Box ES.2 provides an example of one of the highly significant *forthcoming* benefits from the CRC Programme that have been excluded from the economic impact assessment due to the fact that the final economic benefit has not yet been accrued.

Box ES.2

EXAMPLE OF A FORTHCOMING BENEFIT FROM THE CRC PROGRAMME

The CRC for Advanced Composite Structures: Contribution to Hawker de Havilland's Development

The CRC for Advanced Composite Structures' long-standing core participant Hawker de Havilland (HdH) has received a huge payback for its investment of around $17 million in advanced composites R&D through its participation in CRC-ACS. HdH won the contract to construct all the wing trailing edge devices (WTEDs), including flaps, spoilers and ailerons, on the new Boeing 787.

On the 787, Boeing USA will manufacture few of the components, and will concentrate on assembly of large components delivered by an exclusive team of "Tier One" suppliers. Despite intense competition, HdH was able to leverage its advanced composites technologies developed by CRC-ACS to gain a place on this select list of design-build suppliers for the first time.

HdH will be one of only ten companies worldwide that supply 787 assemblies directly to The Boeing Company in Seattle. This Australian work is likely to span three decades, directly support hundreds of jobs, and result in sales of $4 billion over the life of the program. The flow-on effects of this opportunity for HdH include up to 3,300 jobs in the Australian economy.

The CRC-ACS research program has been essential to winning the Boeing contract in the bidding process, in the design phase, and in the manufacturing phase.

The CRC's research convinced Boeing that the product would be sufficiently strong and light for use on the 787. Boeing was also convinced of the depth of manufacturing science available to back up the new processes. In fact, six technologies previously developed, or under development, by CRC-ACS programs were made available to 787 suppliers world-wide under appropriate commercial terms.

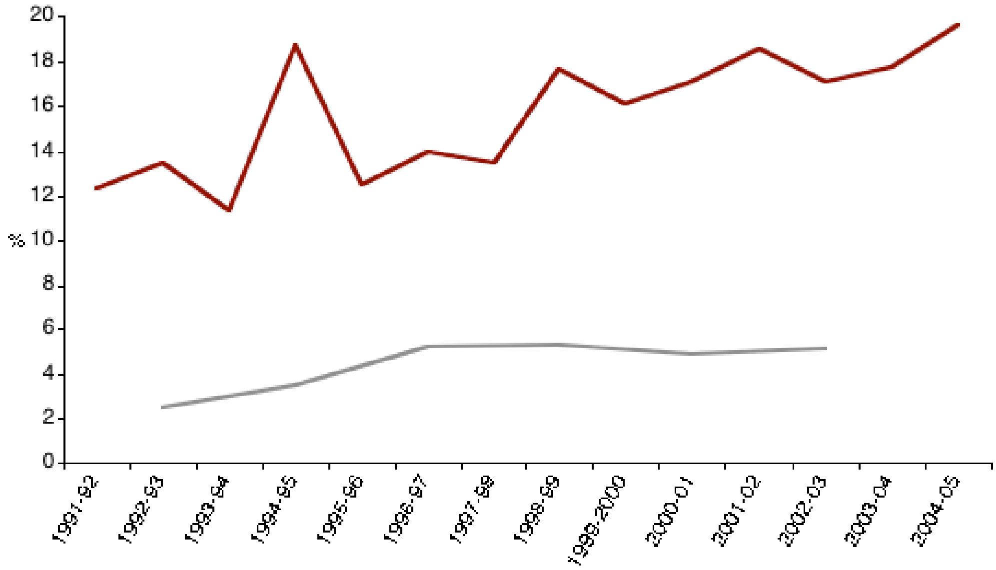
The CRC-ACS research program has introduced and transferred to HdH the main new technologies to be used by HdH to design, analyse and manufacture the 787 WTED package competitively. Vacuum bag resin infusion, diaphragm forming, and unitised construction technologies developed by CRC-ACS are the key manufacturing technologies to be used by HdH. Extensive knowledge of process simulation, postbuckling design, bird-strike simulation, and design optimisation, developed through CRC-ACS programs, is enabling HdH to design the parts efficiently and competitively. The extensive body of CRC-ACS research since 1991 gave HdH the luxury of choosing between different new technologies.

CRC-ACS has trained around half the engineers working on the 787 program at HdH in the relevant new technologies, through their secondment to CRC-ACS research programs, or through their PhD studies. This has given HdH a tremendous wealth of experience in some very new technologies. However, the full economic impact of the contract is yet to be realised and it is difficult to quantify the precise proportional contribution made by the CRC in achieving the outcome.

In addition to the identified pipeline of significant potential CRC Programme impacts, another encouraging sign in relation to the future benefits that are likely to flow from the Programme are the steadily improving outcomes being registered by the CRC Programme in relation to industry engagement – with both industry funding as a proportion of total CRC funding (Figure ES.2) and the number of industry researchers involved in CRCs showing an upwards trend over the life of the Programme.

Figure ES.2

INDUSTRY CONTRIBUTION TO R&D EXPENDITURE IN CRCs (TOP LINE) AND HIGHER EDUCATION INSTITUTIONS 1991-2005[5]



Source: Department of Education, Science and Training and from data collected by the CRCA from past and present CRCs

Implications for the future of the CRC Programme

Given that the CRC Programme is generating a strong measurable *net* benefit for Australia the *prima facie* case for its continuation is clear. In the context of the current debate about the prospects for introduction of 'third stream' funding for universities to pursue the mission of engagement with external stakeholders (alongside the traditional missions of teaching and research), it should be born in mind that programs such as the CRC Programme already exist, and as this study shows, are delivering strong returns for the community. Rather than the creation of new third stream funding programs, the default position should be to increase funding for proven existing programs that target university engagement with external stakeholders, such as the CRC Programme, rather than create new similarly oriented funding programs – which would entail additional administrative costs and risks being incurred.

5 The spike in the industry investment percentage in 1994-95 is largely attributable to the Australian Photonics CRC, which received a considerable increase in investment from industry sources in that year that was related to the launch of several spin-out companies.

Chapter 1

Project overview

1.1 Context for the study

The CRC Programme was established in 1990 to improve the effectiveness of Australia's research and development effort. It links researchers with industry to focus R&D efforts on progress towards utilisation and commercialisation.

Since the commencement of the Programme, there have been nine CRC selection rounds, resulting in the establishment of 158 CRCs over the life of the Programme (100 new CRCs and 58 new from existing CRCs). With the establishment of all CRCs from the 2004 selection round, 72 CRCs will be operating in 6 sectors: environment, agriculture, information and communications technology, mining, medical science and technology and manufacturing[6]. However, from 2006 this number will decline to 54 as some current CRCs complete their seven year terms.

Since the commencement of the CRC Programme, all parties have committed more than $9.6 billion (cash and in-kind) to CRCs. This includes $2.2 billion from the CRC Programme, $2.6 billion from universities, $1.8 billion from industry and more than $1 billion from CSIRO. These figures do not include commitments made in the 2004 selection round[7].

In terms of Commonwealth Government cash support provided through CRC grants, excluding the round nine CRCs, around $1.8 billion has been provided between 1991 and 2005. This represents a significant commitment of taxpayer funding to the CRC Programme. It is important that the returns on this commitment are assessed, to ensure that taxpayers are receiving value for this investment in the CRC Programme.

The CRC Programme has been reviewed a number of times since its inception, most recently in 2003. A key weakness, however, of all these reviews has been the paucity of information available in relation to the actual realised benefits that have resulted from CRCs activities. Rather, information available has tended to focus heavily on projected future benefits that researchers suggest will be realised at some future time. The 2003 *Evaluation of the Cooperative Research Centres Programme*, notes that:

> "The potential for substantial national economic benefits is generally reported by CRCs as being high, but demonstrated actual benefits are a little more difficult to come by."[8]

Taken together, the projected future benefits that CRCs have estimated, amount to several billion dollars, with CRCs generally projecting benefit cost ratios for their CRCs of between 5 and 20 to 1.

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[6] DEST, 2005, DEST Newsletter, *CRCs: Success through Innovation*, Issue 6, October 2005

[7] *Ibid*

[8] Howard Partners, 2003, *Evaluation of the Cooperative Research Centres Programme*, report to DEST, pg.vii

Some of the most prospective future benefits that CRCs may deliver are considered in chapter four of this study alongside a number of actual but unquantifiable benefits that CRCs have delivered. However, in this study the economic impact assessment of the CRC Programme set out in chapter three includes only benefits from CRCs that have actually been delivered and have been quantified and verified by the end users of research. This is of course a very stringent requirement to enforce in the impact assessment, and has no doubt resulted in a considerable underestimation of the value delivered by the program. However, given that the Programme has been in operation for almost fifteen years, it is reasonable to expect that measurable benefits will have been delivered. It is therefore reasonable to consider the scale of these benefits and assess the economic impact of the Programme in light of the benefits delivered and the resources that have gone into generating these benefits. Such an analysis of *delivered* benefits from CRCs has not been previously conducted – an information gap that this study commissioned by the CRC Association is designed to address.

1.2 Study objectives

This study has three core objectives, namely:

- to provide a clear picture of CRC Programme inputs and observed outputs since its inception and to place this performance within the context of the broader Australian R&D system;
- to establish the verified and quantified economic impact of the CRC Programme since its inception; and
- to consider the future prospects for the CRC Programme to contribute to Australia's economic, social and environmental development goals.

1.3 Study methodology

Information gathering for this study involved four elements, namely:

- a review of existing literature in relation to both CRCs and the broader Australian innovation system;
- a survey of all current CRCs. CRCs were asked to provide information on financial inputs into their CRC, student and researcher numbers, identify final outcomes that their CRC has generated, identify where their research had been applied by end users, and provide details of the most promising prospective outcomes that they expect to be generated by their CRC;
- the annual reports of all past CRCs were reviewed and information extracted on financial inputs into these CRCs and student and researcher numbers. The annual reports of those current CRCs that provided insufficient information in their survey responses were similarly reviewed; and
- follow up discussions were held with a number of CRCs and companies to clarify responses to the survey and details surrounding impacts from CRCs.

Based on the information gathered from the above approaches, the inputs and observed outputs of the CRC Programme were assessed, economic impact modelling scenarios were developed, modelling was then conducted by the Centre of Policy Studies, and, finally, an analysis was conducted of future prospects for CRC impacts.

It is important to note that in this study, the round nine CRCs, many of which are still in the process of being established, have not been included in the analysis. It should also be noted that the round eight CRCs, which have been in operation for less than three years, can not yet be reasonably expected to have demonstrated any final outcomes from the application of their research. Therefore, for the purposes of the economic impact modelling conducted in this study (Chapter Three), only the resources devoted to, and outcomes generated by, the CRCs established in rounds one to seven have been assessed.

1.4 Report structure

This report is structured in five chapters and one technical appendix as follows:

- Chapter One: Provides a brief overview of the project
- Chapter Two: Provides an overview of the CRC Programme inputs and observed outputs and outcomes to date and assesses how the CRC Programme's performance is differentiated from that of general performance levels associated with publicly funded R&D in Australia.
- Chapter Three: Describes in detail all the major quantified and verified economic impacts that have already resulted from CRCs' activities. It also provides an explanation of the economic modelling scenarios and of the methodology used to develop them. Results from the economic modelling are then presented.
- Chapter Four: Provides information in relation to a number of delivered benefits from the activities of CRCs that have not been able to be quantified in economic impact terms. It also sets out some of the prospective outcomes associated with the CRC Programme, i.e., those potentially valuable outcomes from more recent investment in the Programme that have not yet been realised.
- Chapter Five: Sets out key findings from the study and considers their implications for the future of the CRC Programme.
- Appendix A: This is a technical appendix relating to the economic modelling scenarios and modelling outcomes. It details key features of the model used and sets out the precise economic shocks entered into the model to assess the delivered economic impact of the CRC Programme.

Chapter 2

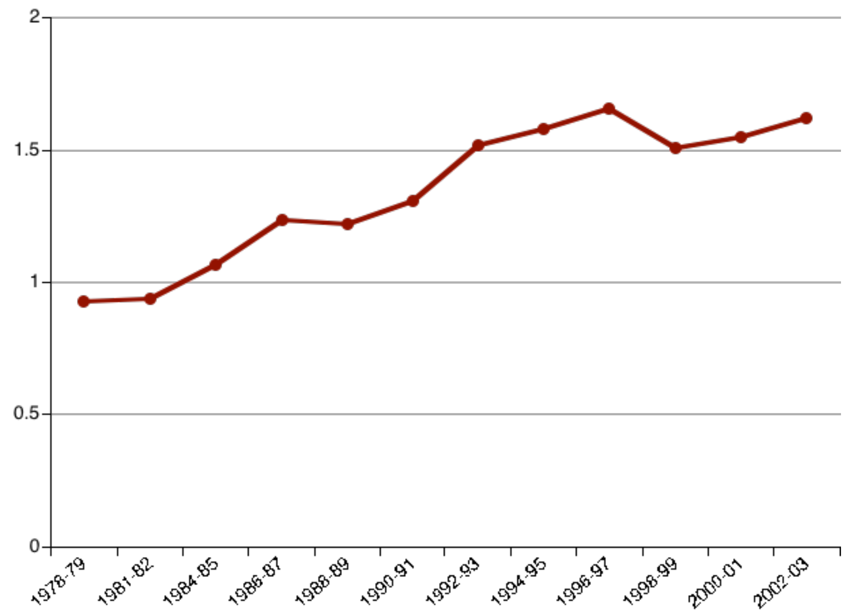
Overview of CRC Programme Inputs and Outcomes

2.1 Resources invested in CRCs

Australia has a broad national R&D system that is funded by both Government and industry. Currently there is decreasing reliance on public funding for R&D activities as research organisations are urged to achieve self-sufficiency through research commercialisation and industry investment. Despite this, there is still a significant reliance on public funding for R&D in Australia particularly for basic research. According to the OECD, more than half of the expenditure on R&D in Australia is from public sources. This has decreased from around 78 per cent in the 1970s. However, the percentage of R&D funded by the public sector is considerably higher in Australia than in the US where only 30 percent of R&D expenditure is publicly funded.[9]

Publicly funded research institutes, the CSIRO, the universities and industry are all key contributors to Australia's R&D system. A total of $12.2 billion was spent by both public and private sources on R&D in 2002-03.[10] Expenditure on R&D in Australia as a percentage of GDP has generally been growing since the 1970s (Figure 2.1). In 2002-03 it stood at 1.62 per cent.[11]

Figure 2.1
GROSS R&D EXPENDITURE AS A PERCENTAGE OF GDP 1978-2002



Source: Australian Science and Technology at a Glance 2004, Department of Education Science and Training

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9 Department of Education Science and Training (2004) *Australian Science and Technology at a Glance 2004*, Commonwealth of Australia, p. 35

