EMERGING INDUSTRIES occasional paper 3

A Study of Government R&D Expenditure by Sector and Technology

FEBRUARY 2000

This report has been commissioned as part of a series of Occasional Papers to encourage debate on issues relating to Emerging Industries and Technologies

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COMPETITIVE AUSTRALIA

A Study of Government R&D Expenditure by Sector and Technology

FEBRUARY 2000

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Summary

The Commonwealth Government's support for R&D and innovation is critical to the nation's future. However, the nature and the extent of this support, in terms of industries and research fields/technologies, is not particularly well documented at present.

OVERVIEW

- This report provides an overview of Commonwealth support for R&D by *industry* sector (ANSZIC code). These estimates are based upon an analysis of the *socio-economic objectives* of R&D funded by the Commonwealth. This is the first time the data has been presented in this form.
- It also contains information on the fields of research supported by the Commonwealth.
- The report focuses on R&D expenditure for the 1996-97 financial year as this is the latest year for which comprehensive detailed R&D data is available.
- In that year total Australian R&D expenditure stood at $8.7bn. Commonwealth funded R&D, including funds derived from levies, stood at $3.48bn.
- In this report, Commonwealth funded R&D is separated into *commercially intended R&D* - R&D in which a specific target industry has been identified by the performer of the R&D; and *underpinning research* - R&D which is aimed at general advancement in knowledge and may have important industrial applications over a longer time-horizon.
- Commercially intended R&D accounts for $1.07bn (31.5% of Commonwealth funded R&D) and underpinning research $2.3bn (68.5%).
- The agricultural and mining industries dominate commercially intended R&D supported by the Commonwealth. Agriculture, with $401m of Commonwealth R&D funding, accounts for 37.5% of total commercially intended R&D funding. Mining, with $196.4m, accounts for 18.3% of total commercially intended R&D. The mining industry also benefits from an additional $101m (25%) of the $402m in tax revenue foregone by the Commonwealth associated with the R&D Tax Concession in 1996-97.
- The critical mass in R&D support for these *resource-based* industries reflects the two major '*innovation platforms*' in Australia – platforms that exploit the nation's *natural capital*. Although mature, these industries lie at the forefront in emerging areas of technological activity in such fields as biotechnology, simulation modelling and environmental and clean technologies. As such, they provide an important focus for other areas of emerging industrial and research activity.
- The allocation of the Commonwealth's R&D support may be too thinly spread to achieve sufficient critical mass necessary to grow emerging industries.

SUMMARY

The Commonwealth Government's support for R&D and innovation is critical to the nation's future. However, the *nature* and the *extent* of this support, in terms of industries and research fields/technologies, is not particularly well documented at present.

The main purpose of the report is to inform policy decision making by examining how R&D and innovation support is deployed across industries; across research fields and technologies; and across socio-economic objectives; and to examine the implications for emerging areas of economic activity.

This report brings together the available data on the nature and extent of Commonwealth support for research and experimental development (R&D) and for activities that support R&D and its commercialisation.

The study draws upon data from the major ISR programs supporting R&D (R&D *Start*, Cooperative Research Centre Program, R&D Tax Concession) and also considers the role of a range of other ISR programs relevant to R&D and innovation. A more general picture of Commonwealth support for R&D is obtained by analysing detailed official statistics on R&D expenditure. This captures R&D expenditure by the following Commonwealth agencies and programs: DSTO; Rural Research and Development Corporations; AGSO; ANSTO; CSIRO; ARC programs; DETYA Block Grants and other programs; NHMRC; Natural Heritage Trust and its pre-existing program; together with other smaller programs.

The major Commonwealth departments, agencies and programs covered in this study are identified in Appendix B.

Scale and Scope

Much of the Commonwealth's support for R&D is either non-discretionary (as with the R&D Tax Concession) or not driven by an overall R&D strategy.

A detailed analysis of Commonwealth R&D funding indicates that it is spread thinly over a wide range of research fields and socio-economic objectives. By implication, there is little potential for exploiting economies of scale in many areas of Commonwealth funded R&D. The inherent risks associated with R&D means that the small scale of many of these R&D investments leads to a degree of '*fragility*' in exposure to risk in the Commonwealth's R&D investment portfolio.

The average level of Commonwealth funding for a detailed research field is $5.5m. There are relatively few detailed research fields that receive more than $15m in Commonwealth R&D funding. For the socio-economic objectives of the R&D the average level of Commonwealth R&D funding is $5.3m.

The situation is exacerbated by the submission basis of many Commonwealth R&D support programs. In most areas, support is built around a "bottom up application for funds" rather than a top down *investment* strategy. Accordingly, the best submissions receive funding, rather than those projects that may build synergies within an overall R&D strategy.

The Australian publicly funded R&D system facilitates a wide scope of basic and applied research but does not facilitate scale-dependent experimental development. The funding of experimental development is largely the province of the private sector (except for defence industries).

By spreading R&D resources too thinly the effectiveness of individual investments will be reduced. Whilst concentrating R&D resources in key target areas may be desirable, targets may be wrongly selected. However, "picking winners" on the basis of sound investment criteria is a strategy that governments have adopted in areas of market failure.

The balance between diagnosis and application

Much of the Commonwealth's support for R&D is allocated to diagnosing problems as opposed to developing potential solutions to these problems. Australia is not unusual in this. The distinction is between expenditure on *discovery* relating to understanding physical behaviour and expenditure on *invention* based, in part, upon this understanding of physical behaviour and systems.

The data collated and analysed in this report does not allow definitive answers to questions over the 'balance' of Commonwealth R&D funding between problem analysis and solution development. However, the data does highlight the fact that relatively large amounts of Commonwealth R&D funding address problem diagnosis issues such as 'environmental knowledge' ($280m excluding levy funded R&D) and 'environmental management' ($37.6m excluding levy funded R&D).

Where Commonwealth R&D funding addressing technological solutions to environmental problems can be identified, the levels of funding appear to be relatively low. For example. $8.97m targeting energy conservation and efficiency and $6.4m targeting waste management and re-cycling and $7.6m targeting renewable energy R&D (these figures exclude levy funded R&D).

Further research is required to determine whether the balance between funding for problem diagnosis versus solution development is appropriate, including assessing

the marginal benefits to additional funding on each side of the equation.

The Commonwealth does support significant levels of industry performed R&D associated with environmental issues via such mechanisms as the R&D Tax Concession. Data in this report shows that the mining industry performed significant levels of environmentally-oriented R&D.

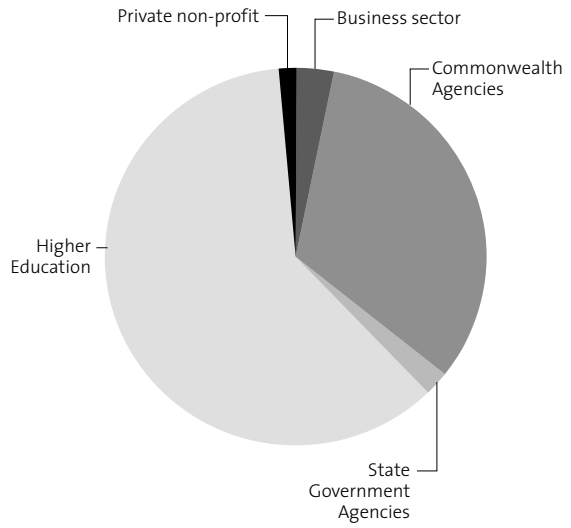
Too much of an emphasis on problem diagnosis and fundamental basic research diverts resources away from the types of R&D likely to generate economic growth. On the other hand, too much emphasis the other way diverts resources away from the types of R&D that improve our knowledge of, for example, the natural environment and the impact that economic and social activity have on this environment.

Commonwealth R&D allocations

Australia has built-up an impressive capability to monitor and analyse its R&D effort. This is reflected in world-class statistics on R&D expenditure and an influential role in the OECD's work in this area. It is therefore easier to produce an overall picture of the Commonwealth Government's support for R&D than it is for many other countries simply by using official statistics.

In 1996/97 the Commonwealth funded $3.48bn of total Australian R&D expenditure of $8.7bn (i.e. 40% of total R&D expenditure). The allocation of this funding to research performing sectors is indicated in the chart below:

Allocation of Commonwealth R&D Funding to Research Performing Sectors



Footnote: The figure for R&D performed in the Business Sector is drawn directly from ABS data. In part it is lower than figures for Commonwealth funding to business R&D programs because the ABS adopts a narrow definition of what constitutes R&D. Most of the difference, however, is due to the fact that a large amount of business R&D activity is subcontracted to universities, the CSIRO and other organisations. This activity is thus recorded as being performed in those organisations.

An analysis of Commonwealth funded R&D allocated to industry sectors (on an ANZSIC basis) has been achieved by developing a concordance between R&D data classified by *socio-economic objective* and ANZSIC sectors. Where the stated socio-economic objective of the R&D identifies a particular industry sector this R&D expenditure has been classified to that industry. This component of R&D expenditure is termed *commercially intended R&D*.

The term '*socio-economic objectives*' (SEO) refers to an official classification of R&D expenditure that has been developed to capture the area of expected national benefit rather than the immediate objectives of the researcher. It describes the purpose of the research.

The advantage of the SEO classification is that it allows the purposes of all R&D to be assessed irrespective of the sector in which the R&D was performed or the source of the R&D funding. For example, it allows us to identify the proportion of mining industry R&D directed at addressing environmental concerns.

Where the socio-economic objective relates to defence and to research targeted at more general advances in knowledge the expenditure has been classified as 'government services'. This component is termed *underpinning research*. Many areas of underpinning research are essential to industry, but are more generic in their impact on industry sectors, or have an impact over a longer time-horizon.

This method for deriving an ANZSIC-based breakdown of R&D has the advantage that it allows all R&D (including all Commonwealth funded R&D) to be mapped to ANZSIC sectors rather that just the R&D performed in the business enterprise sector.[1]

A caveat to these estimates is that the concordance developed has not been validated by the ABS and the results should consequently be treated as preliminary estimates.[2]

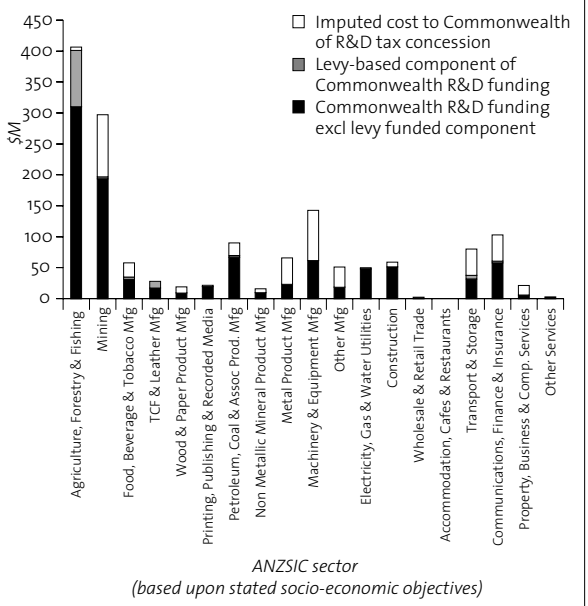
The results indicate that 68.5% ($2.3bn) of Commonwealth funded R&D is allocated to underpinning research and 31.5% ($1.07bn) is allocated to commercially intended R&D. These estimates include the total value of levy funded R&D.[3] The contribution of levy funded R&D can be clearly seen in the following chart – and mainly affects R&D allocated to *agriculture, forestry and fishing*.

1 It proved possible to trace 97.5% of Commonwealth funded R&D using the method adopted ($3.395bn out of $3.48bn). The $87m (2.5%) of Commonwealth funded R&D that could not be traced was performed in the business enterprise sector and could not be traced due to confidentiality constraints in the ABS R&D data.

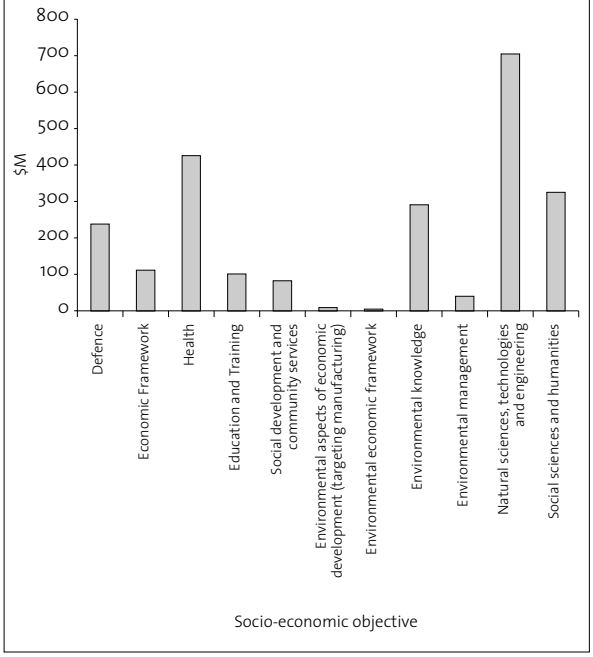
2 The ABS has a stated intention of producing such a concordance in the future.

3 On the basis that the matching, or leverage, of industry levy funded R&D by Commonwealth funding is largely non-discretionary from industry's point of view and consequently should be treated as part of Commonwealth orchestrated R&D support. Compulsory levies are estimated at $132m in combined Commonwealth and industry funds. When the total value of levy funded R&D is excluded, total underpinning research falls slightly to $2.2bn (making up 70.8% of the total) and commercially intended R&D falls to $935m (29.2% of the total).

Breakdown of Commonwealth commercially intended R&D, the R&D Tax Concession, and R&D levies, by ANZSIC sector, 1996–97



Breakdown of the $2.3bn of underpinning research funded by the Commonwealth by socio-economic objective, 1996-97



Allocating all Commonwealth funded R&D to ANZSIC sectors allows the imputed cost to the Commonwealth of the IR&D Tax Concession to be considered in the context of R&D funding. This can also be seen in the above chart. The dominance of the agricultural and mining sectors stands out. Together these two ANZSIC sectors account for $587m, or 55.8% of total commercially intended R&D funded.

The R&D Tax Concession is a major component of the Commonwealth government's support for R&D. This can be seen in the chart above. The mining industry and machinery and equipment manufacturers are predominant in the claims picture.

One reason for this is that these are the industries that invest relatively large amounts in experimental development. This means that these high R&D spending industries, and this market-driven resource allocation, naturally gets reflected in R&D Tax Concession claims.

The R&D Tax Concession facilitates R&D in the mining industry and the industries that supply equipment to mining (and to some extent other 'mechanical' industries), whilst also giving significant support to the information technology sector.

Data on the relationship between ANZSIC sectors and socio-economic objectives for R&D claimed under the IR&D Tax Concession, provided by the ABS, reveals that the mining industry's R&D effort contains a major element of environmental work. Mining accounts for $11.6m of a total of $44m (i.e 26%) of environmentally oriented R&D captured under the R&D Tax Concession.[4]

The $2.3bn of Commonwealth R&D allocated to underpinning research can be broken down by socio-economic objective. The chart above shows that the major objectives supported in 1996-97 were:

- Natural sciences, technologies and engineering;
- Health;
- Social Sciences and humanities;
- Environmental knowledge; and
- Defence.

This $2.3bn of Commonwealth funded R&D allocated to underpinning research is also spread across a wide range of research fields from the mathematical sciences through to the humanities. Although these research fields vary in the extent to which the research involved has potential commercial applications or other benefits, they collectively produce the 'knowledge infrastructure' upon which industrial innovation can draw.

4 The ABS data on the R&D Tax Concession is not, however, a comprehensive picture of the total R&D expenditure claimed under the R&D Tax Concession. There are differences in the number of firms covered, the types of expenditure admissible as R&D and in the location of this expenditure (the ABS survey only counts 'intra-mural' R&D whereas Tax Concession program data includes R&D out-sourced to other organisations, including universities and the CSIRO etc.

The research fields that stand out in terms of the proportion of Commonwealth funding they receive are:

- Geology ($127m);
- Information systems and technologies ($102.9m);
- Material sciences and technologies ($89.5m);
- Genetics, molecular biology and biotechnology ($114.5m);
- Ecology ($77.1m); and,
- Clinical sciences ($144.8m).

Comparatively low levels of Commonwealth R&D funding on a *field of research* basis are indicated for *computer hardware* ($4,534,000) and for *horticulture* ($8, 28,000).

As detailed later in this report (Section 5.1.2), the Cooperative Research Centres (CRC's) exhibit clear dominance of the 'allocation' of Commonwealth funding to the 'government services' sector. This follows from the numerical dominance of university departments, state government and Commonwealth government agencies in the overall range of CRC partner organisations.

This is the consequence of the strong involvement of public sector organisations in the CRC program. The CRC program is playing a useful role in building collaborative research between the public and private sectors in Australia.

Once the public sector is excluded we can see that the mining and the chemical/pharmaceutical industries (grouped by ANZSIC under 'petroleum, coal, chemical and associated product manufacturing) dominate private sector involvement in the CRC program. It is striking that even at this high level of aggregation industry involvement in CRCs is so clustered. There is little indication of involvement beyond the 'second tier' industries in the agri-food industries (*agriculture* plus *food, beverages and tobacco*) and the *machinery and equipment manufacturing and electricity, gas and water industries*.

Support for management capacity building

The functions undertaken within a firm that impact most in the innovation process are R&D, business strategy and planning and marketing. While a great deal of Commonwealth support for innovation is directed towards stimulating take up of R&D, there are a number of programs that *target management capacity*. In general terms management capacity building programs can cover such things as:

- Business planning;
- Market research and analysis; and
- Communications with suppliers and customers.

An effective management capacity to perform in these areas can have a major impact on the efficiency and effectiveness of a firm's R&D investment. In this sense, Commonwealth support for management capacity building is an important complement to specific support for R&D and innovation.

Although the Commonwealth, and ISR in particular, runs a number of programs that target management capacity building they are not explicitly discussed in these terms. Some of these programs have a specific industry focus, others have a more general focus. Management capacity building falls under the '*business and management*' field of research code.

Emerging technologies and industries

Rapid technological advances and convergence in areas such as microelectronics, computers, telecommunications, designer materials, robotics and biotechnology have had substantial impacts on industrial structure, productivity growth and employment. Industries are being transformed by the availability and application of new enabling technologies.

New technologies have allowed for substantial productivity increases in traditional industries such as mining and manufacturing and have made possible expansion and new forms of delivery in the service industries, including retailing, education and health.

Whilst considerable attention is currently paid to software and information technology in general in policy-circles, much of the 'high profile' activity revolves around what are relatively low-level technological projects such as internet-based start-up firms. The technologies used by such firms do not in general involve pushing the 'knowledge frontier' forward so much as 'assembling' existing building blocks of software code in clever and highly commercial new configurations.

It is therefore easy to overlook a fundamental transformation that is starting to take place globally in the way in which information technology is changing goods producing industries. This transformation goes to the heart of what the R&D process actually involves – investment in experimental development. It also opens up major new markets for knowledge-based service providers.

A decision to invest in experimental development often involves committing relatively large sums of money in the expectation of making either a commercial return or meeting a strategic requirement (in the case of defence R&D and related public interest investments). Leading firms are seeking to reduce the cost of experimental development by applying *research* capabilities to the process of experimental development itself.

By measuring, modelling and analysing experimental development, and subsequent full-scale product development and market introduction processes, firms are seeking to find ways of cost-cutting and compressing development times. These *simulation capabilities* not only help existing industries to optimise their production operations and supply chains, *they also promise to revolutionise R&D investment itself*.

Improved simulation modelling will increasingly displace costly experimental development activities. The better the capacity to theoretically predict how a system will behave, the lower the cost and the shorter the time required for product development or bringing a new facility into full scale production. This is particularly important for Australian businesses which, being relatively small, do not have the resources to invest heavily in experimental development.

The development of simulation capabilities is directly associated with key industries such as defence, aerospace and civil engineering. Australia's position in computational fluid dynamics, for example, is already world class. Simulation and modelling is also expected to play an increasingly important role in the emerging environmental and renewable energy industries. Modelling allows design concepts to be evaluated and tested prior to project commitment.

Australia has a good reputation for its science in areas relevant to the environment. Much of this science is performed in the CSIRO and universities. Relevant science and technology is also being carried out in the agricultural Research and Development Corporations (RDCs) and in the CRCs.

The ability to grow industries using new environmental technologies in Australia is also likely to rest upon an effective integration of the sciences involved and the *engineering and technology* necessary to deliver this science in marketed products and services in an ecologically sustainable manner. This new enabling technology will open up opportunities for Australian firms both in supplying the technology and in utilising it to cut the R&D investment levels required to bring new products and services to market.

The process of technological evolution being experienced involves increased complexity in the network of knowledge-based transactions that link firms in different sectors. Technologies developed in one industry sector may have their greatest commercial application in another – and be exploited by new firms rather than the old. Understanding the nature and extent of this complexity within the context of Commonwealth support for R&D will be an essential task for policy makers and advisers.

Commercial pressures and shareholder expectations can act as impediments to R&D investment and new product introduction. However, market pressures demand that firms commit to innovation in both product and process. It is clear that R&D investment *reduction* is a feature of overseas industrial strategy – particularly in industries like aerospace and civil construction industries that lead in modelling capabilities.

A major issue for policy is whether attention should shift from encouraging increases in business R&D investment per se to facilitating increases in the *efficiency* of this R&D investment and its application across industry sectors.

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Introduction

Introduction

This report brings together the available material on the nature and extent of Commonwealth support for research and experimental development (R&D) and for activities that support R&D and its commercialisation. Where possible it identifies this support through reference to particular portfolios and programs. The main purpose of the report is to inform policy decision-making by examining how R&D and innovation support is deployed across industries and across research fields and technologies.

This report brings together the available material on the nature and extent of Commonwealth support for research and experimental development (R&D) and for activities that support R&D and its commercialisation.[1] The data in this report focuses on R&D Expenditure for the 1996—97 financial year, as this is the latest year for which full R&D stastics are available. Where possible it identifies this support through reference to particular portfolios and programs. The main purpose of the report is to inform policy decision-making by examining how R&D and innovation support is deployed across industries and across research fields and technologies.

Although the Commonwealth Government's support for R&D and innovation is critical to the nation's future, the *nature* and the *extent* of this support in terms of industries and research fields/technologies is not particularly well documented at present.

The main reason for this is that it is difficult to trace the pathways upon which different Commonwealth programs and incentives actually impact upon either current technological activity in industry or on technologies of potential future importance to industry.

This is because the funding channels are complex. Funding from different portfolios and programs is merged and then separated again (often in new combinations) as it flows through different organisations. The complexity of the R&D and innovation support system has, so far, defeated attempts to track these funding flows.[2] This problem is by no means unique to Australia – although different countries adopt different approaches to the problem.[3]

It is not necessary, however, to trace all of these pathways in order to piece together a general picture of the nature and extent of Commonwealth support for R&D and innovation. Provided that certain limitations are accepted it is possible to put together a picture of Commonwealth support for R&D and innovation in terms of the industry sectors, technologies/research fields and socio-economic objectives supported.

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1 The concept of 'Research and Experimental Development' (R&D) has a specific meaning in policy discussions in line with accepted OECD guidelines. It is preferable to maintain this clarity and treat non-R&D aspects of Commonwealth support as relating to the more general concept of 'innovation'. The latter concept is far wider and includes aspects of management capacity that guide R&D and the investment stages that follow R&D (e.g. product development and market introduction).

2 An 'input-output' framework is the best means of tracking these complex funding relationships – however it would be a costly and time-consuming task to construct such a framework.

3 For example, the United States makes considerable use of the budget process to establish a link between Federal R&D funding and other funding sources by the type of R&D activity involved. The US approach differs from the OECD norm, and is not restricted by compliance with OECD-defined reporting procedures for R&D expenditure. However the accuracy of the more detailed US R&D statistics that trace funding relationships has not, to our knowledge, been determined.

There are various impediments to doing this, such as the lack of standardised classifications of R&D and innovation support across programs and restrictions to the way in which official statistics on R&D are collected and reported. Nonetheless, it is possible to improve upon the current situation with respect to identifying the industry sectors and technologies and research fields that receive Commonwealth R&D and innovation support.

A particular emphasis in the Report is placed upon identifying the proportion of Commonwealth support for R&D that impacts upon Australia's capacity to grow new industries and sources of export earnings. The nation's future prosperity will depend upon achieving an appropriate mix of growth in efficient traditional industries, growth in emerging new industries, and upon the ability to 'update' traditional industries with emerging technologies. Emerging industries can lie in both the product-producing and service sectors – and the growing inter-relationships between the two. [4]

4 A large part of the explanation for the growth of the service sector in OECD economies lies in the growth of 'producer services' services to goods producing industries – many of which were formerly carried out in-house and were 'hidden' in official statistics.

Policy Issues

Policy Issues

The purpose of this section of the report is to establish the key policy parameters that will be used in the analysis of the allocation of the Commonwealth's R&D support by industries and by research fields.

POLICY ISSUES CONCERNING THE ALLOCATION OF COMMONWEALTH SUPPORT FOR R&D AND INNOVATION

The purpose of this section of the report is to establish the key policy parameters that will be used in the analysis of the allocation of the Commonwealth's R&D support by industries and by research fields.

2.1 Targeting versus allocation

Much of the Commonwealth's support for R&D is either non-discretionary (as with the R&D Tax Concession) or not driven by an overall R&D strategy. It therefore makes more sense to talk about '*allocations*' of support for R&D than the '*targeting*' of support for R&D. Indeed, as the following discussion of 'scale versus scope' in R&D investment suggests – there can be significant opportunity costs associated with pursuing a non-targeted strategy. This must be balanced against the downside of Government attempting to 'pick winners' in R&D terms.

