**INDUSTRY
COMMISSION**

RESEARCH AND DEVELOPMENT

VOLUME 1 : THE REPORT
(Overview and Parts A to C)

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INDUSTRY
COMMISSION

15 May 1995

The Honourable George Gear MP
Assistant Treasurer
Parliament House
CANBERRA ACT 2600

Dear Assistant Treasurer

In accordance with Section 7 of the *Industry Commission Act 1989*, we have pleasure in submitting to you the Commission's final report on the Research and Development.

Yours sincerely

Gary Banks	Helen Owens	Peter Hall
Presiding Commissioner	Commissioner	Associate Commissioner

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VOLUME 1 - THE REPORT

(Overview, Parts A-C)

C UNIVERSITY AND RELATED RESEARCH

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ABBREVIATIONS

AARNET	Australian Academic and Research Network
ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACIAR	Australian Centre for International Agricultural Research
AGSO	Australian Geological Survey Organisation
AIMS	Australian Institute of Marine Science
AIPO	Australian Industrial Property Organisation
AIRG	Australian Industrial Research Group
AMIRA	Australian Mineral Industries Research Association
AMTDP	Advanced Manufacturing Technology Development Program
ANAO	Australian National Audit Office
ANSTO	Australian Nuclear Science and Technology Organisation
ANU	Australian National University
ARC	Australian Research Council
ASIC	Australian Standard Industrial Classification
ASTEC	Australian Science and Technology Council
ATG	Australian Technology Group
BERD	Business Expenditure on Research and Development
BIE	Bureau of Industry Economics
CCST	Coordination Committee on Science and Technology
CRC	Cooperative Research Centre
CRI	Crown Research Institute
CSIRO	Commonwealth Scientific and Industrial Research Organisation

DEET	Department of Employment, Education and Training
DGS	Discretionary Grants Scheme
DIST	Department of Industry, Science and Technology
DPIE	Department of Primary Industries and Energy
DSTO	Defence Science and Technology Organisation
EPA	Environmental Protection Authority
EPAC	Economic Planning Advisory Council
GERD	Gross Expenditure on Research and Development
GATT	General Agreement on Tariffs and Trade
GDP	Gross domestic product
GIRD	Grants for Industry Research and Development
GOVERD	Government Expenditure on Research and Development
GRA	Government Research Agency
GTGS	Generic Technology Grants Scheme
GVP	Gross value of production
HERD	Higher Education Expenditure on Research and Development
IAS	Institute of Advanced Studies
IC	Industry Commission
IIP	Industry Innovation Program
IR&D	Industry Research and Development
ITRI	Taiwan Industrial Technology Research Institute
JCSMR	John Curtin School of Medical Research
KIST	Korea Institute of Science and Technology
MFP	Multi-factor productivity
NBEET	National Board of Employment, Education and Training
NHMRC	National Health and Medical Research Council
NIES	National Industry Extension Scheme

NPDP	National Procurement Development Program
NTCS	National Teaching Company Scheme
OECD	Organisation for Economic Cooperation and Development
PFD	Partnerships for Development
PM&C	Department of Prime Minister and Cabinet
RDC	Research and Development Corporation or Council
SARDI	South Australian Research and Development Institute
SCORE	Survey and Comparison of Research Expenditure
SEO	Socio-economic objective
SIRF	Strategic Industry Research Foundation, Victoria
SMEs	Small and medium-sized enterprises
TFP	Total factor productivity

GLOSSARY OF R&D TERMS

Applied research	Original research undertaken in order to acquire new knowledge with a specific application in view. It is undertaken either to determine the possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives.
Appropriability	The extent to which an innovator can capture the gain from an innovation.
Commercialisation	The set of activities involved in producing and marketing an innovation.
Contestability	The extent to which the provision of a good or service is opened to alternative suppliers.
Depreciation of knowledge	The rate of decline over time in the value of a given stock of knowledge to either private agents (private rate) or society (social rate).
Diffusion	The process whereby new knowledge, know–how and innovations spread from an innovating organisation to the general community.
Direct returns	The returns to R&D that accrue at the lowest level of data aggregation. For firm level studies, the direct returns measure the private returns and, for industry level studies, the direct returns measure the industry return.
Disembodied knowledge	Knowledge that is not embodied in equipment or materials.
Embodied knowledge	Knowledge that is embodied in equipment or materials. For example, the technological knowledge contained in a new computer.
Experimental development	Systematic work using knowledge gained from research to create new or improved products or processes.
Extramural R&D	R&D activity funded by an organisation, but carried out by other organisations.

Industry returns	Private returns to the firm undertaking the R&D plus those external returns accruing to other firms within the same industry (intra–industry spillovers).
Inter–industry spillovers	Spillover benefits (or costs) that accrue to (or are borne by) firms outside the industry of the firm undertaking the R&D.
Intra–industry spillovers	Spillover benefits (or costs) that accrue to (or are borne by) firms within the same industry as the firm undertaking the R&D, excluding the private return to the firm.
Intramural R&D	R&D carried out by an organisation on its own behalf or on behalf of other organisations.
Knowledge spillovers	Refers to the uncompensated flow of new private knowledge and know–how from an innovating firm to competitor firms and/or firms in other industries (see *Spillovers*).
Pecuniary benefits	Benefits that arise through the operation of the market–place. An example is the return to R&D when knowledge is purchased through the market place.
Person-embodied knowledge	Knowledge and know-how carried in the brain and forming part of human capital (sometimes described as part of disembodied knowledge).
Private returns	The returns appropriated by the firm undertaking the R&D. These include not only the profits resulting from the marketing of any products, but also receipts from selling R&D results (for example, royalties).
Process R&D	R&D directed towards the introduction of new or improved methods of production.
Product R&D	R&D directed towards the introduction of new or improved products to the market.
Pure basic research	Experimental and theoretical research undertaken without looking for long-term benefits other than the advancement of knowledge.
Rate of return	The average annual flow of benefits accruing in perpetuity expressed as a proportion of the cost of the asset generating the benefit.

Research & development (R&D)	Refers to creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications.
Social return	The flow of benefits accruing to society expressed as a proportion of the cost of the asset generating the benefit.
Spillovers (in relation to R&D)	Refer to any unpaid benefit or unrecompensed cost that flows to any agent other that a firm undertaking R&D. It is the difference between the private and social rates of return.
Strategic basic research	Experimental and theoretical research undertaken to acquire knowledge directed towards specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the practical solution of recognised problems.
Tacit knowledge	Undocumented knowledge that can be only partly articulated.
Technological innovation	A new or improved product or method of production; also the *process* by which such improvements are brought about.
Total Factor Productivity (TFP)	A measure of the impact of all the other factors, including R&D, on output other than changes in the quantities of physical capital and labour used in production. It represents the residual of output in excess of the quantities of physical capital and labour used.
Total return	See *Social return*.

TERMS OF REFERENCE

I, GEORGE GEAR, Assistant Treasurer, under section 7 of the Industry Commission Act 1989 hereby:

1. refer research and development undertaken by industry, government agencies and higher education institutions to the Commission for inquiry and report within 18 months of the date of receipt of this reference;

2. specify that the Commission examine and report on:

   (a) the effect of research and development activities on innovation in Australia and its impact on economic growth and industry competitiveness; and

   (b) the efficiency and effectiveness of policies and programs which influence research and development and innovation in Australia;

3. without limiting the scope of this reference, request that the Commission report on:

   (a) the roles and capacities of industry, government agencies and higher education institutions in identifying and developing research requirements and in supporting, undertaking and influencing research and development and innovation in Australia;

   (b) policies affecting the performance of industry in undertaking research and development;

   (c) the efficiency and effectiveness of programs, regulations, or other institutional arrangements that affect the level, type, and focus of research and development and its application including:

      (i) government science and innovation grants and taxation measures;

      (ii) government policies toward major scientific research agencies including funding and cost recovery arrangements;

      (iii) the primary industry and energy research and development corporations;

   (d) the appropriateness of the present balance of support between service, manufacturing and rural industries;

   (e) the appropriateness of present methods of government financial support, including funding levels and the efficiency of mechanisms used to allocate funds both within and across programs;

(f) evidence concerning the impact of research and development activities on industry competitiveness in selected overseas countries;

(g) any changes which should be made to enhance program delivery or the impact of current measures (including the Discretionary Grants Scheme and the Generic Technology Grants Scheme (GIRD) should the Government wish to extend funding for the program);

(h) the effectiveness of any policies or practices which impinge on the effectiveness or numbers of joint ventures or other contractual arrangements between government research agencies and private companies in relation to research and development;

(i) the incentives and impediments to:

  (i) the dissemination, uptake and commercialisation of Australian research outcomes;

  (ii) the enhancement of information flows between Australia and other countries in relation to research and development; and

  (iii) the creation of linkages between research agencies, higher education institutions and business;

  (iv) the impact of Australia’s intellectual property law on research and development; and

4. specify that the Commission take account of the Government’s 1992 White Paper, *Developing Australian Ideas*, and recent substantive studies undertaken elsewhere. The Government has in recent years kept under review a number of major reforms in the higher education system. The Commission should not report under paragraph 3(e) on:

  (a) the appropriateness of the overall level of Government funding for the higher education system; or

  (b) sources of funding for higher education (except in relation to research functions), including the balance between government funding and income from student contributions; and

5. specify that the Commission have regard to the established economic, social and environmental objectives of governments, including those of the National Strategy for Ecologically Sustainable Development.

GEORGE GEAR

10 September 1993

Amendment to the terms of reference

In a letter dated 2 February 1995 the Assistant Treasurer amended the terms of reference for this inquiry. The text of the letter read as follows:

Dear Mr Scales,

The Government has sought advice on the potential for cost recovery of industry research and development grants.

Officers from the Treasury, the Department of Finance and the Department of Industry, Science and Technology developed a discussion paper, *Cost Recovery for Research and Development Programs Options for the Industry Innovation Program* broadly covering the issues. I am forwarding you a copy of this paper to assist you in your inquiry.

The Government has now decided to formally refer cost recovery of industry research and development grants to the Industry Commission for consideration in the Commission's final report of the inquiry on research and development.

Accordingly, under section 7(2) of the Industry Commission Act 1989, I hereby amend the reference on research and development grants dated 10 September 1993 to include:

3. (j) appropriateness and options for the cost recovery of industry research and development grants.

Yours sincerely,

GEORGE GEAR

OVERVIEW

This report is about research and development: how it arises, its benefits to the Australian community and, most importantly, government's role in enhancing its contribution. Research and development (R&D) has been aptly defined by the OECD as:

> Creative work undertaken on a systematic basis in order to increase the stock of knowledge — including knowledge of man, culture and society — and the use of this knowledge to devise new applications.

R&D — the creation and application of knowledge — is a major source of innovation and an important driver of economic growth. It also has an important influence on the quality of life within a society.

Because R&D is about knowledge, it is also about people. Research is intellectually demanding. It is performed by some of our most highly educated, talented and creative people. The challenge for society is to ensure that we make the most of what these people have to offer.

Governments have an essential role to play. Knowledge inevitably spreads and may be used in a multitude of ways never initially envisaged. Its benefits are difficult to constrain or quarantine. When individuals create new knowledge, they do more good for the community than they know or can personally benefit from. Governments therefore need to underpin and supplement the processes of knowledge creation, if these wider benefits are to be adequately realised. This is among the most difficult, and important, tasks of government policy.

The proposals in this report are directed at enhancing the contribution of R&D to national welfare by more clearly defining government's roles, improving funding processes and making research more responsive to users and community needs.

Key policy proposals include:

- **CSIRO — a need for wider community influence on its priorities and a greater role for government in monitoring its performance;**
- **the universities — an enhanced role for the ARC in funding research according to performance;**
- **business — more widespread R&D support for smaller companies unable to use the tax concession; and**
- **the rural sector — changes to enhance the role of the RDCs in rural research.**

1. The inquiry

In this inquiry, the Commission has been asked by government to report on the many complex aspects of essentially two very broad questions, namely:

- the effect of R&D on innovation, industry competitiveness and economic growth; and
- the performance of policies and programs which influence R&D and innovation in Australia.

The two sets of tasks are regarded as equally important by the Commission, and indeed are inter-related. A proper evaluation of government's role in relation to R&D and innovation depends on an understanding of the drivers of R&D and the consequent impacts on economic activity and community well being.

Numerous government policies and programs influence R&D. Much R&D is initiated and performed by the public sector in its own right: within government departments, research agencies and universities. Government is also a regulator, facilitator and supporter of R&D within the private sector. This latter role ranges from establishing legal frameworks (patents and other intellectual property laws) to various forms of financial and other assistance for firms and organisations undertaking R&D.

The Commission's terms of reference require it to evaluate government's role and performance in all of these areas, as well as to examine the 'incentives and impediments' to the dissemination and commercialisation of research, international exchanges of information and the creation of linkages between public research institutions and business.

Box 1: **Some facts about Australian R&D**

- Annual R&D expenditure in Australia is running at over $6 billion, of which government support comprises about 60 per cent.
- About 28 per cent of R&D spending is on 'basic' research.
- Research within the public sector accounts for 0.9 per cent of GDP, fourth largest in percentage terms among OECD countries.
- Of all public sector research, higher education accounts for about 50 per cent, and CSIRO performs about one fifth.
- Business R&D represents about 0.7 per cent of GDP. While this ratio is still significantly below the OECD average, BERD grew during the 1980s at an average rate of 13 per cent annually, well above the OECD average.
- Australians produce over 2 per cent of the scientific research papers published world wide.

Wide community input

In conducting its inquiry, the Commission has benefited greatly from the involvement of a large number of individuals and organisations within the public and private sectors. There has been extensive participation from the higher education sector, the business community (including many small businesses), the rural sector, and government departments and research agencies, including CSIRO. To enhance its understanding of the complex and sensitive issues involved, the Commission undertook a wide range of visits and presentations, engaged external consultants and organised a number of roundtable meetings on key topics, which were attended by people with a detailed knowledge of R&D policy or practice within Australia. In addition, a conference was held on the subject *R&D and Economic Growth*, with international and Australian speakers.

Focusing the inquiry

The breadth of the terms of reference provided an important opportunity for the Commission and participants in this inquiry to gain a broader perspective on the R&D system in Australia. Most previous inquiries have looked only at particular components of that system, including earlier inquiries by the Commission itself.

The Commission has concentrated on the role of the main institutions and the processes that influence their performance. They include government research agencies, university researchers and programs for business and rural R&D, as well as mechanisms that promote linkages among them. While intellectual property plays a role in all of these areas, the Commission has not been able to examine in detail the patent system. It has been the subject of recent studies, however, and most participants made little comment.

The Commission has also not attempted to provide answers to questions about the ‘correct’ magnitude and composition of R&D. Rather, it has focused on the importance of getting the processes and incentives for R&D right, in the belief that this should allow appropriate outcomes to emerge from the system.

Consistent with the thrust of the terms of reference, the Commission’s report deals primarily with R&D, which is just one part of the much wider topic of innovation. But it has also devoted attention to the connections between R&D and technological innovation, as well as their impacts on competitiveness and economic growth. In doing so, it has taken into account that research can bring important benefits to society which do not show up in conventional measures of economic growth. Examples include social and cultural benefits, and also environmental amenity. These ‘non-material’ benefits need to be recognised in R&D policy. They all contribute to national welfare.

Many 'positives' in current arrangements

Australia's achievements in research over the years have been substantial and the Commission has found much to commend in current arrangements for R&D. This is of course not surprising. They are the outcome of much deliberate effort by governments and the community over a long period, and have evolved and been modified as conditions have changed and our understanding of the role of R&D has improved. Among the achievements that we have observed are:

- increased awareness within the manufacturing and rural sectors of the benefits of R&D, and higher growth in their expenditure on it;
- some firms and industries that are leading the world in research effort;
- the number of high quality research institutions;
- some innovative and effective mechanisms for supporting research; and
- improved policy advisory and coordination structures.

Need for change

The Commission also found important reasons for change. There is a need to:

- enhance private R&D performance by improving the effectiveness of assistance arrangements and reducing inconsistencies of treatment among firms and industries;
- demonstrate that public funding of R&D is well spent by improving the accountability, transparency and monitoring of government research agencies and funding programs;
- raise the social and economic payoff from public sector R&D by achieving a wider external influence over what research gets done; and
- encourage more cost-effective R&D by increasing the contestability of funding among research providers.

2. Innovation, growth and government

R&D is conventionally categorised into 'basic' and 'applied' research, and 'experimental development' and this usage has been adopted by the Commission (see box 2). This categorisation is useful, but potentially misleading for policy, since the different categories are sometimes difficult to distinguish and are often interactive.

The Commission sees successful technological innovation as involving a more complex interaction of R&D and the market than is captured by either 'science push' or 'demand pull' models.

Box 2: A short glossary of R&D

Pure basic research — experimental and theoretical work undertaken without looking for long-term benefits other than the advancement of knowledge.

Strategic basic research — experimental and theoretical work undertaken to acquire knowledge directed towards specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the practical solution of recognised problems.

Applied research — original work undertaken to acquire knowledge with a specific application in view. It is undertaken either to determine the possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives.

Experimental development — systematic work, using existing knowledge gained from research or practical experience, that is directed to producing new or improved products or processes.

Technological innovation — a new or improved product or method of production; also the *process* by which such improvements are brought about.

Commercialisation — the set of activities involved in producing and marketing an innovation.

Spillover — any unpaid benefit (or unrecompensed cost) from R&D that flows to individuals or organisations other than those undertaking the R&D. It is the difference between the private and social returns from R&D.

Appropriability — the extent to which an innovator can capture the gain from an innovation.

Contestability — the extent to which the provision of a good or service is open to alternative suppliers.

The economic role of basic research is not directly to generate commercial products, but rather to provide essential support for, and raise the return on, more applied R&D. This is a much more diffuse role, but also a critically important one in successful innovation. It occurs through:

- training researchers, many of whom will work for industry or government;
- creating a store of ‘background knowledge’ which improves the effectiveness of technological search activities;
- enabling membership of ‘networks’ yielding access to the large body of knowledge generated worldwide; and
- developing new research techniques and instrumentation.

Basic research accounts for a relatively small proportion of R&D spending by private firms. That being said, (strategic) basic research is often stimulated by research into applied problems, as CSIRO’s experience illustrates.

Australia's 'innovation system'

The extent and direction of technological innovation is greatly influenced by a country's institutional structure and system of incentives, or 'national innovation system'.

As in other countries, Australia has a broad structure of institutions and incentives in which R&D and technological innovation take place. The core performing institutions are the universities, government research bodies like CSIRO and DSTO, and business enterprises. Universities do most of the country's basic research; firms focus on work aimed at bringing new products to market and developing new production methods; and the government research bodies undertake a wide range of the remaining R&D tasks.

Australia appears to have a larger proportion of its research undertaken in the public sector and a wider range of government-funded incentives to engage in R&D than many other countries. Government directly underwrites a large proportion of R&D in the public sector, offers a 150 per cent tax concession and operates a competitive grants scheme for business R&D, and currently funds over three-quarters of all rural R&D. It also provides substantial financial support for linkages between the public and private sector R&D performers.

By international standards, Australia's R&D performance has a number of distinguishing characteristics, including:

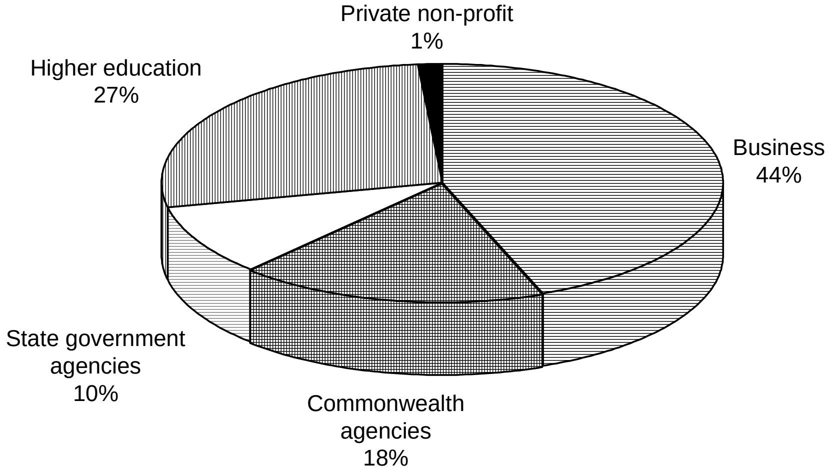
- low gross expenditure on R&D relative to GDP, reflecting relatively low business expenditure on R&D;
- high public relative to private expenditure on R&D;
- a high ratio of basic to applied research (despite a recent decline); and
- middle ranking performance in terms of research publications and patents, although the former has declined while patent applications have increased.

Over the last ten to fifteen years, however, significant changes have taken place in many parts of the system and this in turn is changing the complexion of the system as a whole. For example:

- the ratio of gross expenditure on R&D to GDP has grown much faster in Australia in the early 1990s than in most other countries;
- this is attributable to business expenditure on R&D which has been growing on average by around 13 per cent annually, and as a proportion of GDP rose from 0.3 per cent in 1981 to 0.7 per cent in 1992–93;
- R&D to sales ratios rose sharply in most manufacturing industries during the 1980s;

- public sector R&D spending has grown more slowly than that in the private sector;
- Australian applications for United States patents have grown faster than that of any other country;
- the proportion of business sales estimated to have been generated by significant innovations has risen substantially.

Figure 1: **R&D performance by institutions, 1992–93** (per cent)



Source: ABS, Cat. No. 8112.0.

Even so, many participants have concluded from international comparisons of R&D spending that Australia's innovation system is deficient. In some respects this may be so, but it is not obvious from international data what the most appropriate level and composition of R&D is for Australia in aggregate. It is better to try to understand why our performance is the way it is and seek to bring about any change by remedying deficiencies in the system.

Firm innovation and competitiveness

Firms are a conduit through which R&D, whether undertaken within the public or private sectors, produces innovations which enhance competitiveness and ultimately economic growth. They innovate to create a competitive advantage by introducing new or improved processes to lower costs, or new or improved products or services to capture market share.

The impact of innovation on the competitiveness of firms is to some extent dependent on the social and economic structure within which they work, which in turn is influenced by government. The OECD has argued that firms' competitiveness depends not only on their strengths and weaknesses but also on the efficiency of national production, rates and patterns of capital investment (including training and education and public sector research), and technological infrastructure.

Among the many insights about firm R&D and innovation that have emerged in recent years, the Commission considers the following to have particular significance:

- While technological innovation is important, other forms of innovation are also of importance to Australian firms. These include innovation in management, marketing and distributional processes, and changes in organisational structures within and among firms. As the Business Council has shown, many firms are innovative and competitive, but do little formal R&D.
- The capacity of a firm to innovate effectively is acquired over time in a cumulative process of learning. The effect of R&D on the firm's competitiveness depends on how well it is integrated into the production and marketing activities of the firm and the availability of 'complementary assets', such as distribution networks.
- Factors which influence a firm's R&D decisions include the 'closeness' of its business activities to new science, the cost to competitors of imitating the results of its R&D, the potential size of the firm's market and the nature of the relationships which a firm has with its suppliers, customers and rivals.
- The ability of firms to benefit from the R&D of other firms or research institutions, whether domestic or international, depends on their own technological capability, to which R&D may make an important contribution. In other words, firms need to do R&D in order to make use of the fruits of others' R&D.

These features help explain why business R&D has been less intensive in Australia than in many overseas countries and why it has been rising significantly in recent years. Competitive pressures provide an important spur to innovation. As noted by the Business Council, that incentive was weakened by the high levels of manufacturing protection in Australia during much of the post-war period. Given that R&D involves a cumulative learning process, current levels of business R&D can be seen at least in part as a legacy of those earlier policies.

The opening of the Australian economy has raised technical efficiency in production and prompted a search by business for enhanced competitiveness through innovation. The Commission considers that this in itself is having an important influence on the growth in business R&D.

Economic impacts of R&D

The benefits which firms seek through R&D — lower costs, higher productivity, better products — if realised, also ultimately result in higher GDP. Recent developments in economic theory, known as 'new growth theory', have shown in a formal way how R&D can permanently raise a country's rate of growth. This is seen by some as theory catching up with common sense. The theory recognises that new knowledge is rarely confined to any one firm or even industry and indeed can often be used repeatedly and simultaneously at little extra cost to users. This 'spillover' effect eases the constraint usually placed on growth by the scarcity of capital.

Knowledge spillovers occur among as well as within countries. The generation of knowledge within Australia is overshadowed by that occurring world-wide. Developing and maintaining channels of access to international knowledge can play a critical role in domestic economic performance. Trade and direct investment are thus important sources of domestic innovation and growth.

Attempts to quantify the economic impacts of R&D have been plagued by data problems, which are compounded by the complexity of the task.

The Commission's extensive survey of empirical work around the world on the economic returns to R&D suggests, despite the limitations of many studies, that:

- returns to individual projects and firms undertaking R&D vary greatly, but often exceed the returns on investments in machinery and equipment;
- R&D has a significant positive impact on an economy's productivity; and
- spillover effects from R&D can be substantial, both domestically and internationally, but vary unpredictably from industry to industry.

In the absence of satisfactory work having been done for Australia, the Commission undertook its own quantitative estimates of the rate of return on Australia's R&D effort, including the use of models consistent with new growth theory. This work controlled for some of the sources of bias found in overseas studies. The estimates are sensitive to various assumptions, however, and range from 25 to 90 per cent, with one estimate as high as 150 per cent. The Commission would caution that its estimates are still likely to overstate the returns to actual R&D. Apart from technical sources of upward bias in the highest estimate, they may be capturing the returns to unrecorded R&D or other, non-R&D influences on measured returns.

Although estimated aggregate rates of return to Australia's R&D range widely and some are likely to be biased upwards, they lend support to theoretical analyses and intuitive judgments of the importance of R&D to economic growth.

What role for governments?

Governments play a major role in shaping the national innovation system — both through their own institutions and the incentives they provide to others.

The Commission has reviewed the large (and growing) theoretical literature on innovation and its implications for public policy. Despite a number of useful recent developments, the fundamental rationale for government intervention remains the 'public good' characteristics of knowledge creation — its lack of appropriability and wide applicability — enabling spillovers to society from private investments in R&D.

Where spillovers exist — and empirical work suggests that they are widespread — there is the prospect that not enough R&D will be performed unless government steps in. Whether government intervention is socially beneficial depends largely on what form it takes.

There are three approaches to government intervention in R&D:

- creating and strengthening markets — through intellectual property rights, or facilitating collective industry research arrangements;
- providing various forms of financial support to private firms doing R&D; and
- sponsoring or undertaking research within the public sector — in universities, government departments and research agencies.

The relative merits of these approaches have been greatly debated. Theory and empirical work offer conflicting advice on the optimal forms and levels of intervention, particularly when account is taken of the costs of intervention itself. No single approach is able to meet all requirements. Each has strengths and weaknesses, and their relative performance can differ according to the problem or group being targeted.

The uncertainty and lack of information about the outcomes of government intervention mean that a robust policy for R&D must involve a combination of approaches. Measures that are introduced need to be

recognised as experimental in the first instance, and designed and reviewed accordingly.