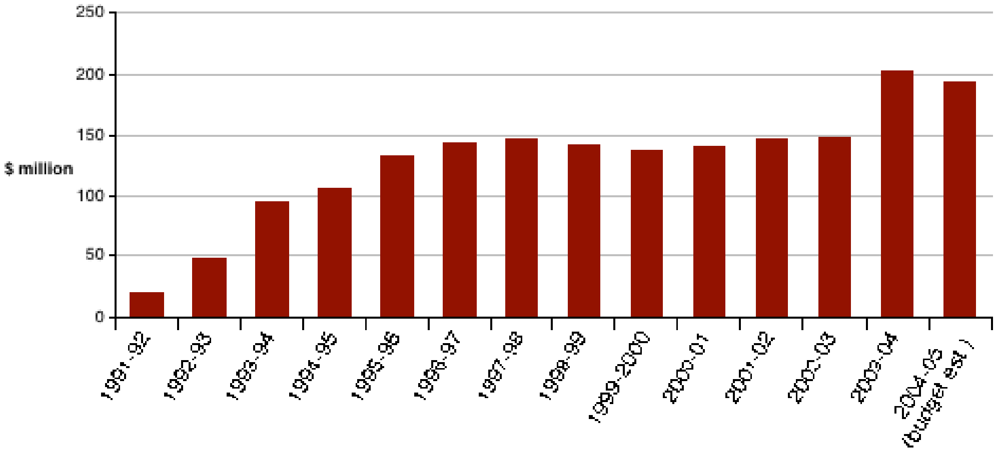
10 *Ibid*, p. 3

11 *Ibid*, p.5

Up until 2005, Commonwealth Government funding distributed to all (round one to eight) CRCs amounts to around $1.8 billion (Figure 2.2). It is estimated that CRCs will account for around 3.6% of the total commonwealth annual budget of $5.3 billion for science and innovation expenditures (Figure 2.3). In 2003-04 expenditure by CRCs on R&D totalled $202.2 million. When other significant contributions from state governments, industry and publicly funded research organisations are considered, then the total funding to CRCs is considerable. Data collected by the CRCA suggests that total cash funding to the CRCs from all sources over the life of the Programme is in excess of $4.5 billion. This is a significant component of the Australian R&D effort.

Figure 2.2

COMMONWEALTH GOVERNMENT FUNDING TO CRCs 1991-2005

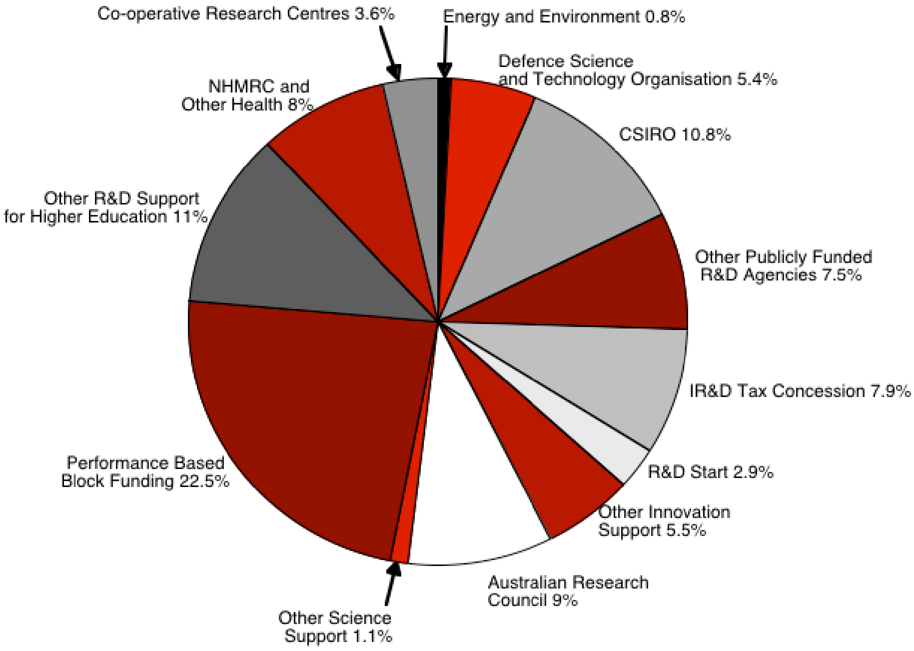


Source: Budget Papers

The CRCs are therefore a significant component of Australia's national R&D system. The unique reliance on partnership between different R&D institutions, industry and government differentiates the CRCs from other research organisations. The formulation of an effective synergy between industry and the research organisations is a key measure of a CRC's success.

Figure 2.3

COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION – 2004-05



Source: Science and Innovation at a Glance 2004, Department of Education Science and Training

2.2 Recorded outcomes from CRCs

Over the life of the CRC Programme the CRCs have generated significant outcomes in the areas of industry engagement, research commercialisation and post-graduate student training. Performance in these areas is outlined briefly below and placed in the context of the performance of the wider Australian publicly funded research system.

Industry engagement

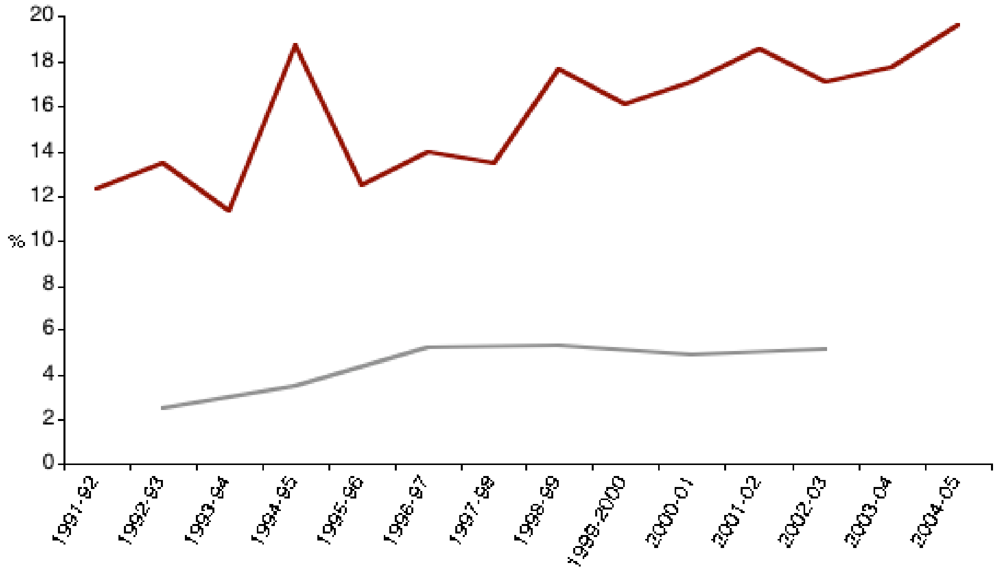
Across the life of the Programme, CRCs have sourced around 17[12] per cent of their funding from industry. This is significantly higher than the average industry contribution to R&D in the universities that stands at around 5 per cent[13] (Figure 2.4).

[12] Data collected by the CRCA from past and present CRCs

[13] Science and Innovation at a Glance 2004, Department of Education Science and Training

Figure 2.4

INDUSTRY CONTRIBUTION TO R&D EXPENDITURE IN CRCs (TOP LINE) AND HIGHER EDUCATION INSTITUTIONS 1991-2005



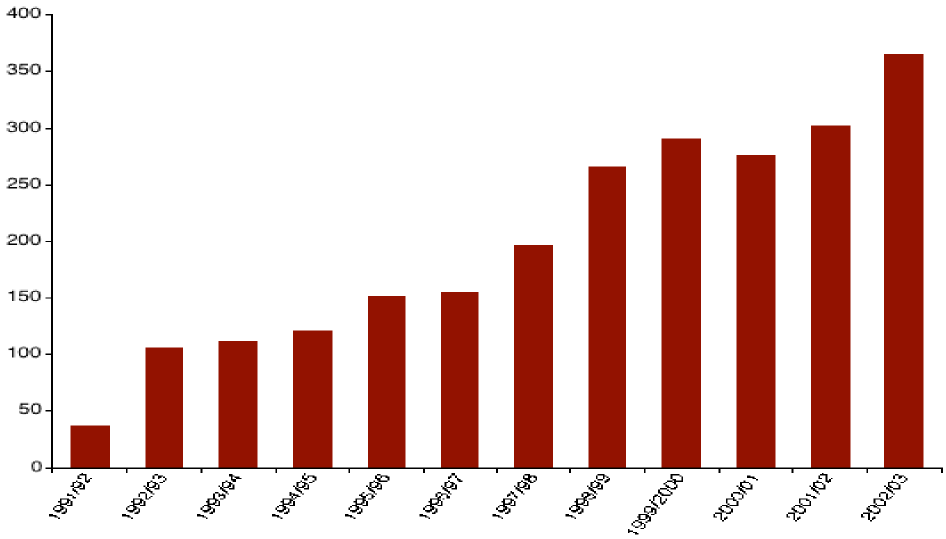
* The spike in industry investment percentage in 1994-95 is largely attributable to the Australian Photonics CRC, which received a considerable increase in investment from industry sources in that year that was related to the launch of several spin-out companies.

Source: Department of Education, Science and Training and from data collected by the CRCA from past and present CRCs

In addition to funding, industry often provides in kind contributions such as research staff time. The number of industry researchers involved in the CRC Programme has grown considerably since the CRC Programme's inception (Figure 2.5).

Figure 2.5

INDUSTRY RESEARCHERS INVOLVED IN THE CRCs 1991-2003

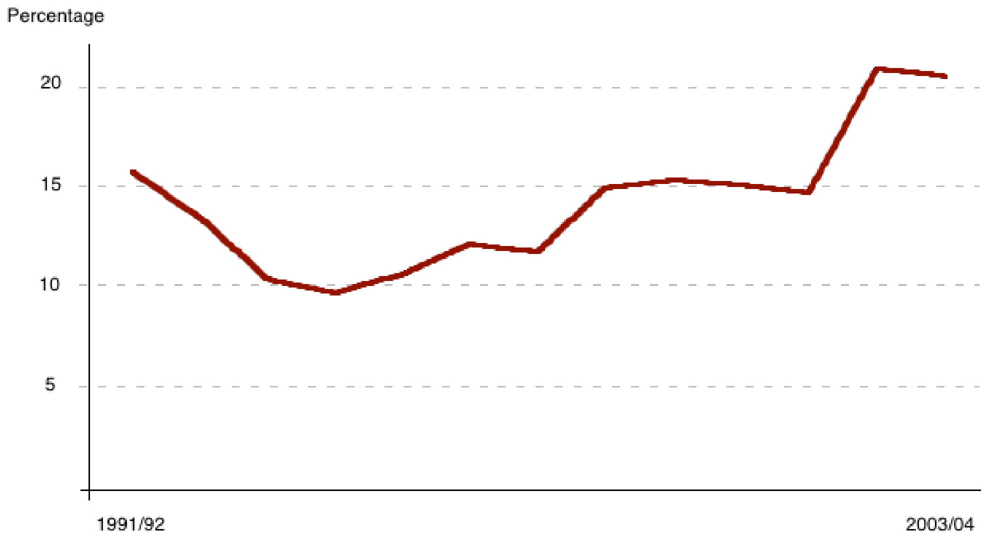


Source: Data collected by the CRCA

The percentage of industry researchers as a share of all research staff involved in CRCs has also increased over the life of the CRC Programme. As shown in Figure 2.6, following an initial decline in this ratio through the early years of the CRC Programme, since 1994 the share of industry researchers has doubled from under 10 per cent of total CRC researchers to over 20 per cent of total CRC researchers.

Figure 2.6

INDUSTRY RESEARCHERS IN CRCs AS A PERCENTAGE OF THE TOTAL NUMBER OF RESEARCHERS



Source: Data collected by the CRCA

Research commercialisation

There has been a strong focus in recent years on achieving commercial outcomes from research activities. One of the objectives of the CRC Programme is to "enhance the transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit."[14] The involvement of industry partners has been a contributor to good commercial outcomes in the CRCs. As early as the 1998 Stocker and Mercer review of Commercialisation in CRCs, it was acknowledged that the CRCs had achieved great success in successfully cooperating with industry. Strong commercialisation performance is evident in the fact that in 2002 the CRCs filed around 17 per cent of the total number of patent applications filed from public sector research institutions. This is impressive when compared with the Commonwealth Government's financial contribution to CRCs in the same year, which was less than 5 per cent of the total government expenditure on R&D. Furthermore, the CRCs have generated other income from commercial activities including consultancy, start-up firms or licensing. The commercialisation success of the CRC model is demonstrated in Table 2.1 that outlines a number of commercialisation performance indicators of the universities and the CRCs relative to the amount of Commonwealth Government funding that they received.

[14] Howard Partners (2003) *Evaluation of the CRC Programme*, Report to the Department of Education, Science and Training

Table 2.1

COMMERCIALISATION OUTCOMES FROM UNIVERSITIES AND THE CRCs IN 2002 (UNITS PER $MILLION OF COMMONWEALTH GOVERNMENT RESEARCH FUNDING)

Commercialisation activity	Universities	CRCs
Inventions disclosed	0.26	0.50
Patent applications filed	0.23	0.51
Patents issued	0.06	0.17
Licenses executed	0.11	0.32

Source: Commercialisation performance data come from Department of Education Science and Training (2004) *National Survey of Research Commercialisation*, Commonwealth of Australia; Commonwealth expenditure data comes from Department of Education Science and Training (2004) *Australian Science and Technology at a Glance*, Chart 36, Commonwealth of Australia.

A range of other data on commercialisation activity within CRCs is provided in Table 2.2. It should be noted, however, that indicators such as patenting and spin-off company formation capture only a narrow range of the ways that CRC research is commercialised in Australia. A more common avenue for commercialisation, as is highlighted in Chapter Three, is for industry application of research findings to improve their existing products or processes.