The discussion of the policy issues relevant to analysing the allocation of Commonwealth support for R&D is based upon the following dilemmas:

- The *scale* of R&D investment in particular areas of R&D versus the overall *scope* of the Commonwealth's R&D investment across all areas of R&D;
- The balance between allocation of R&D support to *problem definition and analysis* as opposed to developing *potential solutions to problems*; and,
- the 'top down' guidance of resource allocations by strategy versus the 'bottom up' evolution of resource allocations without defined strategies.

These three dilemmas lead to challenges for policy makers – and pose a particular challenge for a country of Australia's economic size.

2.2 Scale versus scope

R&D investment involves making a trade-off between the scope of the overall investment 'portfolio' and the scale of effort in each component of the portfolio. A wider scope allows more options to be explored (particularly when basic research is involved) but can result in low returns on the R&D investment due to the small scale of investment in particular areas of the R&D.

The reduced returns associated with low levels of R&D investment result from an increased exposure to risk. R&D is a risky process and the law of large numbers means that these risks tend to reduce as more is spent.

From a policy perspective, the concern is that spreading R&D resources too thinly reduces the effectiveness of investment, whilst concentrating R&D resources in key areas is difficult to accomplish in practice – it risks targeting resources in (what may transpire to be) the wrong areas. The risks of attempting to "pick winners" are frequently rehearsed in Australia, yet the risks associated with spreading R&D investment too thinly are less frequently discussed.

One reason for this may be that the highly aggregated level of R&D expenditure commonly reported masks the low expenditure levels revealed by more detailed analyses of R&D investment. This report contributes to the discussion of this issue by presenting an analysis of detailed R&D investment patterns.

Another dimension of the scale versus scope issue relates to the 'stage' of the R&D activities involved. One million dollars is a significant 'unit' in the direct research cost component of R&D investment in *basic* and *applied* research (setting aside the cost of accessing or constructing major research facilities). On the other hand, one million dollars is much less significant when it comes to the far more costly activities involved in *experimental development*.

Experimental development involves the often considerable expense of building experimental apparatus, pilot plants and prototypes, etc. This usually involves purchasing expensive equipment and materials and a considerable amount of labour costs caused by the non-routine tasks involved in building and operating structures and systems for the first time.

In situations in which there are no well defined strategic priorities for the objectives of R&D these cost factors can result in a tendency to concentrate R&D resources on basic and applied research and to under invest in experimental development. This can end in a widely spread portfolio of investment in basic and applied research but insufficient resources available to exploit these investments in discovery.

Whilst a wide *scope* of R&D investment is necessary in basic and applied research, large *scale* R&D investment tends to be a pre-requisite for commercialising R&D.

Relative under investment in experimental development can also mean that the potential for 'feed-back' R&D is reduced. This type of R&D involves feedback from experimental development and subsequent product development and production activities on areas in which fundamental theoretical knowledge is lacking. This usually becomes manifest in anomalies between theoretical predictions and the actual behaviour of mechanisms and systems, etc.

The role of theoretical models and computer simulations is crucial in facilitating feed-back R&D: they allow the findings from experimental development activities to be analysed against the predictions of theory. When anomalies are discovered between theoretical prediction and actual behaviour new challenges for improving theory are set. This leads to an iterative process that reduces the cost of experimental development by allowing the substitution of theoretical work and computer simulation for expensive 'build it and see how it works' activities. [5]

Defence R&D and procurement can play a key role in providing the capability to invest in an adequate scale of experimental development to progress a technology from concept through to an investment-ready 'technology demonstrator'.[6] It can also make a major contribution to the development of the theoretical and modelling capabilities necessary to facilitate feed-back R&D. [7]

The overall impact of a significant 'critical mass' of defence R&D is to provide sufficient scale in the 'D' component of R&D to allow key enabling technologies to be demonstrated. Often these diffuse to non-defence technology applications. Defence R&D can consequently provide key aspects of 'life cycle support' for innovation because, by necessity, defence R&D must be based upon strategic priorities. [8]

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5 See (Matthews and Johnston 1999) and (Howard and Matthews 1999 (Forthcoming)) for discussions of the importance of these feed-back processes in R&D.

6 A 'technology demonstrator' is essentially a risk-reduction mechanism based upon building operational prototypes that allow actual performance to be compared to predicted performance and establish the viability of moving forward to full-scale development of a system using different combinations of demonstrated technologies.

7 Much of the important mathematical understanding necessary for handling complex non-linear systems originates in US Weapons Laboratories and in defence contracts with universities. These techniques, some of which were developed for modelling nuclear explosions in order to allow the substitution of simulation models for under-ground nuclear weapons testing, now allow many different types of non-linear processes to be modelled. The Clinton administration's push for these weapons laboratories to become more commercially focused in order to offset post cold-war reductions in defence research is leading to increased diffusion of these advanced modelling techniques to US industry.

8 This point is elaborated further in (Howard and Matthews 1999 (Forthcoming)).

These issues are important with respect to emerging industries and technologies because insufficient scale in the 'D' component of R&D, and also in the post-experimental development processes (that are even more expensive than experimental development), means that Australia's capability to grow these industries may be constrained.

2.3 Problem diagnosis versus opening up new science and technology options

Much of the Commonwealth's support for R&D is allocated to diagnosing problems as opposed to developing potential solutions to these problems. Australia is not unusual in this. The distinction is between expenditure on *discovery* relating to understanding physical behaviours and expenditure on *invention* based, in part, upon this understanding of physical behaviour and systems.

Often, the understanding of physical behaviour is made necessary by the unintended consequences of previous innovations and industrial activity. Moreover, diagnosis is often necessary before one can move towards resolution and, when based on fundamental science, can provide strong predictive capability.

The policy dilemma is that too much of an emphasis on problem diagnosis and fundamental basic research diverts resources away from the types of R&D likely to generate economic growth. On the other hand, too much emphasis the other way diverts resources away from the types of R&D that improve our knowledge of the natural environment and the impact that economic and social activity have on this environment.

The issue of the resources allocated to problem diagnosis versus problem solution relates closely to the issue of scale versus scope in R&D. If R&D investment is spread thinly across a large number of basic and applied research fields, with insufficient resources available for experimental development, and subsequent research commercialisation, then the relative lack of 'feed-back' R&D as a driver of problem solving activity tends to focus research upon identifying causal connections in natural processes. This means that scientific research can be particularly vibrant and effective at increasing understanding of natural processes (biological, chemical, etc) but that there is little capability for translating this understanding into outcomes.

Interestingly, one of the major emerging areas of economic and technological activity is widely regarded to be in the environmental management area – essentially rectifying the dis-benefits of current patterns of industrial innovation and economic activity. Environmental management requires an effective balance of problem diagnosis and the development of options for addressing these problems. Australia's strengths in this area, and what they tell us about the scale and scope of the Commonwealth's allocation of R&D resources will be discussed later in this report.

2.4 'Top down' versus 'bottom up' resource allocations

The bottom line produced by the above points regarding the scale and scope of R&D investment and the emphasis on problem diagnosis and solution-generation is that too little emphasis on strategic priorities for R&D may be good for science but bad for technology. If government policy seeks to subsidise the R&D associated with potential emerging areas of economic activity then this will not be feasible without appropriate strategic priorities for R&D. Even if the policy apparatus does not deliver such strategic priorities attention may need to be paid to the scope versus scale issue.

Investment in experimental development is likely to involve aspects of market failure where emerging industries are involved. However, the scale of the investment required will be far larger than for the initial research that led to the generation of the technology options. The policy apparatus must therefore be able to commit relatively large amounts of resources to a decreased number of projects in order to increase the likely-hood of obtaining a net national benefit from the public investment in R&D.

Concentration of R&D effort is inherently risky for the classic investment portfolio reason that risks are not being spread. Project failures are likely. Policy makers in a small economy will therefore 'rationally' attempt to avoid such risky investments. This may restrict the ability of government to subsidise R&D in emerging industries to a sufficient level to attain minimum efficient scale in the R&D effort.

The situation is exacerbated by the submission basis of many Commonwealth R&D support programs. Support is built around a "bottom up application for funds" rather than top down strategic investment decisions. Accordingly, the best submissions receive funding, rather than those projects that may build synergies within an overall R&D strategy.

Assessing Support

ASSESSING THE ALLOCATION OF COMMONWEALTH SUPPORT FOR R&D AND INNOVATION

Australia is very fortunate in having built-up an impressive capability to monitor and analyse its R&D effort. This is reflected in world-class statistics on R&D expenditure and an influential role in the OECD's work in this area. It is therefore easier to produce an overall picture of the Commonwealth Government's support for R&D than it is for many other countries simply by using official statistics.

3.1 The approach adopted in this study

Australia is very fortunate in having built-up an impressive capability to monitor and analyse its R&D effort. This is reflected in world-class statistics on R&D expenditure and an influential role in the OECD's work in this area. It is therefore easier to produce an overall picture of the Commonwealth Government's support for R&D than it is for many other countries simply by using official statistics.

The exception is that some aspects of Australia's R&D support (such as the Cooperative Research Centres) are difficult to reconcile with the long-established sectoral categories used in the official statistics.

This study has consequently focused upon the dual task of forming an overview of Commonwealth R&D support using official R&D statistics, whilst carrying out detailed mapping of aspects of support not well captured in official R&D statistics. The result is the maximum use of existing data concurrent with adding value in areas where this is required.

In carrying out this analysis the intention has been to provide a 'base-line' assessment upon which to build future work. This has involved making as comprehensive as possible an assessment of support mechanisms using multiple data sources as well as refining the assessment framework per se.

In order to provide such a base-line assessment it has been necessary to focus attention on the 1996-97 financial year, since this is the most recent year for which high quality R&D data is available (from the last published full ABS R&D survey). The strategy in compiling this report has been to:

- Establish 1996-97 as the benchmark year for assessing the overall nature and extent of the allocation of Commonwealth support for R&D by industry and research field; and,
- Use more ad hoc program-derived and annual report-sourced data to update this picture against the backdrop of the benchmark 1996-97 assessment.

3.2 The distinction between budget and expenditure-based perspectives

At present there are two principal sources of data on Commonwealth support for R&D and innovation.

The '*Science & Technology Budget Statement*' produced by the Department of Industry, Science and Resources provides an invaluable analysis of budgetary information on resource allocations for science and innovation. However, the short time frame available to produce the S&T Budget Statement means that it cannot forecast how these budgetary allocations will map to individual industries and research fields/technologies on the basis of previous allocations – as captured in the ABS R&D survey.

Such forecasts are, in any case, made particularly difficult by the large proportion of Commonwealth R&D support that is effectively non-discretionary with respect to industries and technologies (notably the R&D Tax Concession). The non-discretionary nature of this support means that the past may not be an accurate predictor of future resource allocation outcomes.

The ABS R&D survey captures R&D expenditure at the points at which R&D is performed.

Even without the issue of non-discretionary R&D support there are severe technical challenges in relating budget data relating to R&D with expenditure data. Not only do definitions of the activities covered differ, the coverage of funding mechanisms and sources also differs. [9]

As a result, the budget data from the S&T Budget Statement is not strictly comparable with the R&D expenditure data captured by the ABS. In fact, the estimates from the budget statement with the Tax Concession excluded are lower than the ABS R&D expenditure figures. The difference is however relatively small. This is evidence of the rigour of the processes used to compile the S&T Budget Statement.

There is also the added complication that the more innovative R&D support programs, notably the Cooperative Research Centres, whilst visible in the S&T Budget Statement are invisible in the ABS R&D data. This is because the cooperative research carried out is either allocated to the business sector (if the CRC is incorporated) or allocated to the respective sectors of the CRC's participants (if the CRC is not incorporated). The end result is that the CRCs are invisible in the ABS R&D data.

9 The S&T Budget Statement covers appropriations relating to whole programs and agencies that includes activities that are not within the internationally accepted definition of R&D. This is offset by the fact that the S&T Budget Statement is not able to capture all the R&D funding provided by departments and agencies. The S&T Budget Statement is produced using data provided by departments and agencies and is therefore reliant upon those sources for the accuracy of the estimates.

Commonwealth Funding

In 1996/97 the Commonwealth funded $3.48bn of total Australian R&D expenditure of $8.7bn (i.e. 40% of total R&D expenditure).

THE INDUSTRIES AND RESEARCH FIELDS SUPPORTED BY COMMONWEALTH R&D FUNDING

4.1 The different areas of support for R&D and innovation

Commonwealth support for R&D and innovation falls into three main areas:

- Support for R&D as defined by the OECD 'Frascati' guidelines and identified in the ABS R&D expenditure surveys;
- Support for other aspects of *technological* innovation and research commercialisation that lies outside of the OECD's definition; and
- More general support for business innovation and management capacity building.

Care needs to be taken when examining Commonwealth 'R&D' support because the definition of R&D used by individual programs and the Australian Taxation Office (ATO) varies and is not perfectly aligned with accounting treatments of R&D. [10]

This assessment covers all three areas using a range of data sources, from official statistics on R&D expenditure to detailed program data.

4.2 The overall level and composition of Commonwealth support

In 1996/97 the Commonwealth funded $3.48bn of total Australian R&D expenditure of $8.7bn (i.e. 40% of total R&D expenditure). Of this Commonwealth funded R&D:

- $102m (3.03%) was performed in the Business sector;
- $1.1bn (32.95%) was performed in Commonwealth Agencies;
- $65m (1.93%) was performed in State Government Agencies;

10 For example, the R&D Tax Concession and R&D Start programs both allow certain types of expenditure to be supported that fall outside of the OECD's definition of R&D. This includes certain types of prototype and pilot plants. In general, the practical support of innovative activity requires that the 'cut-off' between experimental development activities and non-experimental development activities be less severe. Not only does this increase the practical applicability of innovation support, it is in line with the transformation taking place in R&D investment – which is becoming more integrated via 'feed-back' R&D.

- $2.00bn (60.62%) was performed in the Higher Education sector; and,
- $49m (1.46%) was performed in the Private non-profit sector. [11]

Although there is a general relationship between the R&D performed in each sector and the portfolios funding the R&D, the relationship is not straightforward. For example, whilst R&D in the Higher Education sector is largely funded by DETYA there are elements of other portfolio's R&D funding present as well. R&D in the private non-profit sector receives funding contributions from the NHMRC and other portfolios.

4.3 Commonwealth funding of commercially intended R&D

4.3.1 Estimating commercially intended R&D by specific ANZSIC sectors using socio-economic objectives classified R&D data

In order to trace the levels of R&D funding directed at particular industries and research fields it is necessary to obtain detailed data from the ABS that is not usually published and to analyse it in new ways.

The current form in which the ABS R&D data are published does not allow an industry based link to be made between the R&D performed in the public sector and the private non-profit sector and the R&D performed by industry sectors as measured using the ANZSIC classification. This is because the ANZSIC classification (and related product group classifications) is only used for R&D performed in the *business sector*.

As a result, it is difficult to determine what the level of direct Commonwealth R&D support is for particular industry sectors. The solution to this problem is to make use of the '*socio-economic objectives*' (SEO) R&D classification. The SEO classification has been designed to provide an overview of the objectives of R&D wherever it is performed.

Not only does the classification provide a useful breakdown of the nation's R&D effort in its own right, and of the Commonwealth R&D funding contribution, it also allows us to link Commonwealth funded R&D performed outside of the business sector with specific industries classified by ANZSIC. We can make this link because certain segments of the SEO classification explicitly relate to certain industry sectors. Although the ABS has not drawn-up a detailed concordance between the SEO and ANZSIC classification schemes, Howard Partners have been able to draw up a preliminary concordance between these two schemes. [12]

This is, to our knowledge, the first time that Commonwealth R&D funding that directly targets specific industry sectors has been analysed in this way.

There are caveats to the results obtained. Firstly, this is a preliminary assessment made quickly and requires more detailed scrutiny and validation. Secondly, this concordance has only been drawn up at a fairly general ANZSIC level in order to provide a basic overview of Commonwealth R&D support.[13] Thirdly, it is necessary to classify large proportions of the socio-economic objectives of Commonwealth funded R&D to '*government services*'. This includes defence R&D, R&D associated with the '*advancement of knowledge*' and environmental issues.

The rationale used in developing this link between SEO classified R&D and ANZSIC classified R&D is that a direct link is only made when the R&D concerned has an explicitly stated industry-specific relevance. This should not be interpreted as meaning that other R&D does not have relevance to industry sectors as classified by ANZSIC.

The distinction is that some forms of R&D are carried out with the clear objective of contributing to a specific industry's performance (e.g. aerospace R&D) whereas other forms of R&D have a more generic 'enabling' role that potentially impacts upon several, and sometimes all, industries (e.g. advanced mathematical modelling). We discuss the role of these 'enabling technologies' and the R&D associated with their development in a subsequent section of the report.

Where the socio-economic objective relates to defence and to research targeted at more general advances in knowledge, the expenditure has been classified to 'government services'. This component is termed underpinning research. Many areas of underpinning research are essential to industry, but are more generic in their impact on industry sectors and will have an impact over a longer time-horizon.

This method for deriving an ANZSIC-based breakdown of R&D has the advantage that it allows all R&D (including all Commonwealth funded R&D) to be mapped to ANZSIC sectors rather that just the R&D performed in the business enterprise sector. It proved possible to trace 97.5% of Commonwealth funded R&D using the method adopted ($3.395bn out of $3.48bn). The $87m (2.5%) of Commonwealth funded R&D that could not be traced was performed in the business enterprise sector and could not be traced due to confidentiality constraints in the ABS R&D data.

11 ABS (8112.0) 1996-97.

12 The ABS had intended to draw up a detailed SEO to ANZSIC concordance but this work was never completed.

13 Drawing up a more detailed concordance is a major exercise and advice was taken from the ABS that this could not be done accurately in the time available.

4.3.2 Commonwealth funding of R&D by ANZSIC sector

The following table provides a broad overview of Commonwealth funded R&D in terms of ANZSIC. It identifies Commonwealth funded R&D by its sector of performance.

Given the preliminary nature of these estimates they should, at this stage, only be taken as *indicative* of the general pattern of Commonwealth R&D funding. As with all new estimates they will benefit from further discussion and validation.

These estimates include the total value of levy funded R&D on the basis that the matching, or leverage of, industry levy funded R&D by Commonwealth funding is largely non-discretionary from industry's point of view and consequently should be treated as part of Commonwealth R&D support.

These estimates highlight the fact that $2.3bn out of $3.4bn of traceable Commonwealth R&D funding identified in Table 1 lies in underpinning research classified as '*government services'*.

Much of this underpinning research is of critical importance to industry but is not directly associated with any particular industry.

It is worth stressing that ANZSIC, particularly in this aggregate form, is not particularly well suited to capturing many key features of industry-related R&D. For example, pharmaceutical firms (and R&D) are treated as a sub-class of '*Petroleum, Coal, Chemical & Associated Product Manufacturing*'. Ideally, the underlying detailed ANZSIC codes should be re-organised into more meaningful industry groupings – however that would limit the ability to make broad comparisons using the established ANZSIC industry sub-headings. Howard Partners

Table 1 : Breakdown of the Commonwealth funded R&D that can be traced to ANZSIC sectors, 1996–97 ($'000)

ANZSIC Sector	Total	C'wealth Government	State Government	Higher Education	Private non profit	Business Enterprise
Agriculture, Forestry & Fishing	400,906	196,200	84,657	119,808	18	223
Mining	196,353	156,613	67	39,333	-	341
Food, Beverage & Tobacco Mfg	34,521	20,847	777	11,193	-	1,705
TCF & Leather Mfg	27,815	26,939	-	876	-	-
Wood & Paper Product Mfg	9,738	7,123	88	2,283	-	244
Printing, Publishing & Recorded Media	19,336	5,698	86	13,050	-	502
Petroleum, Coal, Chemical & Assoc Prod Mfg	68,947	52,172	817	14,539	206	1,213
Non Metallic Mineral Product Mfg	9,362	5,940	-	3,347	-	75
Metal Product Mfg	23,252	13,893	-	7,667	-	1,692
Machinery & Equipment Mfg	61,393	26,795	-	30,475	171	3,952
Other Mfg	18,675	13,915	-	3,635	-	1,125
Electricity, Gas & Water Utilities	49,424	24,624	428	21,181	-	3,191
Construction	51,249	22,948	16	28,281	-	4
Wholesale & Retail Trade	747	-	-	747	-	-
Accommodation, Cafes & Restaurants						
Transport & Storage	31,852	15,333	89	15,833	-	597
Communications, Finance & Insurance	60,145	25,026	1,279	31,436	67	2,338
Property, Business & Comp. Services	5,714	1,608	-	4,106	-	-
Govt Services	2,325,746	537,753	58,549	1,685,189	42,148	2,107
Other Services		-	-	-	-	-
Total	3,395,176	1,153,427	146,852	2,032,980	42,609	19,309
						+ $87m untraced

Source: Howard Partner's calculations using data specially provided by the ABS.

are preparing more detailed ANZSIC based R&D expenditure figures using this approach. These will be available on request.

It is also important to note that confidentiality restrictions require that Commonwealth funded R&D performed in the business sector is greatly under-estimated in order not to reveal information about particular firms. This is indicated by an 'n.p.' . As a result, $87m of Commonwealth funded R&D performed in the business sector cannot be traced in this analyis.

As a result of university-firm relationships, a significant proportion of industry-targeted R&D support such as the R&D Start program ends up supporting R&D collaboration. This is a positive outcome because this sort of R&D collaboration not only exploits distinctive capabilities in the different R&D performing sectors, it also help to build an 'infrastructural' capability to perform collaborative R&D.

Given the dominance of R&D associated with '*government services*' (defined as underpinning research and including the major proportion of higher education R&D) it is useful to highlight the Commonwealth R&D funding associated with commercially intended R&D.

This is done in the following table, in which *'government services'* ie. underpinning R&D has been *excluded*. R&D funding is expressed in percentage terms as a proportion of the $1.07bn of Commonwealth funded R&D that is directly associated with specific ANZSIC sectors.

Figure 1 draws together both commercially intended R&D funded by the Commonwealth and the cost to the Commonwealth of the R&D Tax Concession (in tax revenue foregone). Overall, the dominance of the agricultural and mining sectors stands out.

Table 2: Percentage breakdown of the $1.07bn of Commonwealth funded commercially intended R&D by ANZSIC sector, 1996-97

ANZSIC 1996/97 $'000	Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
Agriculture, Forestry & Fishing	37.488	18.346	7.916	11.203	0.002	0.021
Mining	18.361	14.644	0.006	3.678	-	0.032
Food, Beverage & Tobacco Mfg	3.228	1.949	0.073	1.047	-	0.159
TCF & Leather Mfg	2.601	2.519	-	0.082	-	-
Wood & Paper Product Mfg	0.911	0.666	0.008	0.213	-	0.023
Printing, Publishing & Recorded Media	1.808	0.533	0.008	1.220	-	0.047
Petroleum, Coal & Assoc Prod. Mfg	6.447	4.879	0.076	1.359	0.019	0.113
Non Metallic Mineral Product Mfg	0.875	0.555	-	0.313	-	0.007
Metal Product Mfg	2.174	1.299	-	0.717	-	0.158
Machinery & Equipment Mfg	5.741	2.506	-	2.850	0.016	0.370
Other Mfg	1.746	1.301	-	0.340	-	0.105
Electricity, Gas & Water Utilities	4.621	2.303	0.040	1.981	-	0.298
Construction	4.792	2.146	0.002	2.645	-	0.000
Wholesale & Retail Trade	0.070	-	-	0.070	-	-
Accommodation, Cafes & Restaurants	-	-	-	-	-	-
Transport & Storage	2.978	1.434	0.008	1.481	-	0.056
Communications, Finance & Insurance	5.624	2.340	0.120	2.939	0.006	0.219
Property, Business & Comp. Services	0.534	0.150	-	0.384	-	-
Other Services	-	-	-	-	-	-
Total	100.00	57.57	8.26	32.52	0.04	1.61

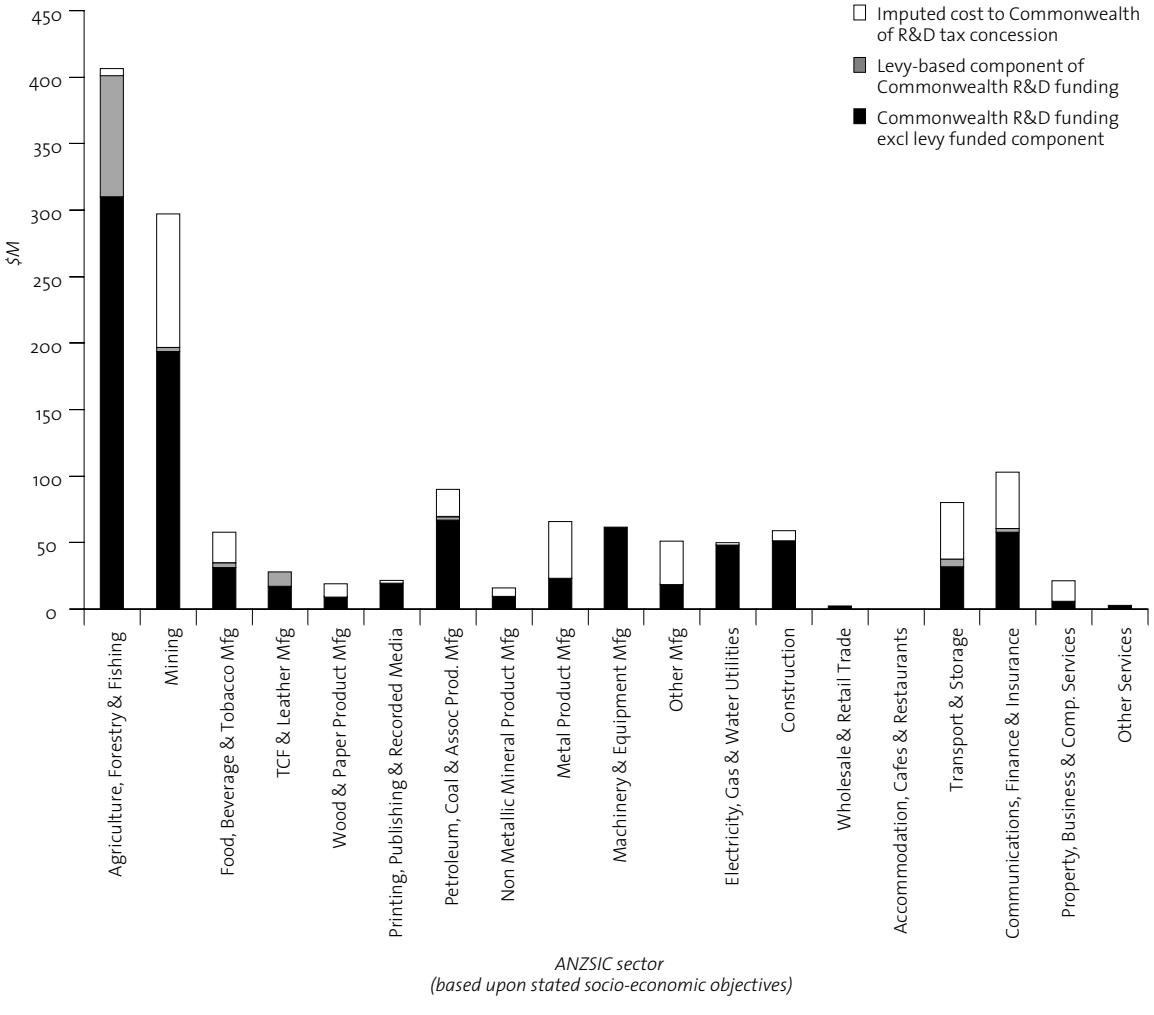
Source: Howard Partner's calculations using data specially provided by the ABS.