The theoretical considerations as well as the experience of government involvement in R&D in Australia and overseas suggest a number of broad guidelines for policy design:

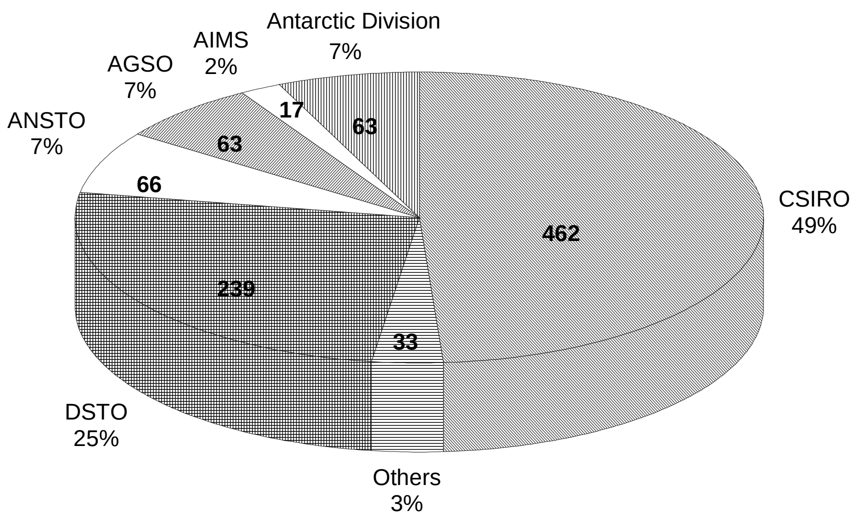
- *Diversity should be encouraged.* Given the uncertainties and information problems, a combination of interventions is desirable, as well as a choice of funders and research performing institutions.
- *Private incentives should be built on where possible.* Much R&D would be done by firms in the absence of any government assistance or involvement. R&D that users initiate themselves is likely to best meet their needs. Government action which promotes user-driven research can therefore be an effective form of intervention.
- *Assistance schemes should be simple and transparent, with well-defined criteria.* Lack of information and uncertainty about the likely social benefits from alternative projects greatly limit any potential payoff to administrative discretion in supporting private R&D. Selective assistance schemes with vague rules also encourage firms to 'position' themselves for support and can be costly to administer.
- *Assistance levels should be broadly consistent.* Where assistance is provided with a similar expectation of social benefits, it should be provided at comparable rates, and 'double dipping' should be avoided.
- *Research should be monitored and evaluated.* To justify support, research needs to produce benefits. Some benefits are hard to measure, but where practicable, evaluation can help ensure that funding goes to the right projects for the right reasons. Objectives need to be specified beforehand, and evaluation should not be limited to successful projects.
- *'Contestability' should have a major role in research funding.* In many areas of research there is scope and potential for a range of providers to do the work. Funding mechanisms which can target the researchers and organisations that produce the best, most cost-effective research, have obvious attractions.
- *Government's roles in sponsoring R&D should be clear and its requirements clearly articulated.* Governments are responsible for three different tasks when sponsoring R&D: one is to determine priorities, a second is to choose particular research projects and the third is to perform and disseminate the research. Each task can require different skills and perspectives, but these roles are often intermingled. There can be benefits

in governments clarifying and in some cases separating their roles in the range of activities for which they are responsible.

3. Government research agencies

Australia stands out internationally with respect to the proportion of its total R&D activity that occurs within the public sector. Over half of public sector research is conducted within government research agencies, among which CSIRO is predominant (see figure 2).

Figure 2: **Major Commonwealth research agencies - estimated budget outlays for 1994–95** ($ million)



Source: Cook 1995a.

Some of these bodies do scientific research, while others do social or economic research. They are organised in various ways with different degrees of autonomy. Given the substantial resources involved in government research, it is important that the agencies concerned are doing research with high social returns and that they are operating as cost effectively as possible.

CSIRO

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia’s largest research institution, with a proud record of achievement extending back through most of this century.

CSIRO originated at a time when there was very little formal research capability in Australia. Its early efforts were largely directed at finding solutions to unique problems facing Australian agriculture and it has been highly successful in this. Over time, CSIRO’s activities have broadened to include work related to the mining, manufacturing and services sectors, and areas of importance to the community generally, such as natural resource management and the environment. It has also become a respected independent source of advice to government on policy issues requiring scientific input.

In common with government research agencies around the world, CSIRO has been subject to considerable scrutiny and debate in more recent years. Successive government reviews and policy changes have helped shape and reshape the organisation. Nevertheless, by current international standards, CSIRO remains a very large and diverse organisation with greater discretion in allocating its public funding than most.

It has become obvious to the Commission in the course of this inquiry, that there is considerable confusion in the community about CSIRO’s role and divergent opinions about its performance. To a large extent, these are related.

What is CSIRO’s role?

CSIRO’s role is defined in broad terms in legislation and Ministerial Directions, which require it to place emphasis on research of significance to national economic development, including research in support of industries and the interests of the Australian community generally. The dissemination of the results is seen as central to its role. These are important and appropriate objectives for a government research agency. They are also very broad and provide little guidance for CSIRO’s research agenda. While CSIRO is required to give ‘due regard to the industry and research policies and priorities of the Government’, it receives little guidance about where to focus its research effort.

In order to enhance CSIRO’s ‘relevance’, the Government has required it since 1988 to achieve an external earnings target equivalent to 30 per cent of its total funding. The Commission considers that the principle of CSIRO being required to contract with users of its research is an important and useful one. However, the current arrangements appear to have shifted CSIRO’s industry orientation towards contractual arrangements with larger private companies, some of which have been cross-subsidised. CSIRO has been criticised for not doing enough for small enterprises and additional resources have recently been allocated for this purpose.

CSIRO is having understandable difficulty in attempting to span the roles of ‘workshop’ or commercial partner for private companies and provider of research with wider benefits to the community.

Both the demand for R&D by industry and the availability of alternative sources of R&D have increased greatly since CSIRO was formed, especially in more recent years. CSIRO’s niche is to be found between the research undertaken within universities, which is often motivated by the desire to advance knowledge for its own sake, and the research that firms have sufficient incentive to initiate themselves (supported by the industry programs). This nevertheless comprises a potentially large field (in which CSIRO is of course already active) including strategic and long-term research of direct benefit to wide sections of industry and the community — loosely described as ‘public good’ research.

The Commission considers that CSIRO’s principal role is to undertake research which has direct value to industry and the community, but lacks sufficient prospective private returns for it to be performed or sponsored by firms (‘public good’ research). The results of such research should be widely disseminated.

Managing contract research

This does not of course preclude CSIRO doing research for or in association with private firms. Such research is important in ensuring that CSIRO’s strategic research is relevant to needs. But it is important that the costs of research which predominantly benefits individual clients not be subsidised from CSIRO’s public funding. And there is the potential for such work to inhibit CSIRO’s responsibility to disseminate its research findings widely where clients require confidentiality or exclusive use of the research results.

CSIRO has developed a Commercial Practice Manual which contains (confidential) guidelines for research costing and pricing that, in part, attempt to avoid cross-subsidising research benefiting its clients, but also meet other objectives. However, it is not clear whether CSIRO is consistently costing its research appropriately or following its own guidelines. Because of confidentiality and lack of information there is no basis for judging whether CSIRO’s contributions to research programs for external clients are justified by additional social benefits, especially when account is taken of the subsidies they already receive.

When contract research is provided at below cost, it can crowd out private research and CSIRO's public good research, as well as providing a 'double dip' subsidy to private firms already benefiting from tax concessions or grants on their R&D expenditure with CSIRO.

The Commission recommends that CSIRO research be priced to recover full costs, unless social benefits not already subsidised by government are identified.

Under current arrangements, the allocation of funding for its public good research is essentially decided by CSIRO. It is very difficult for government (and the community) as the funder of CSIRO, to know whether Australia is getting the best value out of this important national asset — both with respect to the research that is undertaken and its cost.

'Contestable' funding

In a number of other countries, government funding of research agencies is predominantly provided on a program basis, sometimes with competition from other research providers. The Commission considers that providing a greater role for government in priority setting and funding of CSIRO's research would have a number of potential benefits.

It would provide scope for wider 'ownership' of CSIRO's priorities. It would also improve CSIRO's accountability, reduce the scope to cross-subsidise research performed for external clients and allow CSIRO's performance to be tested against that of other researchers.

In its draft report, the Commission put forward for public debate some options that involve an explicit research 'purchasing' role for government:

- one set of options involved the departmental portfolios which represent stakeholders for CSIRO's work funding specific programs of research, replacing much of the single appropriation; and
- the alternative option involved the creation of a separate and independent agency with the responsibility for funding public good research, against priorities developed with the participation of a range of researchers and industry and community representatives.

Both options provide scope for contestability. In each case, the Commission stressed the need to phase in changes to minimise any adjustment difficulties.

Many participants, while generally supportive of the Commission's views about CSIRO's role, and its diagnosis of deficiencies in current arrangements, had doubts about the value of contestable government funding in principle and the options in particular. Issues raised included: the scope for separately identifying public good research; whether government purchasers could make informed decisions about priorities and alternative proposals; the extent to which there were (or ever might be) viable competitors for CSIRO; the costs of a contestable funding system, and how such a system might impact on cooperative and long-term research.

The Commission acknowledges that a number of the arguments have force. While it considers that arrangements could be devised to overcome some of the concerns raised, especially if based on the independent agency model, significant uncertainty would remain about the net effects of such a change — particularly given the lack of information on which to assess CSIRO's performance under current arrangements.

It has therefore looked to other ways of achieving greater external influence on CSIRO's priorities, accountability and cost effectiveness, short of formal contractor arrangements with government customers, while enhancing the ability of government to evaluate CSIRO's performance and the need for further reforms.

Improved priority setting

The Commission considers that CSIRO's priority setting processes can be enhanced by developing and improving forums for government and community input.

The Commission recommends that the Commonwealth Government establish an annual consultative forum with CSIRO for the purpose of achieving a whole of government view on broad priorities for public good research. As proposed by the CSIRO Board's Evaluation Committee, the forum (or 'workshop') should include senior officials from stakeholder departments and be linked to CSIRO's planning and funding cycles. In the Commission's view, such a forum should also:

- **provide an opportunity for government to examine key CSIRO programs;**
- **encompass other government research agencies; and**
- **result in a published statement of priorities.**

CSIRO has long used advisory committees of external stakeholders to assist it in setting its priorities at operational levels, but there has been concern about how effective the committees are in this role.

The Commission considers that the functioning of the advisory committees would be enhanced by:

- **committee members being appointed by the Board; and**

- **the committees' advice being documented and publicly available.**

Greater accountability

While existing mechanisms for CSIRO's accountability appear satisfactory in a public administration sense, there is little basis for evaluating CSIRO's performance in its principal role as a provider of public good research.

The Commission urges that the Resource Agreements and performance indicators for CSIRO (and other government research agencies) being negotiated with DIST and the Department of Finance, be concluded as soon as possible and be made publicly available.

The Commission also recommends that CSIRO's costing and pricing guidelines be reviewed by, and explicitly agreed with, Government and available for public scrutiny.

The above initiatives are unlikely however, to provide a sufficient basis, in themselves, for influencing and evaluating CSIRO's performance. In lieu of a more contestable funding system, the Commission considers that there is a need for CSIRO's performance to be independently monitored on a regular basis.

The Commission recommends that an independent agency be designated to monitor and publicly report on CSIRO's performance against the agreed priorities and performance indicators. (Among existing agencies, the Australian National Audit Office could most appropriately take on this function.) The agency should also, among its tasks:

- **verify that CSIRO is costing and pricing its research according to the guidelines;**
- **examine the extent of CSIRO resources used to supplement projects for external clients, and the justification;**
- **initiate cost-benefit studies of selected programs; and**
- **over time, review (and help refine) performance indicators and costing/pricing guidelines in the light of experience.**

The agency's role could in time be extended to conduct similar performance audits of other government research agencies, including AIMS, ANSTO and AGSO.

These proposals would greatly improve external scrutiny of CSIRO and provide a better basis for influencing how it spends its appropriation. They would thus increase the potential for external earnings to enhance rather than detract from CSIRO's performance in public good research. By getting government more actively involved and generating information necessary to evaluate its performance, they should provide a better basis for determining its budget. They may also help identify whether a greater explicit purchasing role is needed and improve the capacity of government to assume such a role.

DSTO

Defence is DSTO's main customer and a significant proportion of its output is security sensitive or of limited civilian application. As such, DSTO's external sales and the dissemination of its research results will inevitably be constrained.

The Commission accordingly does not recommend any external earnings requirement or target for DSTO.

DSTO has in place a number of mechanisms to make its research expertise and outputs available to industry, including its Business Office and collaborative projects (in conjunction with CRCs as well as with industry). It has licensed some of its technology. External income remains very small.

DSTO's priorities are developed jointly with the Department of Defence. Funding of DSTO is at the Department's discretion and this creates an incentive for it to perform to the Department's satisfaction. Nevertheless, Australia is unusual in the minimal extent to which its defence research is contracted out. This may reflect a lack of the requisite skills outside DSTO. However, the Commission considers that current funding arrangements for defence science may not be taking advantage of the scope for contestability.

The Commission supports the target set for DSTO of contracting out 8 to 10 per cent of its budget by 1998. It recommends that there be a subsequent review by the Department of Defence of the attainment of this target and its effects, as a basis for assessing whether to vary it or implement alternative arrangements to achieve greater contestability.

4. University and related research

Universities play a central role in the development of the intellectual, cultural, social and economic life of a nation. Universities are also key institutions in Australia's innovation system. The distinguishing characteristic of universities among research institutions is their teaching and training role.

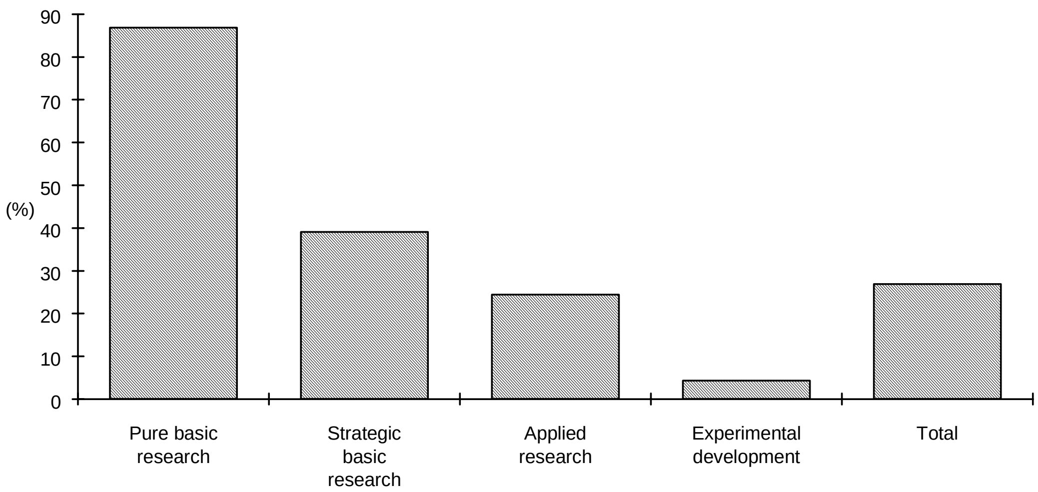
Universities collectively account for around one-quarter of Australia's total R&D expenditure and one-half of government funding for R&D — both relatively high proportions by international standards.

According to available statistics, around two-thirds of university research is basic research. Universities dominate in the provision of *pure* basic research in Australia and are least involved in experimental development (see figure 3).

Nevertheless, in recent years, universities have become more involved in applied research.

The bulk of research funding for universities is provided by the Commonwealth Government through a 'dual funding system', involving operating (or 'block') grants to institutions and competitive grants for selected research projects or programs. The former are provided as single allocations by DEET. Part of the block funding is notionally identified for research (the largest component being the Research Quantum). But universities are broadly free to allocate block funds as they see fit. Competitive funding is largely provided through the Australian Research Council (ARC), which also plays an important role in advising government on research policy.

Figure 3: **Higher education contribution to R&D by type, 1992** (per cent)



Source: ABS, Cat. No. 8112.0, table 5.

Funding was a key issue for participants in this inquiry, as in many others. Concerns were expressed about both the level of funding and the processes for its disbursement. While the Commission's terms of reference preclude it from addressing funding levels, allocation processes have important effects on the quality and composition of research from available resources and have therefore been closely examined. How these processes should best operate depends critically on the perceived role and objectives of university research.

Role of university research

The gains to society from university research accrue through:

- the students whose research skills and learning are increased; and
- the dissemination of knowledge flowing from the research itself.

There are important complementarities between teaching and research. As Murdoch University observed in its submission:

> Research ensures teaching remains 'fresh' and at the 'leading edge' of the discipline, while teaching demands researchers retain breadth in their subject area as well as having the input that informed 'naive' inquiry can provide. This dual task distinguishes universities clearly from a pure research organisation (Sub. 21, p. 2).

The distinguishing characteristic of a university among research institutions is its teaching and research training role. This defines a central rationale for its research that does not apply in other research organisations.

Teaching requires research to enable teachers to maintain familiarity with developments in the discipline areas in which they work. This research in support of teaching might be distinguished from that involved in training and developing the skills of graduate research students, which usually involves some research directed at new discoveries. The benefits to society from interactions between teaching/training and research derive not just from the better 'quality' of the people made available for research and a range of other activities contributing to national well being, but also from the intellectual and cultural vibrancy that comes with an informed and inquisitive population.

Other benefits from university research derive from the body of knowledge it creates (often the result of basic research) which in turn can be drawn on by those seeking to innovate in producing goods and services. Universities are also important in establishing durable links to the global community of scholars and their research (giving Australia a 'place at the international table'). This requires personal contact by people who can both understand and contribute to latest developments.

Are funding arrangements appropriate?

It follows that academic research can in principle be divided into two (interconnected) streams. First, there is that research (including 'scholarship') which is essential for professional academic development. Second, there is research of a more 'discretionary' nature, or that which is considered to be original research leading to the advancement of knowledge. There is considerable overlap between these streams of research and the objectives they serve.

The manner in which financial support is given influences the amount of each type of research produced and the balance achieved among objectives for university research. In broad terms, the funding mechanisms employed to support research in universities fall into three categories:

- block funding related to teaching loads;
- selective grants for individual research projects; and
- selective grants to particular institutions based on their research performance.

In addition, universities undertake research on a contract basis for both the government and the private sector.

Box 3: **University and related research: some key terms**

Operating grants — are provided to universities as a single allocation of funds (or block grant) and have three components; a teaching, a research-related and a capital component.

Research Quantum — is the component of the operating grant notionally attributed to expenditure on research activities not directly associated with teaching activities and research training.

Australian Research Council — provides advice to the Minister on the distribution of resources for the various programs for which it has responsibility. It also provides information and advice to the National Board of Employment, Education and Training on research policy issues.

ARC Large Grants Program — provides funds to specific research projects on a competitive basis using peer review.

ARC Small Grants Program — provides grants to universities to be distributed to specific research proposals in accordance with the institutions' research profiles and priorities.

National Health and Medical Research Council — is an independent statutory authority which provides advice to the Government on matters relating to health and the prevention, diagnosis and treatment of disease and on the funding for health and medical research.

Research which supports teaching and the training of students in research, needs broadly to reflect student numbers in different disciplines. It makes sense that this research should be funded as part of the operating grant, so that institutions have some flexibility to fine tune internally the allocation of funds provided to the disciplines and academic staff most deserving of support.

Universities are well-placed to evaluate their own research needs in support of teaching and research training and the Commission considers that, as

universities are block funded to support their teaching function, the same funding arrangements should continue to apply for this research.

The other dimensions of university research, being more variable across institutions and courses, are more difficult to fund in a way that relates to student numbers and types of teaching. Academics should not all be obliged, nor should they all expect, to undertake research that is not directly related to teaching and research training. These other objectives of university research are best achieved through selective, competitive grants based on the relative merits of different researchers, programs and institutions.

Recent years have seen a reallocation of funding of universities away from the operating grant towards selective programs. In the Commission's view this approach has been appropriate. In a system with diverse institutions, characterised by courses at different standards in similar disciplines, it has permitted limited funding to be allocated according to demonstrated capability.

There are nevertheless significant costs in running a competitive grant scheme. Small grants, which provide useful research support, are likely to be most cost-effectively allocated within universities, as under current arrangements.

The Commission endorses recent approaches to funding of university research which have seen a shift away from use of the operating grant towards the funding of institutions and research projects on a selective basis.

Under current arrangements, the Research Quantum is delivered through the operating grant, although allocated to universities on the basis of their research performance. As a research funding mechanism, the Research Quantum has the desirable features of rewarding strongly performing institutions, while minimising costs associated with the selection process. It provides universities with flexibility and discretion in funding which, among other uses, allows them to support promising young researchers and position themselves in research niches which may not initially attract ARC grants. At the same time, being allocated on the basis of success in contestable project funding and output performance, there is an inherent discipline on universities to spend the Research Quantum wisely. But this means that the value of maintaining the Research Quantum depends in part on the processes by which it is allocated.

The allocation criteria for the Research Quantum were increasingly out of date until a working party including the AVCC undertook the task of devising the Composite Research Index. The Commission commends this initiative, but considers that the ARC is now best placed to assume ongoing responsibility for ensuring the appropriateness of the index and the delivery of funding.

The Commission recommends that the ARC be made responsible for determining the criteria for allocation of the Research Quantum (the 'composite index'). The Commission also recommends that the ARC have responsibility for disbursing the Research Quantum, subject to the requirement that the ARC not reduce funding below its current level.

Excellence, relevance and priorities in university research

The debate about the desirability of using criteria other than academic merit ('excellence') to fund university research under selective schemes is of long standing in Australia and overseas. While some notion of national benefit is needed to justify funding at all, what is at issue is whether explicit regard to criteria other than excellence would better promote this objective.

In response to the Government's view that funding should take into account '... value to research users, potential for innovation, and ability to contribute to research training and international links', the ARC identified five benefits of research to form strategic objectives against which to assess funding.

In the Commission's view, it is questionable whether selection panels associated with many programs administered by the ARC can make meaningful assessments on the basis of such criteria. All proposals will measure up in different ways against relevance criteria. Assessing their net ranking would be extremely difficult, especially when their academic merit differs. Applicants also have an incentive to pitch their proposals in a favourable light. Some will be better at this than others. And those involved in pure basic research may be disadvantaged.

In disbursing public funds, the ARC has a special responsibility for supporting non-appropriable research consistent with the objectives of higher education institutions. Such research will often be basic in character and allocation procedures related to its support are ill suited to the application of criteria other than excellence. Universities may, however, wish to undertake more applied R&D. In such instances, it seems appropriate that universities should seek support from the wide range of other public and private sector sources, and seek to match their research expertise to the needs of particular users.

The Commission does not consider that the 'relevance' criteria developed by the ARC provide an appropriate or operational basis for ARC panels to choose among competing university research projects *which involve basic research*. Programs aimed predominantly at funding the advancement of knowledge, particularly the large grants program, should use excellence as the only criterion.

The direction of research funded through the ARC is also influenced by the weight of funds going to different programs and, within programs, to disciplines. This has a significant effect on the type of research undertaken.

The Commission understands that currently, even though grants are made under the auspices of the ARC, the allocation and reallocation of funding amongst its programs are subject to Ministerial approval. Because the ARC has a range of programs broadly aimed at the same purpose, there is merit in allowing the ARC to pursue those objectives with the range of programs it sees as best suited to meeting them. The ARC should be given direct control over the allocation of funds (subject to any constraints imposed to retain particular programs and maintain the level of Research Quantum funding).

The Commission recommends that the ARC have greater autonomy and responsibility for the distribution of funds among its programs. The Commission considers, however, that the ARC should maintain a diversity of funding programs and the Government may wish to ensure this by specifying minimum allocations in some programs.

In the large grants program, funding allocations among disciplines appear to have been made somewhat arbitrarily initially, then reallocated according to the quality of applications in each area. In practice there has been very little variation in allocations from year to year. There is nevertheless implicit prioritisation in the amounts distributed among the panels.

The Commission recommends that choices about allocation of funding among disciplines be explicitly made by the ARC in the light of priorities it identifies in consultation with major stakeholders.

Once allocated to different discipline areas, panels would then choose among research proposals on the basis of excellence as judged by peer review.

The Commission recommends that the ARC be given additional resources and statutory independence to fulfil the proposed expansion of its role envisaged in this report.

Institute of Advanced Studies

The IAS comprises eight schools of full-time academic researchers in the physical and social sciences. It is part of the Australian National University and its funding ($129 million in 1993–94, plus $17 million for the John Curtin School of Medical Research) is provided through the ANU's operating grant. When the IAS originated (in 1946), it had a unique capability in fundamental research. With the expansion of the university sector in Australia, that is no longer the case.

In response to the Commission's draft report, a number of universities questioned whether the IAS should continue to be in the special position of having its research funded separately from research in the rest of the sector.

The Commission has given close consideration to the arguments of the IAS for maintaining its traditional funding arrangements. While it sees benefits in the continuation of block funding to the IAS, it considers that there should be greater scope than under the existing review processes for funding decisions to be made according to comparative performance against other university researchers.

The Commission recommends that all funding programs supporting research in particular disciplines should be periodically reviewed. Review panels should be required to make recommendations to government on the balance of funding among different funding mechanisms (including the schools of the IAS) for the discipline under review. Members of the review panels should be appointed by the Minister from a list proposed by the ARC, and the ARC should provide the secretariat.

John Curtin School of Medical Research

The JCSMR, part of the IAS, is one of several institutions in Australia whose researchers are devoted full-time to basic medical research. Since 1992, the JCSMR has been block funded by the Department of Human Services and Health. This arrangement followed the Stephen Review, and was seen to be an improvement over its previous funding arrangements within DEET's operating grant to the ANU. The Commission considers that it would now be desirable to transfer responsibility for funding the JCSMR to the NHMRC, which is better placed to evaluate its performance and funding needs relative to the other block funded medical research institutes within its ambit.

The Commission recommends that responsibility for funding the JCSMR be transferred to the NHMRC.

The Commission also directs attention to its views on:

- **funding of infrastructure (C5.1);**
- **success rate of ARC grants (C4.4);**
- **peer review (C4.4); and**
- **the proposed taxing of postgraduate students (C5.3).**

NHMRC

The NHMRC — an independent statutory authority — is Australia's peak advisory body on public health, health care and health and medical research. It funds about one-quarter of total health and medical research. Of the $120 million allocated by the NHMRC in 1993, close to 60 per cent went to the university sector. The NHMRC also block funds several medical research institutes and supports some research conducted in hospitals.

The funding processes of the NHMRC are quite similar to those of the ARC. Questions have been raised as to whether the two institutions should be combined. The reasons for separately funding medical research, apart from its separate importance, include the fact that such research is conducted in institutions other than universities, and that the objectives of funding programs differ significantly from those of the ARC.

The Commission considers that competitive funding for medical research should continue to be allocated through the NHMRC.

Priority setting

The NHMRC is required under its Act to consult in its development of research recommendations and guidelines. In preparing its Research Strategy, it draws on a range of advice and reporting from the medical community, government and community groups.

The Bienenstock report (1993) nevertheless considered that arrangements had been somewhat ad hoc and reactive. It recommended the establishment of a Strategic Health and Research Planning Committee which would, among other things, develop a strategy incorporating identified priority areas and agendas for action by the Principal Committees, and monitor the implementation of such a strategy. It recommended that available health information in Australia and overseas should be marshalled and presented in a way that enables organisations such as NHMRC to develop health plans and policies. The Committee is now in operation.

The Commission supports this initiative, which should bring a broader perspective to priority setting in medical research.

The Commission considers that excellence by international standards should be the major criterion for selection by panels, with priorities being implemented through the allocation of funding among funding areas.

The Commission also draws attention to its comments on:

- **medical research infrastructure and its funding; and**

- **administrative resources of the NHMRC (C6.3).**

5. Business R&D

Business expenditure on R&D in Australia has increased substantially in recent years. Nevertheless, as a proportion of GDP, it remains below the OECD average and, in most industries, Australian companies are less R&D intensive on average than their overseas counterparts. This has been of concern to the Government, which has introduced a number of important assistance measures for business R&D over the last decade.

Recent analysis suggests that Australia's lower BERD to GDP ratio is attributable more to the structure of its manufacturing sector than to the lower R&D intensity of its manufacturing industries. The lower R&D expenditure, relative to production, of Australian companies can be explained largely by the long-standing protection of manufacturing and Australia's traditionally low participation in world trade — a major source of technological knowledge. It is no coincidence that the opening of the Australian economy has coincided with rising use of R&D; but catching up will unavoidably take time.

The Commission does not consider the gap between Australian business R&D intensity and that overseas to be attributable to lack of government assistance. When all forms of assistance are accounted for, business R&D appears to be more highly supported in Australia than in most other countries.

It is also the case, however, that government support for business R&D increased substantially in the 1980s. The main vehicle of support is the Industry Innovation Program, which currently comprises:

- the 150 per cent tax concession — available to firms generally;
- competitive grants for R&D — awarded selectively; and
- concessional loans for commercialisation of technological innovation — a new selective program launched in October 1994.

Other support for R&D occurs through the Partnerships for Development Program and the Pharmaceutical Industry Development Program, and business also receives support through a range of other collaborative grant schemes, including the CRC program.

Underpinning this financial assistance is the patent system and other intellectual property laws, which can play an important role in encouraging R&D, while allowing some dissemination of its results. Nevertheless, some participants saw the patent system as providing limited benefits, preferring other devices to maintain secrecy and to appropriate benefits.