Table 2.2

SELECTED CRC COMMERCIALISATION INDICATORS

Year	Number of patent applications filed	Income from contract research or consultancy ($000)	Income from spin-off companies ($000)
1992 – 1993	20	10,317	0
1993 – 1994	50	19,318	0
1994 – 1995	76	23,479	0
1995 – 1996	104	33,815	0
1996 – 1997	112	42,891	0
1997 – 1998	58	55,932	0
1998 – 1999	81	46,672	0
1999 – 2000	69	45,409	53
2000 – 2001	87	38,152	2,598
2001 – 2002	116	50,262	7,731
2002 – 2003	118	53,571	9,998
2003 – 2004	91	47,237	8,822

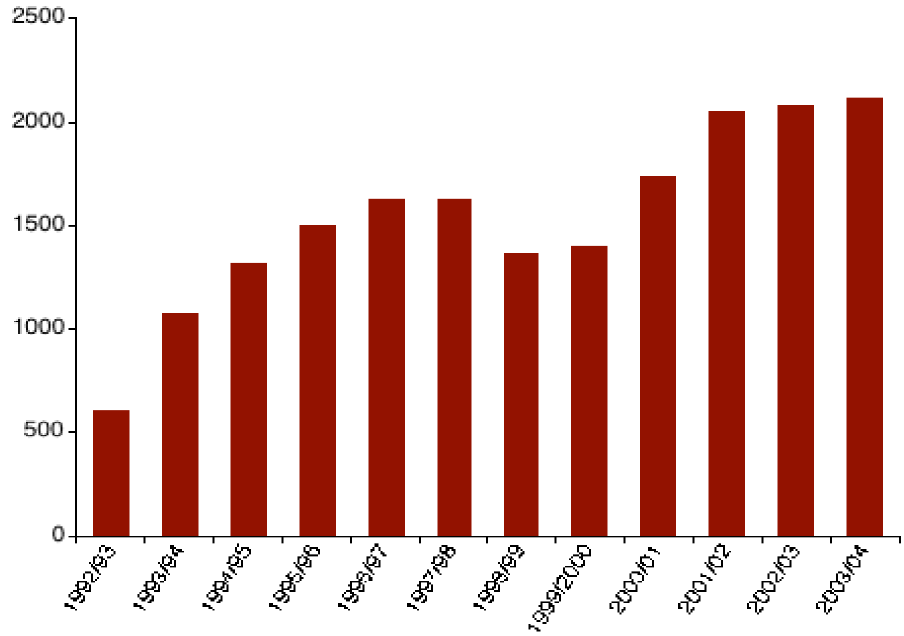
Source: Commercialisation performance data come from Department of Education Science and Training (2004) *National Survey of Research Commercialisation*, Commonwealth of Australia; Commonwealth expenditure data comes from Department of Education Science and Training (2004) *Australian Science and Technology at a Glance*, Chart 36, Commonwealth of Australia

Post-graduate student training

The CRCs have a strong role in the training of postgraduate students and in exposing those students to industry researchers and career opportunities. The number of students trained by the CRCs has grown significantly over the life of the Programme. It is estimated that there are currently over two thousand postgraduate students involved in research within the CRCs. Estimates of the number of postgraduate students involved in research within the CRCs each year are shown in Figure 2.7.

Figure 2.7

POSTGRADUATE STUDENTS STUDYING IN CRCs 1991-2002



Source: MDQ data, Department of Education Science and Training. The information is provided by CRCs and has not been verified or independently assessed by DEST. As such, DEST makes no representation as to the accuracy of this information. DEST suggests that persons or organisations should not rely upon this without seeking to first verify the accuracy of the information. DEST accepts no responsibility for persons or organisations seeking to rely on the information contained in these reports. However, it should be noted that the trends in the MDQ data accord with the trends in the data that has been separately collected in this study through a review of CRC annual reports and through a survey of CRCs.

The CRCs play a role in the education of postgraduate students in a variety of disciplines, with around 4 to 5 per cent of research postgraduate students now being trained within CRCs.

Table 2.3

TOTAL POSTGRADUATE RESEARCH STUDENTS IN AUSTRALIA AND PERCENTAGE OF THOSE EDUCATED WITHIN THE CRCs

	1999	2000	2001	2002	2003
Total postgraduate students in Australia	37,174	37,356	38,499	44,209	45,659
Percentage educated at CRCs	3.77%	4.65%	5.32%	4.69%	4.64%

Source: *Students 2000, Students 2001, Students 2002, Students 2003,* and *Students 2004*, Department of Education Science and Training also Data Collected by the CRCA

As is discussed in Chapter Four, the employment outcomes of this training have the potential to yield considerable economic benefits. Furthermore, the unique linkage between the CRCs and industry exposes the postgraduate students to industry related employment and realities. This can serve to enhance the employability of CRC trained postgraduates. Reflecting this, to date over 2,500 CRC trained post-graduates have taken up employment within Australian industry.

A 2004 study[15] that compared the experiences of CRC-related and non CRC-related PhD students enrolled in science-based disciplines at two research intensive universities suggests that CRC-related PhD students have a more positive experience on a range of important measures. This study reported that the CRC-related students were:

- more likely than non CRC-related students (90.4 to 78.2 per cent) to rate the quality of their university department highly;
- more likely than non CRC-related students (76.7 to 66.4 per cent) to rate the quality of access to specialised equipment highly;
- more likely than non CRC-related students (74.0 to 62.5 per cent) to aspire to a research position within industry; and
- more likely than non CRC-related students (74.0 to 62.0 per cent) to feel positive about their career prospects.

In addition, the study found that CRC-related students were:

- less likely than non CRC-related students (12.3 to 20.1 per cent) to feel ‘trapped in their area of specialisation; and
- less likely than non CRC-related students (23.3 to 27.3 per cent) to feel that ‘research links with industry threaten traditional academic values.

These results, while based on a survey at only two institutions, do suggest that the training delivered within CRCs may contribute to students having a more positive training experience and to students having more positive attitudes towards working within, or collaborating with, industry in the future.

[15] Harman, K., (2004), *Producing ‘industry-ready’ doctorates: Australian Cooperative Research Centre approaches to doctoral education*, Studies in Continuing Education, Vol. 26, No. 3, November 2004

Chapter 3

Quantified and Verified Economic Impacts From CRCs' Activities

3.1 Challenges in assessing economic impacts from the CRC Programme

To assess the economic impact of the CRC Programme it is necessary to identify both collectable output data that are related to economic impacts and to understand the logic that connects research outputs from CRCs to final delivered economic outcomes.

Issues and problems associated with establishing a logic that connects research outputs to final outcomes include:

- time-lags involved in the translation of research outputs into final economic impacts for society may be considerable. It often takes time for the true quality and value of research to become apparent; and
- difficulty in attributing outcome 'effects' to particular research 'causes'. The quality of research, the extent to which the knowledge is diffused to those in a position to use the knowledge to generate impacts, and the ability of research users to extract full value from it will all influence the final impact of research.

These challenges interact in an unfortunate way. The time-lags in translating research to economic impacts mean that establishing the final economic impacts from research may only be able to be done with confidence in relation to research that was conducted a considerable time in the past (more than ten years in many cases). However, in general, the more time that has elapsed between the conduct of research and the generation of final impacts, the more parties have been involved in the process and, therefore, the harder it is to accurately attribute the extent to which the research generator has contributed to the final outcome that is realised. The end result is that while the passage of time mitigates against the time-lag problem, it exacerbates the attribution problem.

As a consequence of the time-lag and attribution problems, many of the economic impacts of the CRC Programme will not be able to be quantified with certainty – and hence, in accordance with the stringent criteria being used in this study, are not included in the economic impact assessment of the program outlined in this section. **Therefore, the economic impact assessment necessarily represents only a partial accounting of the economic impacts of the CRC Programme.**

3.2 Criteria for including benefits in the economic impact assessment

As noted in Section 1.1, a number of previous reviews of the CRC Programme have focused on the projected impacts of the CRC Programme rather than on its actual demonstrated and quantified impacts. In contrast, the economic impact assessment of the CRC Programme in this study is exclusively focused on demonstrated, quantified and verified (by end users) additional impacts from CRCs. For a benefit from the CRC Programme to be included in this economic impact assessment, it must meet each of the following criteria:

- The benefit must have resulted from the activities of the CRC, i.e., the benefit is clearly attributable to the activities of the CRC.
- The benefit must have been unlikely to have occurred (at least in the current timeframe) in the absence of the CRC, i.e., if the participants in the CRC had simply invested the resources that they devoted to the CRC in their own internal research efforts, the benefit is unlikely to have occurred[16].
- The benefits must have either been fully realised or have commenced realisation, with continued realisation of benefits prior to 2010 (the final outlook year for benefits in this study) confirmed as highly likely to occur by the beneficiary, e.g., if a company has utilised CRC research to implement a new process that has been quantified by the user as reducing costs by $X per annum over the past three years *and* the company confirms that the process will continue to be used over the years out to 2010, the benefits in the out years are included in the economic impact assessment. However, it should be noted that no benefits beyond 2010 are included in the study, even if benefits beyond that time are likely.
- The benefits must be quantified and verified, e.g., if it is claimed that a CRC developed process is reducing an end user's costs, these cost reductions must be quantified and verified by the end user that is reaping the benefit.

[16] It can, of course, not be definitively 'proved' that an event would not have occurred in the absence of the CRC Programme. The approach adopted in this study to determine whether an event was 'unlikely' to have occurred in the absence of the CRC Programme was to assess issues such as: whether the problem beneficially addressed by the CRC could only have been effectively addressed through the application of the skills of the range of parties involved in the CRC; whether the scale provided through aggregation of resources into a CRC played an important role in delivering an outcome; whether the collaborative structure of the CRC played a crucial role in the uptake of knowledge by the relevant end user of research; whether the problem solved was in fact only identified as a result of the collaboration involved in the CRC structure; and, whether, in the absence of CRC grant money, the parties involved in a CRC would have been likely to have collaborated anyway on their research. An example of where, following assessment of these issues, it was decided to exclude a measurable economic impact from this study is the case of the CRC for Cochlear Implant and Hearing Aid Innovation and the impact of this CRC on Cochlear Ltd's performance. It was determined that even in the absence of the CRC Programme, Cochlear Ltd would have likely engaged in considerable collaborations with the university researchers who were involved in the CRC. Therefore, even though the CRC has clearly played an important role in Cochlear Ltd's development, it was not possible to determine the 'additionality' of its contribution to Cochlear Ltd when compared to the counterfactual situation that the CRC Programme had not been created and Cochlear Ltd had pursued alternative collaborative arrangements with university researchers.

This approach does mean that a wide range of benefits that are either likely to have resulted from CRCs, or are likely to result from CRCs in the future, have been excluded from the economic impact assessment. The vast majority of benefits claimed in the economic impact assessments that have been conducted by many individual CRCs have not been included in the economic impact assessment conducted in this study. The reasons for the exclusion of most claimed benefits fall into three broad categories:

- The benefits claimed relate to projected benefits not realised benefits – These benefit claims generally fit the format of *process X is being developed by the CRC, process X is predicted to be adopted in the future by Y number of users, adoption of process X is likely to be of benefit Z to these Y users*. These benefits are prospective rather than realised and hence clearly outside the parameters for the economic impact assessment in this study. It should be noted that, for many CRCs, particularly those in operation for less than a full term, it is quite reasonable that benefits are still only prospective rather than realised. It takes considerable time to move from research to the application of research and, finally, to the realisation of benefits from the application of research. Many CRCs have not been in operation for long enough for this process to play out.

- It is not clear to what extent the CRC has contributed to the benefits that have been realised – These benefit claims generally fit the format of *technological advances in industry X have (verifiably) improved productivity by Y per annum, the CRC represented Z per cent of the investment in R&D relevant to industry X over the applicable timeframe, therefore the CRC is responsible for Z per cent of the improved productivity Y*. While it is likely that, in such cases, the CRC will have contributed to the productivity improvement in line with its share of total innovation effort, it has not been verified by end users that it has made this contribution. Also, it is not clear that the CRC has been responsible for additional improvements over and above what would have occurred if the participants in the CRC had simply invested the resources in their own research activities. Therefore, these benefit claims (while likely quite reasonable) cannot be included in the economic impact assessment in this study.

- The dollar value of benefits delivered has not been quantified or, if quantified, has not been verified by end users – These benefit claims generally fit the format of *new process has been developed by the CRC and adopted by X users, researchers suggest that the process saves the users a great deal (unquantified) of time/effort/costs/etc, users have not been approached to quantify or verify the scale of these benefits*. This situation is perhaps the most frustrating of the cases where claims of benefits must be excluded from this economic impact assessment. Theoretically, such claims should be quantifiable and verifiable. Unfortunately, it is simply the case that this quantification and verification process has in some cases not occurred, and hence, such benefits must be excluded from the economic impact assessment in this study. It should be noted, however, that in cases where there are many beneficiaries of research (e.g. in agriculture where many farmers may adopt a new practice) it will in practice be very difficult to have benefits quantified and verified by end users. It is also in practice very hard to quantify and verify benefits in the environmental sphere, where the beneficiary may in fact be the entire community.

Chapter Four details some of the *unquantifiable* benefits associated with the CRC Programme to date that have not been included in the economic impact modelling conducted in this study.

To highlight the considerable difference in results that are obtained between economic impact assessments based on *prospective* outcomes versus the economic impact assessment based on *demonstrated* outcomes that is the focus of this study, it is useful to compare (Table 3.1) some of the results from a number of CRCs prospective economic impact assessment against the outcomes from those CRCs that are included in this study's assessment of *demonstrated* economic impacts.

These examples are not presented with any intention to undermine or criticise the validity of forward looking prospective economic impact assessments. Rather, they are provided solely to demonstrate that it is much harder to verifiably quantify demonstrated economic impacts from research than it is to make forecasts of possible future benefits. This is particularly true for research centres that have been operating for a relatively short period of time.

Table 3.1

PROSPECTIVE VERSUS DEMONSTRATED ECONOMIC IMPACTS

Prospective economic impact assessment outcomes from various CRCs	Demonstrated and verified benefits included in this demonstrated economic impact assessment
Bushfire CRC projected to produce economic benefits over the next 30 years with a net present value of $5,669 million if prevention of lost environmental value is included in the analysis and benefits of $251 million if such environmental value benefits are excluded from the analysis.	No impacts included in the economic modelling in this study.
CRC for Molecular Plant Breeding projected to produce economic benefits over a 20 year period with a net present value of $320 million.	No impacts included in the economic modelling in this study.
CRC for Sustainable Production Forestry projected to produce net economic benefits by 2020 with a net present value of $680 million.	No impacts included in the economic modelling in this study.
CRC for Viticulture projected to produce economic benefits over a 20 year period with a net present value of $61 million.	No impacts included in the economic modelling in this study.
CRC for Soil and Land Management projected to produce economic benefits over a 30 year period with a net present value of $343 million	No impacts included in the economic modelling in this study.

Source: Various CRC Economic Impact Assessment reports.

Further highlighting the difficulties involved in measuring *delivered* benefits, the benefits that are likely to be delivered by some CRCs are intrinsically hard to attach a dollar value to. The research findings of the CRC for Bushfires, for instance, are already used in fire management, community education and other activities intended to reduce the impacts of bushfires and the costs of their management. The close association of user groups with the research program should help see rapid adoption of innovations. The impacts of the CRC will be reflected in commercial, environmental and social benefits.