The critical mass in R&D support for these resource-based industries reflects the two major 'innovation platforms' in Australia – platforms that exploit the nation's natural capital. Although mature, these industries lie at the forefront in emerging areas of technological activity in such fields as biotechnology, simulation modelling/environmental and clean technologies. As such, they provide an important focus for other areas of emerging industrial and research activity. The detailed data provided elsewhere in this report allows the range of technologies involved to be grasped by considering the fields of research covered.

Appendix A contains a detailed table listing the socio-economic objectives of Commonwealth funded R&D by performing sector. This table allows those with a particular interest in a specific industry or socio-economic objective to examine the overall level of Commonwealth R&D funding and the role of the different R&D performing sectors in carrying out that R&D.

Figure 2 provides a breakdown of the underpinning research funded by the Commonwealth government by socio-economic objective. It highlights the relatively high level of funding targeting environmental knowledge - which is comparable to total research funding for the social sciences and humanities.[3] Appendix A Table 6 contains these expenditure figures.

Fig 1: Breakdown of Commonwealth commercially intended R&D, the R&D Tax Concession, and R&D levies, by ANZSIC sector, 1996–97



Source: Howard Partnersestimates using data provided by the ABS.

3 It should be born in mind that a proportion of the environmental research will lie in the social science area - the socio-economic objectives classification simply identifies such work as part of environmentally-oriented research.

4.4 Overview of the research fields funded by the Commonwealth

The preceding sub-section presented estimates of overall Commonwealth funded R&D and isolated the 31.5% of this R&D that is commercially intended with specific industries.

The $2.3bn of Commonwealth funded R&D that targets underpinning research is spread across a wide range of research fields from the mathematical sciences through to the humanities. Appendix A Table 2 details Commonwealth R&D funding by field of research and sector of performance. Although these research fields vary in the extent to which the research involved has potential commercial applications or other benefits, they collectively produce the 'knowledge infrastructure' upon which industrial innovation can draw.

A better idea of the fields of research involved with overall Commonwealth funded R&D can be obtained from Figure 3. This graph indicates, for each 'scientific and technological' research field the total value of Commonwealth funded R&D. These figures exclude levy funded R&D.

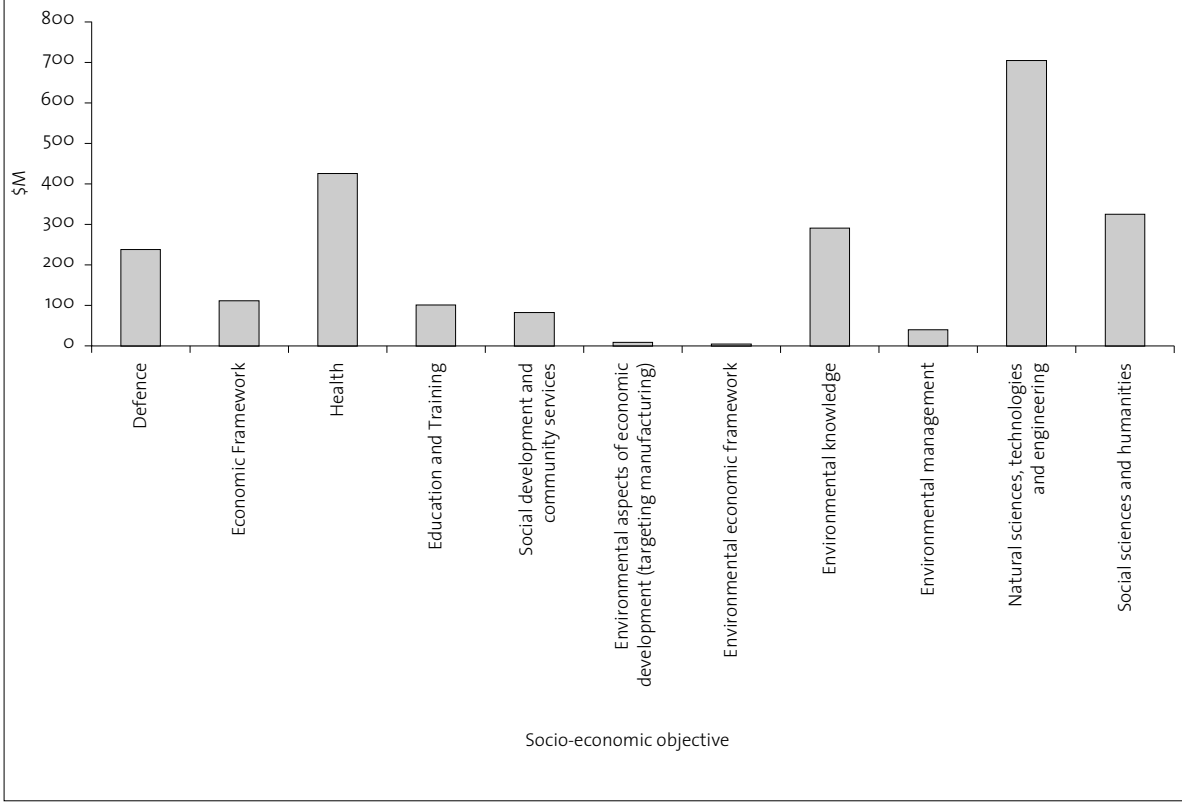
The research fields that stand out in terms of the proportion of Commonwealth funding they receive are:

- Geology ($127m);
- Information systems and technologies ($102.9m);
- Material sciences and technologies ($89.5m);
- Genetics, molecular biology and biotechnology ($114.5m);
- Ecology ($77.1m); and,
- Clinical sciences ($144.8m).

Strikingly low levels of Commonwealth R&D funding on a *field of research* basis are indicated for *computer hardware* ($4,534,000) and for *horticulture* ($8,628,000).

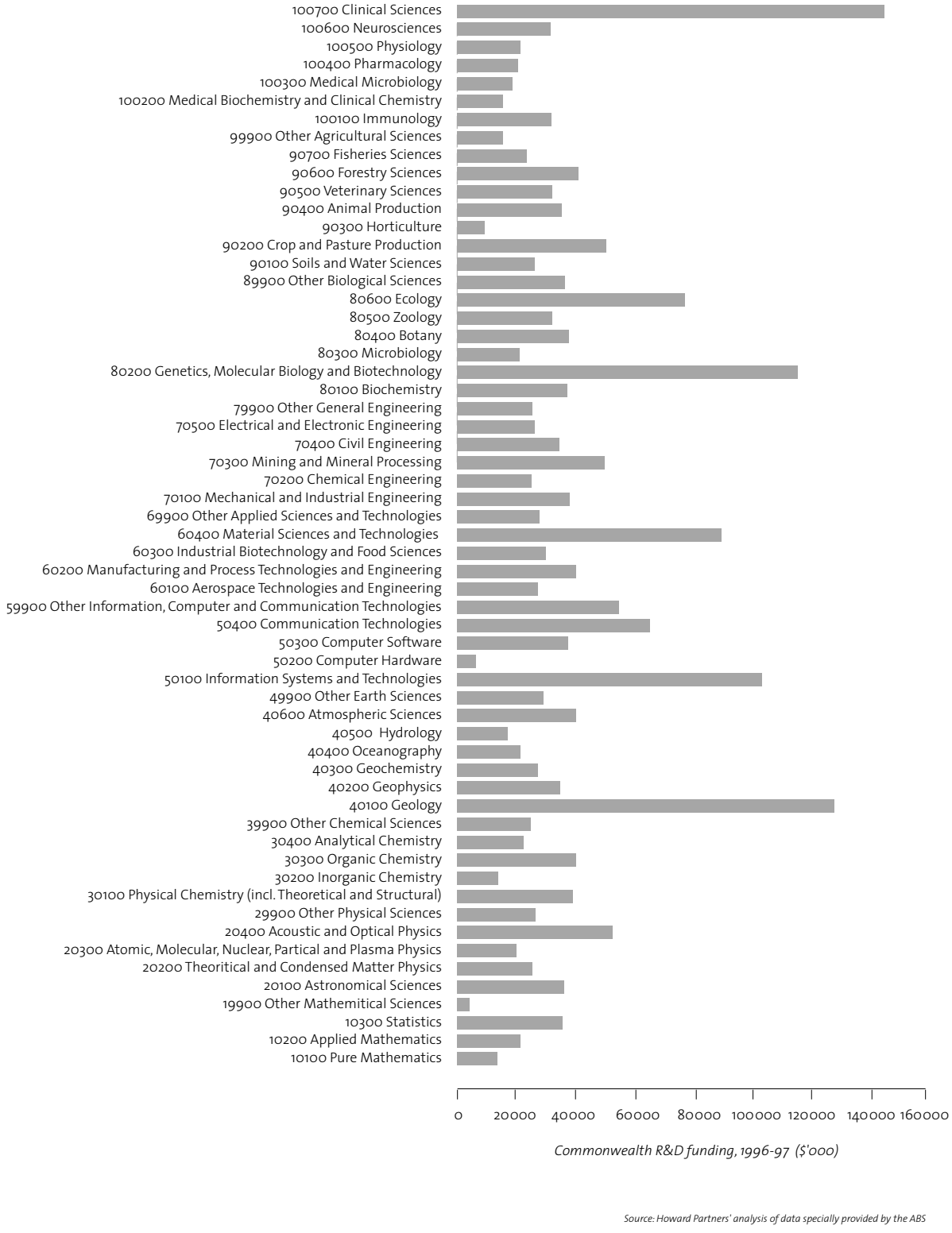
The distribution of funding levels by field of research can be grasped by considering Figure 4.

Fig 2: Breakdown of the $2.3bn of underpinning research funded by the Commonwealth by socio-economic objective, 1996-97



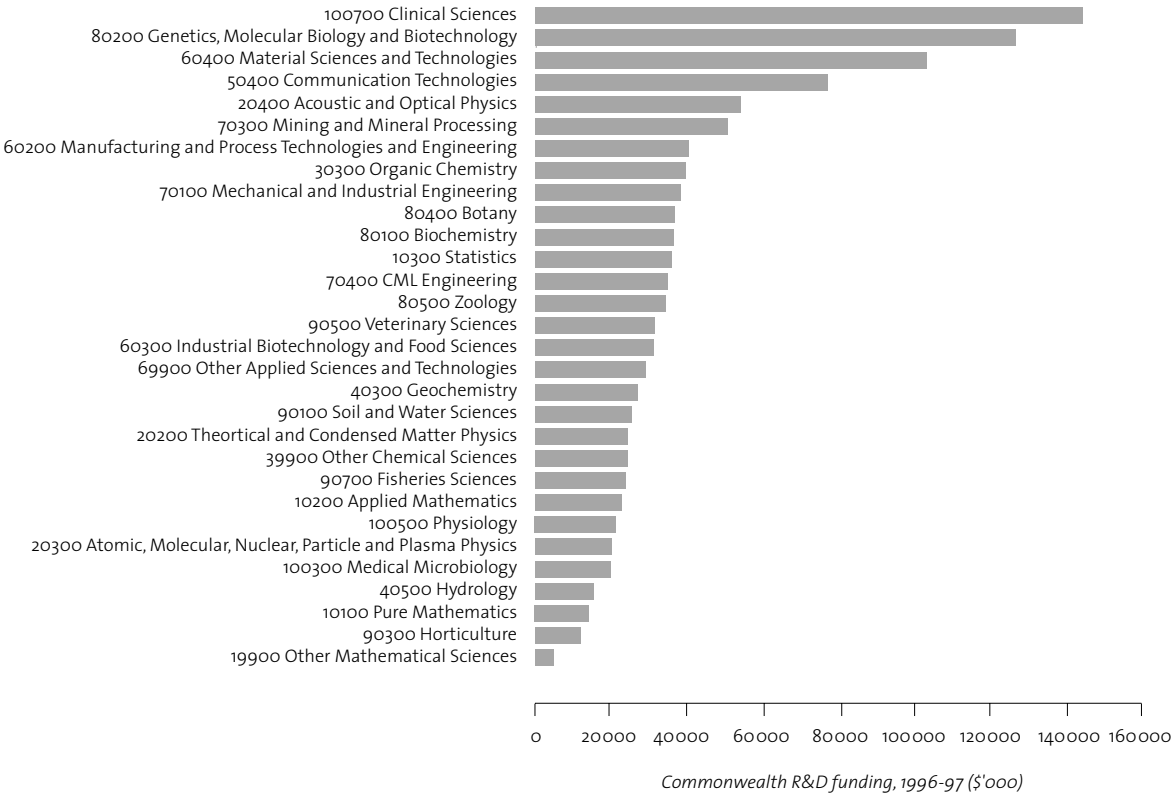
Source: Howard Partnersestimates using data provided by the ABS.

Figure 3: Commonwealth funding for R&D by scientific and technological research field (excludes other research fields)



Source: Howard Partners' analysis of data specially provided by the ABS

Figure 4: Commonwealth R&D funding by research field, 1996-97 (ranked)



Source: Howard Partners' analysis of data specially provided by the ABS

Profile of Support

Profile of Support

The following discussion of the Department of Industry, Science and Resource's support for R&D and innovation necessarily adopts a wider perspective. It covers both funding and tax incentives for R&D as defined by the OECD and support for the more general innovation process.

A PROFILE OF R&D AND INNOVATION SUPPORT PROVIDED BY THE DEPARTMENT OF INDUSTRY, SCIENCE AND RESOURCES

The preceding discussion of overall Commonwealth R&D funding examined a particular area of Commonwealth funding – research and experimental development as defined by the OECD.

The following discussion of the Department of Industry, Science and Resource's support for R&D and innovation necessarily adopts a wider perspective. It covers both funding and tax incentives for R&D as defined by the OECD and support for the more general innovation process. This discussion starts by considering ISR support for R&D and then widens to consider the Department's support for *management capacity building*.

5.1 ISR support for R&D

The department has several programs that support R&D and closely related stages in the commercialisation of R&D. This sub-section considers the industries and research fields targeted either deliberately or by default via market or merit-based resource allocation mechanisms.

5.1.1 R&D Start Program

The R&D Start program, which consists of grants and loans to companies undertaking R&D accounts for an estimated $160.5m of Commonwealth R&D support.

The IR&D Board's Annual Report contains detailed information on the awards made under the R&D START program. We have also made use of data provided in electronic form by program officers. [14]

Although we have been able to cross-tabulate the industry and fields of research supported under the R&D Start scheme the resulting table is too large to be presented in this report. The cross-tabulation does however provide a useful indication of the relationships between industries and fields of research. The full table can be provided by Howard Partners on request.

14 This has mainly been for convenience as the data provided electronically simply duplicates the data provided in the IR&D Board's Annual Report (although there are differences in some of the figures).

It is possible to construct a profile of the industry and field of research composition of the R&D Start program by considering the ANZSIC and field of research composition of awards separately. This is done in Tables 3 and 4. Table 3 indicates the allocation of start grants by field of research and Table 4 indicates the allocation by ANZSIC.

With regard to fields of research the following points stand out:

- '*Information and communication technologies'* are fairly well supported in the systems and software segments, but not in the '*computer hardware manufacture segment'*. Information systems and technologies received 10.4% of total *Start* grant awards by value, and '*computer software*' received 10.2% of total awards by value. '*Communication technologies*' received another 7%. By comparison, '*computer hardware*' received just 0.57% of total awards by value.
- '*Electrical and electronic engineering*' received 7.5% ($16,898,000).
- '*Aerospace technologies and engineering*' received 1.1% of total awards by value ($2,530,00).
- '*Mechanical and industrial engineering*' received 9.1% of the total value of awards whereas chemical engineering receives just 0.96%.

In terms of the industries supported '*electronic equipment manufacturing'*, at $24,697,000 has the largest share – 10.9% of the total value of awards. '*Industrial machinery and equipment manufacturing'* ($13,493,000 at 5.97%) and '*other manufacturing'* at $22,227,000 (9.84%) also feature strongly.

There are also resources concentrated in '*communication services'* (7.28%) and '*health and community*' services (5.8%).

An examination of the cross-tabulated data relating industries and technologies (not presented here) reveals, as would be expected, that '*manufacturing and process technologies and engineering*' (featuring in 36 ANZSIC industry sectors), '*mechanical and industrial engineering*' (featuring in 27 ANZSIC industry sectors) and '*other general engineering*' (featuring in 15 ANZSIC industry sectors) are the most generic fields of research across the industries supported.

'*Information systems and technologies*' also features fairly strongly in the cross-tabulation with 18 ANZSIC industries being associated with this field of research. Aside from this engineering and information systems nexus of industry-field of research relationships there is no clear pattern to be observed.

Table 3: R&D START awards by field of research, total accumulated value of awards, 1995-99

FOR codes	Title	Value of R&D START awards	% of total
024	Acoustic and optical physics	2,760,000	1.22
031	Physical chemistry	840,000	0.37
032	Inorganic chemistry	1,844,000	0.82
033	Organic chemistry	3,082,000	1.36
034	Analytical chemistry	574,000	0.25
042	Geophysics	406,000	0.18
043	Geochemistry	26,000	0.01
044	Oceanography	0	0.00
045	Hydrology	204,000	0.09
051	Information systems and technologies	2,3471,000	10.39
052	Computer hardware	1,291,000	0.57
053	Computer software	23,132,000	10.24
054	Communication technologies	15,840,000	7.01
05X	Other information, computer and communication technologies	4,383,000	1.94
061	Aerospace technologies and engineering	2,530,000	1.12
062	Manufacturing and process technologies and engineering	35,235,000	15.59
063	Industrial biotechnology and food sciences	8,264,000	3.66
064	Material sciences and technologies	3,986,000	1.76
06X	Other applied sciences and technologies	3,574,000	1.58
071	Mechanical and industrial engineering	20,621,000	9.13
072	Chemical engineering	2,164,000	0.96
073	Mining and mineral processing	3,337,000	1.48
074	Civil engineering	1,447,000	0.64
075	Electrical and electronic engineering	16,898,000	7.48
07X	Other general engineering	9,335,000	4.13
081	Biochemistry	1,645,000	0.73

FOR codes	Title	Value of R&D START awards	% of total
082	Genetics, molecular biology and biotechnology	5,373,000	2.38
083	Microbiology	957,000	0.42
084	Botany	664,000	0.29
085	Zoology	359,000	0.16
08X	Other biological sciences	682,000	0.30
091	Soil and water sciences	2,677,000	1.18
092	Crop and pasture production	1,152,000	0.51
093	Horticulture	815,000	0.36
094	Animal production	683,000	0.30
095	Veterinary sciences	151,000	0.07
096	Forestry sciences	0	0.00
097	Fisheries sciences	3,040,000	1.35
09X	Other agricultural sciences	887,000	0.39
101	Immunology	418,000	0.18
102	Medical biochemistry and clinical chemistry	729,000	0.32
103	Medical microbiology	185,000	0.08
104	Pharmacology	4,499,000	1.99
105	Physiology	499,000	0.22
106	Neurosciences	1,198,000	0.53
107	Clinical sciences	1,245,000	0.55
108	Public health research	611,000	0.27
109	Health services research	3,606,000	1.60
10X	Other medical and health sciences	5,080,000	2.25
110	Other Non-manufacturing	1,755,000	0.78
111	Accounting and finance	473,000	0.21
113	Business studies	249,000	0.11
115	Architecture and urban environment	703,000	0.31
11X	Other social sciences	402,000	0.18
		225,981,000	

Source: Program data supplied by ISR

Table 4: R&D START awards by industry, total value of accumulated awards, 1995-99

ANZSIC Code	Industry title	Value of R&D START awards	% of total
00X	Agriculture	1,735,000	0.77
010	Agriculture	3,764,000	1.67
020	Services to agriculture, hunting and trapping	2,576,000	1.14
030	Forestry and logging	416,000	0.18
040	Commercial fishing	2,069,000	0.92
10X	Mining	27,000	0.01
120	Oil and gas exploration	1,001,000	0.44
140	Other mining	320,000	0.14
150	Services to mining	5,310,000	2.35
211	Meat and meat product manufacturing	391,000	0.17
212	Dairy product manufacturing	192,000	0.08
213	Fruit and vegetable processing	3,578,000	1.58
214	Oil and fat manufacturing	232,000	0.10
217	Other food manufacturing	1,932,000	0.85
218	Beverage and malt manufacturing	149,000	0.07
21X	Food, beverage and tobacco manufacturing	1,292,000	0.57
221	Textile, fibre, yarn and woven fabric manufacturing	357,000	0.16
222	Textile product manufacturing	927,000	0.41
225	Footwear manufacturing	481,000	0.21
226	Leather and leather product manufacturing	810,000	0.36
22X	Textile, clothing, footwear and leather manufacture	52,000	0.02

ANZSIC Code	Industry title	Value of R&D START awards	% of total
232	Other wood product manufacturing	682,000	0.30
233	Paper and paper product manufacturing	212,000	0.09
23A	Wood, wood products and furniture	599,000	0.27
241	Printing and services to printing and publishing	256,000	0.11
242	Publishing	842,000	0.37
243	Recorded media manufacturing and publishing	804,000	0.36
24X	Printing, publishing and recorded media n.e.c.	977,000	0.43
252	Petroleum refining	175,000	0.08
253	Basic chemical manufacturing	1,255,000	0.56
254	Other chemical product manufacturing	6,784,000	3.00
255	Rubber product manufacturing	324,000	0.14
256	Plastic product manufacturing	3,556,000	1.57
25X	Petroleum, coal, chemical and associated product manufacture	896,000	0.40
261	Glass and glass product manufacturing	623,000	0.28
262	Ceramic product manufacturing	958,000	0.42
263	Cement, lime, plaster and concrete product manufacturing	240,000	0.11
264	Non-metallic mineral product manufacturing n.e.c.	1,820,000	0.81
271	Iron and steel manufacturing	517,000	0.23
272	Basic non-ferrous metal manufacturing	211,000	0.09
273	Non-ferrous basic metal product manufacturing	55,000	0.02
274	Structural metal product manufacturing	1,044,000	0.46
275	Sheet metal product manufacturing	1,161,000	0.51
276	Fabricated metal product manufacturing	3,097,000	1.37
27B	Fabricated metal	1,151,000	0.51
27X	Metal product manufacturing	3,457,000	1.53
281	Motor vehicle and part manufacturing	2,992,000	1.32
282	Other transport equipment manufacturing	3,828,000	1.69
283	Photographic and scientific equipment manufacturing	9,260,000	4.10
284	Electronic equipment manufacturing	24,697,000	10.93
285	Electrical equipment manufacturing	5,773,000	2.55
286	Industrial machinery and equipment manufacturing	13,493,000	5.97
28A	Transport equipment	1,587,000	0.70
28X	Machinery and equipment manufacturing	5,062,000	2.24
291	Prefabricated building manufacturing	779,000	0.34
292	Furniture manufacturing	752,000	0.33
294	Other manufacturing	22,227,000	9.84
360	Electricity, gas and water supply	858,000	0.38
370	Water supply, sewerage and drainage services	3,160,000	1.40
40X	Construction	1,575,000	0.70
410	General construction	244,000	0.11
420	Construction trade services	422,000	0.19
450	Basic material wholesaling	498,000	0.22
600	Transport and storage	2,912,000	1.29
710	Communication services	16,441,000	7.28
750	Services to finance and insurance	519,000	0.23
77X	Property and business services	21,717,000	9.61
810	Government administration	11,000	
820	Defence	1,262,000	0.56
840	Education	7,234,000	3.20
860	Health and community services	13,118,000	5.80
910	Cultural and recreational services	249,000	0.11
930	Sport and recreational services	755,000	0.33
950	Personal and other services	2,243,000	0.99
99A	Other non-manufacturing	3,006,000	1.33
	unallocated	13,103,000	
	Total	225,981,000	100

5.1.2 Cooperative Research Centres Program

The Cooperative Research Centres (CRC) program is a major platform for Commonwealth support for industrial R&D. It is also a major platform for supporting more general public interest research concerned with identifying and diagnosing problems – particularly in the environmental area.