The 150 per cent tax concession

A general (that is non-selective) approach to providing R&D support for firms is most appropriate when the external benefits are widely spread and relatively uniform among firms. As the Treasury noted:

> ... [tax incentives] are most suitable where it is considered appropriate to support all businesses undertaking R&D (eg because externalities are widespread). Given the large number of firms receiving assistance, it would be difficult to replicate these incentives with grants or loans.

It is also the most appropriate form of support where there is little information available to administrators to distinguish among firms in terms of their need for assistance and capacity to undertake socially beneficial R&D.

Box 4: **Some facts on the R&D tax concession**

Objectives — to make Australian companies more internationally competitive through improving innovative skills in Australian industry by: increasing investment in R&D; encouraging better use of Australia's existing research infrastructure; improving conditions for the commercialisation of new process and product technologies developed by Australian companies; and developing a greater capacity for the adoption of foreign technology.

Benefit — the tax concession enables eligible companies to deduct 150 per cent of eligible expenditure incurred on R&D activities against their taxable income.

Who can claim the concession? — companies incorporated in Australia; public trading trusts; eligible companies in partnership.

What expenditure is eligible? — expenditure on R&D projects that involve either innovation or technical risk. Associated requirements are that the R&D must (generally) be carried out in Australia; it must have adequate Australian content; and the results must be exploited for the benefit of Australia.

Number of registrants — approximately 2 000 per year.

Tax revenue forgone — $520 million (1993–94); $480 million (1994–95 est).

The tax concession was introduced for a trial period in 1985. Following consideration by government as to whether to terminate it or reduce its value, it was announced in the 1992–93 budget that the tax concession would be retained indefinitely at 150 per cent.

As a form of support for R&D, the tax concession has a number of desirable features:

- it allows firms to decide for themselves what R&D to undertake and when;
- it has relatively low administrative and compliance costs; and
- the fact that it is available to all firms with eligible R&D means that firms have limited incentives to lobby for special treatment.

The tax concession also has some disadvantages:

- the assistance it provides can vary with changes in the corporate tax rate;
- the benefit can also vary among recipients depending on dividend decisions of companies and the tax status of shareholders. Part of the benefit can be neutralised or 'washed out' through dividend imputation;
- the concession discriminates against companies in tax loss; but
- it cannot discriminate against projects that would have proceeded without the support it provides.

The BIE conducted a review of the tax concession in 1992–93, concluding that it was 'more likely to have generated a net social benefit for Australia than not.'

The Commission undertook its own quantitative assessment, using a special economy-wide model incorporating R&D. This produced a result, consistent with the BIE's findings, that removal of the tax concession would lead to a reduction in GDP.

The Commission concludes that the 150 per cent tax concession has brought net benefits to the Australian economy.

Many participants argued that the level of the concession should be increased to restore the value of the incentive that existed prior to the reduction in the company tax rate, or to match apparently higher concessions overseas. The BIE has argued, however, that increasing the rate would have doubtful welfare implications because of the costs associated with raising the revenue to support projects that would have proceeded anyway and the possibility of lower spillovers from more marginal projects. The Commission also considers that the 200 per cent tax concessions available in Singapore and Malaysia are unlikely in practice — because of more selective application and lower company tax rates — to be more generous than Australia's 150 per cent concession.

The Commission also agrees with the judgment of some participants that the effectiveness of the tax concession in inducing R&D may have been weakened by the uncertainty surrounding its continuity and level.

The Commission does not support changing the tax concession, either to restore the effective value that applied in earlier years, or to match rates that apply in other countries.

The Commission's modelling highlights that gains would come from a higher 'strike' rate in inducing R&D. A scheme which provides assistance only for additional R&D, such as in the United States and Japan, would have a significant advantage over current arrangements, but is essentially precluded in Australia by the potential for misuse or abuse. Under Australian tax law, it would be possible for firms to claim a subsidy intended only for incremental R&D on all of their R&D spending, by setting up special purpose R&D affiliates. Assuming a relatively high subsidy rate for incremental spending, firms doing this would receive more subsidy than before for doing the same amount of R&D.

Competitive Grants Scheme

The Commission's terms of reference require it to report on the Grants for Industrial R&D (GIRD) program prior to a government decision about extending funding. During the course of this inquiry, the schemes that constituted the GIRD program (the Discretionary Grants Scheme and the Generic Technology Grants Scheme) were absorbed into the current Competitive Grants for R&D Scheme (see box 5). The performance of the previous schemes nevertheless remains relevant to an assessment of current arrangements.

Box 5: **Competitive Grants for Research and Development**

Value of grant payments (under former schemes) — $41.6 m (1992–93); $36.9 m (1993–94).

Objectives:

- to encourage companies, particularly small to medium sized enterprises, to develop internationally competitive goods, services and systems, and to adopt new products, materials and methods to improve manufacturing capability, productivity and quality;
- to strengthen linkages between technology developers and technology users;
- to encourage the development of technologies, including emerging and enabling technologies, that are likely to have wide application in Australian industry; and
- to foster collaboration between companies and research institutions.

In principle, selective assistance for R&D should allow greater scope to target projects with the highest social payoff and to induce those projects which otherwise, through lack of private profitability, would not proceed. In practice, however, the ability of a selective scheme to perform better than generally available assistance is greatly constrained by the difficulty of knowing in advance how different R&D projects will turn out and the great uncertainty that thus surrounds judgments about the relative (social) benefits of alternative claimants for support. Industry applicants have an incentive to provide only information that is favourable to their claim. More generally, the discretion inherent in selective subsidy schemes can induce lobbying and 'positioning', compounding the higher administrative and compliance costs associated with such schemes.

The programs which the IR&D Board administers have induced R&D which would otherwise not have taken place. However, a number of problems are inherent to subsidy schemes of this kind. The following features of their operations are of particular concern:

- The Board has very wide discretion in choosing which projects to support. The recent absorption of the previous five schemes into a single scheme with multiple criteria has increased the Board's flexibility and reduced the transparency of the scheme.
- There is considerable potential under current arrangements for support to become more focused on picking likely successful firms and industries than on addressing market failure in R&D.
- Assistance has tended to be concentrated on a relatively small number of firms, some of which have received several grants. The majority of applicants with proposals involving eligible R&D have received no grant assistance.

When the tax concession and grants schemes are compared, the following points emerge:

- The costs of running the grants scheme, relative to disbursements, may be at least ten times higher than for the tax concession. Participants have argued that their compliance costs are considerably higher as well.
- The rate of support for firms under the grants scheme — 50 per cent of project costs — is high relative to the tax concession. Because of imperfect 'clawback' arrangements under the tax concession, companies in tax loss receiving grant funding are also entitled to tax deductions in respect of the R&D when they become profitable. In total, this provides a higher rate of support than under the tax concession.
- Estimates of the proportion of projects induced by the previous schemes have been significantly higher than for the tax concession (although they are also more likely to involve response bias). They nevertheless indicate that across the largest three former grant schemes, at least 40 per cent of projects would have gone ahead without a grant.

The Commission finds that while the competitive grant schemes may have yielded net benefits in the past, their administrative processes have a number of drawbacks.

Cost recovery schemes

In the course of the inquiry the Commission was given an additional term of reference asking it to consider the issue of cost recovery of industry R&D grants.

Replacing (non-repayable) Competitive Grants with grants or loans that would be repayable in the event of commercial success could serve to reduce the cost of R&D support. Repayable schemes can also be designed to target support more effectively at projects that would not otherwise have proceeded. Such schemes are widely used overseas — in some countries (Japan, Germany, Sweden) they are major forms of support. Nevertheless, they have a number of disadvantages, including relatively high administrative costs, problems of identifying income streams from individual projects within larger companies and potential for avoidance of repayment.

The Commission does not favour introducing cost recovery arrangements in respect of support for companies in tax loss, nor for projects involving collaborative R&D. However, the Commission sees more scope for such schemes in respect of current support for closer-to-market activities outside the scope of the tax concession.

Recommendations

Tax loss companies undertaking R&D are disadvantaged relative to companies in tax profit because they cannot receive the benefit of tax deductions while they remain in tax loss. The inability of tax loss companies to benefit adequately from the tax concession was the chief rationale for the Discretionary Grants Scheme (now absorbed in the Competitive Grants Scheme). But that scheme, on the basis of previous experience, can only operate in a limited way to complement the tax concession and has a number of additional drawbacks.

Hence, on equity, efficiency and administrative grounds, it would be desirable to provide more generally available support to tax loss companies. In the absence of information on social returns by project, it would also be desirable for the rate of support to be more consistent across companies performing R&D.

More generally available support

A general subsidy for tax loss companies equal to the entire value of the tax deduction (150 per cent of expenditure multiplied by the company tax rate) was considered by the Commission for this purpose. However, such an approach would overcompensate tax loss companies — the characteristics of a subsidy are different from those of a tax deduction and provide greater benefits to many shareholders if companies in tax loss move relatively quickly into tax profit.

Instead, the Commission's preferred option is to provide all tax loss companies with a 'workable' level of upfront support in the form of a non-taxable grant equivalent to the 'concessional' element of the tax deduction — 50 per cent of the cost of undertaking R&D (18 cents in the dollar for a 36 per cent company tax rate).

A grant of 18 per cent which is certain is, in the Commission's view, a more attractive proposition for tax loss companies in general than a grant of 50 per cent with a low probability of being selected by the IR&D Board and a relatively high cost of applying (as under the current Competitive Grants scheme).

The Commission recommends that the 150 per cent tax concession be maintained. A generally available non-taxable grant should be introduced in place of competitive grants for tax loss companies, at a rate equal to the nominal value of a tax deduction of 50 per cent of the cost of undertaking R&D (18 cents in the dollar for a 36 per cent company tax rate). The grant could be payable in advance through the IR&D Board.

Syndication

The proposal for a generally available grant for tax loss companies allows them to gain some immediate benefit for their *current* R&D expenditure. There is another mechanism already in place — syndication — which allows companies to bring forward the realisation of their *accumulated tax losses*, and trade these losses for R&D funds.

Syndication appears to have a high inducement rate of new R&D. At the same time, it is a complex mechanism and has large transactions costs. Nevertheless, as the BIE evaluation has shown, it can generate net benefits by encouraging R&D that might not otherwise proceed.

Currently, syndication can be used to convert tax losses from all sources into funding for R&D projects. Except for the presence of various 'brakes' on its operation — the need for approval from the IR&D Board, and the transactions costs — it is likely that syndication would provide excessive incentives for R&D.

The Commission recommends that syndication not be used for tax losses incurred in activities other than R&D; nor should it be used by public or private tax exempt entities.

Tax loss companies accessing syndication, as well as receiving the Commission's proposed R&D grant, would arguably have at least as much incentive as tax profit companies to invest in R&D. But for those companies unable to use syndication, the general grant would leave them at a disadvantage, in that they could not obtain the full value of their R&D deduction until their income was sufficient. The Commission considered a number of ways of providing supplementary assistance to such firms — including through automatic or selectively available grants and loans — but found significant drawbacks with each. Nevertheless, the generally available grant proposed by the Commission would still leave most companies better off than under the current competitive grants program.

Other competitive grants

Some projects that are currently eligible for Competitive Grants involve a significant proportion of early commercialisation activities that are outside the scope of the tax concession — such as product development, trials, demonstration and marketing. These include projects that were supported under the former National Procurement Development Program.

In its earlier inquiry on the NPDP, the Commission's preferred option was that it be terminated. The Commission maintains that view. If the Government decides that support for these activities should continue, the Commission recommends that they be transferred to the Concessional Loans Scheme.

Collaborative projects between research institutions and commercial companies are also currently eligible for Competitive Grants. However, because they typically involve pre-competitive, high risk R&D, and grant payments are made to the research institution partner rather than the commercial partner, the Commission considers that non-repayable grants should remain for these projects.

The Commission recommends that non-repayable Competitive Grants should be retained (at the rate of 50 per cent of eligible project costs) for projects involving collaboration with research institutions where either more than one private company is involved or a single company does not have exclusive use of the results.

'Contamination' provisions of the tax concession

Currently firms receiving a competitive grant, nominally equivalent to the value of the tax deduction, can also obtain some measure of tax deduction for the R&D undertaken. This element of 'double dip' should cease.

The Commission recommends that the 'contamination' provisions of the tax concession should be revised so that companies receiving a grant lose an equivalent value of tax deduction.

Support for commercialisation

Commercialisation can be defined broadly as the process of taking a new product or process beyond the R&D phase and introducing it to the marketplace or in production. Commercialisation is a relatively costly and difficult part of the innovation process, and a number of participants considered that government should extend more assistance to it.

It is widely considered that Australia is poor at commercialising the results of its R&D. Similar judgments are often made about countries overseas. To the extent, however, that such views are based on the lack of take-up of research performed within the public sector, they may be misconceived. Much public sector research is not undertaken in the expectation of commercial exploitation; nor should that be its primary role. As discussed previously, its economic benefits often occur in more diffuse ways.

Unlike R&D, the benefits from commercialisation activities are predominantly captured by the firm concerned. Spillovers are much less likely than at earlier stages of the innovation process, so that this rationale for government intervention does not apply.

The Commission does not support extending the provisions of the 150 per cent tax concession to commercialisation activities.

Government support for commercialisation might also be justified by deficiencies in the market for venture capital, if they systematically operated to deny finance to profitable opportunities. The Commission's earlier inquiry into the *Availability of Capital* heard a number of complaints from small innovative companies about the difficulty of getting finance. However it also heard from many in the finance sector that there was a shortage of good prospects, when risk and the abilities of the existing management were taken into account. The Commission found little evidence of impediments to the supply of venture capital that would warrant government subsidy. That view has been reinforced by the Commission's consultations and discussions in this inquiry.

Current initiatives by the Government to address perceived deficiencies in finance for commercialisation include: the Australian Technology Group, which has received an initial capital injection of $30 million from the Commonwealth Government to invest in the early stages of business development; the Pooled Development Funds program, which provides concessional tax treatment for investment companies and, most recently, a new scheme of Concessional Loans for Commercialisation of Technological Innovation.

Under the latter scheme, the Government has allocated the IR&D Board $48 million over four years to assist small and medium-sized firms seeking to commercialise technological innovations by providing loans at 40 per cent of bank rates. This is the first Board program to involve cost recovery. The Commission has doubts about the scheme's rationale, but considers that it should have a period of operation to judge its success.

The Commission recommends that the Concessional Loans Scheme be reviewed in four years.

6. Rural research

Government has traditionally played a major role in rural R&D. Over three-quarters of recorded R&D is funded by governments and 95 per cent performed within the public sector (including, importantly, CSIRO). In contrast to other sectors, State government expenditure on rural R&D has been twice as large as that by the Commonwealth.

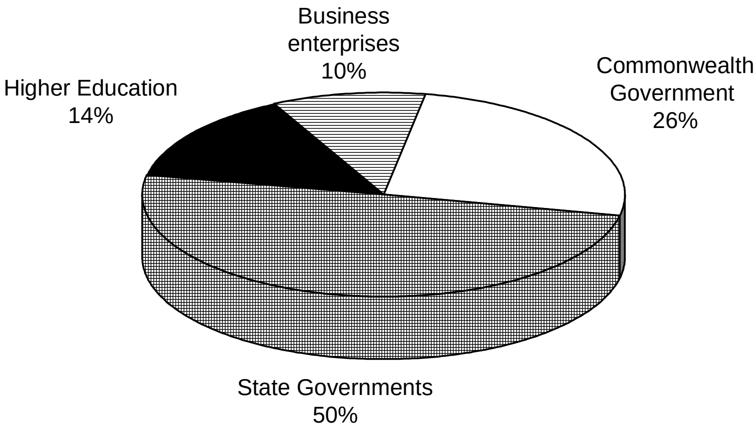
The high level of government funding of rural R&D, relative to other sectors, has been largely a response to the atomistic nature of farming and the high potential for spillovers. The problem of spillovers within the sector can be addressed through collective funding arrangements, which have been the basis for an important innovation in policy in recent years through the matched levy funding of rural research corporations.

Rural research corporations

The rural research and development corporations and councils (RDCs) were in most cases created by legislation enacted in 1989. They are generally funded through a compulsory tax deductible levy from farmers, matched on a dollar-for-dollar basis by government up to a maximum of 0.5 per cent of the gross value of production (GVP). The RDCs essentially act as purchasers of research on behalf of their constituents, who influence priorities.

While there has been limited experience to date with rural research corporations, the Commission judges the evidence so far to be favourable. The system has increased the financial contribution of farmers to rural R&D and the R&D that is done appears to be carefully assessed and directed to the needs of the sector.

Figure 4: **Performance of rural research, 1992–93**



Source: ABS, Cat. No. 8112.0.

Nevertheless, the Commission considers that the system could be improved in a number of ways. The key area relates to the government contribution. A number of participants argued that the ceiling on matched funding was arbitrary and served to limit contributions from the sector. The wider benefits of rural research are unlikely to stop at 1 per cent of GVP. The removal of a limit on government contributory funding would also be consistent with arrangements under the tax concession for business R&D.

It is also the case that, below the ceiling, the government's marginal contribution is significantly more generous than under the 150 per cent tax concession. In its draft report, the Commission argued that this could not be justified in an open-ended scheme, largely because in overcoming 'free rider' problems within the sector, the RDC arrangements in themselves provided a strong incentive for farmers to contribute to R&D. Since it was not apparent that the remaining relevant spillovers exceeded those from manufacturing R&D, the Commission proposed that the Government contribution be reduced from 1:1 to 1:4, closer to that provided by the tax concession.

In considering the responses of participants to this proposition, the Commission accepts that farmers have less incentive to fund R&D through RDCs than would apply for firm-based R&D, and that the more basic nature of rural research and the likelihood of significant community spillovers warrant a higher rate of contributory funding.

However, the Commission does not consider that merely extending 1:1 funding is justifiable. Funding at that rate provided a relatively generous initial incentive to attract participation throughout the sector. That has largely happened and the evidence suggests that farmers in most industries now have a heightened appreciation of the benefits from R&D. Several industries have reached, and some have exceeded, the ceiling. The Commission considers that 1:2 funding would now be a more appropriate ongoing incentive for RDC-sponsored R&D, with 1:1 funding limited to initial contributions.

The Commission recommends that the present levy matching scheme through RDCs, involving dollar for dollar contributions by the Commonwealth up to 0.5 per cent of GVP, be amended as follows:

- **the Commonwealth Government continue to provide one dollar for every industry dollar spent on R&D up to 0.25 per cent of GVP; and**
- **thereafter, to contribute at the rate of one dollar for every two dollars from industry, with no ceiling.**

The Commission considers that this regime would enhance the potential for an expansion in socially beneficial rural R&D. Any risk of disruption to R&D activity in the short term would be minimised by phasing in over five years that component which involves a lower rate of assistance.

The Commission also draws attention to its comments and findings on:

- **assistance for small and emerging rural industries (E4.3);**
- **addressing regional research needs (E4.3); and**
- **extension services (E5.2).**

State government rural R&D

Agricultural conditions vary among States as do research needs. State departments of agriculture have accordingly developed considerable expertise in particular areas of agricultural research. They perform half of the total rural research carried out in Australia. They are also the largest performers of research contracted by RDCs, accounting for 38 per cent of the research funded.

Arrangements for funding and prioritising agricultural research differ among the States. While available information is patchy, in most cases it appears that funding is provided by block allocation and the research bodies decide how it is spent. A number of State governments have reduced funding to their agriculture departments, which has contributed to them cutting back some functions (extension being one) and becoming active in bidding for external funding.

In some State departments of agriculture, there also appears to be significant cross-subsidisation of externally commissioned research, much of it for the RDCs. It seems unlikely that this research would necessarily coincide with the priorities of the States. As a result, some of the research the State departments should be undertaking may not be occurring, while other, RDC-commissioned research, is being subsidised by State taxpayers beyond the Commonwealth Government's contribution.

The Commission considers that State departments should cost all externally commissioned research and price it to recover full costs unless additional social benefits not already subsidised are identified.

The Commission also recommends that those State governments which have not already done so, consider establishing their agricultural research departments as separate corporations or institutes, as well as establishing forums for developing State priorities, and performance indicators to assist in monitoring and evaluating the effectiveness of their research agencies.

7. Linkages in the innovation system

Formal and informal linkages play a key role in the functioning of national systems of innovation. Much interaction occurs naturally — within the research community, among firms and between firms and research institutions (including those overseas). However, it is likely that potentially beneficial interaction can be impeded by lack of information, both about research capacities and available knowledge and about the needs and opportunities of users of research. It is also widely felt that a 'cultural gap' between public sector researchers and private firms has compounded the difficulties confronting interaction. As a consequence, the generation of new knowledge and its dissemination may both be affected.

Given the importance of tacit knowledge and hence of personal interaction among researchers, mobility of researchers within the economy can play an important role. Information on researcher mobility is lacking. But from what is known about CSIRO, it seems that Australia's researchers are less mobile domestically than is observed overseas. That may also help account for 'cultural' impediments between the public and private sectors.

Lack of portability of superannuation, and immigration approval processes, were identified by some participants as factors inhibiting mobility. These problems are clearly not unique to the scientific community. However, given the crucial role that mobility plays in technological innovation, government needs to be diligent in ensuring that it is not unintentionally impeded by such arrangements.

In recent years, governments have directly targeted assistance at creating and strengthening linkage mechanisms, particularly between public sector research institutions and industry, and research institutions themselves have developed mechanisms to improve their interface with industry.

An example of the latter is the 'commercial arms' of universities, which proliferated in the 1980s. Their activities are diverse, but typically include intellectual property management and research commercialisation as well as brokerage for research consultancy and educational services. Their performance also varies widely, but they can perform a useful role.

The linkage mechanisms created by governments occur in three areas: within the higher education sector, between the higher education sector and government research agencies, and between the public sector and business. There are a plethora of programs, especially in the last category (see box 6). Some are of very recent origin and therefore difficult to assess.

Box 6: **Major linkage programs**

Program	*Funding ($m)*	*Linkage*
Special Research Centres (1995)	13	university-user links developing through applied research activities and postgraduate training
Key Centres of Teaching and Research (1995)	6	university-user links effected through research and teaching activities
Collaborative Research Grants (1995)	16	university-user links effected through collaborative projects with university researchers
Advanced Engineering Centres Program (1995)	2	university-user links effected through advanced education courses and consultancies
Australian Postgraduate Awards (Industry) (1995)	8	university-user links effected through research and training at masters and doctorate levels
National Priority (Reserve) Fund (1995)	2	projects focused on improving links between higher education, industry and other sectors
Generic Technology Grants Scheme (1993–94)	18	collaborative research between firms and research organisations
National Teaching Company Scheme (1993–94)	1	university-business links effected through graduates working on company R&D projects
Cooperative Research Centres (1995–96)	127	linkages between universities, CSIRO and other government research agencies, private firms, GBEs and other government agencies effected through participation in Centre R&D and training activities
Total	**193**	

Among the positive features of such arrangements are their competitive selection processes and defined funding periods. Cooperative and collaborative programs have also brought a greater 'user' influence to publicly funded research programs and enhanced the skills of researchers.

However, the Commission has also found:

- assistance often is going to those who have already had a previous research relationship, although it is not clear to what extent this emerged naturally or was a consequence of past access to government programs;
- levels of assistance to firms are very difficult to determine, but they can be quite high where programs deliver benefits that are largely exclusive to individual firms;
- programs have proliferated and there appears to be considerable overlap; and
- the programs focus on particular aspects of the innovation process — especially the creation of knowledge — but are unlikely to lead to economic benefits unless firms possess necessary complementary assets and capabilities.

Cooperative Research Centres

The largest of the government funded linkage mechanisms are the Cooperative Research Centres (CRCs), which involve participants from throughout the innovation system — including universities, CSIRO and other government research agencies, and private firms. Direct government funding for 61 Centres will soon reach $140 million annually. Participants are required to provide at least 50 per cent of the resources for a Centre through cash or in-kind contributions over 7 years. In total, resources valued at $2.7 billion have been committed by universities, government research organisations such as CSIRO and DSTO, industry and the State and Commonwealth governments over the lives of the 61 CRCs.

The objective of the CRC initiative is to build centres of research concentration and strengthen research networks in the areas of the natural sciences and engineering. Research activities in CRCs can span strategic and generic technologies but there has been an increasing emphasis on short-term applied projects and commercialisation potential and the Government has been looking to increase the level of industry participation.

A CRC requires at least one university partner among its core participants. Beyond this, CRCs vary widely in their composition, the extent to which participants are co-located, and also in the extent to which they allow industry and other users to have an effective voice in decision making.

The CRC program is currently being reviewed. With that in mind, and not being in a position to undertake a detailed examination itself, the Commission has looked at a number of the broader issues, to provide some input to the current evaluation.

- *Linkages*: The program has clearly been successful in creating linkages among a range of individuals and institutions. However, an overall assessment of the linkage function of the CRC program would need to take into account the evidence of extensive, and sometimes longstanding, relationships that existed before the CRCs were established.
- *Nature of research*: Since their inception, CRCs have increasingly emphasised near-to-market research and commercialisation activities, which detracts from the public good rationale for government funding.
- *Firm assistance*: The CRC program can generate high levels of assistance for participating companies, when all public sector contributions are taken into account. The potential for CRCs to generate exclusive advantages to private firms, underlines the importance of ensuring that CRC funding serves wider interests than those of participating firms.
- *Building 'critical mass':* The CRC program has helped build a number of integrated research teams by co-locating researchers from different institutions. There has been an increasing tendency, however, to fund more widely dispersed groups, and administration costs can be high. It is important that the cost-effectiveness of CRCs in creating linkages be assessed.
- *Duplication vs. diversity*: The review should also consider whether the CRC and other linkage programs involve unnecessary duplication.

The Commission considers that the current review will need to address all of these issues. It also recommends that the CRC program be evaluated in the wider context of government support for the innovation system, given the tradeoffs that such levels of funding inevitably involve for other research funding needs.

8. National priorities

The Commission considers that the options that it has presented for reorganising the funding of public sector research would improve the quality, cost-effectiveness and social returns from that research. They are designed to achieve much greater user influence over the priorities for research. A question remains, however, as to whether the research funding and performing institutions would benefit from a broader and more systematic process of identifying national priority areas and problems for Australian research.

Many participants argued for a more strategic national approach to R&D policy. In a growing number of overseas countries, processes to get broad community involvement in identifying national priorities for research have been established (often called 'foresight' processes).

In 1990, ASTEC proposed a four yearly 'White Paper' process, involving wide participation of users and producers of research, to define 'broad directions and guidelines ... within which agencies would define their own more detailed priorities'. That ASTEC proposal was not taken up. More recently ASTEC has initiated a new consultative 'foresight' study to identify national problems and needs for science and technology to the year 2010. The Commission sought participants views in its draft report.

Feedback from participants suggests that while there is broad support for some form of national priorities process in principle, there is little agreement about how this should work in practice. Some expressed concerns that the outputs from ASTEC-like processes were too general or abstract to have much effect; others expressed concerns that the outputs might be too detailed or prescriptive. Against that background, the current ASTEC exercise can be seen as an experiment in demonstrating what contribution formal national priority-setting processes might make in Australia.

Regardless of the outcome of that exercise, however, the Commission considers that improved priority-setting processes can make an important difference at the agency level, where most funding decisions are actually made. Its proposals for CSIRO, other government research agencies and the ARC are intended to make such processes more systematic, participative and transparent. This should enhance the value to Australia of the research for which they are responsible and could constitute building blocks for any higher level priority setting in the future.

INTRODUCTION

> One might expect that a review of Government research and development (R&D) would be greatly concerned with answers to such questions as: Are we doing too much, too little, or about the right amount of R&D? Is the balance between pure and applied research about right? Should we do more intramural and less extramural R&D, or *vice versa*? What R&D are we doing which should not be done? What R&D should we do which is not being done? Is there adequate machinery, at the centre, critically to evaluate the overall R&D scene? ... The questions either relate to an out-of-date concept of R&D management, or they are unanswerable (Lord Rothschild, 1971).

In this inquiry the Commission has been asked to examine and report on the many complex aspects of essentially two very broad questions, namely:

- The effect of R&D on innovation, industry competitiveness and economic growth; and
- The performance of government policies and programs that influence R&D and innovation in Australia.