There are some benefits from bushfire prevention that will be directly reflected in changes in financial outlays for bushfire management. It is expected that these will be realised through reduced frequency and intensity of bushfires as well as improved community, government and firefighting responses to bushfire. These all contribute to a reduced risk of property damage from bushfires. Attaching a dollar value, however, to things such as the sentimental value attached to belongings that the CRC's research may prevent being destroyed or to the value of animal and human lives saved may be an impossible task.

3.3 Quantified and verified economic impacts that have already resulted from CRCs' activities

For commercial-in-confidence reasons it is not possible to provide extensive details in relation to the realised economic benefits that have been generated by CRCs. Most industry end users of research placed tight constraints on the information that would be made public prior to providing quantification of benefits from the application of CRC research. In some cases this extended to a requirement not to publicly disclose the name of the company and/or disclose details relating to the specific technology involved in the generation of benefits.

Notwithstanding such constraints, the list below does broadly describe the twenty-five key identified sources of *delivered* and *verified* benefits from CRCs to date[17]. Each of these events meet the four stringent criteria for inclusion in the economic impact assessment that were outlined in Section 3.2[18].

- CRC Mining. Application of universal dig and dump technology in the coal mining sector. Industry (BHP Billiton Mitsubishi Alliance) incurred costs of \$37 million to further develop CRC technology between 2001 and 2003 then from 2003 started reaping a net average cost saving of \$8 million per annum through fitting technology to its existing draglines, and hence reducing the need for purchase of expensive new draglines[19].

[17] In the case of CRCs that have had multiple iterations the name of the current iteration of the CRC is used – this convention is used throughout the report to avoid confusion. It should also be noted that the some CRC's impacts have been presented as multiple events. This is because, within the economic modelling, cost savings to industry are treated differently to output increases and hence are entered into the modelling as discrete events, even if they relate to a common project within a CRC.

[18] In addition to the 25 events outlined, the CRC Cochlear Implant and Hearing Aid Innovation has also generated measured economic impacts that meet the stringent criteria for inclusion in the modelling. However, information relating to these impacts was not finalised in time for inclusion in the economic impact modelling. The events not included in the modelling relate to the gross product revenues associated with the spin-off companies HEARWorks Pty Ltd and Dynamic Hearing Pty Ltd and the licensing of technology to the Victorian SME Polaris Communications Pty Ltd. The two spin-off companies had gross revenues in 2004/05 of \$1 million and \$2.7 million respectively. HEARWorks to date has also returned around \$3 million to the CRC HEAR through the sale or licensing of IP. Polaris Communications Ptd Ltd, to whom Telstra and CRC HEAR agreed to novate their license to an algorithm that they jointly developed which improves the performance of current devices to reduce acoustic shock injury for headset operators, has developed SoundShield, the world's first acoustic shock protection device for telephonists. Polaris, previously an importer/distributor of foreign products, has now sold over \$15million worth of SoundShield product, and made a significant royalty return to CRC HEAR (to date totalling \$600,000). This outcome would not have occurred without the contribution of the CRC to the creation of the underlying intellectual property that led to SoundShield's development.

[19] It costs around \$10 million to retrofit a dragline and two lines per year are being retrofitted. However, every six draglines that are retrofitted is the equivalent (in terms of productivity) of installing one entirely new dragline, which would cost over \$80 million. Hence the effective net capital expenditure cost saving per retrofitted dragline is around \$4 million.

- CRC Welded Structures. Application of CRC technology to allow faster laying of gas pipelines (primarily in Queensland) has resulted in net industry savings of $20 million per annum since 2001. Pipeline laying rates have achieved record performance levels.
- CRC Welded Structures. In 2004 the CRC proved that a $30 million solution for a defence shipbuilder was a viable alternative to the $150 million solution that was going to be used. This allowed a saving of $120 million in costs to be achieved.
- CRC for Bioproducts. A brewer (CUB) adopted strategies to improve the temperature stability of beer, leading to net cost savings totalling $5 million between 2003 and 2005. A food producer (Goodman Fielder) adopted analytical methods for assessing polymer purity that has resulted in a net cost saving of $3 million per annum since 2004.
- CRC for CAST Metals Manufacturing. Adoption of a range of technologies by CRC industry partners since 2004 has been generating net cost savings of $6.6 million per annum in the metals manufacturing sector.
- AJ Parker CRC for Hydrometallurgy. The adoption by industry partners of outcomes from its thickener project led to a $22.3 million increase in industry costs in 2002 to adopt technology followed by a $99 million fall in capital expenditure costs in 2003 and annual net cost savings of $20.6 million being achieved from 2003.
- AJ Parker CRC for Hydrometallurgy. The adoption by industry partners of outcomes from its solvent extraction project lead to $0.6 million per annum net industry cost savings commencing in 2004.
- AJ Parker CRC for Hydrometallurgy. The adoption by industry partners of outcomes from its thickener project led to $6.2 million per annum net increase in industry output from 2003 onwards through increasing the capacity of existing infrastructure.
- AJ Parker CRC for Hydrometallurgy. The adoption by industry partners of outcomes from its solvent extraction project led to $6.7 million per annum net increase in industry output from 2004 onwards, again through increasing the capacity of existing infrastructure.
- CRC for Advanced Composite Structures. An Australian defence company (ADI Ltd) generated gross increases in revenue of $6 million over the 2002 to 2004 period through sale of products based on the CRC's research.
- Australian Photonics CRC. A number of spin-off companies (the Redfern group of companies) have been formed that have generated significant gross revenue (totalling $178 million to date) through the sale of products based on the CRC's technology. It should also be noted that the overall revenue of the companies has been considerably higher than just the revenue associated with CRC research based products.
- CRC for Cattle and Meat Quality. Gross revenue from the sale of CRC developed products (vaccines and gene marker tests) by commercialisation partners (Pfizer Vaccine Animal Health, Intervet Australia Pty Ltd and Genetic Solutions Pty Ltd) between 2001 and 2005 has totalled $6 million.

- CRC for Sensor Signal and Information Processing. Gross revenue has been generated through the sale of radar and communications products by two CRC spin-off companies (Wedgetail TRDC Pty Ltd and GroundProbe Pty Ltd). Revenue from sales to the defence sector totalled $3 million between 2002 and 2004 while sales to the mining sector totalled $12.5m in 2005.
- CRC for Technology Enabled Capital Markets. Spin-off companies (Capital Markets Technology Pty Ltd, Capital Markets Surveillance Services Pty Ltd, Dtecht Pty Ltd and Capital Markets Consulting Pty Ltd) generated gross revenue of $1.2 million in 2005 through sale of new data gathering software and services in the finance sector.
- CRC for Polymers. Gross revenue of $16.6 million between 2004 and 2005 has been generated from sales by commercialisation partners (Olex and Orica) of CRC research based polymer cable products (Pyrolex CeramifiableTM and cellular cable insulation and sheathing materials). Around $11 million of these sales represents import replacement activity.
- CRC for International Food Manufacture and Packaging Services. A spin-off company from the CRC (Plantic Technologies Ltd) has generated gross revenue of $3.7 million between 2003 and 2005 from sale of CRC developed technology. This revenue is largely from import replacement (of plastic resins).
- CRC for Cardiac Technology. A spin-off company (Elastomedic) was sold to a foreign buyer (Aortech International Plc) in 2000. CRC partners received $26 million from the sale (valued at $75 million) which they then reinvested in the Australian medical research sector.
- CRC for Broadband Telecommunications Networking. A spin-off company (Atmosphere Networks) that developed an Autologous Transfer Mode Local Area Network product was sold to a foreign buyer in 2000. CRC partners received $6 million from the sale (valued at over $150 million) which they reinvested in the Australian telecommunications research sector.
- CRC for Water Quality and Treatment. Application of CRC technology by water treatment authorities has resulted in net cost savings of $26 million per annum since 2004 through reduced chemical and sludge disposal costs and reduced equipment needs for the management of pathogen movement into drinking water sources.
- Vision CRC. Net licensing revenue received by the CRC partners averaged $2.2 million per annum between 1999 and 2004 due to licensing of SEE3 contact lens technology to a foreign company (Novartis).
- CRC for Asthma and Airways. Application of CRC research on inhaled corticosteroids has led to changed prescribing patterns leading to a $6 million per annum saving in Commonwealth Government drugs expenditure from 2005 onwards.
- CRC for Sustainable Aquaculture of Finfish. Application of research into use of lights to influence growth of salmon was trialed by two companies who realised a net revenue benefit through higher salmon growth rates of $3.2 million in 2004.

- CRC for Clean Power from Lignite. A spin-off company (Laser Analysis Technologies Pty Ltd) has generated gross revenues of $0.8 million between 2003 and 2005.
- CRC for Vaccine Technology. Licensing revenue totalling $0.6 million has been received between 2003 and 2005 from an international pharmaceutical company.
- CRC for Environmental Biotechnology. Spin-off companies have generated gross revenue of $2.7 million over the 1998 to 2004 period, largely through sale of new environmental management services to the construction industry.

These benefits are attributable to CRCs as, in each case, in the absence of the collaborative research framework provided by the CRC organisational structure, the technological breakthroughs that generated each of these outcomes would have been unlikely to occur in the timeframe under consideration. These benefits are therefore additional to those that would have been likely to have eventuated if the Commonwealth had not provided CRC funding and if all other contributors of resources to the CRCs had instead used those resources internally on their own research activities.

A number of other CRCs have also demonstrated early stage economic impacts, generally involving the commercialisation of new products through spin off companies that have received investment (in some cases in the millions of dollars) but are still in the pre-revenue phase. Such impacts have not been considered in the economic impact modelling.

3.4 Economic modelling methodology

The key step in the economic modelling is to develop realistic *with CRC Programme* and *without CRC Programme* scenarios. Comparison of the *with CRC Programme* scenario with a realistic *without CRC Programme* counterfactual allows the net effect of the CRC Programme on Australian economic performance to be identified.

We know what the *with CRC Programme* scenario of economic performance entails – it is the performance of the economy that has actually been observed. The key then is to describe the counterfactual of what economic performance would have been in the *without CRC Programme* scenario. To answer this question it is necessary to consider:

- where the resources invested in the CRC Programme would have been invested in the absence of the Programme; and
- what benefits that have resulted from the CRC Programme would not have been realised in the absence of the Programme.

Each of these issues are considered in turn below.

Resource allocation – the without CRC Programme counterfactual

The default assumption must be that, other than the Commonwealth CRC grant funds, all the cash and in kind resources allocated to the CRC activities would have been allocated by the funding providers to other R&D activities in the same research areas. While some participant funds may in fact have been induced into R&D by the existence of CRCs, it cannot be proved that this has occurred.

If the Commonwealth had not funded the CRC Programme it is assumed that the money would have been allocated across other Government expenditure. An alternative counterfactual assumption could be that taxes could have been lowered by the amount of CRC funding. However, given the scale of CRC funding in the scheme of the overall Commonwealth budget, it is more likely that the funds would have just been differently allocated out of consolidated government revenue rather than allocated to fund a specific reduction in taxes.

Table 3.2 sets out the level of Commonwealth Government funding into round one to seven CRCs over the life of the CRC Programme.

Table 3.2

COMMONWEALTH GOVERNMENT GRANT FUNDING OF ROUND ONE TO SEVEN CRCs ($MILLION)

92	93	94	95	96	97	98	99	00	01	02	03	04	05
19	48	96	107	133	143	147	142	138	140	146	149	126	113

Source: Budget Papers and CRC Programme media releases.

In the counter-factual scenario in the economic modelling it is assumed that rather than be allocated to the CRC Programme, the above levels of funding are instead allocated across all other Commonwealth Government expenditure areas.

Foregone benefits – the without CRC Programme counterfactual

In the counterfactual scenario in the economic modelling, it is assumed that each of the twenty-five measured economic impacts of the CRC Programme that were outlined in section 3.2 would not have occurred.

In aggregate, across the 1996 to 2010 period, these foregone benefits include:

- Net cost savings to industry of $832 million. These cost savings represent a direct economic benefit as they represent in effect an increase in productivity in Australian industry. When costs are reduced, a given level of output is able to be produced from a lower level of inputs, thus freeing those ‘saved’ inputs to be productively allocated to other activity within the economy.
- A gross revenue increase to Australian industry of $331 million. It is important to note that these are gross revenue increases rather than profits. Hence, in the modelling, it is necessary to also factor in that significant costs are incurred to generate these revenues – meaning that the overall net economic impact of these outcomes is reduced.

- Income from the sale or licensing of IP to foreign companies of $46 million. Given that this income has been reinvested in the Australian research system, this represents an increase in foreign investment in research in Australia.
- Savings to Government on spending on pharmaceuticals of $30 million. This provides a benefit by directly reducing the call on Government resources.

Therefore, under the counterfactual scenario, these events are taken away from the levels of economic activity observed in the base, *with CRC Programme*, scenario.

3.5 Summary of the economic modelling scenario developed

The following summarises the inputs the economic modelling scenarios conducted by the Centre for Policy Studies. These are the specific changes entered into the model to reflect the different outcomes between the *with* and *without CRC Programme* scenarios. The model then measures the effect of these input shocks on key economic outcomes such as Gross Domestic Product, Real consumption, Real Investment and Taxation Revenue (discussed in Section 3.6).

The *with* CRC scenario is compared to the counterfactual scenario that assumes that the CRC Programme had never been created and that the Commonwealth Government funds that have been allocated to the round one to seven CRCs had instead been available for other general Government expenditure.

In this study, twenty-five measured and verified economic impacts of the CRC Programme were identified. In the counterfactual (what would have happened if the CRC Programme was not put in place) *without CRC Programme* scenario in the economic modelling, it is assumed that each of the twenty-five measured economic impacts of the CRC Programme that have been identified would not have occurred. In aggregate, across the 1996 to 2010 period[20], these foregone benefits include:

- Net cost savings (i.e. net of costs incurred to generate the savings) to industry of $832 million – over half of which have already been accrued by 2005 with the remaining cost savings almost certain[21] to be accrued over the 2006 to 2010 period.
- A gross revenue (i.e. additional sales from new products) increase to Australian industry of $331 million – eighty per cent of which have already been accrued by 2005 with the remaining twenty per cent almost certain[22] to be accrued over the 2006 to 2010 period.
- Income to CRCs and CRC participants from the sale or licensing of IP to foreign companies of $46 million – all of which has already been accrued by 2005.

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[20] 1996 is the year that the first measured economic benefit from the CRC Programme was identified while 2010 represents the final out year in the modelling time horizon.

[21] These forthcoming benefits relate to cost savings that are already occurring and which industry end beneficiaries have confirmed will continue to occur over at least the next five years.

[22] These ongoing gross revenue increases are caused by the expansion of productive capacity that the use of CRC technology has generated. These gross revenue increases are a continuation of increases in output that are already being accrued and industry has indicated will continue to accrue at least until 2010.