The CRCs bring together a number of different types of organisations to collaborate over pre-competitive research. CRCs principally link university departments with business firms, government research organisations, industry research associations, private non-profit research organisations and, state government research organisations.

As such, the CRCs are an important part of the Australian research network. Although this network-building feature of the CRCs is an important policy objective, it does make it difficult for the ABS to handle the CRCs. As a result, they are invisible in the ABS' system for tracking national R&D expenditure. Incorporated CRCs are allocated to the '*scientific research services*' sector and unincorporated CRCs are divided up and allocated to the sectors of their various participants.

The CRC secretariat maintains a database on the performance of the various CRCs. On the basis of the information provided to Howard Partners, the structure of this database is not, however, suitable for *directly* producing the sort of data required for this study. This is because it does not allow a matrix of the ANZSIC industry sectors and fields of research supported by the program to be produced.

Given the problems that exist in tracking the role of the CRCs in delivering Commonwealth R&D support to industry, efforts have been made in this study to construct an improved picture of the role of the CRCs. This has involved building a database able to track and analyse the different activities and linkagesof the CRCs.[15] This database was constructed using data obtained from the CRC program's web site backed up by examination of CRC annual reports. [16]

This database allowed us to construct a matrix relating the (ANZSIC) industry sectors and fields of research that are supported by the CRC program.[17] This is, to our knowledge, the first time that such a matrix has been produced for the CRC program. This matrix is too large to present in this report, however it can be provided on request.

Tables 5 and 6 give an indication of the nature and scope of the support for R&D and innovation provided by the CRC program. Table 5 groups CRCs by socio-economic objectives and lists the overall number of partners involved in each CRC.

Table 6 provides a sectoral breakdown of the various types of organisations involved with CRCs.[18] It should be stressed that the organisations identified are the main participants in the CRCs. There is an underlying tier of more informal involvement of individual researchers that, should it be mapped, would generate a longer list of organisations involved. It is worth noting that university departments dominate these linkages (with a count of 189 links), followed by state government agencies (75 links) and scientific research institutions (67 links).

15 In fact, the database has a more general scope that the CRCs per se because it also captures firms and organisations receiving R&D Start support. The database structure has been designed to allow research-related linkages to be traced – however complex they might be. This has been achieved by designing the data-structure around linkages themselves rather than, in the first instance, around allocations to sectors. This work is being carried out by Howard Partners as part of an internally funded research project aimed at mapping the linkages in the Australian research system.

16 It is our understanding that the CRC program's web site material on each CRC is regularly updated on the basis of program information and it has therefore been possible to construct our own database prior to the release of the CRC Compendium for the year 2000.

17 The matrix was produced by linking CRC-specific field of research codings with partner-specific ANZSIC codings. This allows the range of partner sectors associated with each CRC to be mapped out. Given that detailed coding work is involved in this exercise, the recently revised socio-economic objectives and 'research field, courses and disciplines' (RFCD) classifications have been used instead of the older classification.

18 In this table, which is based on a count of distinct organisations and university departments involved with CRCs, there is 'double counting' due to the fact that, for example, a particular university department may be a partner to more than one CRC. These numbers consequently reflect the number of linkages rather than partnership-relationships per se.

Table 5: Cooperative Research Centres grouped by socio-economic objectives

SE-O Code	SE-O Description	Prime Org Name	Number of Partners
		CRC - Australian Telecommunications	14
620000	Plant Production & Plant Primary Products	CRC for Legumes in Mediterranean Agriculture	4
620000	Plant Production & Plant Primary Products	CRC for Plant Science	3
620000	Plant Production & Plant Primary Products	CRC for Tropical Plant Protection	8
620101	Plant Production & Plant Primary Products - wheat	CRC for Quality Wheat Products and Processes	12
620103	Plant Production & Plant Primary Products - rice	CRC for Sustainable Rice Production	6
620106	Plant Production & Plant Primary Products - sugar	CRC for Sustainable Sugar Production	13
620204	Horticultural Crops - Grapes	CRC for Viticulture	12
620300	Forestry	CRC for Sustainable Production Forestry	10
620404	Primary Products from Plants - Cotton	CRC - Australian Cotton	12
620500	Sustainable Plant Production Systems	CRC for Molecular Plant Breeding	14
630103	Animal Production - Beef cattle	CRC for the Cattle and Beef Quality	4
630303	Aquaculture	CRC for Aquaculture	9
640100	Exploration	CRC - Australian Geodynamics	7
640100	Exploration	CRC for Australian Mineral Exploration Technology	7
640100	Exploration	CRC for Landscape Evolution	4
640100	Primary Mining & Extraction Processes	GK Williams CRC for Extractive Metallurgy	2
640200	Primary Mining & Extraction Processes	CRC for Mining Technology and Equipment	12
650100	Energy Resources	Australian Petroleum CRC	7
650302	Preparation & supply energy source minerals - coal	CRC for Clean Power from Lignite	11
660101	Energy Transformation coal - electricity	CRC for Black Coal Utilisation	15
660200	Renewable energy	Australian CRC for Renewable Energy	21
670000	Manufacturing	CRC for Intelligent Manufac. Systems and Techs.	19
670100	Manufacturing	CRC for Micro Technology	12
670100	Processed Food Products and Beverages	CRC for Food Industry Innovation	5
670100	Processing Food Products & Beverages	CRC for International Food Manufac & Packaging Science	13
670202	Fibre Processing & Textiles - Wool scouring	CRC for Premium Quality Wool	7
670300	Wood, Wood Products & Paper	CRC for Hardwood Fibre and Paper Science	4
670400	Prevention - biologicals (eg vaccines)	CRC for Vaccine Technology	7
670402	Diagnostics	CRC for Diagnostic Technologies	7
670403	Treatments (eg. chemicals, antibiotics)	CRC for Biopharmaceutical Research	5
670403	Treatments (eg. chemicals, antibiotics)	CRC for Cardiac Technology	8
670403	Treatments (eg. chemicals, antibiotics)	CRC for Cellular Growth Factors	5
670403	Treatments (eg. chemicals, antibiotics)	CRC for Tissue Growth and Repair	6
670700	Industrial Chemicals & Related Products	CRC for Polymers	16
670800	Basic Metal products	CRC for CAST Metals Manufacturing	18
671000	Fabricated Metal Products	CRC for Welded Structures	13
671699	Manufactured products nec	CRC for Bioproducts	3
671699	Manufactured Products not elsewhere classified	CRC for Advanced Composite Structures	10
690200	Water Transport	CRC - Australian Maritime Engineering	8
700000	Information & Communication Services	CRC - Australian Photonics	32
700000	Information & Communication Services	CRC - Research Data Network	16
700000	Information & Communication Services	CRC for Advanced Computational Systems	5
700000	Information & Communication Services	CRC for Enterprise Distributed Systems Technology	18
700000	Information & Communication Services	CRC for Intelligent Decision Systems	8

SE-O Code	SE-O Description	Prime Org Name	Number of Partners
700000	Information & Communication Services	CRC for Robust and Adaptive Systems	2
700000	Information & Communication Services	CRC for Satellite Systems	6
710103	Water services & utilities	CRC for Water Quality and Treatment	18
710500	Tourism	CRC for Sustainable Tourism	9
720500	Measurement Standards & Calibration Services	CRC for Sensor Signal and Information Processing	10
730000	Health	CRC for Molecular Engineering & Technology	3
730111	Hearing, vision, speech & their disorders	CRC for Cochlear Implant and Hearing	3
730111	Hearing, vision, speech & their disorders	CRC for Eye Research and Technology	7
730200	Public Health	CRC for Aboriginal and Tropical Health	6
730200	Public Health	CRC for Asthma	14
730200	Public Health	CRC for Discovery of Genes for Common	5
770000	Environmental Management	CRC for Coastal Zone, Estuary and Waterway	8
770000	Environmental Management	CRC for Freshwater Ecology	18
770000	Environmental Management	CRC for Waste Management and Pollution Control	14
770100	Climate and Weather	CRC for Southern Hemisphere Meteorology	4
770307	Marine Protected Areas	CRC for the Great Barrier Reef World Heritage Area	7
770400	Coastal and Estuarine Environment	CRC for Catchment Hydrology	14
770800	Farmland	CRC for Soil and Land Management	5
771100	Antarctic & Sub-Antarctic Areas	CRC for Antarctica and the Southern Ocean	5
779901	Air quality	CRC for Greenhouse Accounting	7
779903	Living resources	CRC for Conservation and Management of Marsupials	5
779904	Control of pests & exotic species	CRC for Weed Management Systems	9
779904	Control of pests and exotic species	CRC for Biological Control of Pest Animals	7
779904	Control of pests and exotic species	CRC for Tropical Pest Management	3
779905	Integrated (ecosystem) assessment & management	CRC for the Sustainable Development of Tropical	9
779905	Integrated (ecosystem) assessment & management	CRC for Tropical Rainforest Ecology and Management	11

Source: Howard Partners analysis of CRC program data

Table 6: Sectoral breakdown of organisations involved with CRCs

Organisations	Number
Air Transport	1
Bank Operation	1
Biscuit mfg	2
Business association	9
Business associations	8
Charities & charitable organisations	1
Coal Mining	4
Commonwealth government administration	20
Communication service	1
Computer software manufac or publishing	2
Cotton growing	3
Defence forces operation & administration	10
Electricity generation, supply & distribution	11
Electronic equipment manufacture	4
Electronic Equipment Manufacturing	1
Finance & Insurance	1
Flour Mill & Cereal Food Manufacturing	1
Flour Mill and Cereal Food Manufacturing	3
Food research institution operation	8
Forestry & Logging	3
Hearing aids mfg	1
Hospital operation	4
Industrial research institute operation	3
Industrial research institution operation	7
Industrial research institution organisation	1
Industry research institution operation	1
Industry research institution organisation	1
Iron ore mining	1
Local government administration	5
Medical mfg	13
Medical research institution operation	16
Medical service nec	1
Metal Ore Mining	2
Mining	6
Mining exploration	1
Mining Services nec	2
Motor Vehicle & Parts Manufacturing	1
Pipeline engineering service	1
Plastic Products Manufacturing	1
Professional Association	2
Sate Government Administration	4
Scientific or technical services nec	5
Scientific research institution operation	67
Shire administration	1
State Government Administration	75
Sugar cane growing	1
Sugar mfg	1
Technical & further education college operation	1
Telecommunication Services	1
Turf growing	1
University operation	189
Water Supply Sewerage & Drainage Service	6
Water Supply Sewerage and Drainage Service	5
Zoological garden operation	1

Source: Howard Partners analysis of CRC program data

Having outlined the general linkage profile of the CRCs considered as a group, we now consider the ANZSIC sectors and research fields associated with the CRC program.

The funding figures in the following tables are for current funding commitments to CRCs and thus relate to a number of years. This allows an overall picture of the impact on industries and research fields of the CRC program to be produced. In some cases no funding commitments for the recently announced CRCs were available and these figures are consequently subject to revision as these announcements are made.

Table 7 shows the overall impact of the CRC program on industries as classified by ANZSIC. This impact has been calculated by dividing up the Commonwealth funding commitment to each CRC amongst the various partner organisations and then cross-tabulating the ANZSIC sectors to which these organisations have been classified.[19] Far more detailed data is available on these ANZSIC sectors however it is difficult to present such detailed data in a concise form.

19 Although this is in some respects a fairly crude allocation procedure it has considerable analytical merit because partner organisations are able to 'tap into' a general pool of knowledge within the CRC. In an ideal world, this allocation would be made on the basis of more detailed information on the particular CRC project areas that each partner is involved in. Producing such estimates is however beyond the scope and time frame for this particular study.

Table 7: Overall impact of the CRC program on ANZSIC sectors, current funding commitment

ANZSIC sector	R&D impact
Agriculture, Forestry & Fishing	9,827,912
Mining	26,795,595
Food, Beverage & Tobacco Mfg	10,710,769
TCF & Leather Mfg	-
Wood & Paper Product Mfg	-
Printing, Publishing & Recorded Media	1,725,000
Petroleum, Coal, Chemical & Assoc Prod. Mfg	20,393,333
Non Metallic Mineral Product Mfg	-
Metal Product Mfg	-
Machinery & Equipment Mfg	5,893,750
Other Mfg	-
Electricity, Gas & Water Utilities	6,503,333
Construction	-
Wholesale & Retail Trade	-
Accommodation, Cafes & Restaurants	-
Transport & Storage	-
Communications, Finance & Insurance	818,750
Property, Business & Comp. Services	-
Govt. Services	580,903,689
Other Services	12,289,782
Total	675,861,914

Source: Howard Partners analysis of CRC program data

The striking feature of these estimates is the clear dominance of the 'allocation' of Commonwealth funding to the '*government services*' sector. This follows from the numerical dominance of university departments, state government and Commonwealth government agencies in the overall range of CRC partner organisations.

Whilst this may seem surprising, it is the logical consequence of the strong involvement of public sector organisations in the CRC program. It is precisely because so many public sector organisations and departments are taking part in the CRC program that the CRC program is playing such a useful role in building collaborative research between the public and private sectors in Australia.

A better indication of the impact on private sector industries of the CRC program can be obtained if we exclude the public sector from the picture. The results are shown in Figure 4.

Once the public sector is excluded we can see that mining and the chemical/pharmaceutical industries (grouped by ANZSIC under '*petroleum, coal, chemical and associated product manufacturing*') dominate private sector involvement in the CRC program. It is striking that even at this high level of aggregation the industry involvement in CRCs is so clustered. There is little indication of involvement beyond the 'second tier' industries in the agri-food industries ('*agriculture*' plus '*food, beverages and tobacco*') and the '*machinery and equipment manufacturing*' and '*electricity, gas and water industries*'.

Turning now to the CRC program's impact upon research fields, Figure 5 indicates the broad distribution across research fields, using the new 'research fields, courses and disciplines' (RFCD) classification.

This graph, and the preliminary estimates upon which it is based, suggests that '*engineering and technology*' dominates the research field-based impact of the CRC program, followed by '*agricultural, veterinary and environmental sciences*' and the '*medical and health sciences*'. These are of course very general research headings and it is worth looking at the research field impact in greater detail.

Table 8 provides more detail on the CRC program's impact on research fields. In this table the level of detail varies due to the fact that CRCs have been classified to the greatest detail possible in the new 'research fields, courses and disciplines' (RFCD) classification scheme. In some cases this means that a detailed RFCD classification is appropriate, in other cases it is only possible to use a general RFCD heading because the more detailed sub-divisions are inappropriate.[20]

The more detailed research field classification highlights some of the more interesting aspects of the CRC program's research activities, such as '*biosensor technologies*'. This table allows us to find out the reasons why '*engineering and technology*' features so strongly in the general research field impact assessment. The breakdown of this research field area can be grasped by considering all the codes that start with '29'.

There is a very wide range of technologies involved in this general research area, from '*industrial biotechnology*' *to* '*combustion and fuel engineering*'.

20 It is worth noting that it is very difficult to find appropriate RFCD codes for many CRCs – even though this new version of the research field classification has only recently been completed.

Figure 5: Impact on private sector industries of the CRC program

Source: Howard Partners' analysis of CRC program data

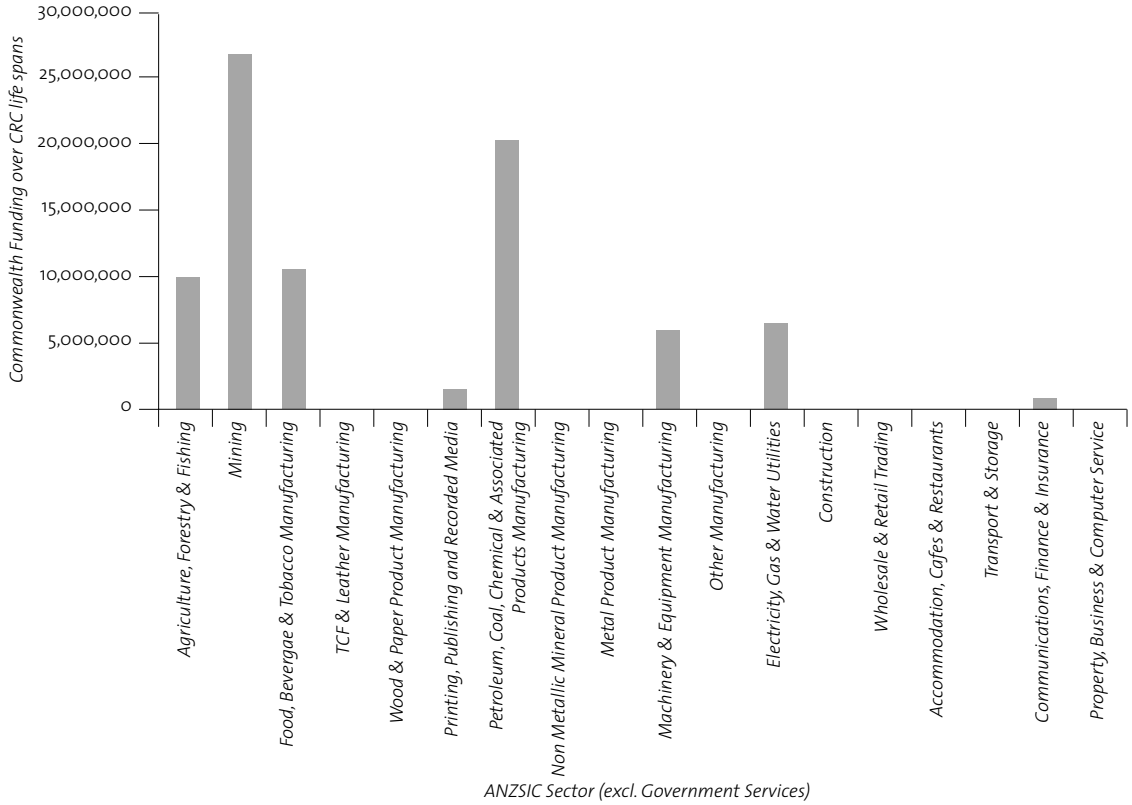


Figure 6: The impact of the CRC program on general research fields, current Commonwealth funding commitments

Source: Howard Partners' analysis of CRC program data

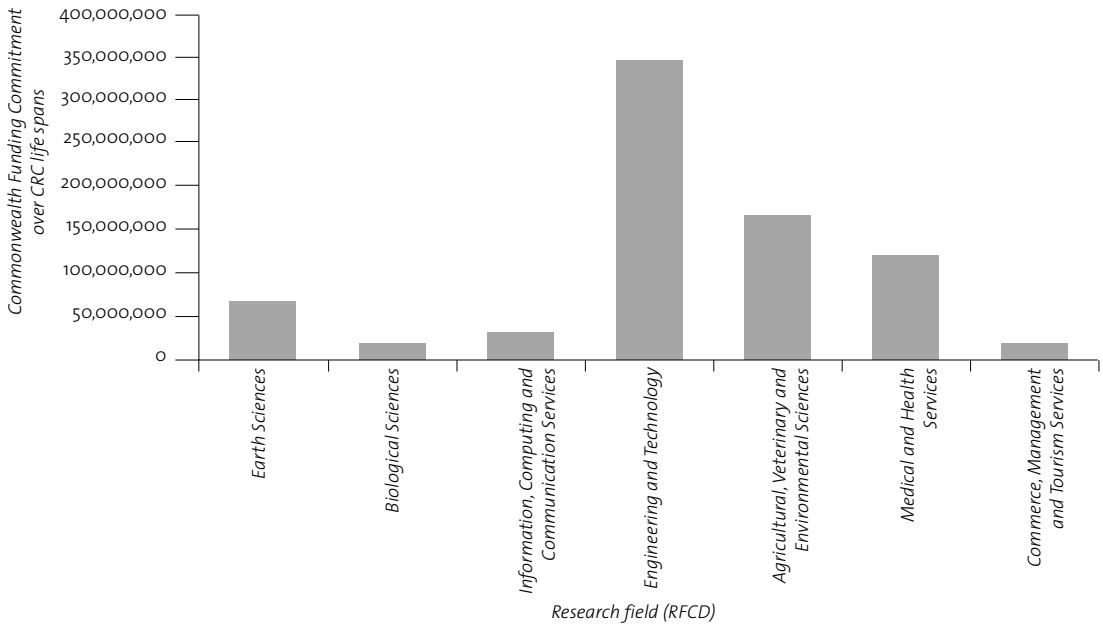


Table 8: Impact of the CRC program on research fields, current funding commitments over CRC life spans

RFCD	Description	Commonwealth Funding Commitment ($)
260100	Geology	30,700,000
260107	Structural Geology	17,300,000
260200	Geophysics	10,100,000
260601	Meteorology	10,300,000
26####	Earth Sciences	68,400,000
270800	Biotechnology	16,900,000
27####	Biological Sciences	16,900,000
280100	Information Systems	6,900,000
280200	Artificial Intelligence and Signal and Image Processing	10,200,000
280500	Data Format	13,800,000
28####	Information, Computing and Communication Services	30,900,000
290100	Industrial Biotechnology and Food Sciences	28,400,000
290207	Satellite, Space Vehicle and Missile Design	18,300,000
290700	Resource Engineering	33,500,000
290703	Mineral Processing	32,100,000
290802	Water and Sanitary Engineering	14,700,000
291000	Geomatic Engineering	16,700,000
291100	Environmental Engineering	24,200,000
291104	Environmental Technologies	25,900,000
291200	Maritime Engineering	13,300,000
291300	Metallurgy	20,500,000
291400	Materials Engineering	34,900,000
291406	Pulp and Paper	13,400,000
291500	Biomedical Engineering	28,200,000
291700	Communications Technologies	13,100,000
299902	Combustion and Fuel Engineering	12,100,000
299903	Biosensor Technologies	15,300,000
29####	Engineering and Technology	344,600,000
300100	Soil and Water Sciences	16,800,000
300200	Crop and Pasture Production	75,000,000
300406	Animal Growth and Development	16,300,000
300600	Forestry Sciences	24,800,000
300700	Fisheries Sciences	15,100,000
300805	Conservation	1,200,000
300903	Sustainable Development	16,700,000
30####	Agricultural, Veterinary and Environmental Sciences	165,900,000
320900	Optometry	29,500,000
321200	Public Health and Health Services	13,900,000
329900	Other Medical and Health Sciences	12,900,000
329902	Medical Biotechnology	60,600,000
32####	Medical and Health Sciences	116,900,000
350400	Transportation	14,500,000
35####	Commerce, Management and Tourism Services	14,500,000
	Total	758,100,000

5.2 The R&D Tax Concession

The R&D Tax Concession is a major component of the Commonwealth government's support for R&D. The estimated 1999-2000 accrual value of the R&D Tax Concession is $406.0m, which is 10.27% of the estimated total value of Commonwealth support for science and innovation (measured on a budget-headings basis), (Department of Industry Science and Resources 1999).[21] The estimated cost to revenue of the Tax Concession in 1996-97 is $402m which is 11.82% of the total Commonwealth R&D expenditure.

Table 9 contains data provided by program officers on the value of the R&D Tax Concession claims by industry. These industry shares are graphed in Figure 6 below. As the graph clearly shows the claims made by the mining industry and by machinery and equipment manufacturers dominate the picture.

One reason for this is that these are the industries that invest relatively large amounts in experimental development. This means that these high R&D spending industries and this market-driven resource allocation naturally gets reflected in R&D Tax Concession claims.

Program officers have also made available some provisional estimates on the fields of research associated with the R&D claimed under the Tax Concession. The graph in Figure 7 indicates the distribution across fields of research. These figures suggest that the bulk of the R&D associated with the claims is concentrated in '*general engineering*', '*applied sciences and technology*' and '*information, computer and communication technologies*'.

There is another source of data on the R&D Tax Concession claims. The ABS recently introduced a question on the Tax Concession claims in their R&D survey. This allows the claims made under the Tax Concession to be related to a wide range of variables relating to R&D. The ABS has provided this data to the study team and it is presented in Table 10. Table 11 – 14 show the cross-tabulation of socio-economic objectives with ANZSIC sectors. Tables 11 and 12 show the cross-tabulation of ANZSIC sectors with fields of research.

The total value of the Tax Concession claims captured in the 1996-97 ABS R&D survey is $2,923.7m. This compares with $4,155.0m of overall claims for that year. In other words the ABS survey captures 70.36% of the overall value of the Tax Concession claims. There are a number of reasons for this difference, including:

- The ABS figures exclude syndicated R&D;
- Many businesses responding to the ABS survey had not yet completed their 1996-97 Tax Concession claims and therefore provided estimates. [22]

Whilst accepting that there are caveats to be applied, it is reasonable to draw some general inferences from the ABS Tax Concession claim data. The following points emerge.

- The ABS figures indicate a degree of 'fragility' in business enterprise R&D supported by the Tax Concession. There are numerous cases in which a particular socio-economic to industry relationship relies upon 1 or 2 reporting units – as indicated by the 'n.p' designation.
- The ABS cross-tabulations confirm the impression given by the Tax Concession program data – that the concession encourages 'mechanical' R&D concerned with mining and the engineering industries. It should be born in mind that the bulk of business R&D consists of experimental development activity, and that those industries with active experimental development projects will tend to dominate Tax Concession claims.
- There is a strikingly low impact upon the fields of research associated with the medical and bio-science areas, and with the chemical sciences. For example, '*industrial biotechnology and food sciences*' only accounts for 3.85% of the total value of the R&D claimed.