The two sets of tasks are regarded as equally important by the Commission, and indeed are inter-related. A proper evaluation of government's role in relation to R&D and innovation depends on an understanding of the drivers of R&D and the consequent impacts on economic activity and community wellbeing.

There are numerous government policies and programs which influence R&D and they take many different forms. The public sector is an initiator and performer of much R&D in its own right — including within government departments, research agencies and universities. Government is also a regulator, facilitator and supporter of R&D within the private sector. This latter role encompasses a range of interventions, from establishing legal frameworks (patents and other intellectual property laws) to various forms of financial and other assistance for firms and organisations to undertake R&D.

The Commission's terms of reference require it to evaluate governments' role and performance in all of these areas, as well as to examine the 'incentives and impediments' to dissemination and commercialisation of research, international exchanges of information and the creation of linkages between public research institutions and business. The Commission is constrained in only one area: it is not to report on the appropriateness of overall funding levels for the higher education system, or on sources of funding (other than for research functions).

Why another inquiry?

Over the years there have been a large number of official inquiries into R&D policy, programs and institutions. At the Commission's public hearings, Dr John Stocker observed:

> We have been reviewed and reviewed and reviewed and reviewed, and we estimate at the moment that either currently or in the last months CSIRO has been participating in 66 different reviews into different aspects of our performance or other government reviews to which we have made submissions. So we aren't short of evaluations in reviews. We do in fact sometimes question the cost benefit of the number and scope and diversity of the reviews to which we are subjected (transcript, p. 1382).

This relatively intense scrutiny no doubt reflects in part the importance which government attaches to scientific and other research, as well as the commitment of considerable public resources to those activities. It also reflects the difficulty government faces in this area of policy of knowing whether it has 'got it right'. R&D is not like a sausage machine: the inputs may be identifiable enough (although data are in many respects poor), but outputs and outcomes can be very hard to evaluate.

It is also the case that in the past 10-15 years, governments around the world have begun to question their 'traditional' functions and ways of doing things. In a number of areas it has become clear that resources were being poorly employed within the public sector, to the detriment of economic performance and living standards. Views about what economic activities should be the preserve of the public sector have changed considerably in a relatively short period of time. And where government has retained functions, it has introduced new administrative and organisational processes designed to ensure that objectives are clear and that government businesses can pursue them efficiently (refer IC Annual Reports). R&D policy is not, and should not be, immune from this process of reassessment.

There are a number of particular concerns in Australia that have motivated scrutiny of existing arrangements and the introduction of new policies and programs.

- One relates to the smallness of the Australian economy, and its limited capacity to generate new knowledge relative to the rest of the world, raising questions about
  - how we should best focus our (limited) R&D resources; and
  - how we can make best use of the international pool of knowledge.

- Compared to the OECD average, business spending on R&D is relatively low, and a much higher proportion of Australia's R&D is conducted within the public sector than in other countries.
- Public sector research is perceived by industry to be not sufficiently 'relevant' or accessible to industry's needs.
- It is generally thought that Australia's performance at commercialising the results of its research is poor.

Such concerns are encapsulated in this passage from the Government's 1992 White Paper, *Developing Australian Ideas*:

> In the past our excellent public sector research produced world-class results but often without reference to Australia's ability to use that research. As a result, the research sometimes withered on the vine or was too often developed overseas. The need to ensure greater relevance of Australian science and engineering through closer links to those who will use it is the thread that runs through this paper (p. 4).

In response to these concerns, there have been significant changes in the nature and extent of government involvement in R&D in recent years. In particular, there has been a proliferation of new programs directed at promoting and supporting business R&D and sponsoring collaborative arrangements between the private and public sectors. Indeed it could be said that R&D policy has been in a state of flux, with many new initiatives and changes to previous ones.

A germane example is the case of the Discretionary Grants Scheme and Generic Technology Grants Scheme, which the terms of reference require the Commission to report on prior to a decision by government on extending their funding. Since this inquiry began, however, these two schemes (together with the other grant schemes that operated under the Industry Innovation Program) have been combined into a single competitive grant scheme (Competitive Grants Scheme for R&D).

The innovativeness of government policy towards R&D is in many respects to be welcomed. As we show later, policy in this area requires some diversity and experimentation to be most effective. But the many changes have also brought problems and created some confusion within the scientific and wider communities. Concerns have been raised about:

- the appropriate roles of government research agencies and university research, and in particular the extent to which they should respond to the needs of business enterprises;
- the way priorities are set and funds allocated for public sector research;
- the decline in funding for some areas of research, including a perceived shift from basic to applied research;

- apparent inconsistencies in assistance levels for private R&D in different sectors; and
- fragmentation, adhockery, and a lack of coordination and accountability in the setting and management of R&D policy.

These in turn raise some fundamental issues to do with the effects of R&D and rationales for government intervention, including:

- What is the value of basic research?
- Why do firms perform R&D, rather than drawing on others' efforts (including international knowledge)?
- Why should governments perform research as well as supporting it in the private sector?
- What emphasis should be placed on the production of knowledge, relative to its dissemination or diffusion? and
- What instruments of government intervention are most effective and how should they be targeted?

All of these questions (and more) are either specified in the terms of reference or implied by them and the Commission has sought to provide answers in this report.

The debate that is taking place within Australia about government policy towards R&D to some extent mirrors the experience in a number of countries around the world. As our own inquiry commenced, some major reviews and policy initiatives were under way or were completed: in the United States (the Clinton program), Korea (the Highly Advanced National program), the United Kingdom (the White Paper) and, closer to home, in New Zealand (the Crown Research Institutes). In each case there has been a concern to find ways of directing government sponsored R&D to make it more relevant to the needs of the economy and the community. That in turn has required some fundamental rethinking about how needs are identified and priorities set.

The Commission's approach

The breadth of the terms of reference provide an important opportunity for the Commission and participants in this inquiry to gain a perspective on the operation of the national innovation system as a whole. Most previous inquiries have looked only at particular components of that system. This includes earlier inquiries by the Commission itself — which has reported on the National Procurement Development Program within the GIRD suite of programs — and the IAC, which conducted an inquiry into rural research policy in the mid-1970s, and into budgetary assistance to industry in 1982.

In commenting on the present inquiry, the IR&D Board said:

> ... I think this is the first occasion this century that an inquiry has been held with such a wide-ranging remit in determining R&D policy. It will certainly be the last occasion this century that such an inquiry will be held, so consequently it is very important. The result of this study in our view should be to establish something like a light on the hill to guide government policy. I think we do need a guide, and the outcome of this inquiry is going to be an important factor in determining future industry and government policy in our view (transcript, p. 809).

CRA Ltd also emphasised the importance and timeliness of the inquiry.

> So given this country’s current economic circumstances and the need to urgently address our massive unemployment problem, it’s our view that the timing of this national R&D inquiry is most opportune. We certainly hope that our submission is going to assist the inquiry in its very important task of charting an appropriate course for Australia as it moves forward into the next century (transcript, p. 368).

The breadth of the inquiry also creates a difficulty, however, in that the time and resources available to the Commission do not permit it to examine in detail every facet of the innovation system. In choosing where to focus its efforts, the Commission has been guided by the concerns raised by participants and the extent to which some aspects have already been adequately reviewed. It has sought to add value to existing reports.

In a number of areas there has been some very useful work which has obviated the need for detailed scrutiny in this inquiry or provided a foundation for our own work. Examples of this are: the evaluation of the R&D tax concession by the BIE; the assessment of the linkage between the Defence Science and Technology Organisation and Australian industry by the Hon Roger Price MP; the 1993 Defence Strategic Review; the McKinnon review of the ANSTO nuclear reactor; and the Senate Committee inquiry into CSIRO’s role in rural research.

The Commission has concentrated on the role of the main funding and research-performing institutions and the processes that influence their performance. These include government research organisations (especially CSIRO and DSTO), universities, the ARC, the NHMRC, business R&D and the programs that support it and rural R&D (notably the rural research corporations), as well as the mechanisms that promote linkages among them. The Commission has not attempted to review in detail the internal management and organisation of these institutions. In the time available it has seen it as more important to focus on the more ‘systemic’ influences on their performance.

While intellectual property plays a role in all of the areas examined by the Commission, it has also not been possible to examine the patent system in detail in this report. It has been the subject of recent studies, and most participants made little comment.

The Commission has also not sought to provide answers to questions about the ‘correct’ magnitude and composition of Australian research. Such questions remain as unanswerable today as they were when Lord Rothschild reported to the United Kingdom Government two decades ago. Indeed, the Commission considers that the impossibility of answering such questions demonstrates the importance of getting the processes and incentives for R&D right, thereby enabling appropriate outcomes to emerge from the system. It is in this area that the Commission has concentrated its efforts.

Our approach has been to develop a framework for understanding why and how governments should intervene in R&D. We have then looked at key components of the innovation system (such as government research agencies, university research and business programs), and how they measure up. Many studies have not addressed fundamental policy issues. Programs have often been reviewed in isolation of the system as a whole and against criteria that are specific to that program.

Consistent with the thrust of the terms of reference, the Commission’s report deals primarily with R&D, just one part of the much wider topic of innovation. But it has devoted attention to the connections between R&D and *technological* innovation, as well as their impacts on competitiveness and economic growth.

In conducting its inquiry, the Commission has recognised the complexity of many of the issues that are central to this area of economic performance and government policy. In contrast to a number of other policy areas where reforms have occurred in recent years, there is much that remains unresolved in theoretical or conceptual terms and, as noted, even interpreting past experience is very difficult. Nevertheless, there have been some important developments in thinking about R&D and the role of government, and the Commission has made considerable efforts to inform itself about recent developments.

- It has commissioned external studies on the most recent theoretical and empirical work, including application of the ‘new growth theories’.
- The Commission has also undertaken, in the absence of any satisfactory studies being available for Australia, its own empirical work on the economic impacts of R&D and the industry incidence of R&D assistance. This and other research has been constrained by a lack of data, which compounds what is already a difficult area of policy analysis.

The Commission used its draft report to present information about the operation of the system, and options for change, noting their advantages and disadvantages. In many areas of R&D policy, while government intervention seems desirable, the best ways of intervening — the instruments, decision mechanisms and institutional support — are not clear. There is no perfect system or single ‘solution’. The real alternatives available need to be compared with each other. Some do better against general criteria for good policymaking than others. The Commission’s evaluation of the alternatives and its judgments about preferred policy approaches have benefited greatly from the feedback from participants on the ideas and proposals in the draft report.

Another aspect of the Commission’s approach in this report is to find ways of implementing desirable change that would not be disruptive to the nation’s research effort. We have also considered how some changes may be introduced in a limited way, allowing feedback and evaluation of performance. This is important for its own sake, but also allows changes to be tested before wider application.

The inquiry process

This inquiry has benefited greatly from the involvement of a large number of individuals and organisations, within the public and private sectors. There has been extensive participation from academia, the business community (including many small businesses), the rural sector and government departments and research agencies, particularly CSIRO (see appendix A in volume 3).

In addition to formal submissions and public hearings (including an extension of hearings to meet additional demand), the Commission had many informal meetings in all States and Territories, and visited a range of universities, companies and research facilities.

Because of the complexity of the issues, the Commission also organised two roundtable meetings on key topics, which were attended by people with a detailed knowledge of R&D policy or practice in Australia (see appendix A). In addition a conference was organised on the subject *R&D and Economic Growth*, with eminent international and Australian speakers. And after the release of the draft report, Commissioners and senior staff made presentations to some groups in government and industry on the draft findings and proposals.

Visits were also made to a number of overseas countries within North America, Asia and Europe, as well as New Zealand, providing much useful information and a basis for comparison in assessing the Australian experience.

Guide to the report

The requirements of the terms of reference have made a long report — or more accurately, a collection of reports — inevitable. The report is organised in seven parts within volumes 1 and 2, with a third volume of supporting appendices. It begins in part A with what we have called the 'big picture'. This covers:

- the meaning of R&D and innovation, and the concept of a national innovation system;
- a description of Australia's innovation system;
- analysis of the role of R&D, and its economic effects;
- the rationale for government involvement in R&D, and the merits of alternative forms of intervention;
- concluding with some broad guidelines for designing policy in this area.

This provides a frame of reference for consideration of the key components of Australia's innovation system, namely:

- Government research agencies (part B);
- university research, including research sponsored by the ARC and the NHMRC (part C);
- business R&D programs (part D);
- rural research (part E); and
- the linkage mechanisms which have developed or been established among these components, including Cooperative Research Centres (part F).

The concluding section of the report (part G) draws out findings from these areas to consider the wider implications, including the question raised by many participants of whether a more explicit and coordinated national strategy is needed to ensure greater coherence in Australia's innovation system.

PART A

THE BIG PICTURE

PART A THE BIG PICTURE

A1 R&D AND INNOVATION

A2 AUSTRALIA'S INNOVATION SYSTEM

A3 THE PERFORMANCE OF AUSTRALIA'S INNOVATION SYSTEM

PART A THE BIG PICTURE

Part A is primarily concerned with setting up the building blocks for the analysis in this report. Subsequent parts of the report then build on the framework established here.

Chapter A1 looks at some critical concepts and definitions. It considers R&D in the context of various possible models of the innovation process and describes, in general terms, the components that make up a national innovation system.

The specific components of the *Australian* innovation system are described in chapter A2. It considers the institutions (government agencies, universities, businesses) in which R&D is performed and analyses the incentive structure within which they operate.

Chapter A3 looks at the performance of the innovation system. The available measures of inputs and output to R&D are examined along with the incentives that are provided to generate R&D.

Chapter A4 considers the role of firms and how they use R&D to produce better products and processes. It offers some observations on why Australia's firm performance has in the past lagged other countries. The chapter also considers the more aggregate-level questions of how R&D contributes to economic growth, looking in particular at *new* growth theories and evidence on the relationship between R&D and economic growth.

Chapter A5 looks at the rationale for government involvement in the support of R&D. It examines the public good characteristics of R&D and considers traditional market failure rationales for intervention.

Chapter A6 considers forms of intervention used by governments and factors that are relevant in assessing their desirability. It concludes with some guidelines for providing government support.

A1 R&D AND INNOVATION

A1.1 Introduction

Much ambiguity surrounds the language used to discuss R&D and innovation. Terms and definitions were a particular concern of participants in the roundtable discussions on R&D organised by the Commission and were raised regularly in the inquiry meetings and hearings.

This chapter introduces and discusses the major concepts used throughout the report (section A1.2). In doing so, it draws on the body of literature that has grown up in response to the need to obtain a better understanding of the innovation process. An important strand of the literature dwells on models of the innovation process (section A1.3). Another important concept shaping discussion of innovation is the idea that each country has a distinctive national innovation system (section A1.4).

A1.2 Definitions and concepts

Technology, broadly defined, is the term used to describe how production takes place. Through production, a nation obtains access to a wide range of economically and socially valuable goods and services.

When *technological innovation* occurs, the nation employs new, usually more efficient methods of production and very often also achieves qualitative improvements in the goods and services produced. This is an important source of economic growth.

Technological innovation may be distinguished from other forms of innovation relating to management techniques and organisational structures, seeking access to new sources of supply for material inputs, and devising novel marketing strategies. These aspects of innovation are complementary to technological innovation but are not the principal focus of this inquiry.

The conventional focus for discussions of innovation was a single event, the introduction of a novel production method or product. But innovation is more accurately viewed as a continuous, complex and often unpredictable *process* (OECD 1992a, p. 24).

Research and development

Critical ingredients of the technological innovation process are the creation, transfer and use of knowledge about technology. *Knowledge* is a stock (an asset) to those who possess it; *research* is any activity which adds to that stock. Of the new knowledge created by research, some serves as an input into other knowledge-producing activities while some is used as an input in developing new products or production methods. This distinction is the conceptual foundation for dividing research into *basic* and *applied* components. It is reflected in the definitions used by the OECD and ABS for the purposes of collecting data on science, technology and innovation (see box A1.1).

Box A1.1: **Defining research and development**

Pure basic research is experimental and theoretical work undertaken to acquire knowledge without looking for long-term benefits other than the advancement of knowledge.

Strategic basic research is experimental and theoretical work undertaken to acquire knowledge directed towards specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the practical solution of recognised problems.

Applied research is original work undertaken to acquire new knowledge with a specific application in view. It is undertaken to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives.

Experimental development is systematic work, using existing knowledge gained from research or practical experience, directed to producing new materials, products or devices, installing new processes, systems or services, or improving substantially, those already produced or installed.

Source: ABS, Cat. No. 1297.0.

In this classification, the different types of research are differentiated by their intended outputs. For example, the output of pure basic research is only intended to advance our knowledge of the physical, biological and social universe. The knowledge generated by basic research is therefore often viewed as *scientific* and the processes of creating it as *science*.

In contrast, applied research is intended to provide solutions to specific problems. The knowledge generated by applied research is often considered as *technological* rather than scientific. But the distinction is actually quite blurred (see box A1.2).

Research and development (R&D) — the focus of this report — comprises all of the elements listed in box A1.1. But for society to reap the full economic benefits of R&D, new products must be effectively marketed and distributed and commercially viable processes to produce them put in place. These activities comprise *commercialisation*, which typically is much more time-consuming and resource intensive than R&D.

Box A1.2: **Science and technology**

The conventional distinction between science and technology suggested that science aimed to deduce general principles about the working of the physical and biological universe while technology took those principles as given and sought to apply them to specific problems.

Today a distinction is starting to be made between so-called *pure* sciences, which explore the boundaries of knowledge without concern for the practical implications of any findings, and *transfer* sciences which are 'driven principally by the urge to solve problems arising from social and economic activities' (OECD 1992a, p. 36). Transfer science, materials science, biotechnology, soil science and some social sciences, all form bridges between conventionally defined (pure) science and 'technology'.

In some areas the convergence between science and technology is very marked. Narin and Noma (1985) found that biotechnology patents were 'using current science just about as quickly as it emerges from the research labs' (p. 3).

Science can play a crucial role in opening up new possibilities for major technological advances. Indeed, industries 'close to' areas of rapid scientific development are often those richest in technological opportunity: pharmaceuticals and microelectronics are good examples. By the same token, the absence of general scientific principles to guide industrial R&D can severely hamper the solution of technological problems: thus fuel efficiency research is hindered by poor understanding of the combustion process (Rosenberg 1991, cited in OECD 1992a, p. 27).

All of this suggests that the boundaries between science and technology are becoming increasingly blurred.

Ambiguities and deficiencies

While the definitions and classification in box A1.1 are widely used, they conceal a variety of ambiguities and difficulties that inhibit their general usefulness. First, defining different types of research by intended outcome poses insuperable problems for accurate measurement. Conversely, when asked to classify their research as pure basic, strategic basic or applied, researchers may incorrectly or misleadingly answer questions about the intended or expected outcomes from their research. On the other, there is no way of checking their intentions by *ex post* objective observations since it is in the nature of R&D that there are often unexpected outcomes, quite at variance with any expectations or intentions which might have been formed at the outset. It therefore seems impossible, in practice, to obtain a precise idea of how much R&D falls into each category.

Second, the definitional lines drawn to construct the classification imply that policy makers might, if they wished, encourage the production of one type of R&D output at the expense of others. Assuming this degree of selective focus is possible may, however, be quite misleading. Not only might research intended for highly specific purposes have more generalised spin-offs (and *vice versa*), but all of the elements of R&D are causally interconnected. Thus, while it is true that an advance in general scientific knowledge may help build the platform for specific technological improvements, it is also true that hitches in the development of new products often drive producers to call on scientists to fill gaps in existing knowledge.

Third, because the classification focuses on intentions, it tends to imply that all new technological knowledge is the outcome of activity undertaken deliberately to generate it. In fact, much new knowledge about production arises as a by-product of undertaking production: it is the result of *learning-by-doing* and often arises incidentally or unintendedly.

Finally, the list of intended purposes for which R&D is undertaken needs to be extended. In particular, firms and other organisations often undertake research to enhance their ability to *absorb* new knowledge generated elsewhere as much as to obtain research results for themselves. This is the point at which it has to be recognised that the generation of new knowledge and its *diffusion* among potential users appear as complementary aspects of the overall innovation process.

Diffusion

Diffusion was traditionally viewed as a process which related to a specific innovation (product or process) and described how the innovation spread through a population of potential users or purchasers. But this perspective is simplistic and too restrictive in two major respects.

First, new technology has not only an artefact dimension (a novel physical process or product) but also the dimensions related to the new knowledge required to produce the artefact, know-how and skills (derived from learning-by-doing) and to organisational structures.

In other words, knowledge relevant to technological innovation may be *embodied* in a physical object, like a machine, or *disembodied.* Disembodied knowledge may be documented knowledge (in a patent or blueprint) or an element of human capital: knowledge and know-how carried in the human brain which may result from formal training or informal learning-by-doing and which it may or may not be possible to articulate.[1] Increasingly, technological knowledge and skills which may be transported around the economy in the form of human capital are being described as *person-embodied*, to distinguish them from equipment-embodied and otherwise disembodied forms of technology.

Once a new product or process has appeared, market conditions will importantly determine the rate at which it diffuses: within a given organisation; among firms in a given national industry; among other industries in the same economy; and internationally. Technology which may be applied in a range of different industries (for example, information processing) is described as *generic*.

As cumulative production experience increases, learning-by-doing occurs on a continuing basis and as people engaged in production move around the economy, so know-how, skills and tacit knowledge also spread. Diffusion may sometimes be facilitated by takeovers and mergers, but just as often by the pressure of competition. In either case organisational change is likely to accompany and be necessary for the facilitation of technology transfer.

There is a second major respect in which the traditional view of diffusion is simplistic and deficient. In the traditional perspective, a given innovation entered the market and spread through a population of potential purchasers at either a given or falling price over time, but at no time underwent any qualitative change. In fact, almost all innovations *evolve* and develop from the day they first reach the market. Producers receive feedback from early users and modify their innovations in the light of what they learn in order to maintain a competitive advantage. The process of diffusion is thus linked integrally to the larger process of innovation itself.

In fact, recent theorising about the innovation process has suggested that once innovation takes off, it will tend to follow a particular course shaped by the fact that knowledge is *cumulative*, and that many knowledge-related investments are *irreversible.* More comes to be known and understood about that method than others and reinforces the tendency to use, develop and learn more about it. For this and related reasons, history always matters in understanding innovation — and often teaches that:

> ... technological systems can be ‘locked in’ to sub-optimal solutions through a succession of small events (Freeman 1994, p. 468).

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1 This is called tacit knowledge. It is distinguished from codified knowledge - know-how that can be written down or otherwise easily communicated to others. The boundaries between the two are somewhat blurred because technology may incorporate both types of knowledge.

An often-quoted example of this tendency is the survival of the QWERTY keyboard well beyond the era in which it made sense as a device to minimise the jamming together of typewriter arms if keys were depressed in too rapid succession (David 1986).

Modern models of innovation (section A1.3) strive to capture some of this complexity.

Spillovers

The diffusion of knowledge is closely associated with *spillovers*. In general, spillovers occur when R&D activity undertaken in one organisation creates benefits or cost reductions elsewhere which are not reflected fully in the rewards reaped by the organisation which carried out the research in the first place. It is possible for this to happen because:

- the organisation which generated the knowledge may be unable to prevent others from using it without itself incurring heavy costs (imitation and reverse engineering are common occurrences); and
- a given piece of new technological knowledge can be employed simultaneously by any number of firms and at no extra cost of provision, without the intrinsic usefulness of the knowledge being in any way diminished for any one of them.

Reference is often made to two types of spillovers, namely *research* and *pecuniary* spillovers. Research spillovers are associated with the spread and use of disembodied knowledge. Because knowledge tend to 'leak', the originators of knowledge can rarely preclude others from acquiring it and appropriating the resulting financial rewards. However, the absorption of research spillovers is rarely costless and may require potential beneficiaries to undertake their own R&D in order to use effectively the knowledge generated elsewhere.

Pecuniary spillovers, on the other hand are associated with embodied knowledge, and relate to the prices user industries or consumers pay for goods in which new knowledge is 'congealed'. If users or consumers pay prices below the level at which they value the goods — perhaps because of competitive conditions in the supplier industry — they will enjoy pecuniary benefits associated with the provision of the good. The more market conditions allow suppliers to charge prices close to their customers' valuation of the goods, the smaller the pecuniary spillovers will be.

Spillovers are discussed in more detail in chapter A5.

A1.3 Models of the innovation process

Much effort has been devoted, within the literature on innovation, to developing models of the innovation process (see box A1.3). In early discussions of innovation and science and technology policy, the so-called linear model provided the explicit (and often implicit) basis for analysis. The first generation model (see figure A1.1) suggested that scientific research is the prime-mover of innovation. In other words, innovation is driven or 'pushed' by new technological opportunities revealed through research.

Box A1.3: **Five models of the innovation process**

First generation:

- *Linear (technology push) model*: simple sequential process. Emphasis on R&D. The market is merely a receptacle for the output of R&D.

Second generation:

- *Market-pull*: also a simple linear sequential process but with emphasis on marketing. The market is the source of ideas for directing R&D. R&D has a reactive role.

Third generation:

- *Chain-link model:* sequential but with feed back loops. Push or pull or push/pull combinations. R&D and marketing more in balance. Emphasis on integration at the R&D/marketing interface.

Fourth generation:

- *Integrated model:* Parallel development with integrated development teams. Strong input supplier and customer linkages. Emphasis on integration between R&D and manufacturing and marketing. Horizontal collaboration (joint ventures etc).

Fifth generation:

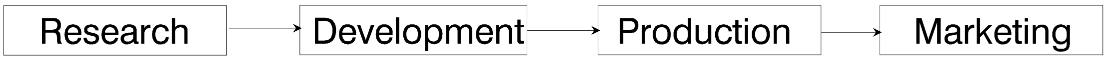
- *Systems integration and networking model:* Fully integrated parallel development. Use of expert systems and simulation modelling in R&D. Strong linkages with leading edge customers ('customer focus' at the forefront of strategy). Strategic integration with primary suppliers including co-development of new products and linked information and design systems. Horizontal linkages: joint ventures; collaborative research groupings; collaborative marketing arrangements, etc. Emphasis on corporate flexibility and speed of development (time-based strategy). Increased focus on quality and other non-price factors.

Source: Rothwell 1992.

The second generation model attributed the major responsibility for directing changes in technology to the ‘pull’ of market need or demand. But although it reversed the direction of causation found in the earlier model it was still linear and, as Freeman has pointed out:

> Innovation should not be viewed as a linear process, whether led by demand or by technology, but as a complex interaction linking potential users with new developments in science and technology (1994, pp. 479–80).

Figure A1.1: **The conventional linear model of innovation**



Source: Kline and Rosenberg 1986.