- Savings to Government on spending on pharmaceuticals of $30 million – of which the majority will accrue over the 2006 to 2010 period[23].

Therefore, under the counterfactual scenario, these events are taken away from the levels of economic activity observed in the base, *with CRC Programme*, scenario.

Table A.1 in Appendix A sets out on a year by year and industry by industry basis the precise shocks entered into the counterfactual *without CRC Programme* scenario.

3.6 Economic impacts of the CRC Programme

The key finding from this modelling is that, as a result of the provision of $1,647 million of Commonwealth Government funding for the first seven rounds of CRCs, over the 1992 to 2010 period the Australian economy's overall performance has been enhanced when compared to the performance that would have occurred in the absence of the CRC Programme. Specifically, over the 1992 to 2010 period[24]:

- Gross Domestic Product (total economic output) is cumulatively (in 2005 dollars) $1,142 million higher than would occurred had the money spent on the CRC Programme instead gone to general government expenditure (which would have itself contributed to GDP). In 2005, GDP is $143 million higher than it would have been in the absence of the CRC Programme (compared to expenditure on round one to seven CRCs of $113 million in that year).
- Real Consumption (the level of private expenditure on goods and services in 2005 dollars – a good proxy measure for overall economic welfare) is cumulatively $763 million higher than would have occurred had the money spent on the CRC Programme instead gone to general government expenditure (which would have itself contributed to real consumption). In 2005, Real Consumption is $108 million higher than it would have been in the absence of the CRC Programme.
- Real Investment is cumulatively (in 2005 dollars) $417 million higher than would have occurred had the money spent on the CRC Programme instead gone to general government expenditure (which would have itself contributed to real investment). In 2005, Real Investment is $41 million higher than it would have been in the absence of the CRC Programme.
- Commonwealth taxation revenue is cumulatively (in 2005 dollars) $66 million higher than the tax revenue that would have been collected had the money spent on the CRC Programme instead gone to general government expenditure (which would have itself generated tax revenue). In 2005, Tax revenue is $10 million higher than it would have been in the absence of the CRC Programme.

[23] This benefit related to savings generated by the changing treatment protocols that have now been implemented for asthma. These savings have already started and are highly likely to continue to be realised for at least the next five years.

[24] The modelling scenario is run out to 2010 as some of the benefits that have already commenced from the CRC Programme are clearly going to continue to be accrued out to at least 2010. For the purposes of the summary of economic impacts from the CRC Programme, all impacts between 2006 and 2010 have be deflated using a real discount rate of 5 per cent to reflect the fact that future benefits have a lower net present value than current benefits.

When compared to the size of Government funding involved in the Programme, these results indicate that, counting only those delivered benefits that have been able to be quantified, a solid return is being delivered to society from the CRC Programme. Given that these returns represent a lower boundary quantification of the impacts of the program, with a number of significant benefits being excluded from the calculations, this is an encouraging result and one that demonstrates the tangible benefits that can be delivered through public investment in R&D.

Chapter 4

Non-Quantifiable or Prospective Outcomes From CRCs' Activities

4.1 Observed but non-quantified impacts from CRCs' activities

As discussed in Section 3.2, in the assessment of the *delivered* economic impact of the CRC Programme that has been conducted in this study, stringent criteria for inclusion of an economic impact within the modelling have been used. To be included, a benefit needed to be attributable to the CRC Programme, must have already been delivered (or be commenced but ongoing), and the benefits must have been quantified and verified by the end users or beneficiaries of the research. Such a strict set of criteria has resulted in a number of observed outcomes from the CRC Programme not being included in the economic impact assessment of the Programme that was detailed in Chapter Three. The exclusion of these impacts has been due to either difficulties in attribution of benefits or in the quantification and verification of the scale of the impacts. However, the exclusion of these benefits from the economic impact assessment does not mean that significant benefits have not been generated by the CRC Programme. It simply means that a number of benefits are very hard to satisfactorily quantify.

Below are a selection of 10 examples of likely significant delivered economic benefits from the CRC Programme that were not included in the economic impact assessment in Chapter Three.

CRC for Cochlear Implant and Hearing Aid Innovation – contribution to Cochlear's development

All technology developed by CRC HEAR in the implant field has been licensed directly to Cochlear Limited. Two such examples are the ADRO technology, and the development of the Contour family of electrode arrays. Beginning in the late 1990s, the development of an electrode array that could be safely positioned in close proximity to the neural elements was a critical need in the implant field, and important for the company to maintain its competitive technology advantage. The work conducted by CRC HEAR was critical to this development. The Contour was introduced in the market in 2000, and was an immediate success, and has now been implanted in over 30,000 patients world-wide, more than any other single electrode design in the history of the field. Cochlear Ltd returned sales of $348 million in 2004/05, and royalty income to CRC HEAR has now reached $1 million. The support provided by CRC HEAR has also included training of surgeons, and development of the surgical approach and technique for safe and atraumatic insertion.

Cochlear Ltd has over the past 4 years brought numerous surgeons from Europe, the US and Japan to Australia under a Visiting Implant Specialists to Australia programme. Each of these surgeons has spent several days at the CRC HEAR, underlining the important support that Cochlear Ltd has received from the CRC for its technology and market activities.

A further support for Cochlear Ltd is in the form of the Cochlear Implant Workshop programme, which has to date trained over 2500 surgeons and clinicians from over 22 different countries, and allowed the establishment of some 24 new clinics that have become new Cochlear Ltd customers, particularly in Asia Pacific.

While it is clear that the CRC has made a positive contribution to the development of Cochlear Ltd, it is not possible to determine the extent to which this contribution is 'over and above' the outcomes that would have occurred in the absence of the CRC Programme. Cochlear Ltd was established prior to the CRC Programme and maintained strong collaborative links to university researchers prior to the establishment of the Programme. If the Programme had not been established it is likely that Cochlear Ltd would have continued to maintain collaborative research linkages (albeit likely at a somewhat lower level) with university researchers. The difficulty associated with determining the additionality of the CRC HEAR's undoubtedly positive contribution to Cochlear Ltd, is the reason why these positive impacts have not been included in the economic impact modelling in this study.

CRC for Cattle and Beef Quality – Protection against Bovine Respiratory Disease

Bovine Respiratory Disease (BRD) is a serious disease of Australian feedlot cattle. Amongst the 1.02 million cattle in Australian feedlots at any one time, BRD can cause deaths, sickness and reduced growth. Losses and cost of treatment costs $60 million per year. Furthermore, treatment of sick cattle with antibiotics is costly and can prevent export due to overseas trade restrictions on the importation of meat with antibiotic residues.

The vaccines "Bovilis MH" and "Pestigard", developed from research by the CRC for Cattle and Beef Quality are a simple, cheap and effective method of preventing BRD. The innovative research to develop the novel vaccines was completed in 1997 and the registration process was completed in 2004. Sales of the two vaccines to December 2004 amounted to 1,055,375 doses and are expected to grow and the proven efficacy of the vaccines becomes well known.

The commercial benefits of the CRC are modest to this point. However, significant benefits are now being realised through the increased efficiency of Australian feedlots and minimisation of potential problems with exports. **In addition to reduced disease incidence, feedlot managers have reported reduced requirements for administering antibiotics to feedlot cattle as a result of the use of the new vaccines**. However, no quantification of the resulting cost savings have been made.

CRC for Landscape Environments and Mineral Exploration – enhanced minerals discovery

Regolith and geochemical research has been used by mineral explorers to improve success rates and make exploration more efficient. **Since the mid-1990s, technology developed by the CRC for Landscape Environments and Mineral Exploration has contributed to the discovery of gold deposits with an in ground value of over $3 billion**. However, it is not possible to know the extent to which the CRC's technology contributed to the discoveries. For this reason, no quantifiable impacts were attributed to the CRC in the economic impact assessment.

CRC for Tissue Growth and Repair – contribution to the growth of GroPep

GroPep is a spin-off company formed by CSIRO and the University of Adelaide in 1988 to commercialise research into novel growth factors. In 1991 these two institutions expanded their research collaboration through the formation of the CRC for Tissue Growth and Repair. GroPep became the commercialisation arm of this CRC. In 1997 the CRC was renewed and Flinders University has also become a participant.

GroPep now develops, manufactures and commercialises biologically active proteins in four areas of the biotechnology industry. In 2000, GroPep entered a ten year commercial agreement with CSL Limited. GroPep develops and manufacturers growth factors which are then sold through CSL's wholly owned subsidiary JRH Biosciences.

GroPep employs over 80 people in Adelaide and had revenue in 2004/05 of $16.6 million. The majority of revenue was generated through exports. The CRC for Tissue Growth and Repair has played an important role in the development of GroPep. However, it is not possible to accurately attribute the extent to which GroPep's development has been contingent on the formation of the CRC. Therefore, the economic activity associated with GroPep has not been included in the economic impact assessment of the CRC Programme described in Chapter Three.

It should be noted that similar difficulties in attribution have resulted in the exclusion from the economic impact analysis of the activities of a number of other significant companies, such as PrimeGro and TGR Biosciences – which have both benefited from the CRC for Tissue Growth and Repair.

CRC for Cattle and Beef Quality – improvements in beef production

One of the major costs of beef production is the cost of feeding cattle. A large proportion Australia's cattle population is raised on improved pasture ranges at any one time. Supplementary feeding with hay, grain and silage is often necessary to fill feed gaps for cows on pasture and to ensure young cattle grow to specification. Such supplementation adds further to the cost of feeding cattle.

Net feed efficiency (NFE) refers to the efficiency of feed utilisation assessed after accounting for the requirements for growth and maintenance of body tissue and is calculated as residual feed intake. This is simply the difference between an animal's actual feed intake and its expected feed requirements for maintenance and a particular growth rate. Genetic selection for improved feed efficiency aims to reduce feed-related costs and thereby improve profitability.

The former NSW Agriculture commenced R&D in this area in the early 1990s, with a major project funded by the Meat Research Corporation (MRC). Since then NFE has been a major area of the CRC for Cattle and Beef Quality research efforts. Application of this research is leading to increased NFE. However, benefits accrued to date have not been quantified and it is also not possible to determine accurately the extent to which benefits can be attributed to the CRC research programs.

CRC for Sustainable Rice Production – more efficient rice production

The CRC for Sustainable Rice Production has coordinated several projects to improve the efficiency of Australian rice production. One project has improved water use on 48 hectares of saline land and brought it back into production.

There have been several other observed impacts from the CRC. The development of improved pre-milling grain quality measurements has improved the feedback to farmers on the quality of their grain deliveries. This allows them to take appropriate actions to ensure consistent quality between deliveries. Another project has resulted in new products being produced by RCL that were not sold in the past and the new vitamin and mineral fortification plus new rice flour applications are new markets which did not exist for the Australian rice industry before the CRC assisted to develop the technology for its manufacture.

The total financial value of the outputs across 13 projects conducted by the CRC, before costs are deducted, is estimated at over $7 million per annum. However, it is difficult to verify exact figures.

CRC for Aquaculture – improved environmental management of prawn farming

During the 1980s and early 1990s the emergence of prawn farming in coastal regions of Australia raised concerns about the potential for adverse environmental impacts. These concerns reflected the serious mistakes made in other countries, including South East Asia and South America, where poor environmental prawn farming practices had caused widespread environmental damage. These concerns were exacerbated by a global lack of rigorous scientific information about intensive prawn pond ecosystems, their impacts on adjacent environments and options for treating pond wastes.

The CRC for Aquaculture and the Fisheries Development Corporation on behalf of the Australian Government, has funded a collaborative research project to address the above issues. This involved the CSIRO Marine Research Unit, in collaboration with the Australian Prawn Farming Industry, initiating a comprehensive, multi-disciplinary study of intensive prawn pond ecosystems, their ecological impacts on downstream environments and the development of cost-effective effluent treatment systems. The study integrated the research skills of 30 scientists from several institutions including CSIRO Marine Research, The Australian Institute of Marine Science, University of Queensland, Queensland Department of Environment and Heritage, New South Wales Environment Protection Authority, Griffith University, University of Sydney, University of Technology, Marine and Freshwater Resources Institute, Victoria and the University of Maryland, U.S.A.

The results of the research provided new insights into several aspects of prawn pond and effluent management. Many of these have had significant, quantifiable impacts on industry practices. Most Australian prawn farmers now use the PONDMAN software developed by the team to assist with their farm data management. This software provides easy access to data for farmers and researchers to evaluate the key factors that affect variations in prawn production efficiency.

One of the practical impacts of the research is that all Australian prawn farms now use effluent treatment systems to meet the nutrient discharge limits recommended by the CRC. These recommendations have also been incorporated into state and federal regulations on nutrient discharge loads. A recent industry survey showed that 17 per cent of a total Australian prawn farm area had been dedicated to effluent treatment. **Industry has invested more than $15 million to improve its environmental performance using the practices developed by the CRC.** This major change in the environmental management of the industry was a direct result of the success of the nationally coordinated research project and highlights the benefits of the collaborative approach that CRC for Aquaculture adopted in tackling major research issues. As yet, there has been little quantification of the economic effects of this research and, for this reason, it is excluded from the modelling data.

CRC Mining – commercialisation of Tight Radius Drilling technology

CBM Innovations Pty Ltd (CBMI) was formed to commercialise CRC Mining's Tight Radius Drilling system. This step-change technology harvests methane from coal seams ahead of mining to reduce explosive hazards in the mine. The extracted methane can also be used to generate energy with considerably lower greenhouse gas emissions than energy sources such as oil and coal.

Micro structurally, coal has a large internal surface area. Consequently coal stores 6 to 7 times more gas than the equivalent rock volume of a conventional gas reservoir (USGS, 1997). In Australia the reported reserves of coal bed methane (CBM) in Queensland's Bowen Basin exceed the reserves of natural gas on the Northwest shelf.

In some countries, CBM is already an important energy source. For instance, in the USA today it accounts for about 8 per cent of natural gas production. It is a rapidly growing business both in North America and elsewhere. The impediment to an even more rapid widespread exploitation of CBM is that most coal seams are relatively impermeable. *Ergo*, it is difficult to separate the gas from the coal. The most effective way to increase the permeability of a coal seam is to drill holes in the seam. Conventional drilling technology adapted from the oil industry exists that can achieve this end and this technology is widely used in the industry today. However, it is relatively expensive and not always effective.

CRC Mining's Tight Radius Drilling technology uses the novel approach of a waterjet powered drill which is able to penetrate coal seams more rapidly and with more flexibility than conventional drills.

BHP Billiton has a 60 per cent interest in the company CBMI with CRC Mining and the CRC staff owning the other 40 per cent. BHP Billiton and BHP Billiton Mitsui Coal have invested in excess of $10 million in the development of the Tight Radius Drilling technology and continue to support ongoing development at more than $1 million a year. **It is too early to place a value on this company but it is likely to be in excess of $100 million when the technology is fully commercialised in five years time.** Even more importantly, this technology is likely to be responsible for a more rapid Australian take-up of CBM as an important energy source.