The overall conclusion with regard to the R&D Tax Concession is that it facilitates R&D in the mining industry and the industries that supply equipment to mining (and to some extent other 'mechanical' industries), whilst giving significant support to the information technology sector.

21 Care needs to be taken when discussing the value of the R&D Tax Concession because (a) Commonwealth support is delivered via tax revenue foregone, (b) there are retrospective claims. The latter means that estimates of the dollar value of the R&D Tax Concession are subject to significant revision as companies are awarded retrospective claims under the scheme.

22 Other factors to consider when relating the ABS to Tax Concession program data are that: (a) not all R&D expenditure was eligible for the Tax Concession; (b) not all eligible expenditure could be claimed at 125%, amounts claimed under the Tax Concession can include claims made for previous years; (d) amounts claimed can include extra-mural expenditure. It is worth noting that some of these factors will inflate the value of Tax Concession claims when compared to the ABS R&D data.

Table 9 : Industry breakdown of R&D Expenditure by Claimants of the R&D Tax Concession

Code	Industry Type	1995/96	1996/97	1997/98
00X	Agriculture	559,087	0	354,948
010	Agriculture	30,798,313	35,612,045	41,825,198
020	Services to Agriculture; Hunting and Trapping	10,307,658	12,855,808	17,680,208
030	Forestry and Logging	3,013,833	2,401,294	2,063,462
040	Commercial Fishing	8,297,305	6,018,701	14,109,016
10X	Mining	10,005,523	14,816,069	7,655,834
110	Coal Mining	156,348,248	110,612,944	109,910,884
120	Oil and Gas Extraction	134,498,490	282,175,131	133,010,895
130	Metal Ore Mining	484,839,427	334,954,737	305,541,373
140	Other Mining	135,976,396	199,291,584	424,421,952
150	Services to Mining	83,697,180	83,261,459	90,682,231
211	Meat and Meat Product Manufacturing	28,230,974	30,073,361	25,402,749
212	Dairy Product Manufacturing	76,725,786	31,805,429	20,658,093
213	Fruit and Vegetable Processing	20,644,923	11,845,327	6,322,704
214	Oil and Fat Manufacturing	2,206,395	1,507,758	1,116,671
215	Flour Mill and Cereal Food Manufacturing	18,604,223	7,254,727	13,093,094
216	Bakery Product Manufacturing	12,181,770	8,266,779	11,787,133
217	Other Food Manufacturing	124,868,130	130,142,804	146,015,539
218	Beverage and Malt Manufacturing	15,636,028	10,993,293	11,342,173
219	Tobacco Product Manufacturing	4,983,643	3,463,692	3,153,282
21X	Food Beverage and Tobacco Manufacturing	2,313,590	206,014	140,083
221	Textile Fibre Yarn and Woven Fabric Manufacturing	3,495,094	2,719,174	3,676,293
222	Textile Product Manufacturing	7,330,490	7,922,396	8,722,503
223	Knitting Mills	271,988	0	0
224	Clothing Manufacturing	96,457	101,310	117,557
225	Footwear Manufacturing	111,688	597,023	0
226	Leather and Leather Product Manufacturing	11,706,631	6,660,682	2,260,983
22X	Textile Clothing Footwear and Leather Manufacturing	25,531	0	0
231	Log Saw milling and Timber Dressing	3,014,502	1,547,099	1,987,324
232	Other Wood Product Manufacturing	11,551,913	4,369,910	7,280,692
233	Paper and Paper Product Manufacturing	164,808,546	83,121,320	102,620,089
23A	Wood Products and Furniture (231+232+292)	996,367	6,012	127,987
23B	Paper Products Printing & Publishing (233+24X)	0	116,000	240,000
23X	Wood and Paper Product Manufacturing	1,450,000	0	0
241	Printing and Services to Printing	10,633,354	4,124,569	7,187,767
242	Publishing	4,124,432	3,109,857	2,727,692
243	Recorded Media Manufacturing and Publishing	9,285,080	5,050,519	5,106,778
24X	Printing Publishing and Recorded Media	0	0	204,458
251	Petroleum Refining	29,187,368	10,157,767	19,196,592
252	Petroleum and Coal Product Manufacturing n.e.c.	12,542,278	11,309,787	8,035,653
253	Basic Chemical Manufacturing	49,364,615	31,702,712	14,658,259
254	Other Chemical Product Manufacturing	125,722,197	126,443,899	105,374,970
255	Rubber Product Manufacturing	5,627,311	7,189,522	7,489,329
256	Plastic Product Manufacturing	38,417,178	23,139,041	20,852,246
25X	Petroleum Coal Chemical and Associated Product Man.	1,800,961	294,137	367,360
261	Glass and Glass Product Manufacturing	5,651,948	5,163,476	5,525,721
262	Ceramic Product Manufacturing	10,310,441	3,304,008	2,740,301
263	Cement Lime Plaster and Concrete Product Manufacturing	49,407,380	34,365,508	69,964,900
264	Non-Metallic Mineral Product Manufacturing n.e.c.	39,132,602	23,280,503	19,161,214
26X	Non-Metallic Mineral Product Manufacturing	259,208	0	251,435

Code	Industry Type	1995/96	1996/97	1997/98
271	Iron and Steel Manufacturing	244,757,591	192,247,056	147,371,424
272	Basic Non-Ferrous Metal Manufacturing	23,733,032	24,956,628	88,374,122
273	Non-Ferrous Basic Metal Product Manufacturing	65,541,116	81,564,203	48,071,513
274	Structural Metal Product Manufacturing	17,826,229	26,083,795	16,710,057
275	Sheet Metal Product Manufacturing	5,417,879	3,750,119	4,687,413
276	Fabricated Metal Product Manufacturing	111,713,743	102,920,602	97,498,504
27A	Basic Metal Product (271-273)	402,870	397,062	338,425
27B	Fabricated Metal (274-276)	515,287	51,927	554,727
27X	Metal Product Manufacturing	1,162,534	2,071,017	2,566,755
281	Motor Vehicle and Part Manufacturing	266,924,928	274,310,724	358,355,089
282	Other Transport Equipment Manufacturing	61,240,440	67,706,833	87,401,843
283	Photographic and Scientific Equipment Manufacturing	47,268,298	32,366,404	36,131,516
284	Electronic Equipment Manufacturing	164,917,632	179,724,039	185,158,411
285	Electrical Equipment and Appliance Manufacturing	100,912,251	95,893,207	74,002,870
286	Industrial Machinery and Equipment Manufacturing	139,079,538	175,053,858	161,310,008
28A	Transport Equipment (281+282)	901,562	656,203	2,742,546
28X	Machinery and Equipment Manufacturing	600,592	482,071	575,801
291	Prefabricated Building Manufacturing	655,747	478,297	1,090,690
292	Furniture Manufacturing	3,855,696	3,165,549	3,467,668
294	Other Manufacturing	372,785,851	323,853,119	298,929,943
360	Electricity Gas and Water Supply	38,578,088	23,932,928	29,339,308
370	Water Supply Sewerage and Drainage Services	3,778,418	7,714,795	4,215,699
40X	Construction	4,823,353	4,431,069	618,897
410	General Construction	13,193,306	69,146,554	104,365,599
420	Construction Trade Services	3,349,845	3,913,331	1,712,660
450	Basic Material Wholesaling	2,912,147	2,292,442	5,585,773
460	Machinery and Motor Vehicle Wholesaling	336,205	752,742	1,268,173
470	Personal and Household Good Wholesaling	3,319,985	2,459,893	1,332,932
49A	Wholesale & Retail Trade	20,211,002	15,217,431	705,913
510	Food Retailing	470,741	2,008,917	921,030
520	Personal and Household Good Retailing	5,319,334	4,492,455	4,045,770
530	Motor Vehicle Retailing and Services	617,434	803,280	1,504,977
570	Accommodation Cafes and Restaurants	253,261	237,812	29,107
600	Transport and Storage	58,798,881	51,314,839	33,090,206
710	Communication Services	324,474,502	352,819,616	331,117,533
730	Finance	73,712,250	33,025,915	71,073,016
740	Insurance	7,028,472	9,445,856	9,284,083
750	Services to Finance and Insurance	68,071,456	40,372,288	48,464,063
77X	Property and Business Services	177,004,809	154,618,378	177,809,299
810	Government Administration	207,501	253,130	938,665
820	Defence	9,032,484	15,950,282	23,381,865
840	Education	1,476,443	1,221,141	1,387,517
860	Health and Community Services	30,314,037	33,124,994	39,976,819
910	Cultural and Recreational Services	205,287	577,258	2,706,444
920	Libraries Museums and the Arts		47,663	201,834
930	Sport & Recreational Services	3,830,264	9,085,745	5,895,464
950	Personal and Other Services	14,201,083	13,594,213	9,626,578
99A	Other Non-Manufacturing	1,868,881	1,091,696	5,296,332
	Total	4,458,664,767	4,155,034,563	4,333,400,506

Source: data provided by ISR.

Figure 7: R&D claimed under the Tax Concession by industry sector and by value

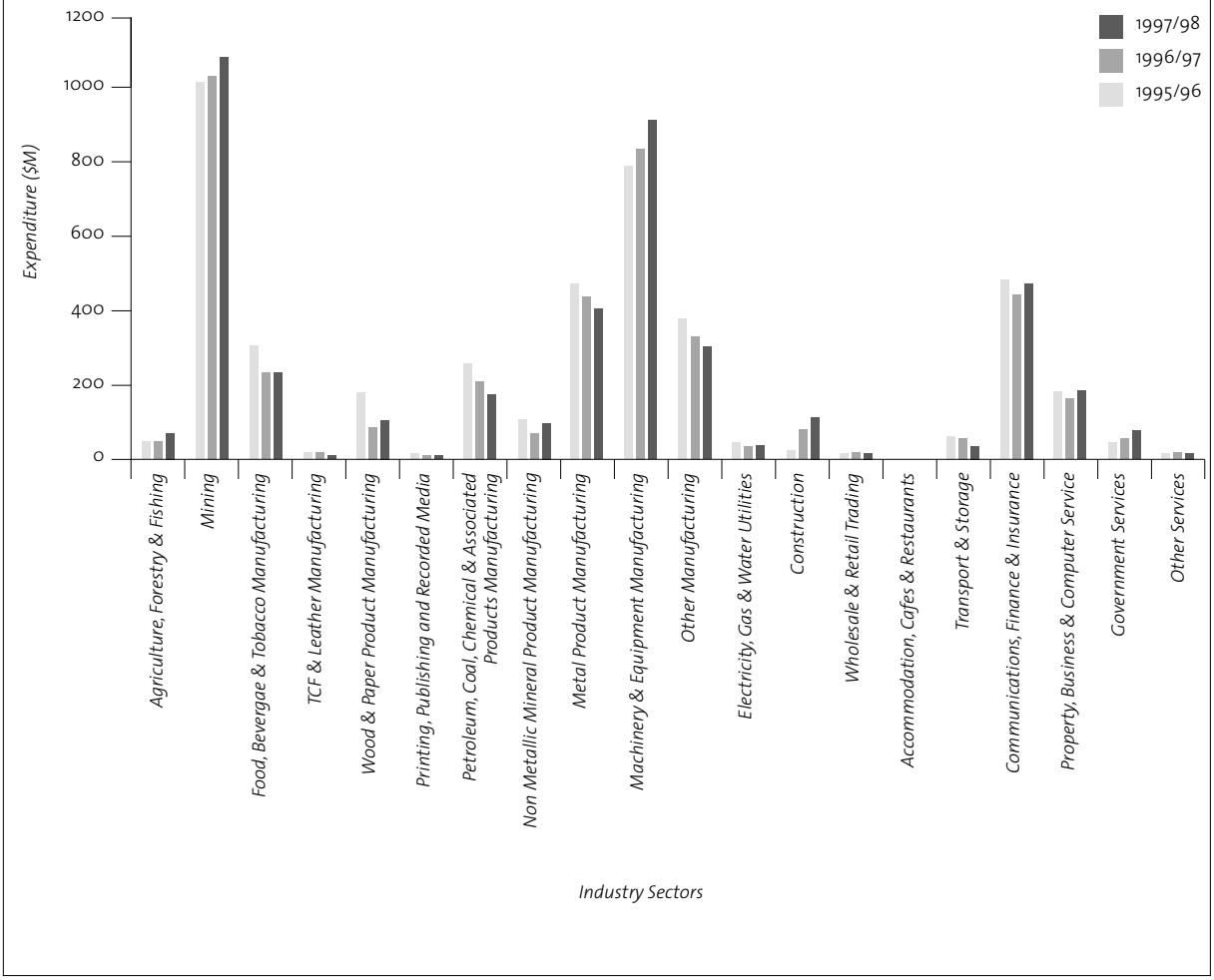
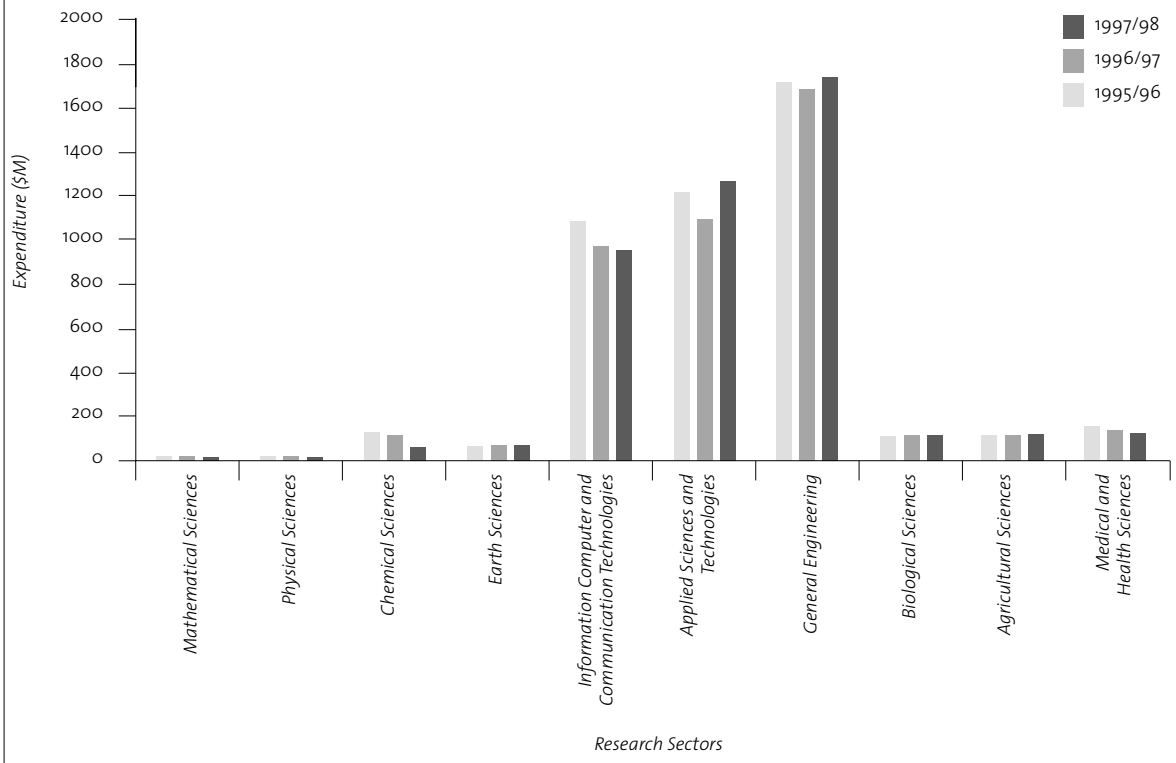


Figure 8: R&D Tax Concession claims by field of research



Source: internal data provided by ISR

Table 10: R&D claimed under the Tax Concession by socio-economic objective and by ANZSIC 1996-97 ($'000)

Socio-Economic objectives	Mining (incl. services to mining)	Food beverages & tobacco	Textile clothing footwear & leather	Wood & paper product	Printing publishing & recorded media	Petrol coal chemical & assoc. product	Non-metallic mineral product	Metal product	Motor vehicle & part &other transport equip.
Defence						**n.p.**		**n.p.**	**n.p.**
Plant - production and primary products	21	6,998		1,127		n.p.		26	40
Animal - production and primary products		n.p.	n.p.			4,210			
Mineral resources (excl energy)	387,991					3,163	n.p.	56,117	n.p
Energy resources	144,531		n.p.	n.p.		n.p.	n.p.	n.p.	
Energy supply	n.p.	n.p.		n.p.		153	n.p.	n.p.	54
Manufacturing	55,079	180,292	9,002	65,074	2,372	123,826	25,573	207,323	315,448
Construction	n.p.		n.p.	n.p.		861	11,155	2,835	n.p.
Transport	n.p.	n.p.				n.p.		1,084	20,767
Information and communication services		n.p.			4,234		86		
Commercial services	587	n.p.	n.p.	n.p.		n.p.	21	n.p.	107
Economic framework						n.p.			
Total economic development	**593,799**	**194,412**	**10,430**	**73,924**	**6,605**	**142,122**	**37,901**	**273,741**	**336,714**
Health	n.p.	4,040	n.p.		n.p.	n.p.		290	
Education and training									
Social development and community services			14			n.p.	86		n.p.
Total society	**n.p.**	**4,040**	**n.p.**		**n.p.**	**21,673**	**86**	**290**	**n.p.**
Environmental knowledge	7,776	n.p.				n.p.	n.p.	417	
Environmental aspects of economic development	2,809	n.p.		n.p.		n.p.	n.p.	n.p.	622
Environmental manage ment and other aspects	1,035	n.p.		n.p.		650	n.p.	n.p.	
Total environment	**11,620**	**n.p.**		**266**		**1,647**	**n.p.**	**8,400**	**622**
Advancement of knowledge	**n.p.**	**340**			**n.p.**	**4,309**	**n.p.**	**83**	
TOTAL	606,418	200,808	10,484	74,190	7,375	169,796	40,778	282,568	355,772

Source: data specially provided by the ABS.

Note: 'n.p.' indicates that a figure cannot be published due to confidentiality constraints.

Photo-graphic & scientific equip.	Electronic & electrical equip. & appliance	Industrial machinery & equip	Other manuf.	Total manuf.	Wholesale & retail trade	Finance & insurance	Property & business service	Scientific research	Other n.e.c.	Total other indust.	TOTAL ALL INDUSTRIES
n.p.	**n.p.**	**n.p.**		**132,988**	**n.p.**		**19,250**	**n.p.**	**62,050**	**82,645**	**215,633**
	n.p.	n.p.		17,517	2,335	88	1,496			3,919	21,456
	696	n.p.		11,446	291		n.p.	n.p.	n.p.	3,336	14,783
n.p.	132	5,565	n.p.	65,697	2,386		2,587		960	5,932	459,620
8	165	1,226	n.p.	n.p.	n.p.		1,976	385	40,688	n.p.	215,391
796	8,597	770	n.p.	n.p.	272		4,127	24,014	10,374	38,788	55,098
28,137	119,246	65,546	4,464	1,146,302	61,764	499	114,440	16,510	6,309	199,522	1,400,904
49	669	n.p.	112	n.p.	937		n.p.	n.p.	3,822	5,590	21,896
50	246	1,189		n.p.	1,099		4,988	11	2,777	8,875	33,146
317	50,798	2,070	n.p.	59,737	32,568	n.p.	102,305	n.p.	79,078	241,019	300,756
	832		n.p.	13,039	7,632	22,186	13,525	18	6,698	50,059	63,684
	n.p.		n.p.	n.p.	n.p.	n.p.	186			n.p.	697
29,545	**181,890**	**76,988**	**5,907**	**1,370,179**	**132,440**	**n.p.**	**248,462**	**n.p.**	**150,719**	**623,452**	**2,587,431**
12,717	n.p.	n.p.	n.p.	n.p.	1,379		6,440	4,775	2,545	15,139	55,870
48	n.p.		n.p.	111	n.p.		n.p.			632	744
	n.p.	n.p.	n.p.	2,614	n.p.		n.p.			2,409	5,023
12,765	**1,425**	**n.p.**	**n.p.**	**n.p.**	**2,503**		**8,357**	**4,775**	**2,545**	**18,180**	**61,636**
n.p.	n.p.	n.p.		6,577	358		597		1,515	2,471	16,824
n.p.	n.p.	3		11,141	n.p.		2,287	182	n.p.	3,746	17,696
	4,168	n.p.		5,551	n.p.		3,503	n.p.	n.p.	3,812	10,397
n.p.	**6,507**	**909**		**23,269**	**1,579**		**6,387**	**n.p.**	**n.p.**	**10,028**	**44,917**
n.p.	**1,049**	**n.p.**	**n.p.**	**n.p.**	**1,759**	**n.p.**	**1,607**	**n.p.**	**n.p.**	**5,482**	**14,065**
55,063	294,781	79,240	6,621	1,577,476	139,597	45,617	284,063	53,184	217,326	739,787	2,923,681

Table 11: Support offered by the R&D Tax Concession by field of research (based on ABS R&D survey results)

Field of Research	%
Mathematical sciences	0.42
Physical sciences	1.85
Chemical sciences	3.57
Earth sciences	3.21
Information systems and technologies	2.26
Computer software	8.59
Communications technologies	6.69
Other information, computers and communications technologies	4.98
Manufacturing and process technologies and engineering	15.58
Industrial biotechnology and food sciences	3.85
Material sciences and technologies	4.33
Other applied sciences and technologies	2.65
Mechanical and industrial engineering	12.97
Mining and mineral processing	17.33
Other general engineering	5.56
Biological sciences	1.28
Agricultural sciences	1.36
Medical and health sciences	3.40
Total natural sciences, technologies and engineering	**99.88**
Social sciences	n/a
Humanities	n/a
Total social sciences and humanities	n/a
Total	

Table 12: R&D claimed under the Tax Concession captured in the ABS R&D Survey by ANZSIC and field of research, 1996-97

	Mathematical sciences	Physical sciences	Chemical sciences	Earth sciences	Information systems & technologies	Computer software
Mining (including services to mining)			**n.p.**	**44,573**		**n.p.**
Manufacturing -						
Food, beverages and tobacco			6,876		n.p.	n.p.
Textile, clothing, footwear and leather			939			116
Wood and paper product	n.p.	n.p.	1,273		n.p.	
Printing, publishing and recorded media					n.p.	3,428
Petroleum, coal, chemical and associated product	n.p.	337	32,978	550	92	
Non-metallic mineral product		533	1,495	1,172	n.p.	68
Metal product	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
Motor vehicle and part and other transport equipment		n.p.	n.p.		n.p.	n.p.
Photographic and scientific equipment	n.p.	20,455	n.p.	481	n.p.	2,037
Electronic and electrical equipment and appliance	288	2,307	n.p.	18	6,278	36,360
Industrial machinery and equipment	n.p.	21	n.p.	n.p.	640	5,732
Other manufacturing	n.p.	n.p.	n.p.		n.p.	n.p.
Total manufacturing	**n.p.**	**52,629**	**75,510**	**4,411**	**10,290**	**n.p.**
Other industries -						
Wholesale and retail trade	312	n.p.	12,645	n.p.	5,239	27,779
Finance and insurance	n.p.				19,912	14,968
Property and business service	284	369	3,001	1,809	18,116	104,075
Scientific research	n.p.	n.p.	n.p.	4		n.p.
Other n.e.c.	57	n.p.	n.p.	41,349	12,507	n.p.
Total other industries	**n.p.**	**1,393**	**n.p.**	**44,996**	**55,774**	**185,878**
TOTAL ALL INDUSTRIES	12,273	54,022	104,240	93,980	66,064	251,141

Source: data specially provided by the ABS.
Note: 'n.p.' indicates that the figure cannot be published due to confidentiality constraints.

Table 12 (con't)

	Communications technologies	Other info computers & communications technologies	Manufacturing & process technologies	Industrial biotechnology & food sciences	Material sciences & technologies	Other applied sciences & technologies
Mining (including services to mining)		**n.p.**	**35,937**		**25,107**	**n.p.**
Manufacturing -						
Food, beverages and tobacco	63	85	61,162	101,573	n.p.	n.p.
Textile, clothing, footwear and leather			4,825		n.p.	1,449
Wood and paper product			56,354	n.p.	n.p.	
Printing, publishing and recorded media	n.p.	543	n.p.		n.p.	
Petroleum, coal, chemical and associated product	n.p.		9,556	671	9,425	6,243
Non-metallic mineral product		n.p.	5,197		5,994	218
Metal product	n.p.	n.p.	48,496		64,256	n.p.
Motor vehicle and part and other transport equipment	n.p.	5,678	77,675		770	n.p.
Photographic and scientific equipment	n.p.	2,757	8,510	97	n.p.	n.p.
Electronic and electrical equipment and appliance	38,520	87,161	18,790	n.p.	1,248	n.p.
Industrial machinery and equipment	n.p.	1,284	7,527	n.p.	271	n.p.
Other manufacturing		87	n.p.		422	
Total manufacturing	**50,458**	**n.p.**	**301,243**	**104,654**	**96,028**	**44,739**
Other industries -						
Wholesale and retail trade	23,195	8,447	27,760	n.p.	2,683	1,205
Finance and insurance	n.p.	n.p.	n.p.			
Property and business service	26,234	16,251	83,172	n.p.	n.p.	1,301
Scientific research	n.p.	n.p.	n.p.		n.p.	24,729
Other n.e.c.	91,956	4,172	6,299		1,284	1,320
Total other industries	**145,168**	**38,594**	**118,464**	**7,775**	**5,366**	**n.p.**
TOTAL ALL INDUSTRIES	195,627	145,526	455,644	112,429	126,501	77,494

Source: data specially provided by the ABS.
Note: 'n.p.' indicates that the figure cannot be published due to confidentiality constraints.