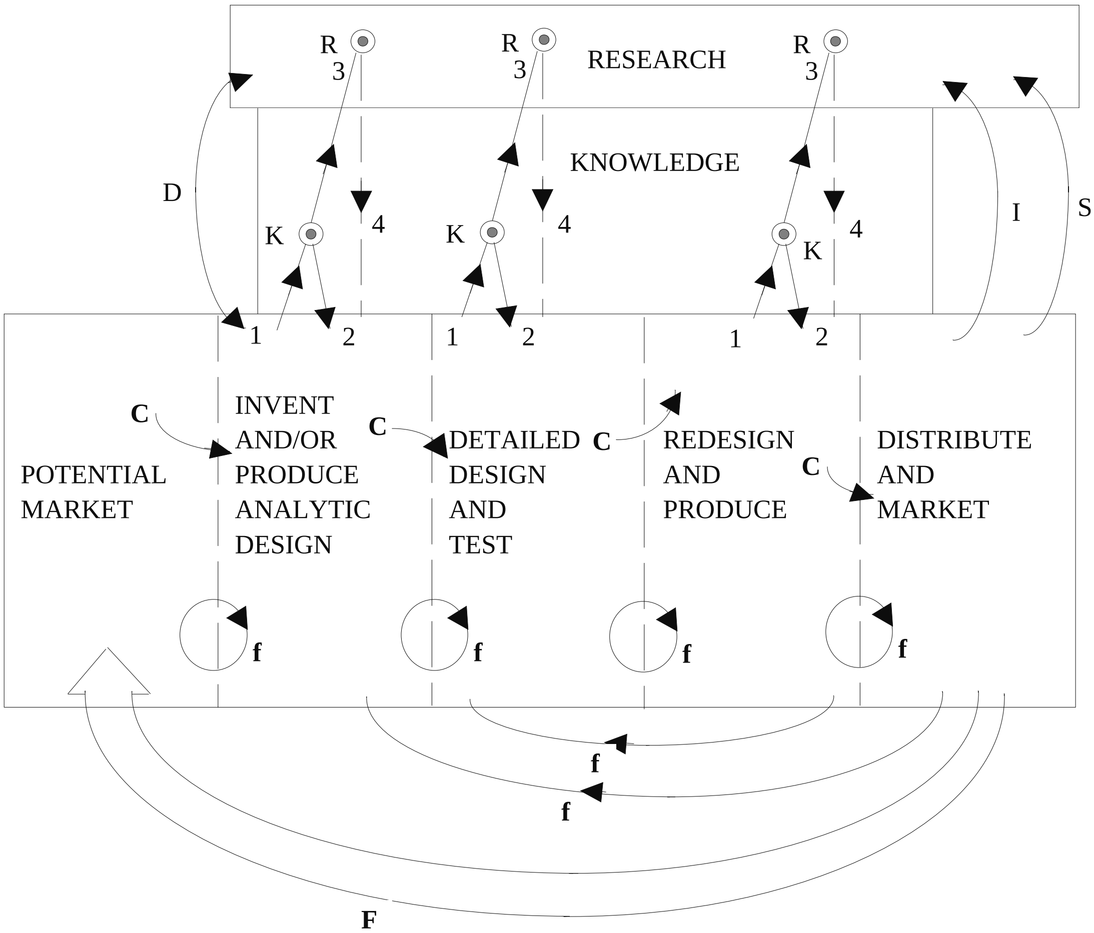
Similarly, in its response to the draft report, the Australian Centre for Innovation and International Competitiveness cites the OECD when it argues that:

> ... the overall innovation performance of an economy depends not so much on how specific...institutions....perform, but on how they interact with each other as elements of a collective system of knowledge creation and use....(Sub. 401, p. 7).

The emphasis on interaction is central to the third and later generation models. Figure A1.2 is a schematic view of the chain-link model of innovation proposed by Kline and Rosenberg (1986) and incorporates two different forms of interaction. At the firm level, innovation begins in the central chain (marked C) with a combination of new technology and a perceived market opportunity. In the subsequent design, development and production phases feedback among the activities is continuous and interaction with potential and actual users/customers is regarded as particularly important. At a more general level, engineers engaged in innovation activity in all firms interact with each other, and with the organisations, institutions and individuals offering access to the existing base of scientific and technological knowledge. More often than not such interaction will resolve technological problems. But when it fails to do so, firms resort to undertaking or commissioning research.

When research is undertaken in-house, the nature of the interaction will depend on the organisation of the company: fourth and fifth generation models emphasise that corporate innovation should be viewed as a team effort in which research groups are designed to include specialist researchers, production engineers and marketing personnel. This enables many of the feedback loops in the third generation model to be internalized within the innovating team and all aspect of the process to be addressed from the start. A stylized depiction of such *simultaneous* engineering or development may be seen in Figure A1.3, provided to the Commission by Toyota.

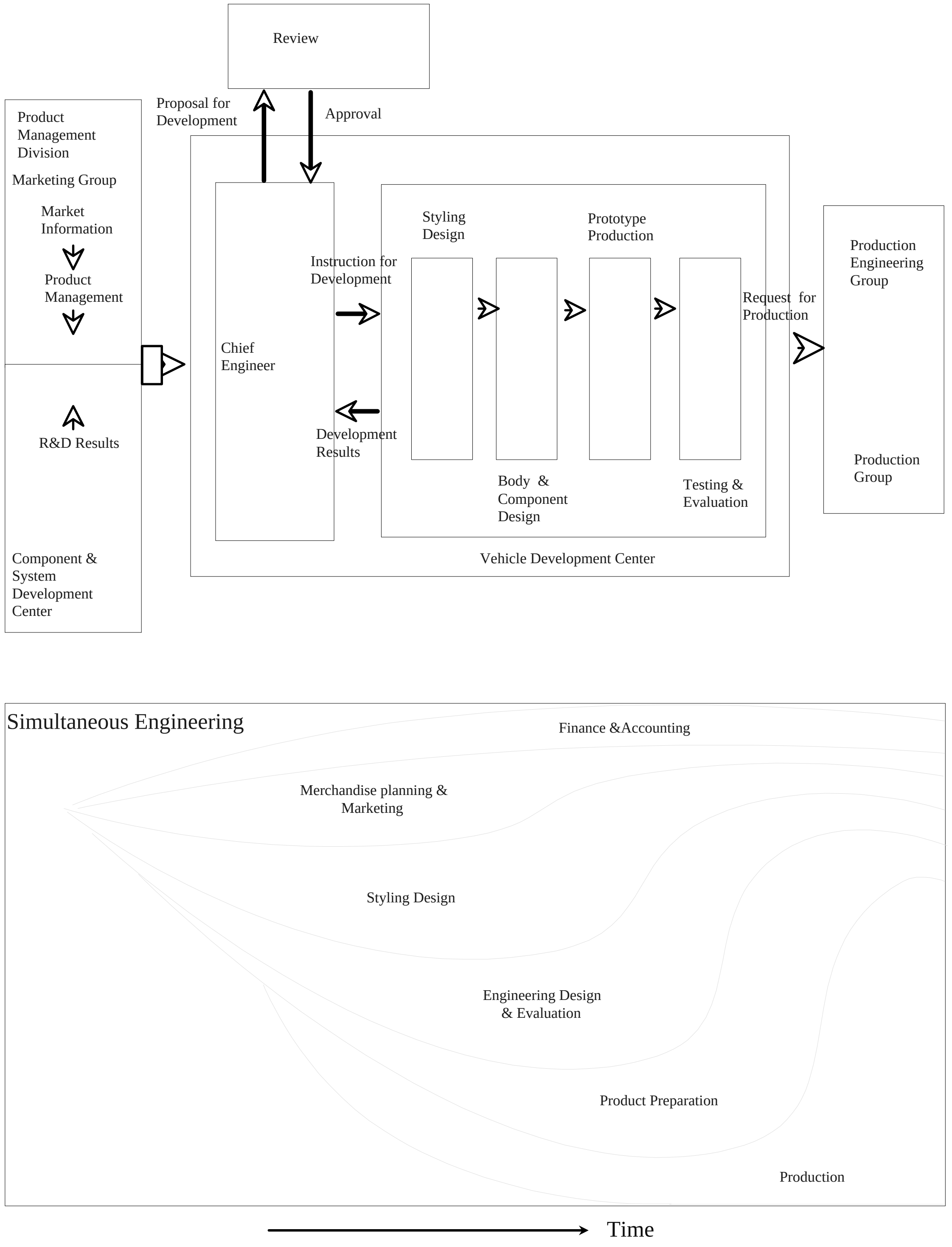
Figure A1.2: **The chain-link model of innovation**



Notes: C = central chain of innovation; f = feedback loops; F = particularly important feedback. K-R = links through knowledge to research and return paths (if problem is solved at node K, link 3 to R is not activated. Return from research (link 4) is problematic - therefore dashed line); D = direct link to and from research from problems in invention and design; I = support of scientific research by instruments, machines, tools and procedures of technology; S = support of research in sciences underlying product area to gain information directly and by outside monitoring work. The information obtained may apply anywhere along the chain.

Source: Kline and Rosenberg 1986.

Figure A1.3: **Toyota's new product development process**



Source: Toyota Motor Corporation 1993.

This view of the innovation process corresponds with the notion that:

> ... a scientific or technical resource has no intrinsic value or use. It is only when the necessary 'complementary assets' of technological support systems, production capacities, and distribution networks are appropriately assembled that knowledge can be converted to profitable use (Sub. 401, p. 5).

The idea that investment in complementary assets is a requirement for profitable innovation was developed by Teece (1986) and points to the conclusion that such investment may make it possible to appropriate significant private rewards from scientific knowledge that has traditionally been seen as a 'free good'.

A1.4 The national innovation system

The formal notion of a national innovation system (NIS) is relatively new. It has been defined recently as:

> The national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning ... in a country (Patel and Pavitt 1994, p. 12).

The process of technological learning must be taken to mean innovation at its most broadly defined, including diffusion and the feedbacks to further adaptation. The models described in the previous section suggested relationships between the activities comprising and contributing to the innovation process. But the boundaries of the process and the institutional structures within which these relationships are consummated remained, deliberately, vague. Yet as Freeman has argued:

> The rate of technical change in any country ... depends upon the way in which ... resources are managed and organised, both at the enterprise and national level. The national system of innovation may enable a country with rather limited resources ... to make very rapid progress ... [but] weaknesses in the national system of innovation may lead to more abundant resources being squandered by the pursuit of inappropriate objectives or the use of ineffective methods (cited in OECD 1992a, p. 80).

Put briefly, the institutional structure and system of incentives within which innovation occurs in any country may have a great deal to do with explaining what and how much the country gets out of the process.

R&D performing institutions

The activities comprising and contributing to innovation were discussed earlier in the chapter. None of these activities is carried out exclusively in one type of institution, and while some institutions specialise entirely in performing only one type of innovation-related activity, many others engage in two or more activities at any time. This suggests that there may often be *complementarities* in performing innovation-related activities, as much at the micro — as at a more macro — level. Figure A1.4 provides a stylised depiction of the main institutions and the outputs they generate for users and potential users.

The three major types of innovation-generating institution are *universities*, *government research agencies* and *privately owned firms*. These are the principal *performers* of R&D.

Universities

Universities are often required by the Acts under which they are established to undertake research. In Australia, they perform almost all of the country's *pure* basic research. Basic research (pure and strategic) accounts for 63 per cent of all the research they do. Performing research (especially basic) is thus an important role for universities in its own right and in relation to their substantial involvement in 'public good science', the work of university researchers,

But universities are unique among the research performing institutions in undertaking their research work in an educational context. The largest proportion of university funds is spent on teaching and research training, and universities undertake research partly because their teaching staffs are by nature curiosity driven. Importantly, however, universities themselves see a beneficial relationship between teaching and research in the same institution, and have created incentive structures for their academic staff which encourage them to undertake research.

The place of the universities in the NIS can be seen in the following terms:

- they pass on state-of-the-art knowledge, and develop analytical and creative faculties in graduates at all levels — which are essential for participation in any aspect of the innovation process within or outside the universities;
- they provide through their research degree programs training and experience which prepares the next generation of researchers to enter the system;
- they undertake work which gains researchers admission to the specialised, high-level international conferences where 'frontier' work is discussed. They may thus become conduits of the most advanced knowledge. The Walter and Eliza Hall Institute of Medical Research said:

  > Being professionally and successfully engaged in research buys one a seat at the international table and in particular in the power elites or 'invisible colleges' which surround each major discovery area. Reading scientific papers and textbooks, or attending large international conferences as an 'outsider' are

> relatively ineffective ways of judging competing new ideas and technologies, not only because of significant delays (9–18 months) between discovery and promulgation in these forms; but also because a deep involvement in the research field of interest lends a perspective and a balance that can be obtained no other way (Sub. 233, p. 1).

Increasingly, universities are also seen not just as repositories of knowledge but as valuable institutional assets which can and should be drawn into interaction with other research performers and users. This may mean undertaking research of a more ‘applied’ nature but also implies participation in formal and informal research links in which universities provide perspectives to others on how knowledge is changing and benefit from what others tell them about emerging research problems and opportunities.

University research is discussed in part C.

Government research agencies

To ensure that research is undertaken which is has direct significance for specific national problems, many countries have research institutions which are wholly or partly publicly funded. They exist to undertake pure basic, strategic or applied R&D of national value that would not otherwise be performed (or performed inadequately or too slowly). Some of this research may have a very strong policy content (as with social and economic policy research institutes). Alternatively, it may focus on scientific questions which may ultimately call for policy intervention.

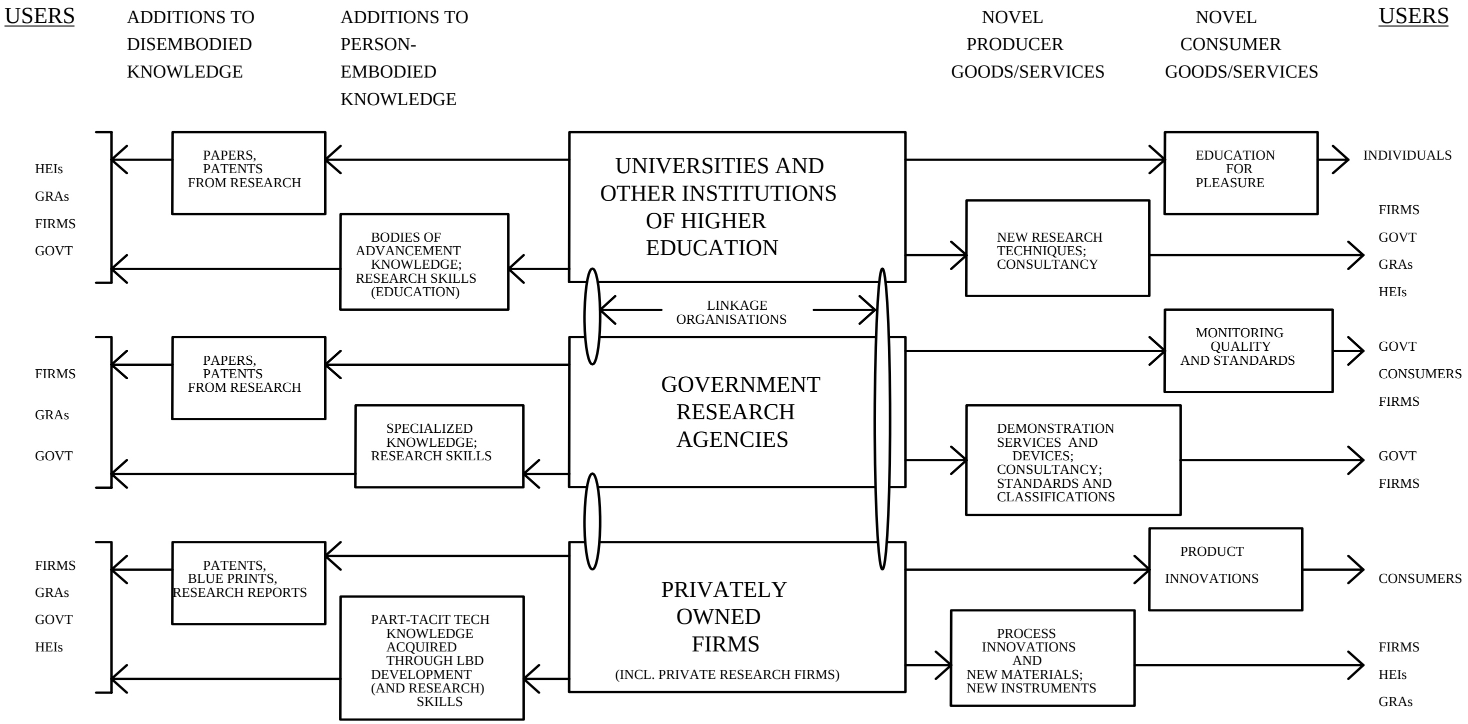
Other important reasons for the existence of such institutions include the desire to ensure that research results of national relevance are quickly disseminated and at low cost; and the need, on the other hand, to perform some research tasks under conditions which specifically constrain dissemination, that is, to obtain research results required for national security purposes.

Government research agencies are discussed in part B.

Private firms

Firms are an important component of national innovation systems. This is partly because little of the R&D work performed by the public sector or publicly funded institutions would ever have a direct impact on the economy if it was not in any way relevant to *firms*. However, many firms also undertake research.

Figure A1.4: **Institutions generating innovation**



Notes:

1 Arrows indicate flows from generating institution to user. In some cases, the user is also the generator (for example, learning by doing). In all cases, users and potential users may provide an initial stimulus to the generating institution, and may sometimes collaborate with it.

2 A wide range of market-generated and informal links also operate among firms, among government research agencies and among universities.

3 Supporting institutions providing broader setting are shown in figure A1.5.

Given the close attention firms are obliged to pay to customer and competitive pressures, their principal focus tends to be on innovation activity ‘close to the market’. Since firms are, among all institutions, most concerned with commercial viability, and since firms are also best qualified through intimate contact to judge commercial potential, they tend to specialise in experimental development and commercialisation. That said, some firms either fund or undertake applied and even basic research where they perceive that competitive threats or opportunities make this desirable and where it can aid in the uptake and utilisation of knowledge from external sources.

Research by business firms and the rural sector is discussed in part D and E.

Incentive structures

The incentives to undertake innovative activities depends largely on the magnitude of potential gains from successful innovation. These rewards, in turn, rest on technological opportunities, market characteristics and the extent to which the innovator can appropriate the gain from the innovation (appropriability).

Technological opportunities

Technological opportunities depend on the extent of unexploited scientific and technological knowledge and the potential for transforming that knowledge into commercialisable products and processes.

Areas likely to be richest in technological opportunity are thus those where new knowledge is expanding most rapidly and where that knowledge could most readily be put to use in addressing either market needs, or costly constraints on production, or both. The incentive to invest in innovation in such areas is the prospect of either cutting production costs or generating high-value new products.

But technological opportunity also depends on what firms already know. New knowledge and the potential, in principle, for gain only contribute genuine opportunity when firms are able: (a) to recognise that the new knowledge could have value; and (b) to employ new knowledge effectively in actually generating value.

While all countries may face the same global technological opportunities in principle, the specific history of each one puts it in a better position to exploit some opportunities more effectively than others.

Appropriability

In general, the incentives to undertake investment in creating new technology and knowledge will be strongest when the researcher or innovator is in a good position to *appropriate* (that is, claim for him or herself) the benefits which the new idea or good or service generates.

To an important extent the potential for appropriability depends on the nature of the innovation. For example, it is often argued that the results of basic research are easy to obtain and use and thus offer little prospect of gain to their originator. This does not mean, however, that scientific knowledge may not be used to generate private returns. As noted earlier, combining new knowledge with the appropriate complementary assets not only permits but may be the only way to make profit out of it.

Appropriability is also positively related to the difficulty and costliness of imitation. For example, a new product which is difficult to reverse engineer would have strong appropriability characteristics. The prospects for appropriability are enhanced by the extent to which production knowledge is product or firm-specific, the extent to which it builds on firm-specific learning and its degree of tacitness.

But even if returns to innovation are theoretically appropriable, this potential may not be realised if there is no legal framework for protecting property rights. National innovation systems vary in the extent to which they offer such support to innovators. For example, national patent systems and copyright laws vary from country to country and may be differentially undermined in their effect by variations in the accessibility of inventors to the legal system, and in the expense of using it to seek redress.

Market characteristics

The incentives for innovation include those provided through the *market* (in the positive form of anticipated profit and the negative force of threat to survival) and those made available through *government intervention*.

Market characteristics of potential importance include market size, the number of firms making similar products, and the number of products already in the market which might be regarded as substitutes.

Government may influence innovators' market environment in many ways, for example:

- by acting as a supplier of new scientific and technological knowledge, or human capital generated in the education system (conveying person-embodied knowledge);

- by acting as a purchaser of innovators' products;
- by invoking competition policy to discourage the exercise of monopoly power;
- by protecting domestic industry from foreign competition, or allowing it to be exposed to such competition;
- by regulating to discourage socially undesirable market practices, such as pollution; and
- by operating on macroeconomic demand through fiscal and monetary policy.

From considerations such as these it is apparent that the *national* innovation system cannot be viewed in isolation from the *international* environment around it. Australia's producers compete to sell in global markets and must pay world-determined prices for inputs. Their decisions about how much and where to innovate thus reflect returns based on international conditions of demand and supply, the impact of national governments' policies on international trade, foreign investment and innovation, and the effects of the multinational operation of large firms.

Secondly, it is important to note that the market conditions in which firms operate themselves reflect decisions made in earlier times in relation to technological innovation. Successful innovation often creates conditions of temporary monopoly which influences the potential for innovation in future.

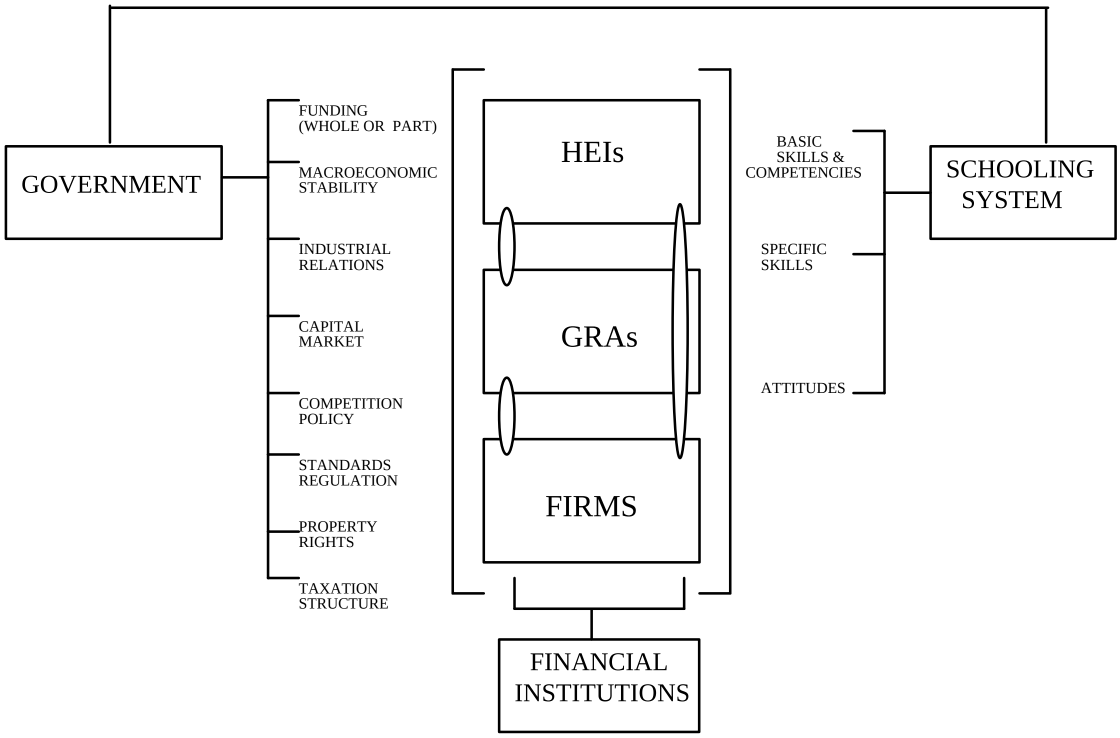
Supporting institutions

While the incentive for firms to innovate is largely determined by the economic environment in which they operate, their ability to capitalise on opportunities depends crucially on access to the required financial, physical and human resources. The availability and price of these inputs in turn depends on the breadth and depth of supplier markets and institutions which may be thought of as supporting the innovation-generating core of the NIS (see figure A1.5).

Important supporting institutions include: financial markets; school systems and governments.

Financial markets are much more varied and flexible in their view of investment risk in some countries than in others. This is of particular concern to innovating start-up and small firms operating in countries with less well-developed financial markets where there are impediments to transactions between users and suppliers of capital. For such firms, the cost of accessing capital markets (including from other countries) may be prohibitively high.

Figure A1.5: **Supporting institutions**



Note: Innovation in the core institutions also influences the supporting institutional environment (for example, multi-media technology in schools, financial innovations).

The major innovation performing institutions (especially universities and firms) are fed by the *school* system and complemented by *vocational training institutions* of many kinds. These institutions provide training for a wide range of production-related skills and also inculcate attitudes to workplace performance which support or inhibit the innovation process. How well these skills and attitudes are built up is reflected in the capacity to learn by doing, to contribute ideas for improved production methods, to work flexibly and achieve consistently high standards of quality output — all essential elements in raising productivity.

School and vocational training systems vary internationally in their capacity to prepare students for a continuously innovating production environment.

Governments also determine the nature of the industrial relations system which in turn either encourages or inhibits firms' flexibility in negotiating with employees to implement new technology. Their demand management policies influence firms' macroeconomic environment and, through that, firms' investment plans. Their industry and competition policies affect the scope for earning monopoly profits and/or collaboration.

Governments may also offer a variety of *financial incentives* to firms through subsidies, grants, loans, tax concessions, credits, and rebates.

The fact that a government has NIS-related policies implies that it also has *priorities* and that its actions may be shaped by *strategy*. Governments may vary widely in the ranking and relative weights they give to different research priorities and potential outcomes of the innovation process in terms of socio-economic goals. They may also differ in the sorts of strategy they adapt to formulate and achieve their objectives.

As a consequence, NISs vary not only because of the performing institutions, their competencies and the incentives they face but also because governments, which partly perform and fund R&D themselves, and differ widely in what they want to get out of their NIS and how they believe their objectives might best be achieved.

A2 AUSTRALIA'S INNOVATION SYSTEM

A2.1 Introduction

The previous chapter (section A1.4) introduced the concept of a national innovation system (NIS). It showed that the NIS of any country could be described and analysed in terms of: the institutions performing innovation-related activities; those providing support; and the incentive structure motivating and guiding innovation-related decisions.

This chapter seeks to build on this by providing a brief description of Australia's innovation system. It describes the current nature and activities of the main innovation-performing groups in Australia (section A2.2); and analyses the incentive structure within which they operate (section A2.3).[1] It also describes the institutional framework shaping innovation policy in Australia (section A2.4).

The complexity of the innovation system mitigates against providing a comprehensive review of innovation in Australia. Detailed descriptions of particular policies and programs are therefore undertaken in specific sections of the report. The focus here is on providing a broad snapshot of the system. A discussion of historical influences, domestic trends and relative international performance (for the purpose of assessing the performance of Australia's NIS) follows in chapter A3.

In providing a broad snapshot of the national innovation system, the Commission has looked at the level of R&D expenditure in Australia and how the performance of R&D by institutional groups contribute to that total. The NIS is also concerned with the funding of R&D and the likely beneficiaries of R&D efforts. Therefore, in its consideration of the innovation system, the Commission has also looked at the funding of R&D by government, the level of support afforded industry by government R&D programs, and those industries that are likely to benefit from R&D.

1 The description is undertaken using 1992–93 data. This is the most recent year for which comprehensive statistics are available. Where available, more recent data have been used to describe trends and for the purpose of international comparisons (see chapter A3).

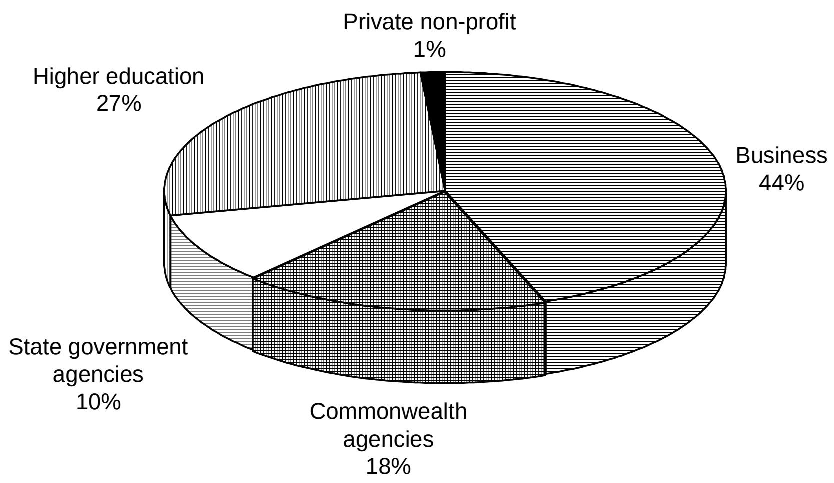
A2.2 R&D performing institutions

As discussed in section A1.4, there are three main forms of R&D-performing institutions. In this section the relative importance of these bodies is described by examining the level and distribution of R&D expenditure between the primary institutions; the objectives (that is, the socio-economic objectives) of R&D expenditure by institution; and the types of R&D activity for each major group.

Level and distribution of R&D by institutional group

Commonwealth research agencies and higher education institutions perform a high proportion (45 per cent in 1992–93) of all R&D in Australia (see figure A2.1).

Figure A2.1: **R&D performance by institutional group, 1992–93** (per cent)



Source: ABS, Cat. No. 8112.0.