CRC for Soil and Land Management – improving productivity of Sodic Soils

Sodic soils are defined as soils with sufficiently high sodium levels to affect soil structure. Characteristics of sodic soils include reduced water infiltration and drainage leading to waterlogging and increased susceptibility to erosion. Poor plant root growth and reduced plant production result. Approximately 30 per cent of Australia's agricultural land is estimated to be sodic. Sodic soils are particularly common in areas of eastern and southern Australia.

The CRC for Soil and Land Management has contributed to a research effort aimed at improving the productivity of sodic soils by developing a simple method of diagnosing soil sodicity. Research work was undertaken to determine the most suitable remedy for particular combinations of problems in soils. Both objectives of the project were achieved.

The project produced a manual entitled 'Managing Sodic, Acidic and Saline Soils'. This manual was published by the CRC and defines tests farmers can undertake to determine if their soils are sodic, acidic and/or saline. Once the soil has been analysed by the farmer, recommendations are provided to address the issues of sodicity, acidity and salinity. Recommendations include whether to apply gypsum and/or lime and the rate of application. Further procedures to enable farmers to monitor, and continue to address soil sodicity following the initial treatment, are also documented in the manual.

The benefits to farmers of accurately diagnosing soil sodicity and salinity include improved soil structure, improved water infiltration, reduced soil erosion, improved plant root growth, and improved production. Both sustainability and production benefits are likely to accrue. Off-farm benefits of adopting strategies to address sodic soils are also likely to accrue. The main benefits include:

- Reduced soil erosion and subsequent reduction in infrastructure damage from flooding and soil movement.
- Improved water quality in off-farm waterways and storages.
- Reduced salinisation resulting from less water entering underground waterways.

It is difficult to quantify the exact economic impact of the research and, hence, it has been excluded from the economic impact data.

Training of Future Industry Researchers

The CRC Management Data Questionnaire information collected by the Department of Education, Science and Training indicates that over 2,500 postgraduate students trained within CRCs have subsequently taken jobs within industry. Given that CRC Programme cash grants account for around 25 per cent of resources that have gone into the CRCs, it is reasonable to assume that at least 25 per cent fewer postgraduates would have been available for employment in industry in the absence of this funding for the CRC Programme. Therefore, it is a reasonable assumption that there are now at least 625 extra post-graduate degree holders working in Australian industry than would have been the case in the absence of the CRC Programme. It is a widely held view that there is a productivity premium associated with postgraduate students. This is reflected in the higher average wages of postgraduate degree holders. **The productivity premium associated with the extra postgraduate degree holders in industry from the CRCs can be estimated to be worth in the order of $6.5 million per annum to the Australian economy**[25].

There may be an even higher productivity premium associated with CRC post-graduates given their prior experience in working in an environment where industry cooperation is encouraged. Anecdotal evidence suggests that one outcome of the CRC organisational structure is that it exposes students more to the possibility of working within industry and encourages more students than is the norm within postgraduate study in Australia to choose this career path. However, in the absence of comprehensive student destination data for the wider postgraduate student population it is not possible to quantify the extent to which the CRC Programme disproportionately generates postgraduate students who then work in industry.

Notwithstanding the above *likely* outcomes of the CRC Programme, it was not felt that these impacts could be verified and quantified with sufficient certainty for their inclusion in the economic impact assessment of the program outlined in Chapter Three.

4.2 Prospective economic impacts from CRCs' activities

The assessment of outcomes to date from the CRC Programme indicates that the generation of significant measurable economic benefits from research generally takes considerable time.

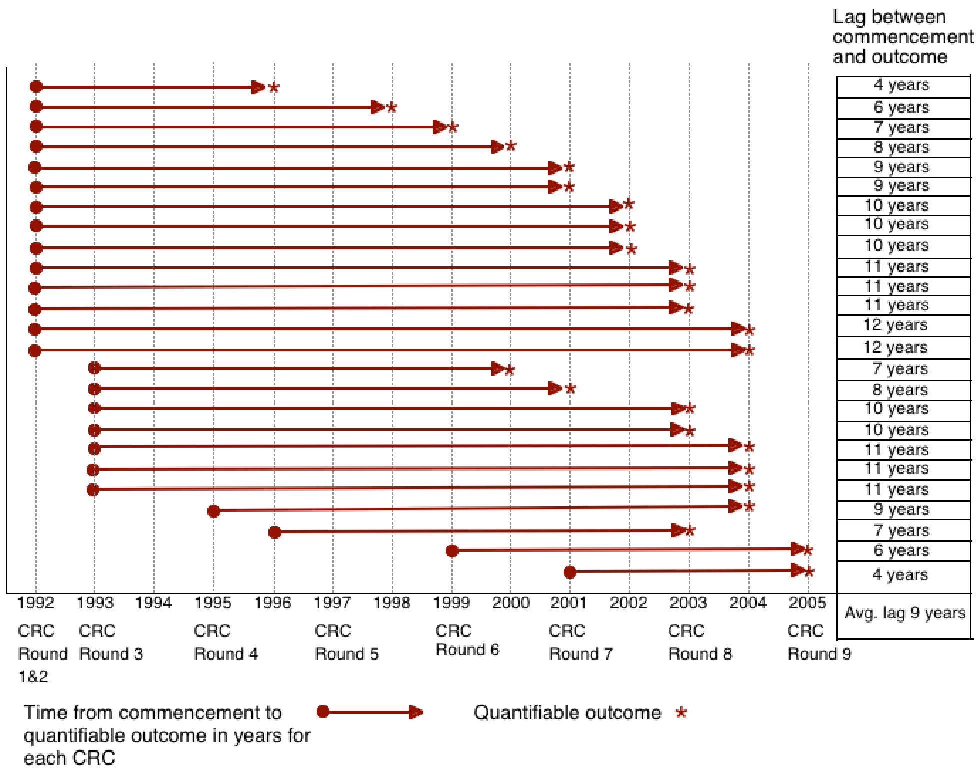
[25] ABS data [ABS, 4230.0, 2003] suggests that postgraduate degree holders earn on average $6,600 p.a. more than bachelor degree holders. Given that around half of output is returned to labour and half to capital, this suggests an output premium of $13,200 p.a. per postgraduate degree holder working in Australia. Studies also have shown that around 80 per cent of the wage impacts of education are attributable to the actual education received rather than natural ability factors. This suggests that the productivity premium attributable to postgraduate qualifications (versus a Bachelor Degree only) is around $10,500 per annum per employed postgraduate degree holder. Therefore the productivity premium associated with an extra 625 postgraduate degree holders employed in Australia would be expected to be around $6.5 million per annum.

The first CRC to generate measurable economic impacts did not generate any impacts until 1996, five years after the commencement of the CRC Programme, the second CRC took until 1999 to generate a measurable benefit, while the third took until 2000, nine years after the establishment of the program, to produce a measurable economic impact. The vast majority of the economic impacts included in the economic impact assessment of the CRC Programme did not commence until after 2001, a full ten years after the commencement of the CRC Programme. Furthermore, of the twenty-five measured economic impacts included in the economic modelling, twenty-two have been generated by CRCs that were in either their second or third terms of operation at the time that the impacts commenced. For one of the three one-term CRCs to generate measured impacts, the impact did not actually accrue until a year after the CRC had finished operating.

The time-lags between commencement of the relevant CRC and the commencement of each of the twenty-five quantifiable economic impacts outlined in Section 3.2 is illustrated in Figure 4.1.

Figure 4.1

THE TIME LAG BETWEEN THE COMMENCEMENT OF A CRC AND THE ACHIEVEMENT OF A QUANTIFIABLE ECONOMIC IMPACT



Source: Data collected by the CRCA from CRCs

The observed time lags between commencement of research and realisation of a measurable economic impact, which averages nine years, suggests that the majority of the economic impacts that will eventually be associated with the activities of the CRC Programme to date, have not yet commenced being realised. Supporting this contention is the wide range of prospective economic impacts associated with the CRC Programme that have been identified through the course of this study.

Below are a selection of 12 case studies of some of the important prospective outcomes that may accrue in the future from the activities to date of the CRC Programme.

CRC for Advanced Composite Structures – assisting Hawker de Havilland to secure a major contract

The CRC for Advanced Composite Structures' (CRC-ACS) long-standing core participant Hawker de Havilland (HdH) has received a huge payback for its investment of around $17 million in advanced composites R&D through its participation in CRC-ACS. HdH won the contract to construct all the wing trailing edge devices (WTEDs), including flaps, spoilers and ailerons, on the new Boeing 787.

On the 787, Boeing USA will manufacture few of the components, and will concentrate on assembly of large components delivered by an exclusive team of "Tier One" suppliers. Despite intense competition, HdH was able to leverage its advanced composites technologies developed by CRC-ACS to gain a place on this select list of design-build suppliers for the first time.

HdH will be one of only ten companies worldwide that supply 787 assemblies directly to The Boeing Company in Seattle. **This Australian work is likely to span three decades, directly support hundreds of jobs, and result in sales of $4 billion over the life of the program. The flow-on effects of this opportunity for HdH include up to 3,300 jobs in the Australian economy**.

The CRC-ACS research program has been essential to winning the Boeing contract in the bidding process, in the design phase, and in the manufacturing phase.

The CRC's research convinced Boeing that the product would be sufficiently strong and light for use on the 787. Boeing was also convinced of the depth of manufacturing science available to back up the new processes. In fact, six technologies previously developed, or under development, by CRC-ACS programs were made available to 787 suppliers world-wide under appropriate commercial terms.

The CRC-ACS research program has introduced and transferred to HdH the main new technologies to be used by HdH to design, analyse and manufacture the 787 WTED package competitively. Vacuum bag resin infusion, diaphragm forming, and unitised construction technologies developed by CRC-ACS are the key manufacturing technologies to be used by HdH. Extensive knowledge of process simulation, postbuckling design, bird-strike simulation, and design optimisation, developed through CRC-ACS programs, is enabling HdH to design the parts efficiently and competitively. The extensive body of CRC-ACS research since 1991 gave HdH the luxury of choosing between different new technologies.

CRC-ACS has trained around half the engineers working on the 787 program at HdH in the relevant new technologies, through their secondment to CRC-ACS research programs, or through their PhD studies. This has given HdH a tremendous wealth of experience in some very new technologies. The full economic impact of the contract is yet to be realised and it is difficult to quantify the contribution made by the CRC in achieving the outcome.

CRC for Sustainable Production Forestry – improved forestry productivity

The CRC for Sustainable Production Forestry's modelling work is being used as the basis for guiding a national *E. globulus* breeding program operated by the Southern Tree Breeding Association (STBA) with whom the CRC has a close working relationship. The STBA is a cooperative for eucalypt and pine breeding programs in Australia. Since its formation in 1995, the Association has built its membership base to 21 companies and research organisations. Members represent most of the forestry companies in Southern Australia and 80 per cent of Association's eucalypt members are partners of the CRC.

A large proportion of the eucalypt plantation industry is expected to benefit from the breeding program as STBA members manage approximately 70 per cent of the plantation area in Australia. Members of the STBA pay an annual membership fee and, in return, have unrestricted access to genetically improved seed and clones released by the Association. Non-members who wish to purchase seed pay a premium price, which is set at about three times the effective price charged to members.

Improved seed emerging from the STBA's breeding program is bulked up in seed orchards. A new company, seedEnergy, has been established to fulfil this task and market the seed. Other companies are also involved in seed production under licence to the STBA. The majority of seed is sold to STBA members, some of whom are vertically integrated companies. The economic impacts of this program could be significant given the scale of the plantation industry.

CRC for Cochlear Implant and Hearing Aid Innovation – HEARWorks

The establishment and operation of the CRC's commercialisation company HEARWorks was internally funded through CRC HEAR commercial receipts. HEARWorks generated income of approximately $1 million from the commercialisation of CRC HEAR IP in 2004/05, and since its inception in 2001, has generated total returns to CRC HEAR of over $3 million.

These funds have been re-invested in the research and commercialisation of CRC HEAR outcomes, and have allowed HEARWorks to attract a Business Investment Fund grant of $600,000 to develop a new generation of computer-based audiological test equipment.

The NAL-NL1 hearing aid fitting software has been licensed by HEARWorks and partner Australian Hearing to all 10 of the major international hearing aid companies, and has returned some $0.5 million to HEARWorks, and Australian Hearing.

CRC HEAR and HEARWorks have currently licensed the "trainable Hearing Aid" IP to Siemens Hearing Instruments. **The world's largest hearing aid company, Siemens will roll this technology out from mid-2007, and estimate that it may encompass up to 20 per cent of the world annual sales of $2 billion in hearing aids, and providing for royalties of some $2 million/annum to CRC HEAR and its partners**. In addition, the application of the trainable hearing aid concept could result in a 0.5hour savings/fitting, estimated to be a return of $2.3 million/year in healthcare costs.

CRC HEAR and HEARWorks are currently negotiating with a number of major international audiological equipment suppliers for the licensing of the HEARLab technology and concept for ongoing provision of a series of computer-based audiological test models. The potential is for ongoing sales and licensing of some $1 million/year based on world-wide sales.

Second generation acoustic shock algorithms, and second generation NAL software will also return small but significant royalty returns to HEARWorks and its partners, estimated to be some $500,000 and $1 million/annum respectively.

CRC for Viticulture – disease detection and management

The CRC for Viticulture has developed several techniques to detect infection with diseases and fungi such as Eutypa dieback fungus and Phylloxera root diseases. The technology should allow the early detection and management of such diseases and result in associated cost savings. Substantial costs savings could be realised given the considerable prevalence and management costs of the diseases. For instance, Phylloxera costs the Shiraz sector of the wine industry around $20 million per annum. The CRC estimates that the costs of Eutypa dieback can be reduced by 10 per cent and the spread of Phylloxera can be curtailed. It will be interesting to observe the economic impacts as this technology is adopted.

CRC for Technology Enabled Capital Markets – Dtecht P/L fraud control software

Data-mining Technology for Evaluating Consumer Health Transactions (Dtecht) was developed by the CRC for Technology Enabled Capital Markets. Dtecht uses data-mining technology to prevent fraud and inappropriate claims in the health insurance industry. It is a highly innovative approach to protecting health funds from fraud and abuse. In 2005 Dtecht won a CRC Association Innovation award.

The private health insurance market in Australia is of the order of $8 billion. There are many estimates as to the value of fraud within the Healthcare industry ranging from accusations of endemic rorting to the HIC admitting to rates of at least 1 per cent. Although some current technologies and processes deter major fraud activity, there is significant small-scale fraudulent activity which continues to increase at disturbing rates, around 8-15 per cent per annum. The real-time intervention will deter many practitioners from attempting fraudulent claims due to the high risk of detection and prosecution.