Table 12 (con't)

	Mechanical & industrial engineering	Mining & mineral processing	Other general engine-ering	Biological sciences	Agricultural sciences	Medical & health sciences
Mining (including services to mining)	**3,259**	**467,157**	**6,413**	**n.p.**	**4,124**	
Manufacturing -						
Food, beverages and tobacco	6,547		n.p.	6,868	8,261	2,578
Textile, clothing, footwear and leather	n.p.	n.p.	n.p.			n.p.
Wood and paper product	n.p.		1,464	n.p.	n.p.	
Printing, publishing and recorded media						
Petroleum, coal, chemical and associated product	3,768	n.p.	3,484	13,505	16,193	70,761
Non-metallic mineral product	4,684	n.p.	13,534	n.p.		
Metal product	18,202	20,025	29,791	n.p.	2,320	290
Motor vehicle and part and other transport equipment	249,933	n.p.	7,689		40	
Photographic and scientific equipment	n.p.		3,899	n.p.		7,539
Electronic and electrical equipment and appliance	25,814	152	56,558			
Industrial machinery and equipment	47,837	5,640	7,171	n.p.	n.p.	n.p.
Other manufacturing	845	n.p.	1,757		n.p.	n.p.
Total manufacturing	**360,886**	**31,695**	**126,600**	**22,571**	**28,491**	**81,562**
Other industries -						
Wholesale and retail trade	4,348	4,094	7,698	n.p.	3,649	6,329
Finance and insurance	346		n.p.	88		
Property and business service	6,406	2,359	9,156	1,668	1,583	421
Scientific research	1,046	n.p.	n.p.	10,334	n.p.	7,892
Other n.e.c.	2,959	n.p.	12,243	n.p.	n.p.	3,109
Total other industries	**15,105**	**7,941**	**29,593**	**n.p.**	**7,146**	**17,751**
TOTAL ALL INDUSTRIES	379,250	506,794	162,606	37,456	39,761	99,313

Source: data specially provided by the ABS.
Note: 'n.p.' indicates that the figure cannot be published due to confidentiality constraints.

Table 12 (con't)

	Total natural sciences, technologies & engineering	Social sciences	Humanities	Total social sciences & humanities	TOTAL
Mining (including services to mining)	**606,418**				**606,418**
Manufacturing -					
Food, beverages and tobacco	200,808				200,808
Textile, clothing, footwear and leather	10,484				10,484
Wood and paper product	74,190				74,190
Printing, publishing and recorded media	7,375				7,375
Petroleum, coal, chemical and associated product	169,796				169,796
Non-metallic mineral product	38,281	n.p.	n.p.	n.p.	40,778
Metal product	282,568				282,568
Motor vehicle and part and other transport equipment	355,772				355,772
Photographic and scientific equipment	55,063				55,063
Electronic and electrical equipment and appliance	294,781				294,781
Industrial machinery and equipment	79,240				79,240
Other manufacturing	6,590	n.p.		n.p.	6,621
Total manufacturing	**1,574,948**	**n.p.**	**n.p.**	**n.p.**	**1,577,476**
Other industries -					
Wholesale and retail trade	139,490	n.p.		n.p.	139,597
Finance and insurance	45,571	46		46	45,617
Property and business service	283,454	n.p.		n.p.	284,063
Scientific research	53,058		n.p.	n.p.	53,184
Other n.e.c.	217,182	n.p.		n.p.	217,326
Total other industries	**738,755**	**907**	**n.p.**	**1,033**	**739,787**
TOTAL ALL INDUSTRIES	2,920,120	n.p.	n.p.	n.p.	2,923,681

Source: data specially provided by the ABS.
Note: 'n.p.' indicates that the figure cannot be published due to confidentiality constraints.

5.3 Innovation Investment Fund

The Government introduced the Innovation Investment Fund (IIF) program to remove financing bottlenecks experienced by small technology based firms, ensuring that Australian innovations flow directly to the economy.

The program is intended to help small, technology based firms access venture capital for growth and expansion[23]. The intended effect of IIF funding is to reduce cost and risk to the venture capital investor through the mechanism of government contribution.

The first round of IIF funding, announced in March 1997, provided $130m on a 2:1 basis with private sector capital – thus creating a pool of $195m. Five IIF licenses have been granted and applications for second round of funding of approximately $91 million have been called for.

As of 30 November 1999 23 companies had received $37.5m from IIF fund managers. This represents approximately $25m in Commonwealth government funding.

5.4 ISR support for management capacity building

The functions undertaken within a firm that impact most in the innovation process are R&D, business planning and marketing. While a great deal of Commonwealth support for innovation is directed towards stimulating take up of R&D, there are a number of programs that *target management capacity*.[24] In general terms management capacity building programs can cover such things as:

- Competitive intelligence gathering and benchmarking;
- Business and technology strategy development;
- Technological diffusion and technology transfer;
- Investment appraisal;
- Network building;
- Project management; and
- R&D and innovation management.

These aspects of management capacity define a firm's ability to analyse what competitors are doing (and planning to do), develop responses and to plan and execute these responses. An effective management capacity to do this can have a major impact on the effectiveness of the firm's R&D investment. In this sense, Commonwealth support for management capacity building is an important complement to specific support for R&D and innovation.

Although the Commonwealth, and ISR in particular, runs a number of programs that target management capacity building they are not explicitly discussed in these terms. [25] Some of these programs have a specific industry focus, others have a more general focus. Management capacity building falls under the '*business and management*' field of research code.

Appendix B contains details on these ISR programs. The following table summarises information on the industries that receive this management capacity building support.

Table 13 details the management capacity building programs that are directly targeted at specific industries. Table 14 lists the management capacity building programs that have no particular sectoral focus.

There are, in addition, a number of programs that do not target a specific industry.

The Small Business Enterprise Culture Program and the New Enterprise Incentive Scheme within the Employment, Workplace Relations and Small Business Portfolio are targeted at building management and business skills.

23 Australia (1997) Investing for Growth,

24 'Capacity building' is a concept usually associated with World Bank efforts to improve the effectiveness and efficiency of public sector operations and policy formulation. The term is used here with specific reference to the private sector but refers to similar strategic and operational capabilities.

25 For example, the ISR Annual Report does not highlight the way in which so many of its AusIndustry programs are concerned with management capacity building.

Table 13: Commonwealth programs targeting management capacity building in specific industries [26]

Industry Sector (ANZSIC)	Commonwealth Programs (Dept)	Planned program expenditure
Agriculture, Forestry, Fishing and Hunting, Food, beverages & tobacco	Food and Fibre Chains Program (AFFA)	$9.2m (1999 to 2003)
	New Industries Development Program (AFFA)	$3.1m (1999 to 2003)
Textiles, clothing footwear & leather	TCF 2000 Development Package (ISR)	$728.5m over 3 years
Wood and paper products	Wood and Paper Industry Strategy Development Program (ISR)	$4.7m over 4 years (ending 30 June 2000)
Machinery and equipment	Shipbuilding and Marine Industries Program (ISR)	$143,500 (98-99)
Construction	Construction Industry Policy Program (ISR)	
	Urban Export Housing Program	
Communication Services	Partnerships for Development program	N.a.
	Information Technology On line	$1m p.a. $150,00 max
	Building on IT Strengths – IT Incubator Program	$78m over five years
Defence	Australian Industry Involvement program	
	Defence Industry Investment Recognition Scheme	

Table 14: ISR management capacity building programs that do not target a specific industry

Management Capacity Building Program	Budget Funds Committed
Business Networks Program	$3.58m (98/99) – discontinued
Business Information Service	$27m over 4 years
Commercialising Emerging Technologies Program (COMET)	$30m over 3 years starting 1999
Energy Efficiency Best Practice Program	$10.3m over 5 years from 1998
Feasibility Study Fund	$300,000 per annum
Venture Awareness	$1.2m over 3 years

26 This table excludes Commonwealth Programs that specifically target R&D – these are dealt with separately.

Emerging Industries

innovation

Rapid technological advances and convergence in areas such as microelectronics, computers, telecommunications, designer materials, robotics and biotechnology have had substantial impacts on industrial structure, productivity growth and employment.

R&D AND INNOVATION SUPPORT FOR EMERGING INDUSTRIES AND TECHNOLOGIES

Rapid technological advances and convergence in areas such as microelectronics, computers, telecommunications, designer materials, robotics and biotechnology have had substantial impacts on industrial structure, productivity growth and employment.

Industries are being transformed by the availability and application of new enabling technologies. New technologies have allowed for substantial productivity increases in traditional industries such as mining and manufacturing and have made possible expansion and new forms of delivery in the service industries, including retailing, education and health. They are also making possible the growth of global corporations as well as a capacity for small firms to develop and perform well in niche markets.

This emerging competitive situation may open up new opportunities for smaller economies by reducing the economies of scale associated with industrial R&D - provided that a distinctive and commercially appropriable set of modelling and simulation capabilities are developed in Australia. This will be an uphill task in Australia given the sophisticated capabilities built-up by the other 'science powers' as part of cold-war defence R&D – capabilities that are now starting to diffuse into the commercial world as a deliberate act of policy by overseas governments.

These changes, together with rapidly expanding demand for "knowledge workers" are well documented by economists [27], social commentators and consultants. What is of particular interest, however, is the capacity of emerging technologies to enable new innovative approaches to the R&D task itself. This issue is discussed below.

27 See for example, Lester Thurow (1999) Creating Wealth: New Rules for Individuals, Companies and Countries In a Knowledge based Economy,

6.1 Mathematical simulation capability as a key enabling technology in R&D cost and lead time reduction

Whilst considerable attention is currently paid to software and information technology in policy-circles much of the 'high profile' activity revolves around what are relatively low-level technological projects such as internet-based start-up firms. The technologies used by such firms do not in general involve pushing forward the 'technological frontier' so much as 'assembling' existing building blocks of software code in clever and highly commercial new configurations. [28]

It is therefore easy to overlook a fundamental transformation that is starting to take place globally in the way in which information technology is transforming goods producing activities. This transformation goes to the heart of what the R&D process actually involves – and opens up major new markets for knowledge-based service providers.

Research and experimental development (usually known as R&D) involves very different activities. 'Research' involves investigations into the way in which physical, chemical and biological processes and systems operate and can involve efforts to intervene in these processes. The knowledge created improves our understanding of how these processes work and what we can do to change the way in which they work. The terms basic research and applied research simply refer to differing extents to which there are specific objectives in mind in carrying out the research.

Experimental development is however a very different activity. Whereas research is concerned with creating new knowledge or learning what the options are for exploiting this new knowledge, *experimental development* involves investments made in order to translate this knowledge into actual products or services.

A commitment to invest in experimental development often involves committing relatively large sums of money in the expectation of making either a commercial return or meeting a strategic requirement (in the case of defence R&D and related public interest investments).

In the commercial world experimental development is a cost, and involves a time lag, that needs to be reduced. The faster and cheaper the experimental development process, the better the chances that the firm will beat its competitors by establishing an early commercial lead.

Experimental development therefore differs from research in the sense that the former (experimental development) is an investment cost associated with exploiting well defined options whereas the latter (research) involves creating and assessing these options. The 'return on investment' for research consequently tends to be very high because it creates options whereas the return on experimental development is lower because it involves exploiting options.

The significance of this distinction for emerging areas of economic activity, and for industrial competitiveness in existing industries, is that leading firms overseas are developing long-term strategies to significantly reduce their experimental development investment levels. In other words to produce products and services faster and cheaper by having to spend less on experimental development.

The way in which leading firms are seeking to do this is by applying research capabilities to the process of experimental development itself. By measuring, modelling and analysing experimental development, and subsequent full scale product development and market introduction processes, firms are seeking to find ways of cost-cutting and compressing development times. [29]

The technological basis of these efforts is to be able to substitute *theory for practice* in experimental development. Rather than build an experimental prototype to find out whether it works, and in some cases test it through destruction – which can be very costly – these firms are striving to develop sophisticated theoretical models that will allow them to reduce their need to actually build prototypes etc.

6.2 Trends in R&D investment

The bulk of business R&D expenditure is on experimental development. This indicates the scope for cost cutting that exists in industrial R&D. Some indicative figures of the dominance of experimental development amongst those OECD countries that collect data on this breakdown of R&D activity are provided in Table 15.

28 This often involves 'de-bottlenecking' existing business process and value adding chains, such as the way in which Amazon.com identified a new market based upon mediating directly between book purchasers and the firms operate warehouses of books awaiting distribution to bookshops etc.

29 See for example, (Howard and Matthews 1999 (Forthcoming)), also (Broughton, Deasley et al. 1995), also Matthews and Johston (forthcoming)

Table 15: Percentage breakdown of BERD by country

Percent of total BERD	Australia (96)	Austria (93)	UK (92)	USA (95)	Portugal (95)	Japan (95)	Italy (93)	France (94)
Basic Research	4.87	4.40	3.05	5.44	1.49	6.64	2.61	4.77
Applied Research	24.23	36.69	21.56	18.80	39.48	22.05	41.50	25.13
Experimental Development	70.90	56.20	70.67	75.76	59.03	71.31	55.89	70.10
Not specified	0.00	2.72	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: OECD Basic Science and Technology Statistics with further analysis by Howard Partners

These figures, which are for the most recent years available for each country and are influenced by differences in the mix of industries. They are therefore not strictly comparable between countries for detailed purposes. However, they do indicate just how dominant experimental development expenditure is in the business enterprise sector's (BERD) internal R&D effort. It is also clear that Australia's pattern of BERD expenditure by type of R&D is in line with apparent international norms – including the proportion of business resources devoted to basic research performed within the firm.

Industries like the aerospace industry lead the way in efforts to reduce experimental development expenditure levels, with automobile and civil engineering companies also making strong efforts (the latter because they tend to produce 'one off' products where the experimental and actual construction work overlap).

What is particularly interesting is that the efforts to (eventually) reduce experimental development costs may well be helping to drive up experimental development investment. This is because firms are seeking to improve the 'feed-back' links between their current experimental development activities and their research aimed at the theory and modelling capability improvements that will eventually replace much experimental development activity. In some cases this involves deliberately exploring a wider range of (expensive) experimental configurations in order to provide data for use in theory and model building.

These trends in R&D investment are not particularly well documented in the literature on R&D and innovation at present, however they are clear in the engineering literature and in industry-driven research strategies. [30]

There are a number of policy implications that fall out from this aspect of R&D investment rationale. These are as follows:

- Policy initiatives to stimulate industry-financed R&D investment will better facilitate long-term competitiveness if they facilitate the development of capabilities that will allow theoretical models to be substituted for key aspects of experimental development activity;
- There is growing scope for productively linking public sector research to industry R&D via reducing experimental development costs for industry;
- New areas of private sector activity are likely to open up as part of this transformation of R&D investment dynamics – with important implications for the growth of producer services;
- Other countries can draw upon substantial government investment in defence R&D, much of which involves developing sophisticated modelling capabilities, in order to assist industrial competitiveness in relation to experimental development. However, Australia's expenditure in this area is relatively modest.

30 (Broughton, Deasley et al. 1995).

6.3 Emerging markets for technical services

The preceding discussion of emerging simulation technologies and their crucial role in the R&D process highlights one area of future service sector growth. We are already witnessing the emergence of 'services to mining' associated with this sort of technology, a trend re-enforced by CRC activity on ore deposit characterisation and related modelling. [31]

Whilst there is nothing new in software-based firms providing specialist technical services to other industries, there is significance in this emerging area of activity for overall patterns of R&D and new product introduction investment (the activities involved in taking a product to market).

Care must be taken in interpreting economic statistics on the growth of scientific and technical services because, as we have pointed out earlier in this paper, incorporated CRCs are classified by the ABS to that sector. As a result, the growth of this area of services is partly due to Commonwealth funding of CRCs rather than a solely private sector-driven move. Nevertheless, there clearly is an emerging market for technical research services and this market is expected to grow in the future.

Aside from the unintended impact on service sector statistics of the CRC program there does not, however, appear to be any Commonwealth R&D/innovation support targeted at firms seeking to develop these technical and research services. Commercially intended Commonwealth R&D support is fairly heavily focused on product producing industries as opposed to the fundamental enabling technologies that cut across industries and that can be delivered by service sector firms.

6.4 Environmental technologies and renewable energy

The environmental industries are widely believed to be a major area of industrial growth in the future. For example, the US Congress has identified a range of environmental technologies as being of such critical importance to the US that they must be retained in the US. These technologies are concerned with monitoring and assessing environmental quality, pollution control, and the remediation and restoration of environmental quality. [32]

There is little doubt that environmental technologies, and emerging industries based upon these technologies, provide major opportunities for export growth.

Some initial scope for selling environmental products, technologies and services overseas lies in tapping into international aid programs (such as the World Bank, UN Development Program etc). However, the longer term potential will lie in host government funding and in sales to private businesses subject to increasing environmental regulation, and community and commercial pressures.

The ability to grow industries using new environmental technologies in Australia is likely to rest upon an effective integration of the sciences involved and the *engineering and technology* necessary to deliver this science in marketed products and services.

The development of this engineering and technology capability involves experimental development, product development and market introduction processes. It is consequently important for Australia to have *both* the complementary assets of the underlying science *and* the technology and engineering capability to deliver this scientific knowledge.

Australia has a good reputation for its science in areas relevant to the environment. Much of this science is performed in the CSIRO and in universities. Relevant science and technology is also being carried out via the RDCs and in the CRCs.

The ability of the private sector to exploit this public sector science base is determined by two factors. Firstly, by firms' abilities to finance and execute experimental development and product development processes. Secondly, by the 'match' between the types of investigation carried out in the public sector and industry requirements for developing commercial applications using environmental technologies.

In this respect, all three policy dilemmas are relevant, but particularly the issue of problem diagnosis versus solution generation. If the public sector science base is heavily oriented towards researching environmental *problems* rather than developing potential *solutions* to these problems then it will be all the more difficult to grow environmental 'clean technology' industries.

How 'healthy' is Australia's R&D effort in the environmental area?

31 Doctoral research is currently being carried out on this issue by Sarah Vandermark at the ANU.

32 US Government 'National Critical Technologies' list, 1995.

The composition of the 'field of research' classification makes it difficult to detect specific research areas that are concerned with developing environmental technologies. This is because they tend to be cross-cutting and involve such things as analytical chemistry, filter and membranes technology, combustion behaviour etc.

On the other hand, the socio-economic objectives classification allows environmental R&D objectives to be clearly identified. The following discussion of environmental R&D funded by the Commonwealth as identified by socio-economic objectives refers to data contained in appendix A.

In 1996-97 the Commonwealth funded a total of $8.975m of R&D targeting *energy conservation and efficiency* with $3.056m being performed in Commonwealth government agencies and $4.804 being performed in the Higher Education sector. In addition, $934,000 is funded by the Commonwealth and performed in the business sector. This compares to total Commonwealth funding on energy supply of $38.166m.

Waste management and re-cycling is another area of environmental technology. In this case the Commonwealth funded a total of $6.432m, with $4.201 being performed in Commonwealth government research agencies, and $1.909 in the Higher Education sector, compared to $321,000 performed in the business sector.

With respect to *renewable energy* the Commonwealth funds a total of $7.580m with the bulk of the expenditure going on *solar-photoelectric* and *geothermal* applications. In addition, there was another $21.641m of R&D in 1996-97 performed mainly in the business sector.[33]

There is other environmentally related R&D funded by the Commonwealth but this lies in '*diagnostic research*' and policy-related areas and is not directly related to developing technological applications. Total Commonwealth funding for these other areas of environmental R&D amounts to $404.283m. [34]

Further research is required to determine whether the balance between funding for problem diagnosis versus solution development is appropriate, including assessing the marginal benefits to additional funding on each side of the equation.

6.5 Space and aerospace

The Commonwealth's funding of space and aerospace R&D is best identified via field of research classified data. This shows that a total of $27.216m was funded in 1996-97 (see Table 2 in Appendix A). This R&D is in fact concentrated in the *aeronautical engineering* and *remote sensing* areas.

Although this is a low level of expenditure it is slightly higher than the combined Commonwealth R&D funding of '*energy conservation and efficiency*', '*waste management and re-cycling*' and '*renewable energy*'.

6.6 Pharmaceuticals

The Commonwealth funds $31.89m of R&D into human pharmaceuticals and $11.213m into veterinary pharmaceuticals. In this case the private sector funds some 3.8 times more R&D than the Commonwealth – assisted significantly by the Factor F Program.

33 ABS R&D statistics, provided to Howard Partners by the ABS for research purposes.

34 See figures for 'environmental knowledge' ($279.858), 'environmental aspects of economic development' ($86.756), 'environmental management and other aspects' ($37.669) in the appendix.

Scale of Funding

Scale of Funding

Australia is a small country in economic terms and the question of the effectiveness of the concentration of support given the existence of economies of scale in R&D is therefore of particular importance.

THE SCALE OF COMMONWEALTH R&D FUNDING

Australia is a small country in economic terms and the effectiveness of the concentration of support given the existence of economies of scale in R&D is therefore of particular importance.

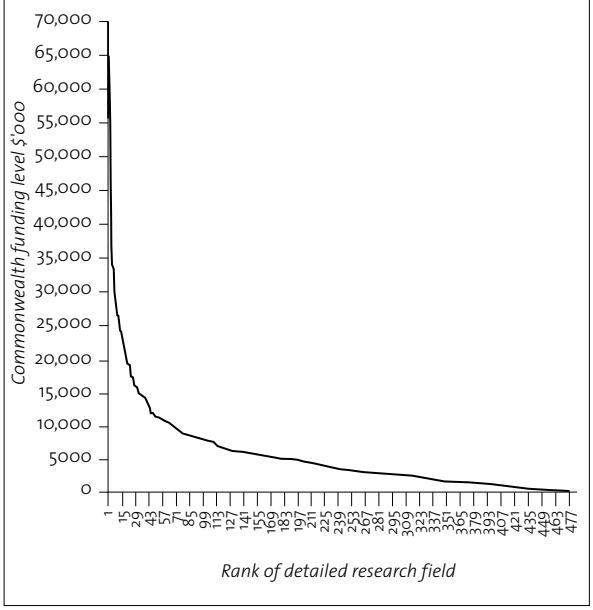
At present, Commonwealth supported R&D performed in public sector research organisations and in universities is spread fairly thinly over both socio-economic objectives and fields of research.

This is indicated in Figure 9, which shows ranked detailed field of research codes for Commonwealth funded R&D. These figures exclude R&D funded by levies.

The average level of Commonwealth funding per detailed research field is $5.5m. As can be seen, there are relatively few detailed research fields that receive more than $15m in Commonwealth R&D funding. For the socio-economic objectives of the R&D the average level of Commonwealth R&D funding is $5.3m (i.e. very similar).

This means that the low levels of Commonwealth R&D funding for the emerging industries and technologies discussed above are not unusually low – most research fields receive comparably low levels of funding.

Figure 9: Commonwealth funded R&D at detailed field of research level (ranked), 1996-97



Conclusions

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This study has pieced together much of the available evidence on the nature and extent of Commonwealth support for R&D and for innovation.

CONCLUSIONS

This study has pieced together much of the available evidence on the nature and extent of Commonwealth support for R&D and for innovation.

In *methodological terms* the study has demonstrated that it is possible to monitor the industries and technologies supported by the Commonwealth provided that the socio-economic objectives (SE-O) framework is used as the 'backbone' of the monitoring framework. Use of the SE-O framework allows Commonwealth funded R&D performed outside of the business sector to be directly related to ANZSIC sectors.

The wide-spread classification of program-specific data by SE-O would significantly improve the Commonwealth government's ability to trace its impact upon R&D expenditure and innovative performance.

In *policy terms* this study has highlighted the way in which the current systems for delivering Commonwealth support for R&D tend to disperse R&D support in small amounts across a wide range of SE-O and fields of research.

The R&D Tax Concession stands out in the sense that it probably facilitates large-scale experimental development and helps to counter-act the dispersion of R&D investment. Given that the emerging industries analysed in this study are tending to exhibit greater private sector R&D investment than Commonwealth R&D investment, the R&D Tax Concession can be expected to become increasingly important as a means of facilitating R&D in emerging industries.

Cases in which emerging industries are still heavily dependent upon Commonwealth funded R&D may be the cause for some concern. Although the R&D Start program provides a useful potential means of launching significant increases in R&D investment in emerging industries its submission-based operation can make this a risky process.

To what extent does better policy information relating to innovation lead to better innovation?

The sort of exercise carried out here inevitably raises questions about the 'pay-off' to an increased investment in tracking the nation's R&D effort, and the Commonwealth's contribution in particular. It would be easy, but perhaps naive, to make a set of far-reaching technical recommendations designed to allow a more accurate picture of the allocation of Commonwealth R&D support to be produced.

The increased 'reporting burden' would have to be justified on the basis of better outcomes from modified resource allocations. In a pluralistic market with a merit based R&D resource allocation system significant modifications to resource allocations are unlikely to occur – and may not be beneficial if they did occur.

In a sense, the most important conclusion for policy to arise from this study is that the allocation of the Commonwealth's R&D support may be too thinly spread to achieve sufficient economies of scale to commercialise research. In particular, there may be under-investment in the key stage of experimental development. This may limit the ability to grow emerging industries in Australia.