Spending of Commonwealth research agencies is dominated by several large bodies. For example, CSIRO accounts for 47 per cent the major Commonwealth government agencies' planned budget outlays of $903 million on R&D for 1995–96, and the five largest agencies (CSIRO, DSTO, ANSTO, AGSO and the Antarctic Division) together account for 95 per cent of this funding.

Business enterprises were responsible for 44 per cent of R&D performed in 1992–93, up from 40 per cent in 1990–91 when data were previously available.

Objective of R&D performance by institutional group

Of the total R&D performed in Australia in 1992–93, 62 per cent had an economic development objective (table A2.1). Other important objectives were: the advancement of knowledge (13 per cent); society (12 per cent); and the environment (7 per cent).

A large proportion of R&D performance by the non-business sector (that is, Commonwealth and State research agencies, universities and private non-profit organisations) is directed at achieving economic development objectives (40 per cent). However, society and advancement of knowledge objectives are also important (20 and 23 per cent approximately).

Economic development objectives account for nearly 90 per cent of R&D performance by the business sector. Within this category, the bulk (60 per cent) was directed at manufacturing.

Type of R&D activity by institutional group

Broadly, most basic research is performed in universities, while experimental development is largely the preserve of business (see figure A2.2).

The higher education sector performed 87 per cent of Australia's pure basic research in 1992–93. Government research agencies undertook 43 per cent of strategic basic research and 41 per cent of applied research. Business enterprises carried out 80 per cent of experimental development, but performed only 3 per cent of Australia's pure basic research.

The higher education sector includes all universities and other institutions of post-secondary education (excluding TAFEs). Under the Unified National System, introduced in 1987, the number of institutions referred to as universities rose from 19 to 38, as Colleges of Advanced Education and Institutes of Technology were given university status and some mergers took place.

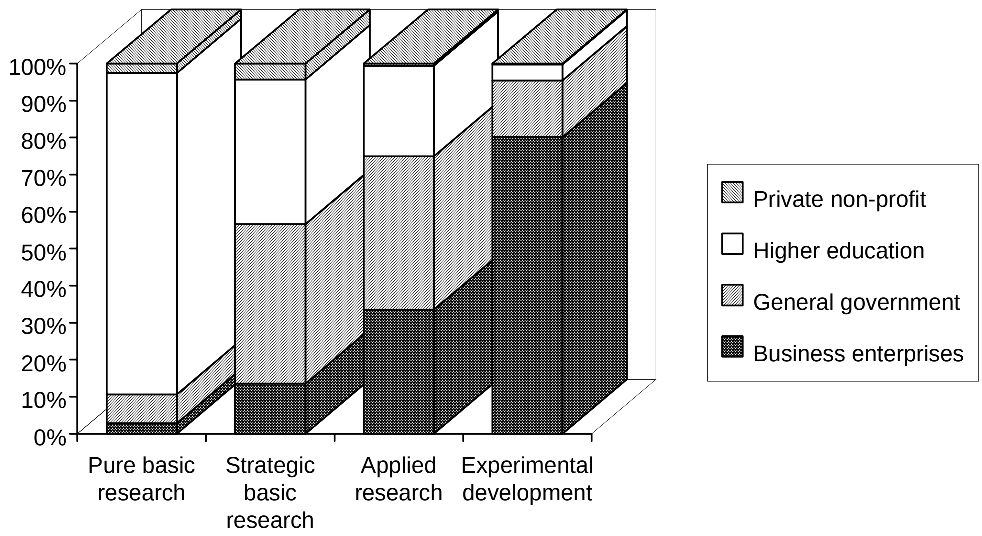
Of total higher education R&D performed in 1992, approximately 64 per cent was on pure and strategic basic research. Only 6 per cent was directed towards experimental development.

Table A2.1: **Objective of R&D, business and non-business sectors, 1992–93**

Socio-economic objective	*Non-business sector*		*Business*	*Total*
	$m	*%*	*$m*	*$m*
Defence	204.2	5.8	134.7	338.9
Economic development				
Plant and animal	626.6	17.8	71.3	698.0
Mineral resources (excl. energy)	92.6	2.6	100.5	193.1
Energy resources and supply	110.5	3.1	170.7	281.2
Manufacturing	294.5	8.4	1483.1	1777.6
Construction	77.6	2.2	25.7	103.3
Transport	26.0	0.7	65.4	91.4
Information and communication services	67.5	1.9	380.3	447.8
Commercial services	21.1	0.6	198.1	219.2
Economic framework	100.2	2.8	5.1	105.3
Sub-total	**1 416.7**	**40.2**	**2 500.3**	**3 916.9**
Society				
Health	502.1	14.3	54.8	556.9
Education and training	94.5	2.7	4.5	99.0
Social development and community services	89.9	2.6	8.1	97.9
Sub-total	**686.5**	**19.5**	**67.3**	**753.8**
Environment				
Environmental knowledge	225.6	6.4	12.3	237.9
Environmental aspects of economic development	151.3	4.3	20.9	172.2
Environmental management and other aspects	35.9	1.0	17.6	53.6
Sub-total	**412.9**	**11.7**	**50.8**	**463.7**
Advancement of knowledge				
Natural sciences, technologies and engineering	519.2	14.7	34.8	553.9
Social sciences and humanities	281.5	8.0	0.01	281.5
Sub-total	**800.7**	**22.7**	**34.8**	**835.4**
TOTAL	**3 520.9**	**100.0**	**2 787.9**	**6 308.8**

Source: ABS, Cat. No. 8112.0.

Figure A2.2: **Type of R&D performed by institutions[a], 1992–93**



a Data within this classification are subjectively allocated by respondents at the time of reporting, using OECD/ABS definitions.
Source: ABS, Cat. No. 8112.0.

The key Commonwealth research agencies are the CSIRO, DSTO, ANSTO AGSO and the Antarctic Division. In 1992–93, CSIRO accounted for over 94 per cent of Commonwealth expenditure on 'plant and animal production and primary products' (that is, agriculture) and 'manufacturing'. When State governments, universities and other government agencies expenditures are included, CSIRO accounts for over a quarter of Australia's public sector R&D expenditure on 'plant and animal', but nearly two-thirds of the expenditure on 'manufacturing' R&D.[2]

State Governments undertake a significant portion of agricultural R&D.

A2.3 Incentive structures

The incentive to innovate flows from the potential rewards to successful innovation. These rewards, in turn, rest on technological opportunities, appropriability conditions and market characteristics (chapter A1). The way these conditions interact to generate the incentives to innovate vary from industry to industry, and over time. They are also influenced by government interventions.

[2] Information supplied by CSIRO and based on ABS socio-economic objective classifications.

Technological opportunities, appropriability and market characteristics

Describing the incentives facing R&D performers (particularly private firms) requires an understanding of the impact of the market characteristics confronting industry, appropriability conditions and technological opportunities on the incentive to innovate. While indicators for these factors taken separately are often hard to obtain, their overall importance may be inferred from examining the R&D performance of industry.

In general, it may be argued that where economic incentives and pressures to undertake R&D are greatest, the ratio of R&D to sales or value added will be highest. This ratio is R&D intensity, and varies across Australian manufacturing as shown in table A2.2.

Table A2.2: **R&D intensity[a] in Australian manufacturing, 1990–91**

	1990–91
Electronics, computing	8.717
Instruments	5.718
Pharmaceuticals	4.975
Non-electrical machinery	1.816
Motor vehicles	1.282
Chemicals	1.100
Electrical machinery	0.884
Ferrous metals	0.703
Fabricated metal	0.521
Rubber & plastics	0.497
Petrol refining[b]	0.369
Stone, clay, glass	0.363
Non-ferrous metals	0.361
Paper, printing	0.239
Food, beverages and tobacco	0.228
Textiles, clothing and footwear	0.092
Wood, furniture	0.074

a R&D intensity is the ratio of R&D to the value of production.
b The Commission has adjusted the statistics for petrol refining. A change in accounting practices by these businesses in 1989–90 has significantly affected the comparability of turnover and associated statistics.
Source: Based on DIST 1994a.

Higher R&D intensity ratios may reflect: abundant technological opportunities; favourable market demand characteristics; and relatively higher levels of appropriability. However, they may also reflect specific interventions by government (for example, financial incentives for business R&D or funding of government research agencies).

The mining industry produces relatively homogeneous goods and hence may have fewer product innovation opportunities than manufacturing. But this does not mean that incentives for developing process innovations will also be low. In fact, inventions in mining and construction machinery have traditionally scored well when United States patents granted to these sectors are compared with overall United States patenting success on an international basis (Gannicott 1986, chapter 5). Downstream industries (non-metallic mineral products and fabricated metal products) have also done well in the past on indices linked to United States patent success.

Agriculture is what Pavitt (1984) describes as a supplier-dominated industry in innovation terms: on-farm innovations are easily observed and imitated (reducing appropriability) while agriculturally relevant R&D is often too costly for a single farmer to finance and the potential for collective action may be negated by the threat of free-riding. This means that, in the absence of external intervention, farmers will largely rely on suppliers to develop new, or improve existing, equipment and other inputs. The principal incentive in agriculture itself will be to diffuse new technology as effectively and quickly as possible.

But there is also an incentive for suppliers to respond to a relatively large local market and develop the capability to identify and meet its particular needs. The evidence that this has happened can be seen in the prominence of the farm machinery and agricultural chemicals sector in rankings which show the relative success of Australian industries in being granted United States patents (Gannicott 1986, chapter 5). Agricultural chemicals will also have been assisted by the rapid growth of scientific knowledge (and hence technological opportunity) in that area.

The incentive structure for innovation also reflects government intervention. To enhance appropriability while encouraging dissemination, the Australian Government has (like most other countries) legislated for the granting of patents and copyrights to protect intellectual property rights. To secure performance of sufficient and appropriate public good research and ensure the provision of adequate education, the Australian Government raises taxes to pay researchers and educators and buy the equipment they must use. To compensate firms for lack of appropriability, the Australian Government provides tax concessions and direct subsidies in the hope of encouraging increased private sector R&D.

The incentive structure embedded in such interventions has changed almost continuously over the last few decades and requires careful analysis to quantify.

Government support for R&D

Government provides support for R&D through two major avenues. It offers incentives to encourage business sector R&D and it provides funding to government research agencies and universities. It also undertakes its own research. Through these mechanisms, Commonwealth and State governments fund about 60 per cent of all research undertaken in Australia. In the case of rural research, over three-quarters is publicly funded.

In order to examine the value of these incentives to the business sector in its role as performer of R&D and producer of goods and services, the Commission looked at information about government funding of R&D and attempted to match this to the industry sector that benefits from that R&D.

Government funding of R&D

About 58 per cent of Commonwealth Government funding supporting industry is channelled into government research agencies and universities (see table A2.3). The funding in these programs is directed at the maintenance of a R&D capacity within a particular public or educational institution.

Over one-fifth is allocated to granting and other public programs by the Commonwealth Government. Under these programs, government provides funding for particular R&D projects rather than maintaining a research capacity in a particular public institution (for example, ARC research grants and government support to rural RDC research programs).

Table A2.3: **Commonwealth R&D funding of benefit to industry, by method of delivery, 1989–90 to 1992–93** ($ million)

	1989–90	*1990–91*	*1991–92*	*1992–93*
Public research agencies and universities	1 278	1 340	1 439	1 494
Granting and other public programs	325	405	534	601
Business R&D	308	354	439	468
Total	**1 911**	**2 099**	**2 412**	**2 563**

Source: IC 1995a.

The remainder (18 per cent) goes to financing incentives for business sector R&D. This research may be undertaken in-house or contracted from specialist organisations, including government research agencies. The major program in the group, the income tax concession, accounts for about three-quarters of this support.

Industry sectors that benefit from government R&D support

As part of this inquiry the Commission undertook a major piece of analysis of government support to research across different industries and sectors (see IC 1995a).

The major beneficiaries of government programs analysed are the agricultural, manufacturing, mining and community services sectors (see table A2.4). The manufacturing sector mainly benefits from granting and other public programs (particularly the income tax concession) but also receives considerable support from government research agencies. Finally, community services benefit from Commonwealth support to research agencies, granting programs (for example, ARC and NHMRC) and universities (including the block funding to universities).

Quantifying net support to industry

The main rationale for government support to R&D is to obtain social benefits arising through the spillovers from induced R&D. For example, tax concessions are intended to induce more private R&D effort with consequentially more social returns. Government R&D is intended to provide R&D in areas not normally the province of business R&D, again with social returns. Given the role of government R&D support in correcting for externalities, that support differs in nature from some other forms of assistance to industry. Nevertheless, support to R&D like other forms of assistance boosts private returns to industry and assistance measures can be used to compare R&D support with other forms of assistance.[3] Such information enables relative levels of assistance across sectors to be correlated with perceptions of the relative contribution of support programs to the generation of social benefits.

Some Government R&D programs (such as the taxation concession) provide support for the performance of R&D by business, and the Commission's estimate of the net support to the performance of such R&D reaches about 24 per cent of value added in business R&D (appendix QD).

[3] The Industry Commission has traditionally included government support for rural R&D in its industry assistance measures for agriculture, but excluded support for R&D that benefits manufacturing from its assistance measures for this sector.

Table A2.4: **R&D funding under selected government programs, by initial beneficiary industry, 1990–91** ($ million)

Industry	*Commonwealth programs*					
	Public programs					
	Research agencies	*Granting and other public programs*	*Business R&D*	*Total*	*State programs*[a]	*Total*
Market sector						
Agriculture, forestry, fishing and hunting	126.2	52.3	4.5	183.0	179.6	362.7
Mining	84.4	4.9	17.5	106.7	na	106.7
Manufacturing	170.0	37.7	310.4	518.2	0.6	518.8
Electricity, gas and water	21.1	2.6	0.4	24.1	na	24.1
Construction	0.1	1.0	1.6	2.6	1.0	3.6
Wholesale and retail trade	3.1	1.8	3.5	8.4	na	8.4
Transport and storage	12.6	0.5	0.8	13.9	na	13.9
Communication	2.0	4.0	0.3	6.3	na	6.3
Recreation, personal and other services	8.4	10.4	4.4	23.2	na	23.2
Total market sector	**427.9**	**115.2**	**343.4**	**886.4**	**181.2**	**1 067.7**
Other industries						
Finance, property and business services	18.1	11.7	8.9	38.7	na	38.7
Public administration and Defence	186.3	2.8	..	189.1	4.0	193.1
Community services	708.2	274.9	1.5	984.6	0.2	984.8
Total all industries	**1 340.4**	**404.6**	**353.8**	**2 098.8**	**185.4**	**2 284.3**

a State support to industry underlying these estimates covers: current expenditure on agricultural research by States, and State contributions to the Australian Road Research Board and the Federalism Research Centre. State involvement in R&D is discussed in this chapter and appendix QE.

Source: IC 1995a.

More broadly, government support to industry through R&D programs comprises support for the performance of R&D by business, just mentioned, plus support obtained through the government research agencies and granting programs. The overall benefit to industries of all kinds of government support to R&D then depends on the relative significance of that support to the overall activity levels of industry. Because R&D typically is a relatively small proportion of overall industry activity levels, support to it adds relatively little to the overall level of government assistance afforded industries. This is shown in table A2.5 which indicates the percentage points by which industry assistance is raised through all avenues of government support. Only the agricultural sector receives R&D support of significance, representing around 3 per cent of its value added. Even there support through R&D accounts for about one-third of other types of assistance to the agricultural sector.

Table A2.5: **Effective rates of assistance to beneficiary market sector industry, 1990–91** (per cent)

	Assistance through R&D					
		Commonwealth support for				
Industry	*State assistance*	*Business R&D*	*Research agencies*	*Other R&D programs*	*Total*	*Non-R&D support*
Agriculture, forestry, fishing and hunting	1.7	..	1.2	0.5	3.4	9.9
Mining	na	0.1	0.5	..	0.6	-2.8
Manufacturing	na	0.7	0.4	0.1	1.2	14.3
Electricity, gas and water	na	..	0.2	..	0.2	-3.5
Construction	na	..	..	..	..	-6.1
Wholesale and retail trade	na	..	..	..	..	-3.7
Transport and storage	na	..	0.1	..	0.1	-4.0
Communication	na	..	..	..	0.1	-1.7
Recreation, personal and other services	na	..	..	0.1	0.1	-3.5
Total market sector	0.1	0.2	0.2	0.1	0.5	1.0

.. Nil or less than 0.5 per cent.
na Not available.
Source: Appendix QD.

Across all market sector industries, R&D support raises the returns to value added by around 0.5 percentage points with the benefits to manufacturing being second in importance to those afforded agriculture. Mining and service industries receive less government support from R&D programs than agriculture and manufacturing. Those industries generally do not receive output assistance. However, mining and service industries must absorb the cost of more highly priced inputs (mainly due to tariffs). The cost to industry of tariffs is reflected by negative effective rates for those industries.

Since 1990–91, the reference year for this study, overall assistance to both agricultural and manufacturing activities has declined (IC 1995c). As government support to industry through R&D programs has increased over the same period (IC 1994a, appendix J), support to industry through R&D programs is likely to have grown relative to other forms of assistance. The increased adoption of syndication arrangements to support business R&D (which is not taken into account in the above analysis) will also have raised the level of support for business R&D.

State government R&D

State government R&D performance

In 1992–93, R&D expenditure by State government agencies was $616 million, representing 10 per cent of total R&D performance in Australia. Of this total, 75 per cent was provided by State governments and about 9 per cent by the Commonwealth Government.

In real terms, State government R&D performance increased by 4.5 per cent annually between 1984–85 and 1992–93, compared with an increase in Commonwealth Government R&D of 1 per cent (ABS, Cat. No. 8109.0).

The capacities of States to undertake research have also increased substantially, and faster than that of the Commonwealth. As shown in table A2.6, the number of person years engaged in State government R&D has increased by 4 per cent annually between 1984–85 and 1992–93, whereas some small declines have occurred at the Commonwealth level.

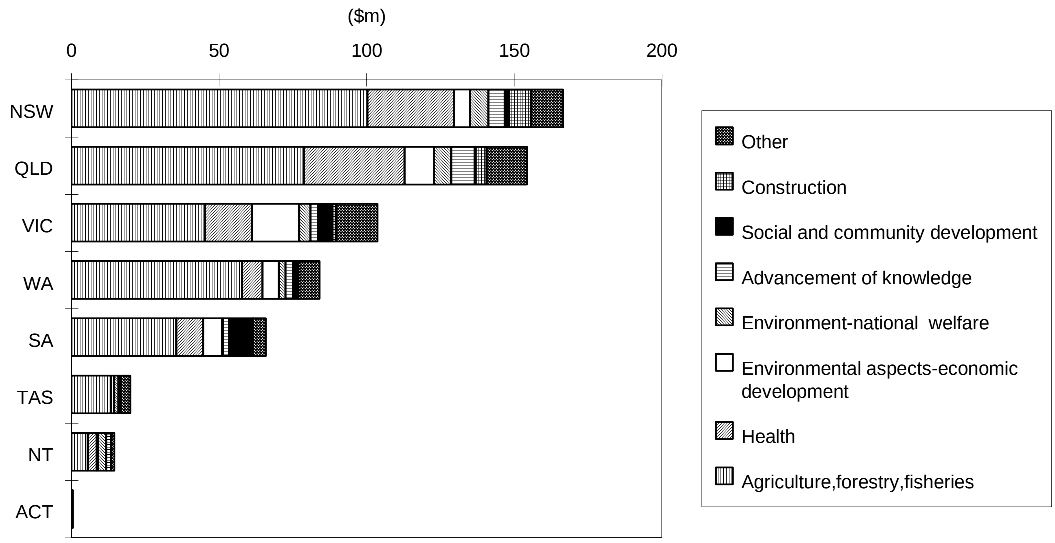
Table A2.6: **Government R&D employment** (person years)

	1984–85	*1992–93*	*Growth rate (%)*
Commonwealth	11 119	10 964	-0.2
State	6 018	8 224	3.9

Source: ABS, Cat. No. 8109.0.

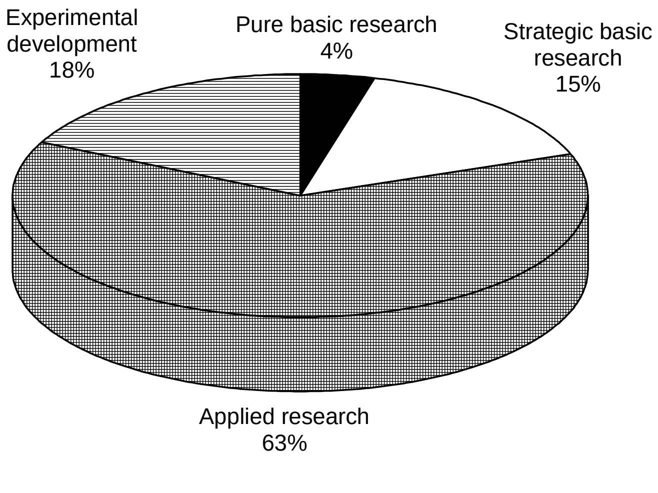
Figure A2.3 shows State R&D performance by purpose for 1990–91. In undertaking or funding R&D, State governments have traditionally concentrated on regional problems and needs. Consequently, the R&D performed by State government agencies tends to be of an applied nature (see figure A2.4). State activity in agricultural R&D dates back to well before Federation. Probably partly because at Federation the States retained responsibility for land management, rural research has always been an important component of State R&D activity. In effect State expenditure on rural R&D represents more than half of all State R&D as well as about half of all rural R&D performed in Australia.

Figure A2.3: **State government R&D performance by purpose, 1990–91**



Source: DIST 1994a.

Figure A2.4: **State government R&D performance by category, 1992–93**



Source: ABS, Cat. No. 8112.0.

Funding of State R&D

The performance of R&D by State government departments forms part of the overall involvement of State governments in R&D. Other components of their involvement include R&D performed by State trading enterprises, contracting out of R&D, involvement in cooperative arrangements (for example, through CRCs) and grants to business (and others) to perform R&D.

From submissions made by the States to this inquiry, the Commission estimates that total State involvement in R&D in 1992–93 was valued at around $700.5 million (table A2.7)[4]. About one quarter of this total ($189.9 million) was funded from external sources with the remainder being funded from State Consolidated Revenue Funds (CRFs) and the balance sheets of state trading enterprises.

State government R&D resources are concentrated in departments and agencies with responsibility for agricultural and other primary industry matters (table A2.7). Overall, State agencies responsible for agriculture, forestry and fishing account for around 53 per cent of State funding to R&D. A number of submissions grouped agricultural, natural resource and environmental R&D together to emphasise the collective importance of natural resource and environmental issues to State involvement in R&D. When this is done, those activities comprise over two-thirds of state support for R&D.

The importance of agricultural R&D varies between States. For example, agricultural research in NSW, Queensland and WA account for around two-thirds of State R&D funding, and approximately 50 per cent. In Victoria, however, research supported by its Department of Agriculture accounted for around 25 per cent of R&D funding.

To complement funds available from State budgets, funds are received from external funding sources. The main source is the Commonwealth. While there is a significant degree of variation between the States, common elements to emerge are that: in most States rural research is predominantly funded from State resources although there is an important contribution from Commonwealth RDCs; and the Commonwealth makes substantial (and sometimes the main) funding contribution to environmental research undertaken by the States.

4 Data were supplied by all States and Territories, other than Tasmania and Northern Territory. In 1992–93, their estimated government expenditures on R&D, according to the ABS, were $20.2 million and $23.1 million respectively (ABS Cat. No. 8109.0). Note that these figures do not include the R&D expenditures carried out by State government business enterprises.

Table A2.7: **State Government funding of R&D by government department or agency, 1992-93[a] ($ million)**

Departments and agencies of	*NSW*	*Victoria*	*Qld*	*WA*	*SA*	*ACT*	*Total*
Agriculture, forestry and fishing	108.8	33.0	78.3	40.7	18.0	-	278.8
Mineral and energy resources	4.9	9.0	11.3	11.4	-	-	36.6
Environmental protection	3.0	8.7	6.0	8.4	0.7	0.4	27.2
Utilities	21.1	36.0	-	3.2	4.0	-	64.3
Transport	13.3	3.0	0.8	-	1.3	-	18.4
Community services and health	8.6	22.0	9.2	5.8	12.1	..	57.7
Public works	0.9	-	-	-	2.5	0.1	3.5
Business services	-	14.0	6.3	-	0.2	-	20.5
Tourism	-	-	0.1	-	0.1	-	0.2
Other	-	1.0	2.6	-	-	-	3.6
Total	**160.6**	**126.7**	**114.6**	**69.5**	**38.8**	**0.5**	**510.7**
Funding from:							
Commonwealth & other sources	55.0	24.7	50.3	18.8	41.1	na	189.8
R&D outlays by State authorities	215.6	151.4	164.8	88.3	79.9	0.5	700.5

.. Values less than $50 000.

- Nil or not provided.

a Data are generally available for 1992-93. However, for some States and some departments data are not available for this year and information from an adjacent year is taken as a proxy for 1992-93. No data were supplied by Tasmania or the Northern Territory. The source information is shown in detail in the discussion for the respective States.

Source: Submissions.

The disposition of funds between in-house and out sourcing of R&D differs between areas of responsibility. Most R&D relating to agriculture is performed in-house by State departments of agriculture and other authorities. On the other hand, there is a tendency for R&D in the areas of transport and utilities to be contracted out to organisations such as the CSIRO, and universities. Health, environmental protection agencies and some community services both provide and outsource their R&D requirements. Involvement in cooperative arrangements particularly with the CSIRO and CRCs was reported by most States. Involvement in cooperative arrangements dealing with natural resource and environmental considerations were given the greatest emphasis in submissions.

A2.4 Policy making

Australia has a number of formal science and technology policy advisory mechanisms intended to bring science and technology considerations into the broader national policy framework. Figure A2.5 depicts the flow of policy advice. The most important advisory bodies are discussed below.

Commonwealth policy-making bodies

Prime Minister's Science and Engineering Council

The Prime Minister's Science and Engineering Council (PMSEC) is responsible for overall government science policy and priority setting.[5]

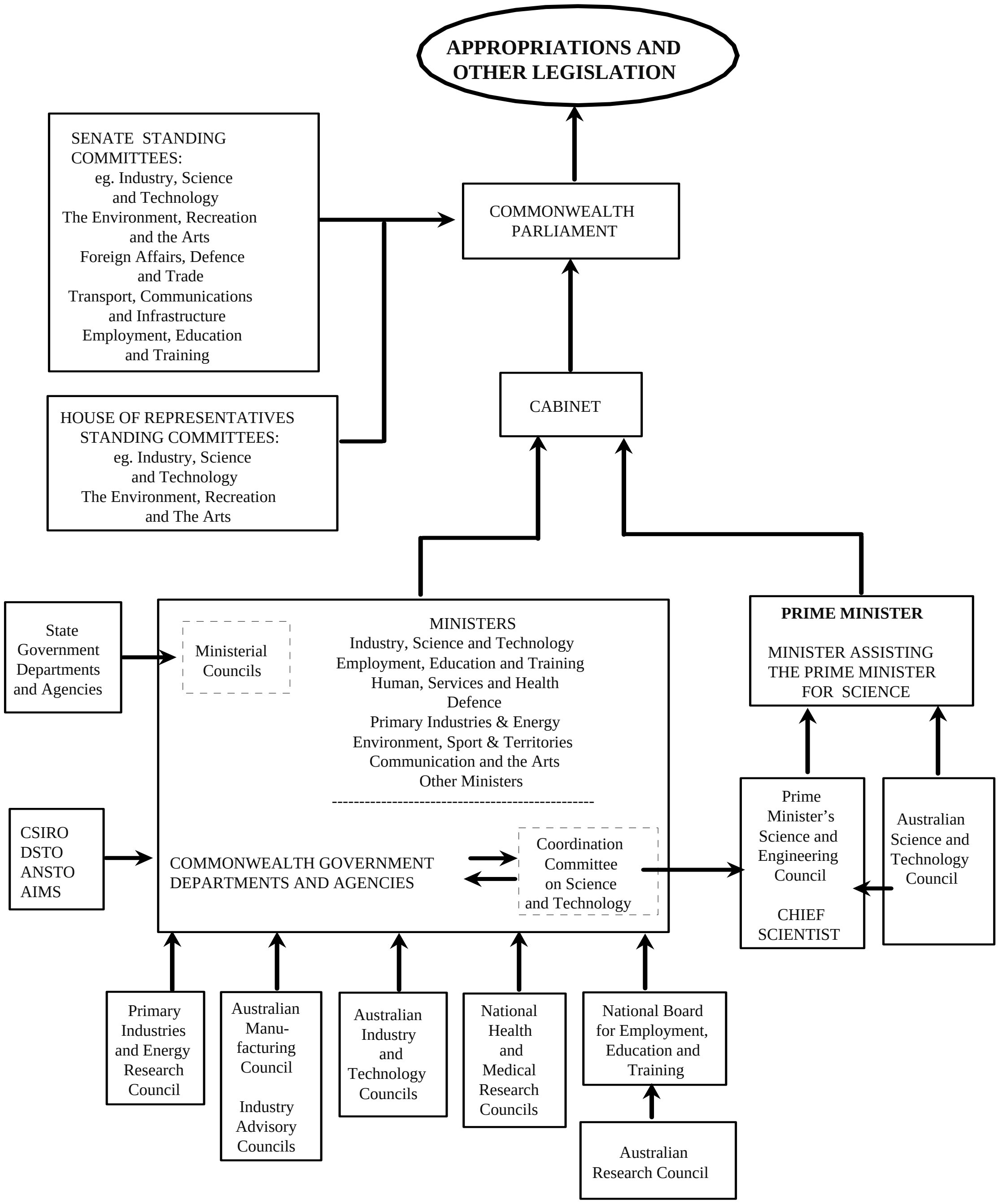
The PMSEC is chaired by the Prime Minister, with the Minister assisting the Prime Minister for Science as deputy chairman. Members of the Council include the Ministers for: Employment Education and Training; Primary Industries and Energy; Human Services and Health; and Environment, Sport and Territories. The Council also has representatives from the science community and Australian industry. The Chief Scientist, supported by the Office of the Chief Scientist in the Department of Prime Minister and Cabinet, is the Executive Officer of the Council.