Dtecht provides health insurers with:

- Improved compliance and control.
- Improved assessment of provider behaviour.
- Reduction of drawing rates.
- Improved health insurance products.

In June 2004 a proof of concept project was initiated with 23 of the restricted membership industry funds to test the Dtechtive fraud control software being developed by Dtecht. **Dtecht stands to be the market leader in data mining technology application in the health insurance industry over the long term and is very well positioned to gain substantial revenue from saving even a small proportion of the $2 billion currently lost each year in Australia from claims which should not be paid by health insurers**.

The CRC, through its commercialisation arm has invested $760,000 in Dtecht and the Health Bureau has provided a further $100,000. Additional capital raising efforts are under way to fully commercialise Dtecht. Based upon the receipt of an anticipated $1 million for 40 per cent of the company's equity, Dtecht has a current market value of $2.5 million.

CRC for Sustainable Rice Production – screening cold tolerant varieties

The CRC for Sustainable Rice Production has undertaken a project to reduce the loss of crop yield from cold temperatures. The project "Cold physiology at the plant level" aims to identify cold tolerant rice varieties/genotypes that may be used as parent material by the rice breeders for developing cold tolerant varieties. Approximately 140 varieties of more cold tolerant genotypes (compared to the local varieties) were brought from overseas and tested for their adaptability and performance under the local agro-climatic conditions.

Of those varieties tested, seven genotypes consistently performed better than the Australian cultivars in withstanding low temperatures during the reproductive stage. The results of the experiments revealed that low temperatures lowered the harvest index of the overseas varieties by an average of 20 per cent compared to 50 per cent for the typical Australian cultivars. However, the yield and quality of those varieties are low compared to the local commercial rice varieties. Hence the intent of a breeding program is to use the cold tolerance genes of the overseas varieties with well-adapted local varieties to develop new varieties that combine cold tolerance with high yield and grain quality. It is anticipated that considerable savings could be realised through this project.

CRC for Innovative Dairy Products – marker assisted selection project

The CRC for Innovative Dairy Products is researching the discovery and application of DNA markers in the dairy cow across partners at University of Sydney, Melbourne, Animal Genetics Breeding Unit in NSW, Garvan and CSIRO Livestock Industries. The focus is on markers that will predict desirable characteristics in dairy cows, such as fertility and resistance to mastitis and other diseases. Markers such as these will help farmers to breed animals that can produce more milk for less. It should not be long before farmers will be able to send off a sample of a cow's hair to a laboratory to determine whether she has particular traits. This will assist breeding and herd management decisions and has the potential to streamline bull breeding processes. These are currently very expensive processes.

As part of this research the CRC recently commenced analysis with an international organisation to genotype samples of single nucleotide polymorphisms (SNPs) with a view to identifying new breeding processes for Australian dairy cattle. This project has elicited strong support from Dairy Australia and Genetics Australia Pty Ltd, Australia's largest cattle breeding company. It has the potential to put the CRC at the forefront of international research.

Genetics Australia has provided resources such as DNA semen samples and significant cash support to this project. It has secured a preferential arrangement for a non-exclusive license to CRC IP generated and first rights to negotiate commercialisation rights.

CRC for Bioproducts - Ingredia Pty Ltd.

The CRC for Bioproducts developed a novel process to produce a natural food additive, which is used extensively in the food industry. Ingredia was a start up company that was formed to commercialise this discovery. Currently, Australia imports its total requirements for this product. The innovative process, that was developed exclusively by the CRC, has several competitive advantages over conventional industrial processes including capital cost savings of around 40 per cent, direct productions cost savings of around 30% and improved product usage properties.

Ingredia has released an information memorandum in June 2004 to raise $45 million to construct a greenfield plant in country NSW. A large Japanese company has signed a letter of intent to collaborate with an Australian company to build the plant. The Japanese firm has committed $12.5 million and is in discussions with other Japanese companies to raise another $6 million. The Australian company has verbally committed to the project and is in the final stages of formally committing to 50 per cent of the funds required. The remainder of the funds will be debt financed. **When the plant is operational it will employ 38 people and have an income stream of $35 million 90 per cent of which will be export derived. This will result in the generation of a royalty stream of $2 million per year.** Given the stage of the commercialisation, it is difficult to assign a market valuation to Ingredia.

CRC for CAST Metals Manufacturing – new technologies

The CRC for CAST Metals Manufacturing has developed a number of new magnesium alloys. These alloys have been exclusively licensed to the Australian company Advanced Magnesium Technologies (AMT). AMT has further developed these alloys and is marketing these globally for a number of applications, particularly in the automotive industry. These alloys will enable the automotive sector to reduce the weight of cars in a cost effective manner and will deliver benefits in terms of reduced fuel consumption, reduced emissions and increased performance. There is a significant time lag from invention to adoption in the market place due to the conservative nature of the sector and the lead times associated with new models. The benefit to Australia will be in terms of sales of the alloys as well as the benefits to the consumer through access to improved products.

The CRC has also developed a number of technologies for the die casting sector. These technologies are currently being commercialised and will be adopted by die casting companies. They will enable casting companies to increase their manufacturing efficiency and reduce costs. Examples of these technologies include new idle coatings, vacuum valves and inspection systems.

Other technologies have been developed for the aluminium industry. These include new equipment that has been licensed to Australian casting equipment manufacturers. These will be sold to industry and increase the casting efficiency. Examples include new casting moulds and a new casting wheel which enables aluminium to be poured into moulds more effectively. Many of these technologies have the potential to yield significant benefits to industry.

CRC Vaccine Technology – synthetic vaccine technology

In January 2004, the CRC for Vaccine Technology completed contracts with Australian biotechnology company EQiTX Limited to establish the Centre's first start-up company, VacTX Pty Ltd. VacTX Pty Ltd is exploiting human applications of novel synthetic vaccine technology developed by CRC-VT scientists Associate Professor David Jackson, Dr Weiguang Zeng and colleagues at The University of Melbourne.

The technology has the potential to enable production of simple, safe and effective vaccines for human use in the prevention or treatment of a number of infectious diseases, cancers, allergies and some inflammatory disorders. A mix-and-match assembly of small peptides with simple lipids is used to trigger the immune system to respond as though it has been challenged by an infection. There is no need to add other immune stimulants that cause some of the side-effects of conventional vaccines. Depending on the peptides used, the vaccines can be designed to induce antibody or T cell responses against viruses, bacteria, cancer cells, hormones or other targets. Because the vaccines are simple in structure and totally synthetic, the quality of the final product can be rigorously controlled.

Earlier CRC-VT development of the technology was supported under the Australian Government's Cooperative Research Centres Program and showed that vaccines made with this technology can induce immunity against various infections, tumours and self-proteins in animals following injection or intranasal delivery. **The EQiTX investment of $3.5 million over 27 months will allow VacTX Pty Ltd to take one or more candidate vaccines through laboratory development and preclinical testing to early stage clinical trials**.

Associate Professor David Jackson, one of the inventors of the technology, is the Chief Scientist at VacTX Pty Ltd and supervises the company's research at its laboratories in The University of Melbourne's Department of Microbiology and Immunology.

Value Added Wheat CRC – soft grain development

The Wheat CRC is currently engaged in a range of commercialisation activities that show promise in relation to the generation of future economic impacts. These activities include:

- Development of new soft wheat varieties and germplasm,
  - QAL2000 is the first variety released from the CRC’s soft wheat program, which is being produced, distributed and marketed under licence by AustGrains International at Moree. It was grown commercially for the first time in 2001. The line is being trailed in other areas of Australia to determine its performance in different environments. QAL2000 has a Soft classification in NSW and Queensland from AWB.
  - QALBis is a new prime soft wheat variety with improved rust resistance, which will be grown in conjunction with QAL2000. QALBis is suitable for cake and biscuit manufacture, and is being commercialised by Austgrains International in the Eastern States. Trials of QALBis are also being conducted in other areas of Australia to determine its performance. QALBis has a Soft classification in Northern and Central NSW from AWB.

  - DM5637*B8 is a line that incorporates sprouting tolerance, blackpoint tolerance, low polyphenol oxidase and zero late maturity amylase, for use as germplasm by breeding programs, under the terms of a germplasm transfer agreement. The line has been provided under agreement to three breeding programs in Australia and is also being used by the CRC to produce germplasm and varieties.
- New wheat breeding technologies,
  - Triticarte Pty Ltd is a joint venture between the CRC and DArT Pty Limited, that offers a whole genome, high throughput, low cost genotyping service targeted towards the wheat and barley breeding programs.
- Diagnostics tests and instruments,
  - WheatRite® is a diagnostic test licensed to C-Qentec Diagnostics to determine the extent of pre-harvest sprouting of wheat when rain occurs at harvest.
  - ReadRite® is a calibrated instrument to read the WheatRite® test to provide an indication of Falling Numbers for wheat samples. ReadRite® is also licensed to C-Qentec Diagnostics.
- Bakery process control technology,
  - OptiDoughTM is a dough stickiness meter. OptiDoughTM hardware, software and manuals have been developed for commercialisation. The aim of OptiDoughTM is to allow plant bakeries to use ingredients more efficiently and improve the quality of bread produced.

CRC for Railway Engineering and Technologies – noise monitoring technology

The CRC for Railway Engineering and Technologies has developed noise train monitoring technology that has been adopted by RailCorp, one of the major industry participants.

Economic benefits accruing from savings in track maintenance costs are anticipated to be $850,000 per company per year. The technology has just entered commercialisation stage. Tests in the US are scheduled for October and the technology is protected by PCT patent applications.

The CRC has had other successes including testing of their products by Pacific National and BHP Billiton. Shedulemeister train scheduling technology, developed by the CRC, could potentially yield up to $900,000 in savings each year for companies that adopt the technology.

Chapter 5

Conclusions

5.1 Key findings

The key finding from the modelling of the delivered impact of the CRC Programme is that over the 1992 to 2010 period the Australian economy's overall performance has been considerably enhanced when compared to the performance that would have occurred in the absence of the funding for round one to seven CRCs that was provided between 1992 and 2005.

In 2005 dollars[26], the Commonwealth Government expenditure to date on round one to seven CRCs totals $1.92 billion. The cumulative net impact of the Programme on GDP of $1.14 billion can be compared to this figure to give a sense of the rate of the *measurable* return on investment in the CRC Programme to date. **For every $1 the Commonwealth Government spent on the program, GDP is cumulatively $0.60 higher than it would have been had that $1 instead been allocated to general Government expenditure.**

Similarly, for every $1 the Commonwealth Government spent on the Programme, real consumption has been cumulatively $0.40 higher than it would have otherwise been, real investment has been $0.22 higher than it would have otherwise been and tax revenue has been $0.03 higher than it would have otherwise been.

Consideration of the range of delivered (but unquantifiable) and prospective economic benefits associated with the CRC Programme, that were outlined in Chapter Four, suggests that the *actual* economic impact of the Programme is considerably higher than this *measured* economic impact figure.

Beyond these economic impact assessment findings, this study has identified a number of important issues that have implications for both the assessment of the CRC Programme and for the assessment of the economic impacts from research more generally. These include that:

- Measuring delivered impacts is a challenging undertaking. To confidently assess delivered impacts of a research program you must be able to determine additionality, make attribution of impacts to the research program, quantify outcomes and verify outcomes. These hurdles will inevitably result in assessments of delivered impacts being only a partial accounting of the actual benefits that are delivered by a research program. Certainly the economic impacts of the CRC Programme assessed in this study should be viewed as only partial capture of benefits to date from the CRC Programme.

[26] CPI data from the Reserve Bank of Australia is used to convert actual dollars spent in each year to equivalent 2005 dollars.

- Time lags to generation of impacts are considerable – in the case of the twenty-five measured delivered benefits from the CRC Programme the average time lag observed was nine years. This suggests that the majority of benefits from Round 4, 5, 6 and 7 CRCs are not likely to have been delivered yet. This accords with the finding that the pipeline of prospective impacts from the CRC Programme looks strong. Also encouraging is the growing industry share of CRC projects – as measured in both funding contributions and researcher involvement.
- Most benefits from the CRC Programme have come from industry application of research rather than through narrowly defined "commercialisation" events such as spin-off company formation and licensing of IP.
- In relation to the monitoring of the CRC Programme in the future, based on difficulties encountered through this study in accessing clear, verifiable information on the final impacts of research, more focus in the future should be placed on tracking final research impacts, rather than an exclusive focus being placed on the collection of data relating to intermediate outputs (such as patents) or on projecting future outcomes.

5.2 Implications for the future of the CRC Programme

Given that the CRC Programme is generating a strong measurable *net* benefit for Australia the *prima facie* case for its continuation is clear. In the context of the current debate about the prospects for introduction of 'third stream' funding for universities to pursue the mission of engagement with external stakeholders (alongside the traditional missions of teaching and research), it should be born in mind that programs such as the CRC Programme already exist, and as this study shows, are delivering strong returns for the community. Rather than the creation of new third stream funding programs, the default position should be to increase funding for proven existing programs that target university engagement with external stakeholders, such as the CRC Programme, rather than create new similarly oriented funding programs – which would entail additional administrative costs and risks being incurred.

Appendix A

Economic Modelling Details

A.1 Detailed modelling report provided by the Centre of Policy Studies

Introduction

The Centre of Policy Studies (CoPS) has been commissioned by the Allen Consulting Group to simulate the economic impacts of the CRC Programme. The analysis reported here is undertaken using the MONASH Multi-Regional Forecasting (MMRF) model. MMRF is a bottom-up model of Australia's six states and two territories.

This report contains a brief overview of the model. Aspects of simulation design are then described. Finally, simulation results are then reported.

Model overview

MMRF is a very detailed dynamic, multi-sectoral, multi-regional model of Australia. The current version of the model distinguishes 49 industries, 54 products, 8 states/territories and 56 sub-state regions.

MMRF is founded on the Monash Multi-Regional (MMR) model, and was built in three stages. In the first stage, MMR was transformed into a dynamic system by the inclusion of dynamic mechanisms. These were added as self-contained blocks, allowing MMRF to include MMR as a special case. The second stage involved a range of developments designed to enhance the model's capacity for environmental analysis. In the third stage, a regional disaggregation facility was added, which allows state-level results to be disaggregated down to sub-state regions.

MMR

MMR divides Australia into the six states and two territories. There are five types of agents in the model: industries, capital creators, households, governments, and foreigners. The number of industries is limited by computational constraints. For each industry in each region there is an associated capital creator. The sectors each produce a single commodity and the capital creators each produce units of capital that are specific to the associated sector. Each region in MMR has a single household and a regional government. There is also a federal government. Finally, there are foreigners, whose behaviour is summarised by export demand curves for the products of each region and by supply curves for international imports to each region.