The Australian system facilitates a wide scope of basic and applied research but does not facilitate *scale-dependent* experimental development. Whilst the funding of experimental development is largely the province of the private sector (except for defence industries)a vicious circle can exist in which insufficient levels of experimental development and product development activity leads to insufficient 'feed-back' R&D linking backwards to applied and basic research. Weak feed-back relationships reduce the overall 'yield' on R&D investment and focus.

Countries with high levels of 'mission oriented' R&D funded by government in defence and selected areas(e.g. NASA in the US) are able to fund experimental development thereby reducing the risk faced by business. The transfer of technologies from such mission oriented R&D, usually on preferential terms to domestic firms, assists in the growth of emerging areas of economic activity. Australian firms do not get the benefit of such experimental development funding and subsequent technology transfer.

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Appendices

Appendices

Appendix A: Additional data

Appendix B: Other information

Appendix Table 1: Commonwealth R&D funding by socio-economic objective and performing sector, 1996-97 (excludes levy funded R&D)

	1996-97 $'000					
Socio-economic objective	**Total**	**Commonwealth Government**	**State Government**	**Higher Education**	**Private non profit**	**Business Enterprise**
10100 DEFENCE	237,383	227,717	3,489	6,177	0	n.p.
20100 FIELD CROPS	77,535	36,153	2,460	38,708	0	214.4
20200 HORTICULTURAL CROPS	24,190	10,048	516	13,625	0	n.p.
20300 FORESTRY	29,137	17,744	2,788	8,606	0	n.p.
20400 PRIMARY PRODUCTS FROM PLANTS	2,561	352	223	1,987	0	
TOTAL: PLANT - PRODUCTION AND PRIMARY PRODUCTS	133,423	64,297	5,987	62,925	0	214
30100 LIVESTOCK	75,856	43,464	1,127	31,265	0	
30200 PASTURE, BROWSE AND FODDER CROPS	18,695	14,838	287	3,561	9	n.p.
30300 FISHING	27,456	17,611	5,227	4,618	0	
30400 PRIMARY PRODUCTS FROM ANIMALS	7,661	3,939	412	3,311	0	
TOTAL: ANIMAL - PRODUCTION AND PRIMARY PRODUCTS	129,668	79,851	7,053	42,755	9	0
40100 EXPLORATION	43,661	34,181	43	9,436	0	n.p.
40200 PRIMARY MINING AND EXTRACTION PROCESSES	14,239	6,056	0	7,841	0	341
40300 FIRST STAGE TREATMENT OF ORES AND MINERALS	30,051	20,857	0	9,194	0	n.p.
TOTAL: MINERAL RESOURCES EXCL. ENERGY	87,950	61,094	43	26,472	0	341
50100 EXPLORATION	70,613	65,965	0	4,648	0	n.p.
50200 MINING AND EXTRACTION	19,995	13,545	20	6,430	0	n.p.
50300 PREPARATION AND SUPPLY OF ENERGY SOURCE MINERALS	1,415	247	0	1,169	0	n.p.
59900 OTHER	355	0	0	355	0	
TOTAL: ENERGY RESOURCES	92,378	79,756	20	12,602	0	0
60100 ENERGY TRANSFORMATION	11,753	7,450	63	4,239	0	n.p.
60200 RENEWABLE ENERGY	7,580	2,111	0	4,641	0	828.28

Socio-economic objective	1996-97 $'000 Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
60300 ENERGY DISTRIBUTION	8,244	3,312	0	4,932	0	n.p.
60400 CONSERVATION AND EFFICIENCY	8,975	3,056	180	4,804	0	934.4
69900 OTHER	1,615	1,324	0	279	0	12
TOTAL: ENERGY SUPPLY	38,166	17,253	243	18,895	0	1,775
70100 PROCESSED FOOD PRODUCTS AND BEVERAGES	31,076	18,175	3	11,193	0	1704.8
70200 FIBRE PROCESSING AND TEXTILES; FOOTWEAR AND LEATHER PRODUCTS	17,303	16,426	0	876	0	n.p.
70300 WOOD, WOOD PRODUCTS AND PAPER	9,429	6,842	60	2,283	0	244
70400 HUMAN PHARMACEUTICAL PRODUCTS	31,890	25,354	539	4,689	206	1102.4
70500 VETERINARY PHARMACEUTICAL PRODUCTS	11,213	9,068	29	2,009	0	107
70600 AGRICULTURAL CHEMICALS	2,468	2,033	0	434	0	n.p.
70700 INDUSTRIAL CHEMICALS AND RELATED PRODUCTS	19,534	13,296	0	6,238	0	n.p.
70800 BASIC METAL PRODUCTS (INCL. SMELTING)	12,214	6,890	0	3,633	0	1691.7
70900 CERAMICS, GLASS AND INDUSTRIAL MINERAL PRODUCTS	9,362	5,940	0	3,347	0	75.15
71000 FABRICATED METAL PRODUCTS	11,038	7,003	0	4,035	0	n.p.
71100 TRANSPORT EQUIPMENT	11,893	4,720	60	7,114	0	n.p.
71200 COMPUTER HARDWARE AND ELECTRONIC EQUIPMENT	9,596	62	0	7,665	41	1827.9
71300 COMMUNICATION EQUIPMENT	13,799	5,778	0	8,021	0	n.p.
71400 INSTRUMENTATION	22,925	13,326	0	9,180	129	289.98
71500 MACHINERY AND EQUIPMENT	14,676	7,549	0	5,610	0	1517.1
79900 OTHER MANUFACTURED PRODUCTS	11,652	9,123	0	1,725	0	804.4
TOTAL: MANUFACTURING	240,066	151,584	691	78,051	376	9,364
80100 PLANNING	6,552	2,449	0	4,102	0	
80200 DESIGN	15,467	4,164	0	11,299	0	3.5
80300 MATERIALS PERFORMANCE AND PROCESSES	16,593	10,449	10	6,134	0	n.p.

Socio-economic objective	1996-97 $'000 Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
80400 CONSTRUCTION PROCESSES	5,823	2,156	0	3,667	0	n.p.
80500 BUILDING MANAGEMENT AND SERVICES	5,231	3,353	0	1,878	0	n.p.
TOTAL: CONSTRUCTION	49,667	22,572	10	27,081	0	4
90100 GROUND TRANSPORT	11,189	5,369	0	5,820	0	n.p.
90200 WATER TRANSPORT	1,123	599	0	524	0	n.p.
90300 AIR TRANSPORT	988	656	0	246	0	86
99900 OTHER TRANSPORT	1,649	315	0	1,335	0	n.p.
TOTAL: TRANSPORT	14,949	6,938	0	7,925	0	86
100100 COMPUTER SOFTWARE AND SERVICES	50,093	22,668	133	25,036	67	2188.4
100200 OTHER INFORMATION SERVICES	4,329	1,256	41	3,033	0	n.p.
100300 COMMUNICATION SERVICES	14,861	4,342	0	10,018	0	501.7
TOTAL: INFORMATION AND COMMUNICATION SERVICES	69,283	28,265	175	38,087	67	2,690
110100 ELECTRICITY, GAS AND WATER SERVICES AND UTILITIES	5,854	3,518	0	1,699	0	636.2
110200 WASTE MANAGEMENT AND RECYCLING	6,432	4,201	0	1,909	0	321
110300 WHOLESALE AND RETAIL TRADE	747	0	0	747	0	n.p.
110400 FINANCE, PROPERTY AND BUSINESS SERVICES	5,247	212	0	5,035	0	n.p.
119900 OTHER COMMERCIAL SERVICES	3,821	131	0	3,690	0	
TOTAL: COMMERCIAL SERVICES	22,101	8,062	0	13,082	0	957
120100 MACROECONOMIC ISSUES	19,247	5,230	0	14,017	0	
120200 MICROECONOMIC ISSUES	25,524	11,387	1	14,069	67	
120300 INTERNATIONAL TRADE ISSUES	12,300	3,519	41	8,740	0	n.p.
120400 MANAGEMENT AND PRODUCTIVITY ISSUES	31,454	2,994	0	28,326	134	
120500 MEASUREMENT STANDARDS AND CALIBRATION SERVICES	10,421	9,789	0	632	0	
129900 OTHER ECONOMIC ISSUES	11,738	628	1	11,110	0	n.p.

Socio-economic objective	1996-97 $'000 Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
TOTAL: ECONOMIC FRAMEWORK	110,684	33,547	43	76,893	202	0
130100 CLINICAL (ORGANS, DISEASES AND CONDITIONS)	272,839	8,407	20,561	211,881	31,990	n.p.
130200 PUBLIC HEALTH	98,285	6,254	5,414	78,082	8,535	n.p.
130300 HEALTH AND SUPPORT SERVICES	52,831	2,129	5,403	44,578	194	525.5
TOTAL: HEALTH	423,954	16,790	31,378	334,541	40,719	526
140100 EARLY CHILDHOOD AND PRIMARY EDUCATION	9,277	0	110	8,844	324	
140200 SECONDARY EDUCATION	17,655	0	263	17,392	0	
140300 HIGHER EDUCATION	30,978	959	77	29,942	0	
140400 TECHNICAL AND FURTHER EDUCATION	2,585	178	340	2,068	0	
140500 SPECIAL EDUCATION	5,334	18	93	5,183	40	
149900 OTHER EDUCATION	34,185	1,318	593	31,818	457	
TOTAL: EDUCATION AND TRAINING	100,015	2,473	1,475	95,247	821	0
150100 COMMUNITY SERVICES	20,170	7,096	233	12,773	68	
150200 PUBLIC SERVICES	15,467	7,371	109	7,987	0	n.p.
150300 ART, SPORT AND RECREATION	16,976	1,437	58	15,481	0	n.p.
150400 INTERNATIONAL RELATIONS	9,450	2,698	0	6,752	0	
150500 ETHICAL ISSUES	2,797	0	0	2,763	34	
159900 OTHER SOCIAL DEVELOPMENT AND COMMUNITY SERVICES	16,290	2,693	0	13,597	0	
TOTAL: SOCIAL DEVELOPMENT AND COMMUNITY SERVICES	81,150	21,295	399	59,354	102	0
160100 CLIMATE AND ATMOSPHERE	69,185	49,500	326	19,359	0	
160200 OCEAN	19,735	13,161	132	6,442	0	
160300 WATER	34,798	19,681	1,312	13,595	0	209.85
160400 LAND	42,878	27,756	1,331	13,790	0	n.p.
160500 NATURE CONSERVATION	72,477	34,289	6,178	31,709	301	n.p.

Socio-economic objective	1996-97 $'000 Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
160600 SOCIAL ENVIRONMENT	32,405	22,892	683	8,770	4	56.75
169900 OTHER ENVIRONMENTAL KNOWLEDGE	8,381	0	0	8,314	0	67.1
TOTAL: ENVIRONMENTAL KNOWLEDGE	279,858	167,279	9,962	101,980	305	334
170100 PLANT PRODUCTION AND PLANT PRIMARY PRODUCTS (INCL. FORESTRY)	31,410	22,966	311	8,133	0	
170200 ANIMAL PRODUCTION AND ANIMAL PRIMARY PRODUCTS (INCL. FISHING)	15,297	9,282	21	5,995	0	n.p.
170300 MINERAL RESOURCES (EXCL. ENERGY)	11,955	11,362	3	590	0	n.p.
170400 ENERGY RESOURCES	2,910	2,072	0	839	0	
170500 ENERGY SUPPLY	4,241	3,641	13	587	0	n.p.
170600 MANUFACTURING	7,006	6,330	0	422	0	254
170700 CONSTRUCTION	1,414	213	0	1,200	0	
170800 TRANSPORT	4,237	3,420	21	795	0	n.p.
170900 INFORMATION AND COMMUNICATION SERVICES	2,221	803	54	1,364	0	
171000 COMMERCIAL SERVICES	1,865	1,449	0	415	0	n.p.
171100 ENVIRONMENTAL ECONOMIC FRAMEWORK	4,201	1,057	21	3,123	0	
TOTAL: ENVIRONMENTAL ASPECTS OF ECONOMIC DEVELOPMENT	86,756	62,595	444	23,463	0	254
180100 ENVIRONMENTAL MANAGEMENT	27,636	7,003	1,432	18,662	0	538.76
189900 OTHER ENVIRONMENTAL ASPECTS	10,033	8,301	0	1,732	0	
TOTAL: ENVIRONMENTAL MANAGEMENT & OTHER ASPECTS	37,669	15,304	1,432	20,395	0	539
190100 MATHEMATICAL SCIENCES	44,258	1,907	0	42,351	0	
190200 PHYSICAL SCIENCES	104,934	18,877	0	86,057	0	n.p.
190300 CHEMICAL SCIENCES	74,037	406	0	73,521	0	111
190400 EARTH SCIENCES	44,954	8,295	28	36,631	0	n.p.
190500 INFORMATION, COMPUTER AND COMMUNICATION TECHNOLOGIES	70,888	685	90	70,089	0	24.4
190600 APPLIED SCIENCES AND TECHNOLOGIES	41,842	1,240	22	40,580	0	n.p.

Socio-economic objective	1996-97 $'000 Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
190700 GENERAL ENGINEERING	56,616	400	11	56,205	0	
190800 BIOLOGICAL SCIENCES	155,261	2,493	878	151,889	0	n.p.
190900 AGRICULTURAL SCIENCES	16,823	162	0	16,661	0	
191000 MEDICAL AND HEALTH SCIENCES	94,172	1,427	721	92,024	0	n.p.
TOTAL: NATURAL SCIENCES, TECHNOLOGIES & ENGINEERING	703,785	35,891	1,750	666,008	0	135
200100 SOCIAL SCIENCES	162,306	2,833	56	159,418	0	
200200 HUMANITIES	161,681	0	50	161,631	0	
TOTAL: SOCIAL SCIENCES AND HUMANITIES	323,988	2,833	106	321,049	0	0

Note: Total commonwealth funded R&D (excluding levy sourced R&D) amounts to $3.3bn. Of this, $86.7m cannot be traced due to confidentiality constraints. In such cases the figures are indicated by 'n.p.'

Appendix Table 2: Commonwealth R&D funding by field of research and performing sector, 1996-97 (excludes levy funded R&D)

	1996-97 $'000					
Field of Research	**Total**	**Commonwealth Government**	**State Government**	**Higher Education**	**Private non profit**	**Business Enterprise**
10100 PURE MATHEMATICS	13,655	16	0	13,639	0	
10200 APPLIED MATHEMATICS	21,137	6,749	0	14,388	0	n.p.
10300 STATISTICS	35,196	22,532	7	12,656	0	n.p.
19900 OTHER MATHEMATICAL SCIENCES	3,445	442	6	2,996	0	
20100 ASTRONOMICAL SCIENCES	35,946	19,536	0	16,410	0	
20200 THEORETICAL AND CONDENSED MATTER PHYSICS	24,983	1,432	0	23,551	0	
20300 ATOMIC, MOLECULAR, NUCLEAR, PARTICLE AND PLASMA PHYSICS	20,195	3,113	0	17,082	0	n.p.
20400 ACOUSTIC AND OPTICAL PHYSICS	51,719	39,429	0	12,136	155	285
29900 OTHER PHYSICAL SCIENCES	25,833	15,796	159	9,869	10	n.p.
30100 PHYSICAL CHEMISTRY (INCL. THEORETICAL AND STRUCTURAL)	38,639	10,532	41	28,005	62	314
30200 INORGANIC CHEMISTRY	12,799	320	25	12,455	0	n.p.
30300 ORGANIC CHEMISTRY	39,436	16,442	67	22,655	272	246
30400 ANALYTICAL CHEMISTRY	22,022	16,049	240	5,732	0	n.p.
39900 OTHER CHEMICAL SCIENCES	24,317	16,448	104	7,765	0	438
40100 GEOLOGY	127,000	102,038	228	24,734	0	n.p.
40200 GEOPHYSICS	34,210	23,771	4	10,435	0	n.p.
40300 GEOCHEMISTRY	26,462	15,808	0	10,654	0	
40400 OCEANOGRAPHY	20,647	15,228	0	5,418	0	
40500 HYDROLOGY	15,007	6,937	261	7,809	0	
40600 ATMOSPHERIC SCIENCES	39,581	30,006	709	8,866	0	n.p.
49900 OTHER EARTH SCIENCES	28,794	16,498	594	11,702	0	n.p.
50100 INFORMATION SYSTEMS AND TECHNOLOGIES	102,947	65,338	439	37,065	105	n.p.
50200 COMPUTER HARDWARE	4,534	687	0	3,847	0	n.p.

Field of Research	1996-97 $'000 Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
50300 COMPUTER SOFTWARE	36,603	14,434	192	21,977	0	3,198
50400 COMMUNICATION TECHNOLOGIES	64,478	35,693	0	28,785	0	971
59900 OTHER INFORMATION, COMPUTER AND COMMUNICATION TECHNOLOGIES	54,098	37,026	90	16,941	41	503
60100 AEROSPACE TECHNOLOGIES AND ENGINEERING	27,216	14,419	3,569	9,228	0	123
60200 MANUFACTURING AND PROCESS TECHNOLOGIES AND ENGINEERING	39,868	27,849	0	12,019	0	3,765
60300 INDUSTRIAL BIOTECHNOLOGY AND FOOD SCIENCES	29,239	17,419	0	11,820	0	853
60400 MATERIAL SCIENCES AND TECHNOLOGIES	89,542	66,356	16	23,130	41	1,283
69900 OTHER APPLIED SCIENCES AND TECHNOLOGIES	27,537	19,576	0	7,961	0	1,741
70100 MECHANICAL AND INDUSTRIAL ENGINEERING	37,065	20,246	212	16,607	0	1,450
70200 CHEMICAL ENGINEERING	23,685	6,872	0	16,812	0	328
70300 MINING AND MINERAL PROCESSING	49,578	34,996	3	14,579	0	336
70400 CIVIL ENGINEERING	34,575	5,127	73	29,350	26	716
70500 ELECTRICAL AND ELECTRONIC ENGINEERING	26,018	3,844	0	22,174	0	3,264
79900 OTHER GENERAL ENGINEERING	24,865	11,805	0	13,034	26	465
80100 BIOCHEMISTRY	36,108	9,687	256	24,899	1,266	10
80200 GENETICS, MOLECULAR BIOLOGY AND BIOTECHNOLOGY	114,578	41,841	3,618	62,226	6,893	991
80300 MICROBIOLOGY	20,204	9,614	366	10,212	13	233
80400 BOTANY	36,771	12,364	484	23,908	14	
80500 ZOOLOGY	32,234	12,167	1,038	18,784	245	13
80600 ECOLOGY	77,143	39,361	4,930	32,818	35	
89900 OTHER BIOLOGICAL SCIENCES	36,823	10,158	520	25,782	362	
90100 SOIL AND WATER SCIENCES	25,890	15,816	1,416	8,642	16	n.p.
90200 CROP AND PASTURE PRODUCTION	50,327	30,777	3,054	16,496	0	148
90300 HORTICULTURE	8,628	3,364	491	4,773	0	472

Field of Research	1996-97 $'000 Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
90400 ANIMAL PRODUCTION	35,002	16,783	943	17,276	0	875
90500 VETERINARY SCIENCES	31,887	20,293	355	11,239	0	n.p.
90600 FORESTRY SCIENCES	40,305	26,830	3,516	9,960	0	39
90700 FISHERIES SCIENCES	23,446	12,676	5,513	5,258	0	n.p.
99900 OTHER AGRICULTURAL SCIENCES	14,676	8,030	217	6,394	36	67
100100 IMMUNOLOGY	31,979	475	4,709	16,183	10,612	n.p.
100200 MEDICAL BIOCHEMISTRY AND CLINICAL CHEMISTRY	15,355	531	978	11,099	2,746	n.p.
100300 MEDICAL MICROBIOLOGY	17,581	238	5,976	8,513	2,854	n.p.
100400 PHARMACOLOGY	20,122	0	575	19,145	402	n.p.
100500 PHYSIOLOGY	20,540	1,255	549	17,527	1,209	n.p.
100600 NEUROSCIENCES	31,331	2,385	200	26,318	2,429	n.p.
100700 CLINICAL SCIENCES	144,813	4,371	9,864	116,533	14,044	42
100800 PUBLIC HEALTH RESEARCH	58,456	10,627	4,020	42,763	1,045	8
100900 HEALTH SERVICES RESEARCH	35,878	361	1,920	33,443	154	n.p.
109900 OTHER MEDICAL AND HEALTH SCIENCES	12,700	1,018	58	11,070	554	n.p.
110100 ACCOUNTING AND FINANCE	18,335	0	0	18,335	0	n.p.
110200 ECONOMICS	78,656	29,820	24	48,811	0	n.p.
110300 BUSINESS STUDIES	38,053	1,888	50	35,964	151	0
110400 POLITICAL SCIENCES AND PUBLIC POLICY	28,909	2,096	32	26,680	101	0
110500 ARCHITECTURE AND URBAN ENVIRONMENT	14,793	1,109	18	13,667	0	0
110600 SOCIOLOGY	26,823	3,522	31	23,270	0	0
110700 ANTHROPOLOGY	50,037	2,514	363	47,161	0	0
110800 SOCIAL STUDIES	19,246	1,257	81	17,908	0	0
110900 HUMAN GEOGRAPHY	8,545	612	0	7,934	0	0

Field of Research	1996-97 $'000 Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
111000 POPULATION STUDIES	7,997	2,475	0	5,522	0	0
111100 LAW	38,513	4,668	51	33,795	0	0
111200 PSYCHOLOGY	46,544	4,700	66	41,584	195	0
111300 EDUCATION	79,170	0	1,368	75,854	1,947	0
111400 MEDIA AND COMMUNICATION STUDIES	6,958	140	1	6,779	38	0
119900 OTHER SOCIAL SCIENCES	7,862	1,060	31	6,771	0	0
120100 LANGUAGE AND LITERATURE	52,649	0	0	52,649	0	0
120200 HISTORICAL STUDIES	41,128	0	37	41,091	0	0
120300 ARCHAEOLOGY AND CLASSICAL STUDIES	7,421	0	123	7,298	0	0
120400 ARTS	31,178	0	0	31,178	0	0
120500 DESIGN STUDIES	3,451	0	0	3,345	106	0
120600 PHILOSOPHY	12,187	0	0	12,168	19	0
120700 RELIGIOUS STUDIES	3,648	0	0	3,648	0	0
120800 HISTORY AND PHILOSOPHY OF SCIENCE AND MEDICINE	2,029	0	0	2,029	0	0
129900 OTHER HUMANITIES	10,359	1,670	0	8,689	0	0

Note: Total commonwealth funded R&D (excluding levy sourced R&D) amounts to $3.3bn. Of this, $86.7m cannot be traced due to confidentiality constraints. In such cases the figures are indicated by 'n.p.'

Appendix Table 3: Breakdown of overall commercially intended R&D and underpinning research supported by the Commonwealth and the imputed cost of the R&D Tax Concession, 1996-97 ($m)

ANZSIC	Total Commonwealth R&D support	Commonwealth R&D funding excl. levy funded component	Levy-based component of Commonwealth R&D funding	Imputed cost of R&D tax concession
Agriculture, Forestry & Fishing	406	310	91	6
Mining	297	194	3	101
Food, Beverage & Tobacco Mfg	58	31	3	23
TCF & Leather Mfg	30	17	11	2
Wood & Paper Product Mfg	18	9	0	9
Printing, Publishing & Recorded Media	21	19	0	1
Petroleum, Coal & Assoc Prod. Mfg	90	67	2	21
Non Metallic Mineral Product Mfg	16	9	-	7
Metal Product Mfg	66	23	-	43
Machinery & Equipment Mfg	143	61	0	81
Other Mfg	51	18	1	32
Electricity, Gas & Water Utilities	53	48	1	3
Construction	59	51	0	8
Wholesale & Retail Trade	2	1	-	1
Accommodation, Cafes & Restaurants	0	-	-	0
Transport & Storage	37	31	1	5
Communications, Finance & Insurance	103	58	3	43
Property, Business & Comp. Services	21	6	0	15
Govt. Services	2,331	2,310	16	5
Other Services	2	-	0	2
Total	3,802	3,263	132	407

Source: Howard Partner's calculations using data specially provided by the ABS and by ISR

Appendix Table 4: Commercially intended R&D funded by the Commonwealth and the imputed cost of the R&D Tax Concession by ANZSIC sector, 1996-97 ($m)

ANZSIC	Total Commonwealth R&D support	Commonwealth R&D funding excl. levy funded component	Levy-based component of Commonwealth R&D funding	Imputed cost to Commonwealth of R&D tax concession
Agriculture, Forestry & Fishing	406	310	91	6
Mining	297	194	3	101
Food, Beverage & Tobacco Mfg	58	31	3	23
TCF & Leather Mfg	30	17	11	2
Wood & Paper Product Mfg	18	9	0	9
Printing, Publishing & Recorded Media	21	19	0	1
Petroleum, Coal & Assoc Prod. Mfg	90	67	2	21
Non Metallic Mineral Product Mfg	16	9	-	7
Metal Product Mfg	66	23	-	43
Machinery & Equipment Mfg	143	61	0	81
Other Mfg	51	18	1	32
Electricity, Gas & Water Utilities	53	48	1	3
Construction	59	51	0	8
Wholesale & Retail Trade	2	1	-	1
Accommodation, Cafes & Restaurants	0	-	-	0
Transport & Storage	37	31	1	5
Communications, Finance & Insurance	103	58	3	43
Property, Business & Comp. Services	21	6	0	15
Other Services	2	-	0	2
Total	1,471	953	116	402

Source: Howard Partner's calculations using data specially provided by the ABS and by ISR.