The terms of reference for the PMSEC are wide-ranging:

- to address important issues in science, technology, engineering and relevant aspects of education and training;
- to examine the contribution of science, technology and engineering to the economic and social development Australia;
- to enhance awareness in the community of the importance of science, technology and engineering for Australia's economic and social development;
- to examine Australia's science and engineering resources and the effectiveness of their organisation and utilisation; and
- to examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

5 PMSEC was established in 1989 but was then called the Prime Minister's Science Council. It was renamed in 1992 to reflect the importance of engineering in capturing the full benefits of scientific knowledge.

Figure A2.5: **Flow of policy advice**



Source: Based on Rubenstein 1994.

The PMSEC meets twice a year and provides advice and recommendations directly to the Prime Minister and the Cabinet.

Coordination Committee on Science and Technology

The Coordination Committee on Science and Technology (CCST) is chaired by the Chief Scientist and consists of heads of agencies and deputy secretaries of departments with an interest in science and technology. It is intended to complement the work of the PMSEC and has the following main purposes:

- to facilitate the sharing of information about programs, policies, problems and future work plans between departments and agencies with responsibilities in science and technology;
- to ensure coherence and consistency in the implementation of government policy for science and technology;
- to allow an overview of policy;
- to report to government on the mechanisms used to set science and technology priorities, and to address the adequacy of these mechanisms and the resulting priorities; and
- to keep a watching brief on the development of specific proposals for national research facilities, particularly those that cross departmental boundaries.

The CCST meets four times a year and provides a forum for discussion and exchange of views on the full range of science and technology policy. The Committee operates in support of the PMSEC, undertaking follow-up action arising from PMSEC discussions, and preparing responses to reports as requested. The Office of the Chief Scientist provides the secretariat for the CCST.

Australian Science and Technology Council

The Australian Science and Technology Council (ASTEC) is a statutory body, originally established in 1975 to provide independent advice on the role of science and technology in the formulation and realisation of national objectives, to a newly formed ministerial committee. It later became, and still is, responsible directly to the Prime Minister.

The role of ASTEC has changed over time. For example, in June 1993, the Government announced that ASTEC would focus on preparing independent advice for consideration by the PMSEC and the CCST as well as continuing to provide advice through its reports tabled in Parliament. The Chief Scientist became a member of ASTEC and at least two members of ASTEC were appointed to the PMSEC. More industry members were to be appointed to ASTEC and, in March 1994, ASTEC’s staff were transferred to the Office of the Chief Scientist. ASTEC now focuses on strategic planning for science and technology, particularly with regard to current capacity and future needs.

Office of the Chief Scientist

The Office of the Chief Scientist was established in 1989 within the Prime Minister's portfolio to provide policy advice, briefing and support directly and through the Chief Scientist to the Prime Minister and the Minister Assisting for Science. It provides secretariat services to the PMSEC, the CCST and ASTEC, allowing better coordination between those bodies.

The Office of the Chief Scientist played a central role in launching the Cooperative Research Centres Program in May 1990. This program has now been placed under the auspices of the Department of Industry, Science and Technology (DIST).

Commonwealth Departments

Various departments with science and technology responsibility provide policy advice concerning matters within their portfolio. For instance, the Department of Industry, Science and Technology (DIST) provides advice to the Minister for Science and Technology; the Department of Employment, Education and Training (DEET) through DEET and the ARC, provides advice concerning higher education research; the Department of Primary Industries and Energy provides advice on R&D relating to agriculture and energy matters; the Department of Defence advises on defence R&D and the Department of the Environment, Sports and Territories advises on the need for environmental research.

All these departments also have a role in implementing science and technology policy.

Other Commonwealth advisory bodies

Policy advice also emanates from a number of standing committees at the parliamentary level. Recent reports include the inquiry into public sector R&D by the Parliamentary Joint Committee of Public Accounts and the inquiry into higher education by the Senate Committee on Higher Education and Training.

There are also a number of advisory councils which provide advice to ministers. For instance the Australian Industry and Technology Council (AITC) is a forum for discussion of State and Commonwealth issues affecting science and technology. Other examples are the Australian Manufacturing Council, the Industry Advisory Council, and the Rural Industries and Energy Research

Council. However, the advice provided by these organisations is not necessarily confined to science and technology matters.

State priority setting

The motivation behind State research involvement is generally towards the solution of particular State management problems (see appendix QE). Thus, when there is an involvement in basic research, an applied management problem will normally be the underlying motivation. Where comments were provided on developments in priority setting, these often related to the adoption of a more applied focus in departmental priorities.

During the 1980s, most States sought to achieve greater integration and coordination between their policies for R&D and for economic development. Some formed science and technology councils and some established development corporations which provided venture capital to innovative firms. Most of the latter have now been abolished or restructured.

More recently, some of the States have been reviewing their R&D policies. Common threads in the motivation for these reviews are (a) the need to allocate reduced R&D resources more effectively, and (b) the need to take advantage of additional research capabilities offered by cooperative arrangements (for example, CRCs) or funds available from industry programs (for example, rural RDCs). Greater industry involvement in State R&D programs is not only expected to make State R&D more relevant and responsive to industry needs, but also to result in increased external funding for State R&D agencies.

In general, most States described their R&D systems in terms that showed that research priorities are implicitly set through the State budgetary process in which funds are allocated to individual departmental portfolios, according to overall spending priorities. Detailed research programs are established within the portfolios using a variety of priority-setting procedures. An exception is SA which has established the South Australian Development Council (SADC) to translate State development priorities to State R&D efforts, particularly through the operation of the South Australian Research and Development Institute (SARDI).

Within portfolios, priority-setting procedures often involve expert committees or councils comprised of departmental and industry representatives. Cost benefit assessments are used by a number of States as an important part of the priority-setting process, particularly in the primary industry areas. Nevertheless, the administrative structures supporting priority setting differs between States. For example, in the Victorian Department of Agriculture a centralised approach is adopted to departmental priority setting. A chief scientist has been appointed to coordinate research within the department and industry teams comprised of departmental and industry representatives have just completed a five-year forward plan for R&D. SA also has a centralised approach to priority setting. On the other hand, the Western Australia Department adopted a more decentralised approach. In that State, there is no dedicated research unit(s), research responsibility being integrated into commodity programs managed by a program leader. Specialist commodity committees have been appointed to assist in the management task.

A2.5 Conclusion

The major R&D performing bodies in Australia are: universities, government research agencies, and private firms. The public sector (universities and research agencies) accounted for around 55 per cent of Australia's total R&D performance in 1992–93. The remainder was carried out by the business sector.

Of the total R&D performed, more than 60 per cent had an economic development (as opposed to general welfare and advancement of knowledge) objective. While 90 per cent of business sector expenditure went to achieving economic development objectives, only about 40 per cent of total public sector expenditure had this objective.

With respect to the type of R&D, the higher education sector undertook most of the pure basic research (87 per cent) in Australia. Government research agencies carried out a large proportion of strategic basic research (43 per cent) and applied research (41 per cent). The business sector undertook 80 per cent of experimental development.

The incentive structures within the NIS are an important influence on the propensity for R&D-performing bodies to undertake research. Important aspects of the incentive structure are technological opportunities, market characteristics and appropriability conditions. The impact of these factors on incentives to innovate in Australia is likely to vary from industry to industry and over time.

While market structures influence incentives to undertake R&D, government assistance can also be a powerful determining force. Financial incentives offered by government for business R&D lowers the cost of acquiring knowledge and therefore raises the returns to other factors of production. This in turn, will raise the incentive for business to enter assisted activities.

A3 THE PERFORMANCE OF AUSTRALIA'S INNOVATION SYSTEM

A3.1 Introduction

The previous chapter provided a brief sketch of Australia's innovation system. It described the major institutions, the incentive structures facing producers of R&D, and identified the major policy making bodies. This chapter seeks to go beyond this description to examine, in broad terms, the performance of Australia's innovation system over time and against international benchmarks.

In the broadest possible terms, Australia does about 1 per cent of the world's R&D, produces about 2 percent of the world's scientific papers and is moving quickly up the rankings of external patent applications per unit of GDP. These and other indicators corroborate the essentially positive view of Australian science and its contributions.

In assessing the performance of Australia's innovation system in more detail, it is useful to view innovative activities within a country as being fed by physical and non-physical *inputs* and generating physical or non-physical *outputs*. The performance of the system can then be gauged by examining what the nation gets out of these inputs.

Inputs to innovation include the intellectual and physical services of labour, the services of capital equipment like computers and lathes, and disembodied knowledge (see section A3.3). Outputs include documented ideas and knowledge, acquired skills, prototype devices and the products and production processes which constitute innovations themselves (see section A3.4).[1] Some inputs are sourced locally and others abroad. Similarly, some outputs are used locally while others are exported.

The outputs of innovation may take many forms (not just new products and processes). The difficulty is that there are few specific indicators for many of these outputs. There are however, a range of indirect measures of outputs. Examples include publication and citation counts as well as education attainment and completion statistics.

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1 Clearly many outputs of innovative activity are inputs into other activities. For example, the innovations such as instruments and computers are used as inputs in R&D. But from the point of view of the innovation process at large it is a good approximation to think of R&D as generating an intermediate input.

While the output of innovation is important in its own right, the innovative outputs must also be adopted and used as widely as possible if their full benefits are to be realised. An assessment of Australia's performance must therefore also focus on the diffusion of innovation (section A3.5).

There are a number of caveats to the analysis undertaken in this chapter. First, the quality of the data used varies. For example, series distinguishing between different types of research (for example, between basic and applied) often depend on the subjective judgments of researchers and non-researchers. In addition, many data sets are incomplete, both in terms of the frequency of observations and the breadth of activity encompassed. Moreover, countries differ in the ways in which they classify activity and present statistical findings.

Outputs of the whole innovative process are product and process innovations. These may be distinguished from outcomes of the innovation process — higher productivity and economic growth both locally and globally (see section A3.6).

The discussion in section A1.4 noted that the specific histories of countries shape the development of NISs. In this context, it is worthwhile briefly examining some of the major factors that have shaped the development of Australia's NIS. This will help explain some of the trends described in the remainder of the chapter.

A3.2 Historical influences

In a recent analysis of Australia's NIS, Gregory (1993) argued that the system had evolved in response to three dominant structural features of the economy:

- the ability of a small population to produce high living standards from the production of primary products;
- small-scale, simple manufacturing which, because of high costs found it difficult to export and compete against imports; and
- a high degree of government provision of business and social services.

He cites Schedvin (1987) for suggesting that:

> ... as the result of the efficient export of primary products there was no obvious and important direct association between economic development and the systematic application of new and sophisticated scientific knowledge (p. 324).

This may help account for the historically low levels of R&D intensity observed throughout Australian industry. But Gregory says *private* sector R&D has been low because of the orientation of domestic manufacturing to a small home market, tariff protection, and dependence on imported technology. The high degree of *government* involvement in both funding and performing research can be traced back to the dominance of small-scale rural production and a tradition of 'colonial socialism'.

While some of these structural features still exist (for example, Australia still relies heavily on primary commodity exports), important changes are occurring. Manufactured and service sector exports rose through the 1980s and now account for a larger share of exports than agricultural products. Tariff protection is being systematically dismantled and is now at significant levels only in the motor vehicle and textile, clothing and footwear industries. Government funding and performance of R&D is the subject of intense scrutiny — as this inquiry attests.

As a result of these changes, certain features of the NIS are also being gradually transformed. For example, there is an increasing inclination for firms to start seeking to apply scientific and technological knowledge in a more systematic manner (see section A3.6). And as government reviews its own involvement in innovation, so the balance of national R&D effort is moving in favour of private sector efforts. These trends are apparent in the review of the NIS below.

A3.3 Inputs to innovation

Inputs to innovation in Australia can be examined by considering: the level of R&D expenditure; the type of R&D activity; and inputs to R&D itself such as labour.

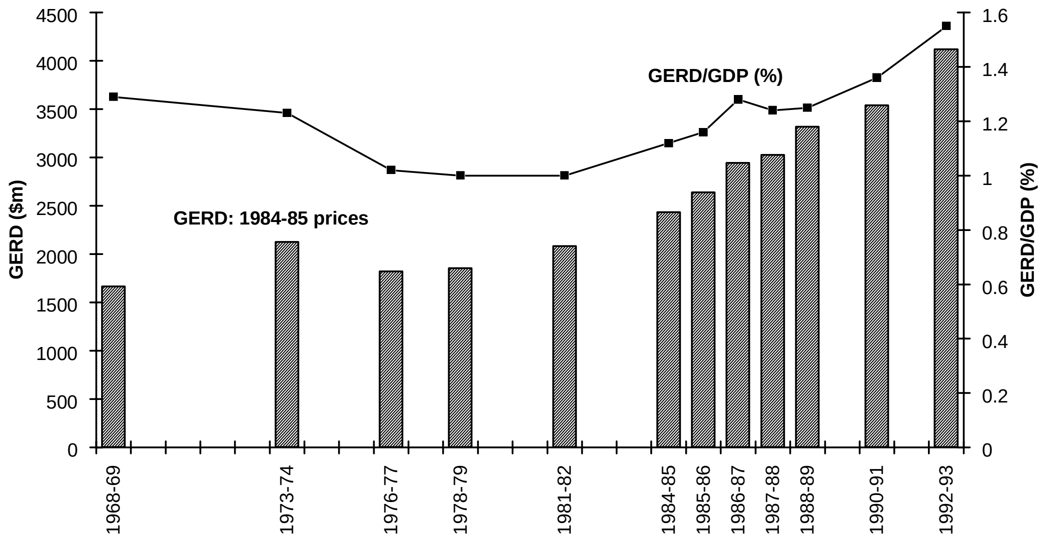
Levels of R&D spending

In 1992–93, the latest year for which complete data are available, Australia spent more than $6.3 billion on research and development. This amounted to about 1.6 per cent of gross domestic product (GDP).[2] The increase in GERD/GDP of the two years to 1992–93 is equal to the increase of the last five years to 1990–91.

Since 1976–77, real gross expenditure on R&D in Australia has been growing without interruption, although it did not exceed its 1973–74 level until the 1980s (see figure A3.1).

2 There is a slight difference between ABS ratios and DIST ratios used in table A3.1 and A3.2 since different measures of GDP are used. The Commission has rounded the ABS ratio to one decimal place.

Figure A3.1: **Gross expenditure on R&D** (GERD)



Source: ABS, Cat. No. 8112.0, various years; and IC estimates.

By international standards, Australia's ratio of GERD to GDP has been and remains relatively low (see table A3.1). In 1992 the ratio for Australia was 1.6 per cent compared with the average ratio for the countries in the table of 1.8 per cent. Australia's position is low relative to the largest performers of R&D (like Japan, the United States and Germany), some Asia-Pacific performers (like South Korea and Chinese Taipei) and even quite a few medium and small performers (like Sweden and Switzerland).

On the other hand, Australia is ranked relatively highly in terms of average annual growth in GERD/GDP over the period 1981–92. On this measure, Australia has recently moved from a position below the international average to a ranking higher than the average. This is because the most recent annual growth rates in GERD/GDP in Australia have been above the growth rates in most other countries and faster than rates in Australia in earlier years. Over the period 1990–91 to 1992–93, GERD/GDP grew in Australia at an average annual rate of 7 per cent, compared with an average annual growth rate 3 per cent for 1981–1991. In a number of larger countries (for example, Japan, USA, UK and Germany), GERD/GDP fell between 1990 and 1992/93.

Table A3.1: International ranking by GERD as a percentage of GDP, growth rate in GERD and growth in GERD/GDP

GERD/GDP (%)		*Average annual % growth in GERD (1984–85 prices)*		*Average annual % growth in GERD/GDP*[a]	
Country	*1992*[b]	*Country*	*1981 to 1992*	*Country*	*1981 to 1992*[b]
Sweden (1993)	3.11	South Korea (1990)	24.2	Singapore (1990)	10.61
United States	2.81	Singapore (1990)	22.3	South Korea (1990)	9.99
Japan	2.80	Chinese Taipei (1990)	15.8	Spain	6.20
Switzerland	2.68	Spain	10.8	Finland	5.50
Germany	2.50	India (1990)	9.4	Chinese Taipei (1990)	5.43
France	2.40	Ireland	7.8	**Australia**	**4.04**
Finland	2.18	Finland	7.6	Denmark (1991)	3.96
United Kingdom	2.12	Japan	7.0	Italy	3.72
South Korea (1990)	1.86	Denmark (1991)	7.0	Ireland	3.48
Netherlands	1.86	**Australia**	**6.9**	Norway (1993)	2.82
Norway (1993)	1.76	Italy	6.6	Sweden (1993)	2.74
Denmark (1991)	1.70	Norway (1993)	5.3	India (1990)	2.65
Chinese Taipei (1990)	1.69	Austria	4.8	Japan	2.49
Belgium (1991)	1.67	Sweden (1993)	4.4	Austria	2.44
Australia	**1.56**	Germany	4.2	Canada	1.86
Canada	1.51	France	4.1	France	1.79
Austria	1.53	Canada	4.1	Switzerland	1.43
Italy	1.31	Switzerland	4.0	United States	1.32
Ireland	1.07	United States	3.7	Belgium (1991)	0.28
Singapore (1990)	0.90	Belgium (1991)	2.9	Germany	0.26
New Zealand (1991)	0.88	Netherlands	2.8	Netherlands	0.10
Spain	0.85	United Kingdom	1.8	United Kingdom	-1.01
India (1990)	0.79	New Zealand (1991)	0.1	New Zealand (1991)	-1.25
China (1990)	0.72	China (1990)	na	China	na
Average[c]	**1.76**		**7.5**		**3.08**
OECD average[c]	**1.91**		**5.3**		**2.22**

a This growth rate is found by using the formula, $Ae^{rt}=B$. Where: A = initial expenditure; e = natural logarithm; r = rate of change; t = time period; and B = final expenditure.
b 1992 unless otherwise indicated.
c Average of the numbers in the columns shown.
Source: Cook 1995a, based on DIST compiled data; DIST 1994a; and IC estimates.

An important statistical explanation for Australia's relatively low overall R&D performance relates to its comparatively low level of business expenditure on R&D (see table A3.2). In 1981 Australia had a BERD/GDP ratio of only 0.3 per cent compared to the then international average of 0.8 per cent. Since then real BERD has grown more quickly in Australia than elsewhere in the OECD and its BERD/GDP ratio has also risen faster than in most countries. Despite this, Australia remains lowly ranked. Its BERD/GDP ratio stood in 1992 at 0.7 per cent, compared with an international average of 1.1 per cent and 2.1 per cent for the top-ranking countries, Sweden and Japan.

International comparisons such as these, however, do not take into account the wide variation in industrial structure among countries. Australia's ranking rises when BERD is adjusted for differences in industrial structure (see part D).

Table A3.2: **International rankings by business expenditure on R&D as a percentage of GDP (BERD/GDP), 1981 and 1992 and growth rate**

Business R&D expenditure as a percentage of GDP (BERD/GDP)				*Average annual % real growth in BERD*	
Country	*1981*	*Country*	*1992*[a]	*Country*	*1981 to 1992*[a]
United States	1.71	Sweden (1993)	2.14	South Korea (1990)	31.6
Germany	1.71	Japan	2.06	Singapore (1990)	23.8
Switzerland	1.70	United States	2.04	Chinese Taipei (1990)	16.5
United Kingdom	1.49	Switzerland	1.88	**Australia**	**13.0**
Sweden	1.46	Germany	1.70	Spain	12.8
Japan	1.41	France	1.51	Ireland	11.7
France	1.16	South Korea (1990)	1.38	Denmark (1991)	8.3
Belgium	1.05	United Kingdom	1.33	Japan	8.2
Netherlands	0.98	Finland	1.24	Finland	8.2
Norway	0.68	Belgium (1991)	1.11	India (1990)	7.2
Austria	0.65	Denmark (1991)	1.00	Italy	7.1
Finland	0.65	Netherlands	0.97	Norway (1993)	5.7
Canada	0.60	Norway (1993)	0.89	Canada	5.4
Denmark	0.54	Chinese Taipei (1990)	0.89	Sweden (1993)	5.0
Chinese Taipei	0.52	Canada	0.82	Austria	4.9
Italy	0.49	Austria	0.80	France	4.8
Ireland	0.32	Italy	0.77	New Zealand (1991)	4.6
South Korea	0.25	**Australia**	**0.69**	Germany	4.0
Australia	**0.25**	Ireland	0.67	United States	3.8
New Zealand	0.22	Singapore (1990)	0.49	Switzerland	3.5
Spain	0.19	Spain	0.47	Netherlands	3.2
India	0.16	New Zealand (1991)	0.28	Belgium (1991)	2.8
Singapore	0.15	China (1990)	0.19	United Kingdom	2.1
China	na	India (1990)	0.18	China (1990)	na
Average[b]	**0.80**		**1.06**		**8.6**
OECD average[b]	**0.91**		**1.18**		**6.3**

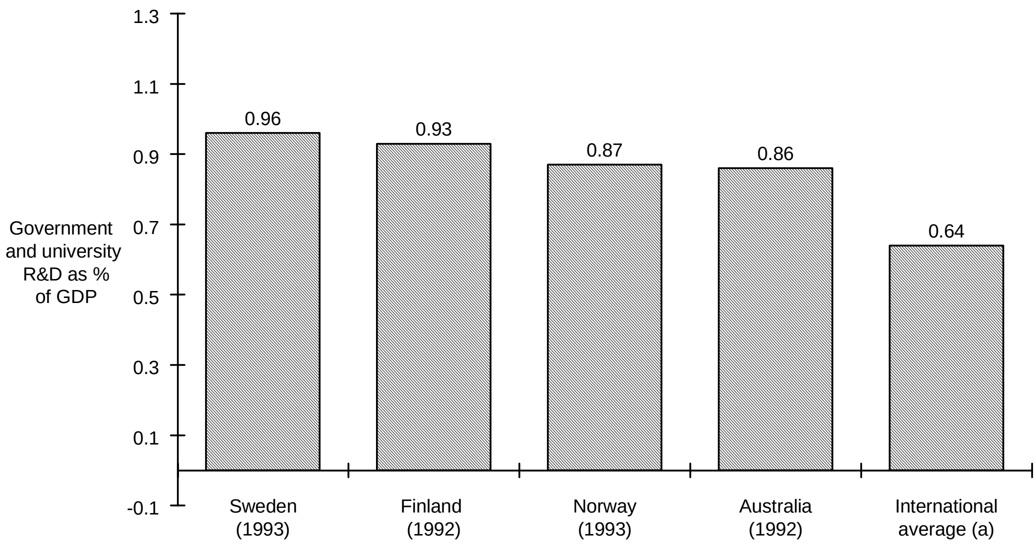
a 1992 unless otherwise indicated.

b Average of the numbers in the columns shown.

Source: Cook 1995a, based on DIST compiled data.

In contrast to business R&D, government and university R&D in Australia comprised 0.9 per cent of GDP in 1992, compared with an international average (over most OECD and some Asian countries) of 0.6 per cent (see figure A3.2). The result is that, in terms of the ratio of government and university R&D to GERD, Australia is at a level well above the international averages.[3]

Figure A3.2: **Five countries with highest ratios of government and university R&D to GDP**[a] (per cent)



a Selected OECD and Asia-Pacific countries as shown in table A3.1.
Source: Cook 1995a, based on DIST compiled data.

Australia's R&D performance relative to other countries is discussed further in chapter A4, while chapter D1 looks in detail at business R&D performance.

Type of R&D activity

More than 60 per cent of Australia's R&D effort can be described as either basic (28 per cent) or applied (33 per cent) research. The remaining 39 per cent is experimental development. Basic research comprises pure basic research (12 per cent) and strategic basic research (16 per cent). Figure A3.3 provides a summary.

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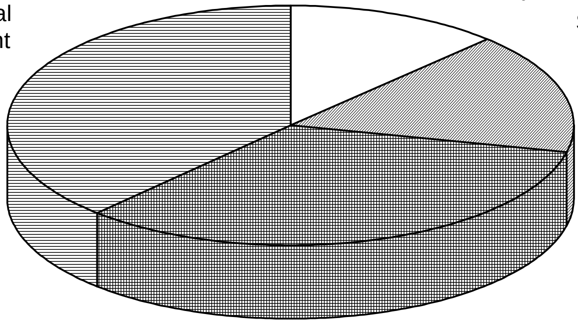
3 The Australian Research Council (Sub. 361) claimed that Australia's university R&D is overstated in official statistics, making international comparisons suspect. However, the Department of Industry, Science and Technology (Sub. 412) has challenged this view.

Figure A3.3: **Types of research performed[a], 1992–93**



a Classifications based on the ABS/OECD categories described in box A1.1.
Source: ABS, Cat. No. 8112.0, table 5.

Significant changes in the type of research have occurred in Australia over the past decade. In particular, there has been an observable shift from research to experimental development (see table A3.3). The increase in the share of experimental development is largely due to the rapid growth in business R&D.[4]

Table A3.3: **Types of research, Australia** (percentage of GERD)

Year[a]	*Pure basic*	*Strategic basic*	*Applied research*	*Experimental development*
1978–79	18	15	44	23
1981–82	19	17	41	23
1984–85	15	17	39	29
1986–87	13	15	38	34
1988–89	12	15	40	33
1990–91[b]	12	17	37	34
1992–93	12	16	33	39

a Data were not available for 1985–86 and 1987–88 inter-year surveys.
b Revised ABS data.
Source: ABS, Cat. No. 8112.0, various years.

4 As noted in chapter A2, business directs most of its R&D spending into experimental development.

As noted earlier, considerable caution must be exercised in making international comparisons of R&D performance and this is especially true in relation to types of R&D where subjective judgments play such an important role in allocating work to one category or another. Even allowing for considerable error, however, it is clear from table A3.4 that Australia does less experimental development as a proportion of all R&D than many other countries — only one-third as compared with well over a half in the United States, Sweden and Japan. It also spends proportionately more on basic research than any of the other countries listed.

Table A3.4: **International comparison of types of research, selected OECD countries**[a] (percentage of GERD)

Country[b]	*Basic research*	*Applied research*	*Experimental development*
United States	15	23	62
Sweden	24	17	59
Japan[c]	12	22	58
Norway	15	36	49
France	20	32	48
Ireland (1988)	13	42	45
Spain (1988)	18	41	41
Portugal	21	42	37
Italy	18	46	36
Netherlands[c]	15	29	36
Australia (1988)	**27**	**40**	**33**
Austria[c]	22	47	28
Iceland	24	50	27

a Data for the United Kingdom, Germany, Switzerland, Belgium, Canada, Denmark, Finland, New Zealand, Greece and Turkey are not available.
b 1989 unless otherwise indicated.
c Rows do not add to 100 due to a non-specified component of research.
Source: OECD 1993a.