MMR determines regional supplies and demands of commodities through optimising behaviour of agents in competitive markets. Optimising behaviour also determines industry demands for labour and capital. Labour supply at the national level is determined by demographic factors, while national capital supply responds to rates of return. Labour and capital can cross regional borders so that each region's stock of productive resources reflects regional employment opportunities and relative rates of return.

The specifications of supply and demand behaviour co-ordinated through market clearing equations comprise the general equilibrium (GE) core of the model. There are two blocks of equations in addition to the core. They describe regional and federal government finances and regional labour markets.

From MMR to MMRF: dynamics

There are two main types of inter-temporal links incorporated into MMRF: physical capital accumulation and lagged adjustment processes.

Physical capital accumulation

It is assumed that investment undertaken in year t becomes operational at the start of year t+1. Thus, given a starting point value for capital in t=0, and with a mechanism for explaining investment through time, the model can be used to trace out the time paths of industry capital stocks.

Investment in industry i in state/territory s in year t is explained via a mechanism that relates investment to expected rates of return. The expected rate of return in year t can be specified in a variety of ways. In MMRF two possibilities are allowed for, static expectations and forward-looking model-consistent expectations. Under static expectations, it is assumed that investors take account only of current rentals and asset prices when forming current expectations about rates of return. Under rational expectations the expected rate of return is set equal to the present value in year t of investing $1 in industry i in region r, taking account of both the rental earnings and depreciated asset value of this investment in year t+1 as calculated in the model.

Lagged adjustment processes

One lagged adjustment processes is included in MMRF. This relates to the operation of the labour market in year-to-year policy simulations.

In comparative static analysis, one of the following two assumptions is made about the national real wage rate and national employment:

1. the national real wage rate adjusts so that any policy shock has no effect on aggregate employment; or

2. the national real wage rate is unaffected by the shock and employment adjusts.

MMRF's treatment of the labour market allows for a third, intermediate position, in which real wages can be sticky in the short run but flexible in the long-run and employment can be flexible in the short-run but sticky in the long-run. For year-to-year policy simulations, it is assumed that the deviation in the national real wage rate increases through time in proportion to the deviation in aggregate employment from its basecase-forecast level. The coefficient of adjustment is chosen so that the employment effects of a shock are largely eliminated after about ten years. This is consistent with macroeconomic modelling in which the NAIRU is exogenous.

MMRF: Environmental enhancements

MMRF has been enhanced in a number of areas to improve its capability for environmental analysis. These enhancements include:

1. an energy and gas emission accounting module, which accounts explicitly for each of the 49 industries and eight regions recognised in the model;
2. equations that allow for inter-fuel substitution in electricity generation by region; and
3. mechanisms that allow for the endogenous take-up of abatement measures in response to greenhouse policy measures.

Most of the emitting activities are the burning of fuels (black coal, natural gas, brown coal or petroleum products). A residual category, named Activity, covers emissions such as fugitives and agricultural emissions not arising from fuel burning.

MMRF: Disaggregation to sub-state regions

Few multi-regional models of the Australian economy have the level of sectoral detail supported by MMRF. This detail is usually more than adequate for contributions to public discussions on the effects of changes in policies concerning taxes, trade and the environment. However, people wanting to use MMRF in business and public sector planning are often frustrated by the lack of relevant regional detail. This applies especially to people interested in regional adjustment issues.

It is with these people in mind that we have incorporated into MMRF a tops-down method that enables disaggregation of state-level results for output, employment and greenhouse-gas emissions down to projections for 56 sub-state regions.

These regions are based on the Statistical divisions defined in the Australian Standard Geographical Classification (ABS catalogue number 1216.0). Our division structure differs slightly from that of the ABS. We combine the ABS's Darwin and Northern Territory - balance divisions into one division, Northern Territory. Similarly, Canberra and ACT - balance are combined into one division, Australian Capital Territory. Note that both territories are distinguished as separate regions in MMRF. Hence, the tops-down disaggregation facility provides no additional detail for them. We also adopt a slightly different regional classification for WA than that defined by the ABS. Our WA regions are based on the classification used by the WA department of Commerce. Finally, we identify the energy intensive La Trobe Valley in Victoria as a separate region (region 24), with 23 Gippsland defined to include all areas in the ABS statistical division Gippsland other than the La Trobe Valley.

Simulation design

In generating our results, we model two scenarios covering the period 1992 to 2010.

1. Basecase. The basecase is a sequence of annual projections for the Australian economy, constructed using state/territory macroeconomic forecasts from Access Economics and historical trends for changes in industry production technologies and household preferences. We include in the basecase the spending and outcomes associated with the CRC Programme. In effect, this scenario shows what has happened and what is expected to happen with the CRC Programme in place.

2. No CRC. In this scenario, we assume that there is no CRC Programme, with the national and state economies adjusting away from basecase trends to accommodate the program's absence. The Program is removed by imposing on the model a sequence of annual shocks that lower productivity, output etc in a number of industries relative to their levels in the basecase scenario. The shocks are explained below.

We report the effects of not having the CRC Programme as deviations between the values of variables in the No CRC scenario and their values in the basecase scenario.

Key assumptions

Supply-side structure

The standard MMRF treatment of input-structure applies to all industries. Capital and agricultural land are assumed to be industry specific, while there is only one type of labour employed by all industries in all regions. There is no explicit allowance for natural-resource as a fixed factor of production in mining. The primary-factor substitution elasticity is set to 0.5 for all industries. Trade elasticties for international and interstate imports and exports are available on request.

Labour markets

At the national level, we assume that the deviation in the national real wage rate from its basecase level increases in proportion to the deviation in economy-wide employment from its basecase level. Eventually, the real wage adjustment eliminates the deviation in national employment. Thus in the long-run the national labour-market impacts of not having the CRC Programme will be revealed as changes in the national real wage rate, rather than as changes in national employment.

At the state/territory level, we assume that labour is imperfectly mobile between state economies. Thus a region that is relatively favourably affected by not having the program will experience a mix of increased employment and increased wage-rates relative to regions that are relatively less favourably affected.

People move between regions so as to maintain unemployment-rates at their basecase levels.

Public expenditure, taxes and government budget balances

We assume that real consumption by regional governments and real consumption by the federal government are unaffected by not having the Program. We assume that all indirect tax rates have the same values as in the basecase simulation. The Federal government's budget balance is fixed to its basecase value via endogenous adjustments to the average PAYE tax rate. State government budget balances are fixed via endogenous changes in direct transfer payments to households.

Consumption, investment, ownership of capital and measurement of welfare

In each year of the deviation scenarios, the composition of aggregate real consumption across states/territories diverges from its basecase level by an amount reflecting the divergence in real income available to residents. In calculating real income available for consumption we take account of: direct income from factors (with an allowance for the net flow of foreign income); income from other sources such as government welfare payments; and income tax. Because the balances on government accounts are kept fixed, the impacts on real private consumption in each region are reliable indicators of the impact of not having the Program on the economic welfare of incumbents.

Rates of return on capital

In deviation simulations MMRF allows for short-run divergences in rates of return on industry capital stocks from their levels in the basecase forecasts. Such divergences cause divergences in investment and capital stocks. The divergences in capital stocks gradually erode the divergences in rates of return, such that in the longer term rates of return have returned to their basecase values.

Production technologies

MMRF contains many types of technical change variables. In the deviation simulations we assume that all technology variables, other than those required to implement the shocks, have the same values as in the basecase simulation.

Exogenous shocks

The exogenous shocks associated with removing the CRC Programme are summarised in Table A.1. The first two rows show the annual reductions in Government spending on the program and annual increases in government spending elsewhere that could have been afforded without the CRC spending. In our simulation we assume that the switch in government spending has no net impact on macroeconomic variables. Thus, for example, the effects on national employment and on employment at the state level of reduced government spending on research and development are assumed to be exactly offset by the effects on employment of increased government spending elsewhere.

The remaining rows in Table A.1 show the estimated impacts of removing CRC outcomes. For example, the numbers in the row corresponding to outcome 1 show estimates of the annual net increases in costs for the coal mining sector arising from the absence of CRC-developed dig and dump technology. [27]

[27] BHP incurred costs of $37m to further develop CRC technology between 2001 and 2003 then from 2003 started reaping a net cost saving of $8m per annum.

The shocks for outcomes 1 to 7 and 19 were imposed via changes in rates of all-primary-factor technological change. For example, the additional annual costs from 2004 onwards associated with outcome 1 were introduced by reducing relative to baseline values the rate of all-primary-factor technological progress in coal mining. The reduction in technological progress was calibrated to achieve initially in each year from 2004 onwards an $8 million increase in total costs for the coal industry. [28] Note that in nearly all of the cases, reduced output means reduced exports and/or reduced sales on the local market due to increased imports.

The shocks for outcomes 8 to 16, 22, 23 and 25 were also introduced via changes in rates of all-primary factor technological change. The changes were calibrated to ensure that their initial impacts on industry output in each year were as shown in Table A.1. For example, we observed from a separate simulation that for the telecommunication equipment industry a $10 million increase in costs due to a reduction in all-factor technological progress reduces output in the same year by around $15 million. Thus, as shown for outcome 11, to achieve a $49.7 million reduction in output in 2000 we reduced the rate of all-factor technological change in the telecommunications equipment industry in 2000 sufficiently to increase initially total costs by $33.1 million (= $49.7 million ×10/15).

The shocks for outcomes 17, 18, 20 and 24 were introduced either by reducing household income or by reducing research industry investment. The shock for outcome 21 was introduced via a shift in household spending tastes towards pharmaceuticals representing increased spending on these items.

Effects

Deviations from basecase values for national macroeconomic variables are given in Table A.2. Note that these effects are in $m and are measured in constant 2005 prices. For example, Table A.2 shows that without the CRC Programme in 2005 real GDP would be $143.4 million less than its basecase level.

[28] Ex ante the change in total cost will differ from $8 million to the extent that the additional costs affect the industry's supply schedule and hence its production.

Table A.1

EXOGENOUS SHOCKS ASSOCIATED WITH THE REMOVAL OF THE CRC PROGRAMME ($M DEVIATIONS FROM THE BASECASE VALUES, CURRENT PRICES)

	92	93	94	95	96	97	98	99	2000	2001	2002	2003	2004	2005	Annually, 2006 to 2010
Increase in other Commonwealth Govt expenditure - generally	19	48	96	107	133	143	147	142	138	140	146	149	126	113	0
Decrease in Commonwealth Govt expenditure into R&D	19	48	96	107	133	143	147	142	138	140	146	149	126	113	0
CRC Outcome shocks - Without Round One to Seven															
1. Net cost changes in coal mining sector.	0	0	0	0	0	0	0	0	0	-12.3	-12.3	-4.3	8	8	8
2. Net cost changes in gas pipeline sector.	0	0	0	0	0	0	0	0	0	20	20	20	20	20	20
3. Net cost savings in naval shipbuilding.	0	0	0	0	0	0	0	0	0	0	0	0	120	0	0
4. Net cost changes in food and beverage manufacturing.	0	0	0	0	0	0	0	0	0	0	0	1.7	4.7	4.7	0
5. Net cost changes in metals manufacturing.	0	0	0	0	0	0	0	0	0	0	0	0	6.6	6.6	6.6
6. Net cost changes in minerals extraction.	0	0	0	0	0	0	0	0	0	0	-22.3	119.6	20.6	20.6	20.6
7. Net cost changes in minerals extraction.	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.6	0.6
8. Net output change in minerals extraction.	0	0	0	0	0	0	0	0	0	0	0	-6.2	-6.2	-6.2	-6.2
9. Net output change in minerals extraction.	0	0	0	0	0	0	0	0	0	0	0	0	-6.7	-6.7	-6.7
10. Gross output change in the defence shipbuilding sector.	0	0	0	0	0	0	0	0	0	0	-2	-2	-2	0	0
11. Gross output change in telecommunications equipment sector.	0	0	0	0	-0.7	-1.4	-8.9	-8.4	-49.7	-29.2	-26.8	-23.4	-16.9	-13	0
12. Gross output change in cattle medicine sector	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-2	0
13. Gross output changes in IT software sector.	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-13.5	0
14. Gross output change in financial services sector.	0	0	0	0	0	0	0	0	0	0	0	0	0	-1.2	0
15. Gross output change in polymer insulating cables sector	0	0	0	0	0	0	0	0	0	0	0	0	-8.3	-8.3	0
16. Gross output change in plastics manufacture sector.	0	0	0	0	0	0	0	0	0	0	0	-0.7	-1	-2	0
17. Net change in foreign IP revenue in medical research sector.	0	0	0	0	0	0	0	0	-26	0	0	0	0	0	0
18. Net change in foreign IP revenue in telecommunication research	0	0	0	0	0	0	0	0	-6	0	0	0	0	0	0
19. Net cost change in water treatment sector.	0	0	0	0	0	0	0	0	0	0	0	0	26	26	26
20. Net change in foreign IP licensing incoming in health products	0	0	0	0	0	0	0	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	0	0
21. Net change in Government health (drugs) costs.	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6
22. Net change in output in fishery sector.	0	0	0	0	0	0	0	0	0	0	0	0	-3.2	0	0
23. Gross output change in scientific equipment sector.	0	0	0	0	0	0	0	0	0	0	0	-0.2	-0.3	-0.3	0
24. Net change in foreign IP revenue in pharmaceuticals research	0	0	0	0	0	0	0	0	0	0	0	-0.1	-0.2	-0.3	0
25. Gross change in output in services to the construction industry.	0	0	0	0	0	0	-0.4	-0.7	-0.7	-0.2	-0.2	-0.2	-0.3	0	0

Table A.2

MACROECONOMIC VARIABLE (ABSOLUTE DEVIATIONS FROM BASECASE VALUES

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Real gross value added (GDP/GSP) ($million, 2005 prices)	Aus	-0.6	-1.2	-8.0	-8.4	-41.3	-39.2	-16.2	-166.5	-275.1	-143.4	-107.6	-104.8	-102.0	-100.5	-99.6
Real consumption ($million, 2005 prices)	Aus	-0.1	-0.4	-2.3	-3.3	-14.1	-22.1	-14.4	-84.1	-148.0	-107.6	-90.9	-87.0	-84.0	-82.5	-81.8
Real investment ($million, 2005 prices)	Aus	-0.4	-0.9	-5.5	-4.9	-26.3	-16.5	1.5	-96.3	-129.7	-40.8	-21.9	-22.7	-22.9	-22.9	-22.7
Taxation revenue ($million, 2005 prices)	Aus	0.0	0.0	-0.1	-0.3	-0.3	-1.5	-2.3	-0.5	-3.6	-9.7	-11.2	-11.0	-10.9	-10.9	-11.0