Appendix Table 5: Breakdown of the total Commonwealth funded R&D that can be traced to ANZSIC sectors, 1996-97 (excludes levy funded R&D) ($'000)

ANZSIC	Total	Commonwealth Government	State Government	Higher Education	Private non profit	Business Enterprise
Agriculture, Forestry & Fishing	400,906	196,200	84,657	119,808	18	223
Mining	196,353	156,613	67	39,333	-	341
Food, Beverage & Tobacco Mfg	34,521	20,847	777	11,193	-	1,705
TCF & Leather Mfg	27,815	26,939	-	876	-	-
Wood & Paper Product Mfg	9,738	7,123	88	2,283	-	244
Printing, Publishing & Recorded Media	19,336	5,698	86	13,050	-	502
Petroleum, Coal & Assoc Prod. Mfg	68,947	52,172	817	14,539	206	1,213
Non Metallic Mineral Product Mfg	9,362	5,940	-	3,347	-	75
Metal Product Mfg	23,252	13,893	-	7,667	-	1,692
Machinery & Equipment Mfg	61,393	26,795	-	30,475	171	3,952
Other Mfg	18,675	13,915	-	3,635	-	1,125
Electricity, Gas & Water Utilities	49,424	24,624	428	21,181	-	3,191
Construction	51,249	22,948	16	28,281	-	4
Wholesale & Retail Trade	747	-	-	747	-	-
Accommodation, Cafes & Restaurants						
Transport & Storage	31,852	15,333	89	15,833	-	597
Communications, Finance & Insurance	60,145	25,026	1,279	31,436	67	2,338
Property, Business & Comp. Services	5,714	1,608	-	4,106	-	-
Govt. Services	2,325,746	537,753	58,549	1,685,189	42,148	2,107
Other Services	-	-	-	-	-	-
Total	3,395,176	1,153,427	146,852	2,032,980	42,609	19,309

Source: Howard Partner's calculations using data specially provided by the ABS.

Appendix Table 6: Breakdown of Government Services (underpinning R&D) 1996–97 ($m)

Defence	237.49
Economic Framework	110.68
Health	425.37
Education and Training	100.08
Social development and community services	82.00
Environmental aspects of economic development (targeting manufacturing)	8.12
Environmental economic framework	4.30
Environmental knowledge	290.05
Environmental management	39.73
Natural sciences, technologies and engineering	703.92
Social sciences and humanities	324.00
Total Government Services	2,325.75

Source: Howard Partner's calculations using data specially provided by the ABS.

Appendix Table 7: Summary of ISR programs targeting R&D, management capacity building and other innovation supporting activities

The following data is adapted from a pre-print version of a paper to be published by ISR, 'Summary of Commonwealth and State Programs in Support of Innovation in Firms'

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
Automotive Market Access and Development Strategy	R&D investment benefit Management Capacity Building	Automotive industry	Business and Management Auto-engineering, component production, automotive services	Australian automotive firms entitled to import duty credits equal to a percentage of their production and investment in plant and equipment. Component firms, toolmakers, design and engineering firms, and car manufacturers producing components not for use in their own vehicles can also claim credits. Import duty credits equal to up to 45 percent of R&D expenditure and 25 percent of investment in plant and equipment can be claimed	$1.46m (1998/99) Estimated 200 firms will be assisted	$2 billion over five years (including non innovation components)
Biotechnology Australia	Management Capacity Building	Industries associated with biotechnology, State & Territory governments	Policy and Administration Biotechnology	The establishment of two new agencies to ensure Australia realises the potential gains being offered by biotechnology: Biotechnology Australia (a Federal Government Initiative) and the Office of the Gene Technology Regulator		$17.5 million committed in 1999 Budget
Business Information Service	Management Capacity Building	Non Sectoral	Business and management	Information is provided on government and industry association programs and services, general information to assist business, and information on all licenses and permits that are required to operate a business	Available on the internet to all businesses	$27m over 4 years

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
Commercialising Emerging Technologies Program (COMET)	Management Capacity Building	Industries that apply emerging technologies	Business and Management	*Stream A:* Provide the opportunity for firms to work with case managers to attract and manage capital through equity or debt funding. Specific strategies will generally focus on areas such as developing a sound management team, intellectual property, a proper business plan and market research, all of which are required to compete for capital *Stream B:* For companies that have an immediate need for management skills related to innovative practices and the financial management of commercialisation. Companies receive assistance to undertake private sector management development programs	Stream A: $100,000 maximum (Average $20-30,000) Stream B: $5,000 maximum	$30m over three years beginning in 1999
Cooperative Research Centres Program	To strengthen linkages between university research and its commercial and other applications.	See text of report for details	See text of report for details	Promotes high quality cooperative research and education programs through centres of research concentration. Supports long term collaborative ventures linking researchers from universities and government research organisations with businesses and public sector research users.	$142.98m Average funding per CRC - $2.5m.	On going commitment

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
Energy Efficiency Best Practice Program	Management Capacity Building	Non-sectoral.	Business and Management	Identifies current energy use, performance and potential for improved efficiency. Establishes energy performance benchmarks Motivates economic improvements in energy efficiency Monitors sectoral progress towards improved energy efficiency.	5-10 industry sectors. Partnership agree-ments signed with: Australian Aluminium Council; Australasian Fleet Managers' Association; Australian Dairy Products Federation. $10.3m over five years from 1998	$10.3m over five years from 1998
Factor F Scheme (Discontinued)	R&D investment subsidy	Pharmaceutical Industry	Pharmaceuticals	Subsidy to increase R&D expenditure based on merit selection		
Feasibility Study Fund	Management Capacity Building	Minerals and mineral based processing Hazardous waste re-cycling Food processing	Business and Management	Provides grants to prospective investors to undertake a pre-feasibility or feasibility study of a new investment project to assess commercial viability. Criteria for support includes development of new technology, new management practices and establishment of strategic alliances and technology transfer	$50,000 max. Six projects	$300,000 per annum

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
Innovation Investment Fund (IIF)	Support for commercialisation of research and development activities	Information technology and telecommunications, bioscience and engineering	IT&T, biotechnology and other eligible technologies	Provides access to equity capital for small, new technology firms through licensed funds management companies. Government funds are provided to funds managers on 2:1 basis.	$3-4m per company Estimated that 75 companies will receive assistance	$220m over 10 years – from 1998-99.
Intelligent Manufacturing Systems Program	R&D Collaboration	Manufacturing	Manufacturing and process technologies	International cooperation to develop greater efficiency and sophistication in manufacturing operations - Terms of Reference for the program place Australia as an equal partner with Canada, EFTA, the European Union, Japan and the USA		
Major National Research Facilities (MNRF) Program (Discontinued)	Research infrastructure			Seven MNRFs have been established to provide users from various scientific disciplines and areas of application, including industry, with access to state of the art research facilities	$8-9m per MNRF	$60m over 7 years
Pharmaceutical Industry Investment Program (PIIP) – replaces Factor F	R&D investment and manufacturing incentive	Pharmaceutical industry	Pharmaceuticals	Subsidy to increase R&D expenditure based on merit selection (replaced factor f scheme on 1 July 1999). PIIP will compensate the pharmaceutical industry, in part, for the impact on activity of the Government exercising its monopoly purchasing power under the Pharmaceutical Benefits Scheme. It will do so by paying higher prices on nominated products supplied by participating companies in return for those companies meeting commitments to undertake certain activities in Australia, including manufacturing and research and development.	$60m maximum per company over 5 years Support provided to nine companies over five years	$300 million for five years from 1999-2000

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
Pooled Development Funds Program	Provision of venture capital for SMEs	Non Sectoral Includes targeted funds for the following industries: agribusiness, wine, bioscience, mining and resources, manufacturing and other service industries.	Non sectoral	Promotes the establishment of private sector venture capital funds that provide long term equity investments in small to medium sized Australian companies that are expanding production capacity and markets. Tax Concession to investors as an incentive to invest in venture capital activities in SMEs	$5 million (tax revenue foregone)	
R&D Start- Core	R&D funding	See detailed tables elsewhere in the report	See detailed tables elsewhere in the report	Provides assistance of up to 50% of eligible project costs for small to medium Australian companies with an annual turnover of less than $50m in each of the three previous years for: R&D projects Employment of graduates on R&D related projects Concessional loans for the early commercialisation of technological innovation of goods, systems or services for companies with fewer than 100 employees	Maximum $15m per company ($100,000 for graduate projects) Average $0.8m Median $0.3m. Estimated 250 participants	$739m over 4 years
R&D Start – Plus	R&D funding			Provides grants for R&D projects of up to 20% of eligible project costs for companies with an annual turnover of $50m or more		

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
Regional Headquarters Program	Foreign Direct Investment	Non Sectoral – Services focus	Business and management	Promotes and facilitates establishment of regional headquarters and regional operation of research and development through promotion, facilitation, support services, tax breaks and streamlined immigration processing	Variable - often zero financial support 40 companies assisted.	$5m revenue foregone
Renewable Energy Equity Fund (REEF)	Financing of the Commercialisation of Renewable Energy Technologies	Renewable Energy	Renewable Energy Technologies	Specialised venture capital fund for small companies which are commercialising renewable energy Based on the IIF model	$4m maximum.	$19.5m over 10 years from 1999/2000
Shipbuilding and Marine Industries Program	Management Capacity Building	Shipbuilding and Marine Industries	Business and Management	Grants to facilitate information flow on market opportunities and strategy development for firms		$143,500 (1998-99)
Shipbuilding Innovation Scheme	Subsidy for ship building costs	Shipbuilding and marine	Mechanical and industrial engineering Materials sciences and technologies	Provides a subsidy to ship builders of up to 50 percent of eligible R&D costs incurred, capped at two percent of eligible costs in the construction or modification of a vessel	Varies widely. 10-15 ships per annum – average $0.75m-$1m	$51.5m over five years
Tax Concession for Research and Development	R&D Subsidy	See detailed tables elsewhere in the report	See detailed tables elsewhere in the report	Tax deductions aimed at increasing R&D activity in established firms	Revenue foregone per company is $0.1m on average. Estimated 3,500 claimants	$400m per annum (revenue foregone)

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
TCF 2000 Development Package- Strategic Investment	Management Capacity Building	Textiles, Clothing & Footwear	Business and Management	Incentives for industries to continue progress towards global competitiveness.	Maximum of five percent of sales in previous year	$700m over 5 years
TCF 2000 Development Package – Technology Development Fund	R&D Support	Textiles, Clothing & Footwear	Mechanical and industrial engineering Materials sciences and technologies	Support for the development of new product and process technologies		$10m over 5 years
TCF 2000 Development Package – Best Practice Program	Management Capacity Building	Textiles, Clothing & Footwear	Business and management	Grants to achieve best practice in areas of management and operations (all funds have been committed)	$50,000 - $250,000 35 companies over 4 years	$7.5m over 4 years
TCF 2000 Development Package – Business Improvement	Management capacity building	Textiles, Clothing & Footwear	Business and management	Payments to encourage the adoption and development of quality business management skills through a range of consultant assisted projects. (The program terminates on 30 June 2000)	$5,000 - $20,000. 150 firms assisted	$2.5m over 2 years
TCF 2000 Development Package – Supply Development	Management capacity building	Textiles, Clothing & Footwear	Business and management – logistics	Support for TCF manufacturers in value adding chains by encouraging them to develop partnerships with suppliers and customers. Encourages widespread adoption of supply chain management principles and practices. (The program terminates on 30 June 2000)	$30,000 maximum. 20 firms assisted	$1.9m over 2 years

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
TCF 2000 Development Package - Benchmarking	Managements capacity building	Textiles, Clothing & Footwear	Business management – benchmarking	Support for international benchmarking across a broad range of business success factors. Enable firms to analyse company performance against 1700 best practice measures. (The program terminates on 30 June 2000)	180 firms assisted	$1m over three years
TCF 2000 Development Package – Education, Knowledge and Training Infrastructure Grants	Skills development	Textiles, Clothing & Footwear	Business management	Support for improvements in the TCF education and training infrastructure. (The program terminates on 30 June 2000)	12 education institutes supported	$5.6m over 3 years
Technology Diffusion Program – Technology Alliance	International R&D Collaboration	Non sectoral	Broad project support for all areas of science and technology	Issues grants to support non-research costs (travel etc) incurred in undertaking international collaborative research through showcasing technologies overseas, accessing overseas major research facilities, and attracting prestigious international scientific, technological and engineering conferences to Australia.	$1,000 to $100,000	$6.19m (1998-99)
Technology Diffusion Program – Technology Transfer	Technology Transfer	Non sectoral	Broad project support for all areas of science and technology	Discretionary funding of domestic technology diffusion projects that facilitate the uptake of new and leading edge technologies by Australian industry. Projects include technology diffusion networks and demonstration activities and awareness activities aimed at small to medium sized businesses.	In excess of 30,000 companies involved	$5,58m (1998-99)

Program name	Type	Industries currently supported	Technologies & research fields supported	Description of support supported	Value of support to firms	Budget funds funds committed
Value Chains Partnership Program	Management Capacity Building	Non sectoral	Business and Management	Funds teams to develop and implement industry demonstration projects that link companies with complementary skills and capabilities with their respective suppliers and customers to overcome barriers and pursue growth opportunities.	$100,000 maximum 12 projects and approx. 30 companies over three years	$1.8m over three years
Wood and Paper Industry Strategy Development Program	Management Capacity Building	Wood and Paper	Business and Management	Provides grants to support projects that encourage the industry to become more competitive and innovative, and increasing its level of value adding. All funds have been allocated. (The program terminates on 30 June 2000)	$5,000 - $200,000 per firm per year. 65 firms assisted.	$4.7 m over 4 years

Appendix Table 8:Concordance between socio-economic objectives classification and ANZSIC, 1996 - 97

Socio-economic objectives	$ '000	ANZSIC Allocation
10100 DEFENCE	**237,383**	**M, N, O**
20100 FIELD CROPS	109,141	allocated via TOTAL below
20200 HORTICULTURAL CROPS	39,467	allocated via TOTAL below
20300 FORESTRY	30,369	allocated via TOTAL below
20400 PRIMARY PRODUCTS FROM PLANTS	4,036	allocated via TOTAL below
TOTAL: PLANT - PRODUCTION AND PRIMARY PRODUCTS	**183,013**	**A**
30100 LIVESTOCK	101,343	allocated via TOTAL below
30200 PASTURE, BROWSE AND FODDER CROPS	23,240	allocated via TOTAL below
30300 FISHING	33,444	allocated via TOTAL below
30400 PRIMARY PRODUCTS FROM ANIMALS	8,450	allocated via TOTAL below
TOTAL: ANIMAL - PRODUCTION AND PRIMARY PRODUCTS	**166,476**	**A**
40100 EXPLORATION	44,296	allocated via TOTAL below
40200 PRIMARY MINING AND EXTRACTION PROCESSES	14,431	allocated via TOTAL below
40300 FIRST STAGE TREATMENT OF ORES AND MINERALS	30,102	allocated via TOTAL below
TOTAL: MINERAL RESOURCES EXCL. ENERGY	**88,829**	**B**
50100 EXPLORATION	71,210	allocated via TOTAL below
50200 MINING AND EXTRACTION	20,836	allocated via TOTAL below
50300 PREPARATION AND SUPPLY OF ENERGY SOURCE MINERALS	1,420	C25
59900 OTHER	355	allocated via TOTAL below
TOTAL: ENERGY RESOURCES	**93,820**	**B (less 50300)**
60100 ENERGY TRANSFORMATION	11,822	allocated via TOTAL below
60200 RENEWABLE ENERGY	7,587	allocated via TOTAL below
60300 ENERGY DISTRIBUTION	8,244	allocated via TOTAL below
60400 CONSERVATION AND EFFICIENCY	9,009	allocated via TOTAL below
69900 OTHER	1,615	allocated via TOTAL below
TOTAL: ENERGY SUPPLY	**38,277**	**D**
70100 PROCESSED FOOD PRODUCTS AND BEVERAGES	34,521	C21
70200 FIBRE PROCESSING AND TEXTILES; FOOTWEAR AND LEATHER PRODUCTS	27,815	C22
70300 WOOD, WOOD PRODUCTS AND PAPER	9,738	C23
70400 HUMAN PHARMACEUTICAL PRODUCTS	32,644	C25
70500 VETERINARY PHARMACEUTICAL PRODUCTS	12,499	C25
70600 AGRICULTURAL CHEMICALS	2,486	C25
70700 INDUSTRIAL CHEMICALS AND RELATED PRODUCTS	19,894	C25
70800 BASIC METAL PRODUCTS (INCL. SMELTING)	12,214	C27
70900 CERAMICS, GLASS AND INDUSTRIAL MINERAL PRODUCTS	9,362	C26
71000 FABRICATED METAL PRODUCTS	11,038	C27
71100 TRANSPORT EQUIPMENT	11,910	I
71200 COMPUTER HARDWARE AND ELECTRONIC EQUIPMENT	9,596	C28

Socio-economic objectives	$ '000	ANZSIC Allocation
71300 COMMUNICATION EQUIPMENT	13,799	C28
71400 INSTRUMENTATION	22,969	C28
71500 MACHINERY AND EQUIPMENT	14,713	C28
79900 OTHER MANUFACTURED PRODUCTS	12,244	C29
TOTAL: MANUFACTURING	**257,441**	**allocated via detailed allocation above**
80100 PLANNING	6,552	allocated via TOTAL below
80200 DESIGN	15,516	allocated via TOTAL below
80300 MATERIALS PERFORMANCE AND PROCESSES	16,664	allocated via TOTAL below
80400 CONSTRUCTION PROCESSES	5,823	allocated via TOTAL below
80500 BUILDING MANAGEMENT AND SERVICES	5,281	allocated via TOTAL below
TOTAL: CONSTRUCTION	**49,836**	**E**
90100 GROUND TRANSPORT	11,219	allocated via TOTAL below
90200 WATER TRANSPORT	1,133	allocated via TOTAL below
90300 AIR TRANSPORT	988	allocated via TOTAL below
99900 OTHER TRANSPORT	1,692	allocated via TOTAL below
TOTAL: TRANSPORT	**15,031**	**I**
100100 COMPUTER SOFTWARE AND SERVICES	52,527	J and K
100200 OTHER INFORMATION SERVICES	4,457	C24
100300 COMMUNICATION SERVICES	14,879	C24
TOTAL: INFORMATION AND COMMUNICATION SERVICES	**71,863**	**allocated via detailed allocation above**
110100 ELECTRICITY, GAS AND WATER SERVICES AND UTILITIES	5,933	D
110200 WASTE MANAGEMENT AND RECYCLING	6,432	C29
110300 WHOLESALE AND RETAIL TRADE	747	F
110400 FINANCE, PROPERTY AND BUSINESS SERVICES	5,249	J and K
119900 OTHER COMMERCIAL SERVICES	3,830	L
TOTAL: COMMERCIAL SERVICES	**22,190**	**allocated via detailed allocation above**
120100 MACROECONOMIC ISSUES	19,247	allocated via TOTAL below
120200 MICROECONOMIC ISSUES	25,524	allocated via TOTAL below
120300 INTERNATIONAL TRADE ISSUES	12,300	allocated via TOTAL below
120400 MANAGEMENT AND PRODUCTIVITY ISSUES	31,454	allocated via TOTAL below
120500 MEASUREMENT STANDARDS AND CALIBRATION SERVICES	10,421	allocated via TOTAL below
129900 OTHER ECONOMIC ISSUES	11,738	allocated via TOTAL below
TOTAL: ECONOMIC FRAMEWORK	**110,684**	**M, N, O**
130100 CLINICAL (ORGANS, DISEASES AND CONDITIONS)	273,846	allocated via TOTAL below
130200 PUBLIC HEALTH	98,692	allocated via TOTAL below
130300 HEALTH AND SUPPORT SERVICES	52,831	allocated via TOTAL below
TOTAL: HEALTH	**425,369**	**M, N, O**

Socio-economic objectives	$ '000	ANZSIC Allocation
140100 EARLY CHILDHOOD AND PRIMARY EDUCATION	9,290	allocated via TOTAL below
140200 SECONDARY EDUCATION	17,661	allocated via TOTAL below
140300 HIGHER EDUCATION	30,979	allocated via TOTAL below
140400 TECHNICAL AND FURTHER EDUCATION	2,585	allocated via TOTAL below
140500 SPECIAL EDUCATION	5,334	allocated via TOTAL below
149900 OTHER EDUCATION	34,230	allocated via TOTAL below
TOTAL: EDUCATION AND TRAINING	**100,079**	**M, N, O**
150100 COMMUNITY SERVICES	20,763	allocated via TOTAL below
150200 PUBLIC SERVICES	15,467	allocated via TOTAL below
150300 ART, SPORT AND RECREATION	16,976	allocated via TOTAL below
150400 INTERNATIONAL RELATIONS	9,637	allocated via TOTAL below
150500 ETHICAL ISSUES	2,797	allocated via TOTAL below
159900 OTHER SOCIAL DEVELOPMENT AND COMMUNITY SERVICES	16,290	allocated via TOTAL below
TOTAL: SOCIAL DEVELOPMENT AND COMMUNITY SERVICES	**81,930**	**M, N, O**
160100 CLIMATE AND ATMOSPHERE	70,144	allocated via TOTAL below
160200 OCEAN	20,255	allocated via TOTAL below
160300 WATER	35,836	allocated via TOTAL below
160400 LAND	47,565	allocated via TOTAL below
160500 NATURE CONSERVATION	74,757	allocated via TOTAL below
160600 SOCIAL ENVIRONMENT	33,074	allocated via TOTAL below
169900 OTHER ENVIRONMENTAL KNOWLEDGE	8,381	allocated via TOTAL below
TOTAL: ENVIRONMENTAL KNOWLEDGE	**290,012**	**M, N, O**
170100 PLANT PRODUCTION AND PLANT PRIMARY PRODUCTS (INCL. FORESTRY)	35,037	A
170200 ANIMAL PRODUCTION AND ANIMAL PRIMARY PRODUCTS (INCL. FISHING)	16,371	A
170300 MINERAL RESOURCES (EXCL. ENERGY)	12,196	B
170400 ENERGY RESOURCES	2,929	B
170500 ENERGY SUPPLY	4,433	D
170600 MANUFACTURING	8,032	M, N, O
170700 CONSTRUCTION	1,414	E
170800 TRANSPORT	4,401	I
170900 INFORMATION AND COMMUNICATION SERVICES	2,221	J and K
171000 COMMERCIAL SERVICES	1,884	L
171100 ENVIRONMENTAL ECONOMIC FRAMEWORK	4,295	M, N, O
TOTAL: ENVIRONMENTAL ASPECTS OF ECONOMIC DEVELOPMENT	**93,212**	**allocated via detailed allocation above**
180100 ENVIRONMENTAL MANAGEMENT	29,357	allocated via TOTAL below
189900 OTHER ENVIRONMENTAL ASPECTS	10,377	allocated via TOTAL below
TOTAL: ENVIRONMENTAL MANAGEMENT & OTHER ASPECTS	**39,734**	**M**

Socio-economic objectives	$ '000	ANZSIC Allocation
190100 MATHEMATICAL SCIENCES	44,258	allocated via TOTAL below
190200 PHYSICAL SCIENCES	104,934	allocated via TOTAL below
190300 CHEMICAL SCIENCES	74,037	allocated via TOTAL below
190400 EARTH SCIENCES	44,954	allocated via TOTAL below
190500 INFORMATION, COMPUTER AND COMMUNICATION TECHNOLOGIES	70,888	allocated via TOTAL below
190600 APPLIED SCIENCES AND TECHNOLOGIES	41,842	allocated via TOTAL below
190700 GENERAL ENGINEERING	56,616	allocated via TOTAL below
190800 BIOLOGICAL SCIENCES	155,308	allocated via TOTAL below
190900 AGRICULTURAL SCIENCES	16,823	allocated via TOTAL below
191000 MEDICAL AND HEALTH SCIENCES	94,259	allocated via TOTAL below
TOTAL: NATURAL SCIENCES, TECHNOLOGIES & ENGINEERING	**703,919**	**M, N, O**
200100 SOCIAL SCIENCES	162,306	allocated via TOTAL below
200200 HUMANITIES	161,681	allocated via TOTAL below
TOTAL: SOCIAL SCIENCES AND HUMANITIES	**323,988**	**M, N, O**

APPENDIX B: OTHER INFORMATION

List of Commonwealth Departments, Agencies and Programs

The ABS R&D expenditure data captures almost all of the R&D funded by Commonwealth agencies and programs. The one industry in which the ABS does not carry out an R&D survey is the agricultural sector itself. The rationale for this is that levels of R&D expenditure are assumed to be too low in this sector to warrant a survey. The major Commonwealth agencies and programs covered in this study, either directly via program data or indirectly via the ABS R&D expenditure data therefore includes:

Departments with a range of discrete R&D support mechanisms delivered independently of agencies:

- Agriculture, Fisheries and Forestry – Australia (mainly via the Rural Research & Development Corporations)
- Department of Education, Training and Youth Affairs
- Environment & Heritage
- Health and Aged Care
- Industry, Science and Resources
- Australian Geological Survey Organisation
- Australian Nuclear Science and Technology Organisation
- Transport and Regional Services

Specific departmental agencies:

- Commonwealth Scientific and Industrial Research Organisation
- Defence Science and Technology Organisation
- Australian Research Council
- National Health and Medical Research Council
- Bureau of Meteorology

In addition the following ISR programs were analysed:

- IR&D Tax Concession scheme
- Cooperative Research Centres program
- R&D Start
- Plus a wide range of management capacity building and related programs (see Appendix Table 3).