R&D inputs

Human resources devoted to R&D have risen steadily in recent years to reach 78 500 person years during 1992–93. A similar trend may be observed for the fraction of the labour force comprising R&D personnel with a significant rise between 1990–91 and 1992–93.

Labour costs are the largest component of total R&D costs. Expenditure on labour engaged in R&D amounted to $3 350 million in 1992–93, or 53 per cent of total expenditure (see table A3.5). However, the share of labour costs has been falling steadily since the 1970s.

Table A3.5: **Australian R&D personnel and input costs as percentage of GERD**

	R&D personnel		*Input costs as % of GERD*			
Year	*Total*	*% of labour force*	*Land & buildings*	*Other capital*	*Labour costs*	*Other current*[a]
1968–69	40 966	0.80				
1973–74	51 371	0.87				
1976–77	43 746	0.71	4	6	70	20
1978–79	43 643	0.68	5	7	67	21
1981–82	45 211	0.67	6	7	66	21
1984–85	51 255	0.73	4	8	64	24
1985–86	53 258	0.75	3	9	62	26
1986–87	60 080	0.80	3	9	60	28
1987–88	62 442	0.81	3	9	60	28
1988–89	65 926	0.84	4	10	57	29
1990–91	68 345	0.81	4	9	56	31
1992–93	78 538	0.92	3	10	53	34

a Other current costs include materials, rent and leasing, repair and maintenance, data processing, general administration and other overheads.
Source: ABS, Cat. No. 8112.0, various years.

When Australia’s inputs into R&D are compared with those in other countries, the Australian labour cost share is at the upper end of a fairly narrow range running from 44 per cent (Japan) to 59 per cent (Portugal) (OECD 1993a). In table A3.6, Australia is just above the OECD median for the number of (full time equivalent) researchers per 10 000 members of the labour force. With the median at 46, the range is from 12 (Portugal) to 76 (United States) and 75 (Japan — an overestimate). Australia stands at 50. But this is well above Switzerland (40) which has one of the highest GERD/GDP ratios, and well below Ireland (58) which has an even lower GERD/GDP ratio than Australia.

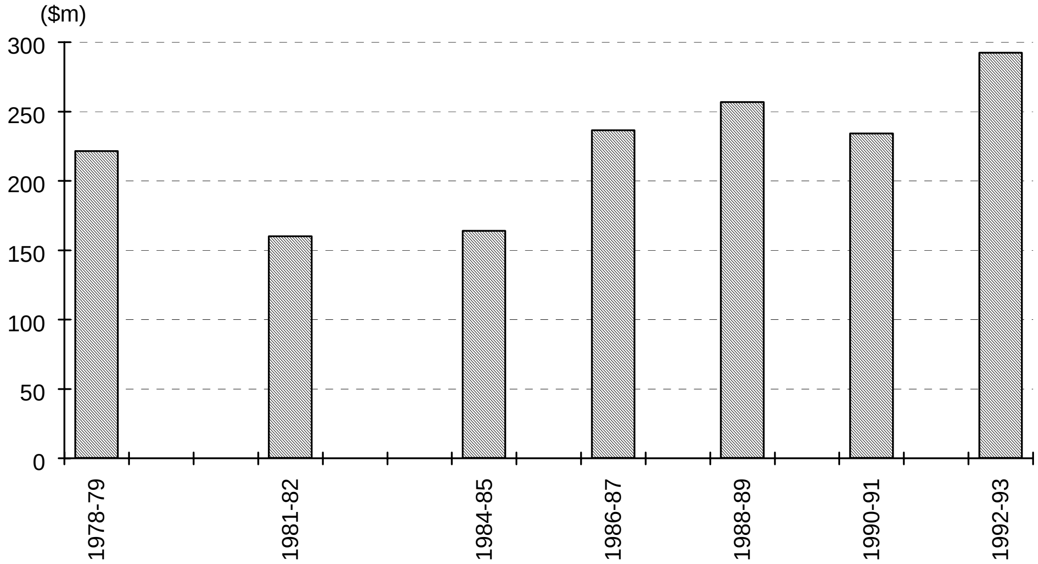
Table A3.6: International comparison of numbers of researchers in R&D

Country (1991 unless otherwise indicated)	*Researchers[a] (national totals)*	
	Full-time equivalent	*Per 10 000 labour force*
United States (1989)	949 300	76
Japan[b]	491 102	75
Norway	13 460	63
Germany (1989)	176 401	59
Ireland	7 684	58
Sweden[c]	25 400	56
Finland	14 030	55
France	129 205	52
Australia (1990)	**42 367**	**50**
Iceland	695	49
United Kingdom[d] (1988)	130 019	46
Canada (1989)	62 510	46
Belgium (1990)	18 465	44
Denmark	12 049	41
Switzerland (1989)	14 250	40
Netherlands (1989)	26 680	40
Italy	75 238	31
New Zealand (1990)	4 721	30
Austria (1989)	8 782	25
Spain (1990)	37 676	25
Greece	6 230	15
Portugal (1990)	5 908	12
OECD Median		**46**

a Or holders of university-level degree engaged in R&D.
b OECD adjusted data.
c Underestimated as data for R&D performed by the Government and Private non-profit sectors exclude the social sciences and humanities.
d Underestimated as R&D personnel in the Private non-profit sector are excluded.
Source: OECD 1994c and 1993a.

Knowledge is another important input into R&D. Given our small share of the world's R&D, linkages with overseas sources of technological knowledge are particularly important. Figure A3.4 shows how payments for technical know-how by Australia have risen since 1981–82. Technical know-how is the specialised technical knowledge required for successful production. These payments are made by Australians to allow them to use patent licences, technical information, engineering assistance, etc.

Figure A3.4: **Payments for technical know-how, 1978–79 to 1992–93** ($ million, average 1984–85 prices)[a,b,c]



a The ABS does not publish constant price data for payments of technical know-how. The available current price estimates are deflated by using implicit price deflators of business R&D (BERD).
b The data include local Australian and overseas based firms.
c Payments for technical know-how are not available for the higher education sector.
Source: ABS, Cat. No. 8112.0, various years.

Australia pays out nearly 7 per cent of its GERD to foreigners for use of their know-how — compared with 2.1 per cent in the United States, 2.8 per cent in Japan and 10.5 per cent in the United Kingdom. Although the fractions of business enterprise R&D (BERD) are larger, the international rankings and relativities are much the same (table A3.7).

Table A3.7: **Payments for technical know-how, selected countries**

	As a percentage of GERD (%)		*As a percentage of BERD (%)*	
Country	*1986*	*1990*	*1986*	*1990*
Australia	**8.34**	**6.96**	**21.95**	**17.55**
United States	1.14	2.10	1.59	3.00
United Kingdom	9.83	10.45[a]	14.48	15.51[a]
Japan	2.83	2.84	4.26	4.01

a 1989 figure.
Source: Derived from OECD 1993a.

A3.4 Outputs from national R&D

Despite relatively modest levels of overall R&D expenditure, Australia enjoys a high reputation for the quality of its science and a range of indicators suggests improving performance in the national innovation system as a whole. The New Scientist said:

> If you take any of the conventional measures of scientific excellence, whether it be number of Nobel prizes, scientific papers published, citations per paper, heads of international conferences and so on, then Australia does extremely well for its GNP and population (29 October 1994, p. 30) .

The output from R&D more generally may take several forms: documented knowledge (publications and patents), person-embodied knowledge (such as enhanced research skills) or experimental and demonstration devices. While there is no official data on numbers of new devices, such inventions would often have been accompanied by a patent application. Trends in patent applications may therefore provide a guide to the outcomes of R&D, and provide at present grounds for guarded optimism.

Scientific publications

Over the last ten to fifteen years increasing effort has been devoted to the bibliometric analysis of documented research outputs including papers in scientific journals (van Raan 1988).[5]

One of the fruits of this work has been the production of national and international tables showing publication performance by country, field and discipline. Table A3.8 shows that between 1980 and 1992 Australia on average produced about 2.3 per cent of all scientific papers published in the world. To some extent national fractions reflect the relative sizes of countries, with the United States easily topping the list at 36.3 per cent, followed by the United Kingdom, Japan and Germany. While Sweden and Switzerland lie below Australia on this measure, they top the international rankings for papers per annum per million head of population. To put these results into perspective, Australia, Switzerland and Sweden each account for only 1 per cent of all world spending on R&D.

According to recent work (Bourke and Butler 1994), Australia's share of world scientific publications appears a little lower than that reported by DIST. These authors found that the share fell between 1982–86 and 1987–89. However, they said:

5 Bibliometric analysis is the analysis of the generation and use of documented forms of knowledge.

> ... we do not regard the decline in publication shares as of particular significance; rather, we emphasise that the particular feature of the Australian performance is a relatively constant publication share associated with a decline in citations (Sub. 267).

Table A3.8: **Scientific publications: international comparison** (12 years to 1992)

Annual papers per million population		*World share of annual papers*	
Country	*Number*	*Country*	*(%)*
Switzerland	1 088.0	United States	36.27
Sweden	1 025.0	United Kingdom	8.77
Canada	861.6	Japan	7.80
Denmark	831.4	Germany	6.21
United Kingdom	726.4	France	5.73
United States	704.9	Canada	4.69
New Zealand	694.6	Italy	2.90
Australia	**662.7**	**Australia**	**2.28**
Netherlands	657.7	Netherlands	2.04
France	485.6	Sweden	1.83
Germany	452.6	Switzerland	1.52
Japan	302.8	Denmark	0.90
Italy	239.0	New Zealand	0.49

Source: DIST 1994b, figure 35, based on the Institute for Scientific Information and OECD data.

Another common measure of the impact of scientific research is the frequency with which publications are cited. This is discussed in section A3.5.

Patents

An application for a patent is an indication that an inventor or researcher feels he or she has a novel device of prospective commercial value. In Australia, the granting of a patent requires four criteria to be met by an invention:

- it must be a *clearly defined product or process* (not just an idea);
- it must be *novel* by world standards;
- it must offer a solution to a problem that technical experts believe non-obvious; and
- it must be useful in achieving its stated purpose (BIE 1994d).

Applying for and being granted a patent are thus two entirely separate matters — and countries vary widely in the ratio of patents granted to patents applied for (Soete 1987, p. 108). A recent study carried out by Watermark (1995) found that over half of Australian patent applications by Australian residents lapsed before they were granted.

As is the case in many small economies, local residents in Australia apply for fewer domestic patents than foreigners (8 294 compared with 19 378 in 1991) and are granted fewer (1 112 as against 11 524 in the same year). More than 90 per cent of Australian patents are thus currently granted to non-residents — a state of affairs which has been true since the 1960s (Mandeville 1982, cited in BIE 1994d, p. 34).

As is shown in table A3.9, Australians have over the last decade become much more active by international standards in applying for patents abroad. This suggests a growing awareness of the need to patent globally to obtain full protection for an innovation — and growth in the number of inventions perceived to be patentable. The Department of Industry, Science and Technology noted that:

> The introduction of international treaties around 1980 made the application process easier and can in part explain the early increase. However there has been rapid increase since 1986, the highest among OECD nations. This may reflect increasing innovation and internationalisation in Australian industry (1994b, p. 21).

Using the measure of external patent applications standardised to take account of differences in GDP, Australia's position in a ranking of OECD countries rose from 14th to 9th between 1981 and 1991, implying an annual average growth rate of 17 per cent, faster than that for any other nation.

US patents applied for by Australians are a subset of all external applications but taken to be a particularly helpful guide to where the technological strengths of an applicant country lie. Between 1979 and 1990 these rose from 579 to 1 398. Analysis of such applications between 1963–70 and 1977–84 suggests that, compared with other countries, Australia's technological strengths probably lie in activities which complement its natural resource endowments — such as farm machines, ferrous and non-ferrous metals and products, fabricated metals and food (Gannicott 1986, p. 224).

A3.5 Diffusion

As discussed in section A1.2, the results of R&D often take the form of *disembodied knowledge*. While producing and publishing this knowledge is an important output from R&D, it must be widely taken up and used if it is to have maximum effect. In this section, the published document is regarded as the product of a piece of research and subsequent citations of the document as evidence on the extent to which it has diffused. Similarly citations to existing patents may be taken to reflect how far the ideas they contain have spread.

Table A3.9: **Nineteen OECD countries ranked by external patent applications per unit GDP[a] and growth rate**

Country	*1981*	*Country*	*1991*	*Country*	*Average annual % real growth*
Switzerland	21.47	Switzerland	26.83	**Australia**	**16.9**
Sweden	12.43	Sweden	24.19	Finland	16.6
Germany	10.45	Finland	20.46	Denmark	15.3
Netherlands	7.38	Denmark	20.30	Norway	15.0
Denmark	5.61	Netherlands	14.39	Spain	12.6
United Kingdom	5.40	Germany	13.27	Ireland	12.4
Austria	5.34	United Kingdom	11.63	United Kingdom	11.1
Finland	4.99	Norway	11.20	Japan	11.1
France	4.70	**Australia**	**8.61**	United States	10.2
Japan	3.91	Austria	8.53	Netherlands	9.8
United States	3.53	France	7.66	Italy	9.5
Belgium	3.30	United States	7.19	Belgium	9.1
Norway	3.26	Japan	7.02	Sweden	8.9
Australia	**2.50**	Belgium	6.18	Canada	8.8
Ireland	2.31	Canada	4.86	Austria	8.7
Italy	2.14	Ireland	3.82	France	8.1
New Zealand	1.95	Italy	3.62	Germany	7.6
Canada	1.54	Spain	1.44	Switzerland	4.9
Spain	0.65	New Zealand	1.07	New Zealand	-2.6
Average	**5.41**		**10.65**		**10.2**

a GDP values are expressed in $USm at 1985 prices.
Source: DIST 1994a, table 3.7 and 3.8.

But other important outputs of research are *new technological devices* and *technological knowledge*. These are diffused through education; the movement of knowledge-bearing people; and by investment in and use of equipment embodying new technology. These are all dealt with below.

Disembodied knowledge

The decline in Australia’s share of global publications in science has also been accompanied by a fall in the share of citations which Australians have attracted around the world (table A3.10). This has been viewed by some as evidence of declining quality in Australian science. However, as some participants suggested, it may also reflect a change in attitudes by scientists — they may not wish to publish for commercial reasons (that is, to maintain secrecy). But

Bourke and Butler (Sub. 267) have questioned this view and say that no evidence has been presented to support such an explanation.

Table A3.10: **Australia share of world publications and citations**

Year	*% share of world publications*	*% share of world citations*	*Australia's relative citation impact*[a]
1982–86	1.98	2.03	1.03
1987–91	1.92	1.81	0.95
1982–91	1.95	1.96	1.00

a Relative citation impact compares Australia's share of publications with the share of citations these publications receives. If the unit receives a higher share of citations than publications, then the RCI will be greater than 1.00 and vice versa.
Source: Bourke and Butler, 1994, table 2.

Over the period 1981–1990, the scientific papers of the Swiss and Swedes were cited most often in proportion to the total number of papers they wrote (see table A3.11), with mean citations per paper of just above and below 7 respectively, compared with Australia's 5.4. Japan has the third highest world share of published papers but a citation rate (4.4) well below that for Australia.

Finally, table A3.12 provides evidence by discipline of citation rates for Australians compared with the average of all other countries' citation rates. Compared to the non-Australian average, Australian engineers are cited more often than any scientists from any other discipline, followed by chemists, agricultural scientists, and plant and animal scientists. Australian physicists, immunologists, molecular biologists and computer scientists were cited least often compared to world averages.

Person-embodied knowledge

In discussing the role of higher education institutions in the NIS (see section A1.4), it was recognised that the education sector both teaches and provides research training. Movements of university graduates and trained researchers within the economy act like a beneficial infection and constitute a major mechanism for diffusing knowledge through the NIS. They are also an important source of spillovers.

Table A3.11: **International rankings by citations per paper, 1981–90**

Country	*Mean citations per scientific paper*[a] *(1981–90)*
Switzerland	7.33
Sweden	6.72
United States	6.65
Denmark	6.22
Netherlands	6.01
United Kingdom	5.62
West Germany	5.47
Belgium	5.38
Australia	**5.36**
Canada	5.31
France	5.05
Finland	4.97
Norway	4.85
Japan	4.42
Italy	4.26
New Zealand	4.23
Ireland	3.94
Spain	3.17

a Mean citations are obtained by dividing the number of citations by the number of annual papers for each country.
Source: Science Watch 1991, p. 2.

Universities aid diffusion by exposing students to existing bodies of knowledge and by creating an awareness of how those bodies of knowledge are changing.

Trends in degree completions therefore provide a partial indicator of the diffusion of person-embodied knowledge.[6] An increase in completions can be seen as reflecting more extensive diffusion of knowledge and an increase in the capacity of working population to absorb and apply knowledge.

Universities also pass on research skills in the course of supervising research degrees. This is diffusion in itself and not only creates new research skills but also a capacity to communicate research ideas effectively. In this connection, university performance in relation to higher research degrees is critical.

6 More detailed analysis of university sector performance is found in part C.

Table A3.12: **Australian research performance ranked by impact[a], 1980–1992**

Discipline	*Index of relative citation success. (%)*
Engineering	33
Chemistry	28
Agricultural Science	25
Plant & Animal Sciences	24
Geosciences	20
Materials Science	15
Ecology/Environment	14
Pharmacology	13
Mathematics	11
Astrophysics	10
Clinical Medicine	3
Biology & Biochemistry	-8
Neurosciences	-10
Physics	-12
Immunology	-14
Molecular Biology	-15
Computer Sciences	-19

a This is found by performing the following calculations. First, find the average number of citations per Australian-produced paper in any given discipline. Second, subtract from this the average number of citations for all papers in the world produced in that discipline. Third, divide the difference by the all-world average. A positive value of this index reflects above-average citation of Australian-produced papers; a negative value, below-average citation
Source: DIST 1994b, figure 37, based on the Institute for Scientific Information data.

Total degree and diploma completions at Australian universities rose by 62.3 per cent between 1981 and 1991. Within the total, higher research degree completions rose from 1 729 in 1981 to 2 558 in 1991 (an increase of 48 per cent), and Masters coursework degree completions grew by 250 per cent from 1 561 to 5 461. The total of all post graduate courses completed rose 115 per cent to 27 145, compared with an increase of 50 per cent in all undergraduate completions (bachelor degrees, diplomas and associate diplomas).

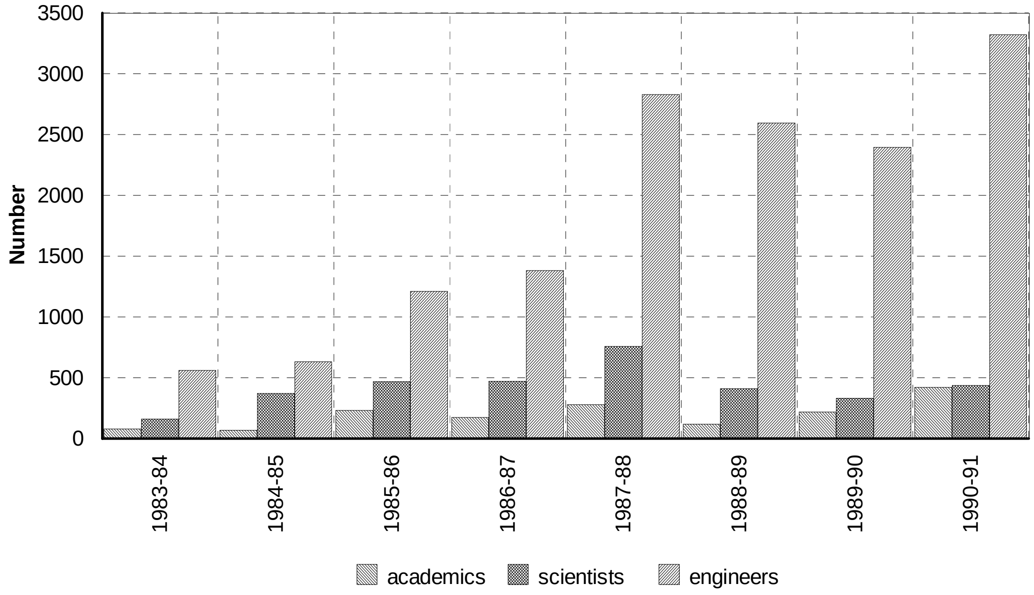
By field of study, all-level degree completions rose most rapidly from 1981 to 1991 in the areas of health-related studies (212 per cent), business (144 per cent) and law (122 per cent). In engineering and science the growth rates were 68 per cent and 60 per cent (DEET 1993a).

In Australia's 25–64 year old population, 10 per cent have had higher (university-level or equivalent) education as against 23 per cent in the United States, 15 per cent in Canada and 13 per cent in Japan.

While the Australian education system provides 'home-grown' talent for the NIS, Australia is also able to draw on the knowledge and skills of foreigners if they choose to work here. At the same time, Australians sometimes take their human capital abroad, a phenomenon often described as a ‘brain-drain’.[7]

The difference between inward migration and outward movements of people is *net migration*, and figure A3.5 shows that, at least since 1983–84, Australia has been a net beneficiary in terms of flows of academics, scientists and engineers.

Figure A3.5: **Net migration of selected professionals into Australia[a], 1983–84 to 1990–91** (number of persons)



a DIST derives the net gain of migration from finding the difference between long-term arrivals (settler arrivals, long-term residents returning and long-term visitor arrivals) and departures (permanent departures, long-term residents departing, and long-term visitor departures).
Source: DIST 1994a, table A1.8.

New products and techniques

New technological knowledge embodied in machines and equipment diffuses among domestic users either by local purchases of Australian-made capital or by local purchases of capital goods produced abroad. The Australian capital goods sector is relatively small and local producers depend heavily upon imported equipment to gain access to new technology.

[7] The emigration of Australians need not be regarded as a concern. For example, it could be a signal that Australia is ‘doing the right thing’ in its education system. In addition, if those leaving acquire skills that are then brought back to Australia, departure of researchers may have a beneficial effect.

Recent statistics show that more and more enterprises are using advanced manufacturing technologies. Table A3.13 shows that advanced manufacturing technologies are now used by an industry average of 41 per cent of manufacturing establishments. Between 1988 and 1991, diffusion of these technologies occurred at a positive rate in all industries except textiles. Diffusion appears most rapid in the non-metallic minerals and basic metal products industries.

Table A3.13: **Advanced manufacturing technologies**

	Proportion of manufacturing establishments having one or more technologies (%)	
Industry subdivision	*1988*	*1991*
Food, beverages and tobacco	28	32
Textiles	34	34
Clothing and footwear	15	29
Wood, wood products and furniture	23	30
Paper, paper products, printing and publishing	21	27
Chemical, petroleum and coal products	43	44
Non-metallic mineral products	41	47
Basic metal products	50	62
Fabricated metal products	31	46
Transport equipment	47	54
Other machinery and equipment	56	64
Miscellaneous manufacturing	34	44
Total manufacturing	**33**	**41**

Source: ABS, Cat. No. 8123.0, table 2.

Associated with the new technology embodied in equipment, new techniques of managing the equipment and other inputs to achieve maximum output are also spreading. This is illustrated in table A3.14.

Underlying these developments is the enhanced awareness of the value of technological innovation at the company board level in Australia, as reflected by the increasing incidence of companies using technology strategies. A study carried out by the Centre for Technology and Social Change (1990) found that the rate of technology strategies adoption in Australian firms is high, suggesting a rapid uptake of technology strategies and an increased interest in technological innovation in Australian boardrooms. It found that:

> ... almost all the firms that had adopted technology strategies were managing them actively, using them as a regular guide to decision-making, and reviewing their strategies at least annually (TASC 1990, p. vii).

Table A3.14: **Use of advanced manufacturing techniques**

	Proportion of manufacturing establishments (%)	
Techniques	*1988*	*1991*
Total quality control/management	15	24
Just-in-time	15	22
Manufacturing resource planning	6	11
Computer integrated manufacturing[a]	na	2
Value adding management[a]	na	2
Proportion having one or more techniques	**24**	**39**

a Not surveyed in 1988.
Source: ABS, Cat. No. 8123.0, table 22.

A3.6 The contribution of technological innovation

New products and processes

The final outputs of technological innovation are the innovations themselves. There are no official statistics on technological innovations for Australia. But an Australian study (McLean and Round 1978) used a government survey of most enterprises undertaking R&D in 1971–72 and from a useable sample survey of 980 respondents, identified the proportions of overall sales accounted for by innovations of varying degrees of novelty. In the early 1990s, the BIE used a similar method to analyse the innovative activities of firms registered to participate in the 150 per cent tax concession scheme.

The results presented in table A3.15 provide evidence that Australian firms that undertake R&D have become markedly more innovative. In 1971–72, 68 per cent of the manufacturing output studied involved no innovative products or processes at all; by 1990–91, this proportion was only 38 per cent. In the 1990s, 22 per cent of sales were said to derive from ‘totally new’ products and products compared with only 9 per cent twenty years before. The percentage contribution of ‘significantly improved’ products and processes to sales had risen almost threefold, and ‘marginally improved’ products and processes from 13 per cent to 21 per cent. It is also worthy of note that the number of R&D performers itself rose from 1 278 in 1981–82 to 2 766 in 1992–93.

Table A3.15: **Contribution of innovation to output and sales, 1971–72 and 1990–91**

		Totally new products/ processes[a]	*Significantly improved products/ processes*[a]	*Marginally improved products/ processes*[a]	*Unchanged products/ processes*[a]
McLean & Round estimate	Percentage of 1971–72 output	9	7	13	68
BIE estimate	Percentage of 1990–91 sales	22	19	21	38

a The similar categories employed by McLean and Round were new products, radical redesigns, slight modification, unchanged, and discontinued products. For purposes of comparison, discontinued products (2.27 per cent) are not included in the table.
Source: McLean and Round 1978; and BIE 1993b.

Other recent commentary has stated that Australian firms currently rely more heavily on product innovation than foreign firms. Unlike their overseas counterparts, many the Australian companies surveyed are not primarily focused on cutting costs:

> When asked to comment on the major area of economic leverage in the near future, the Australian companies we spoke to nominated the development of new and improved products (McKinsey 1993, p. 22).

It appears that Australian firms may also be more successful at product innovation than many believe. In a recent study of firms known to be active in new product development, Dwyer and Mellor (1992) find that respondents on average derive half of their current sales from products introduced in the previous five years, and that the new product success rate was as high as 69 percent.

A3.7 Conclusions

While Australia devotes relatively fewer resources to R&D than many other countries, this situation is slowly changing.

In 1992–93, Australia spent $6.3 billion on research and development, amounting to about 1.6 per cent of gross domestic product (GDP). The international average for the OECD and some Asia-Pacific countries was 1.8 per cent.

A major reason for Australia's relatively low overall R&D performance relates to the comparatively low level of business expenditure on R&D, the reasons for which are analysed in part D.

A somewhat different picture emerges when growth rates in R&D expenditure are considered. Since 1981 total R&D expenditure in Australia has grown by an average of 7 per cent per year. This growth rate compares favourably with the average for OECD and some Asia-Pacific countries. In addition, growth in business R&D has been much more rapid (13 per cent per annum compared to an international average of 9 per cent).

The type of research undertaken in Australia is also changing. In particular, there has been an observable shift from research to experimental development. This reorientation in R&D spending is largely the result of the rapid growth in R&D expenditure by the business sector (the largest performer of experimental development).

The outputs of R&D (such as knowledge and new or improved products and processes) are hard to measure. However, there is evidence to suggest that outputs have increased. For example, between 1981 and 1991, external patent applications by Australians grew on average by around 17 per cent per year. This also suggests that Australians are becoming increasingly aware of the need to patent globally to obtain full protection for innovations — and growth in the number of patentable inventions.

While innovating is an important activity in its own right, innovations must be taken up and widely diffused if they are to have maximum effect.

Diffusion occurs through, *inter alia*: education; the movement of knowledge-bearing people; and by investment in and use of equipment embodying new technology. In this context, there is evidence that Australia's capacity to understand and use new knowledge and technology is rising.

Between 1981 and 1991, degree and diploma completions at Australian universities rose by 62 per cent. Around 10 per cent of Australia's (25–64 year old) population have higher educational qualifications, compared with higher levels in the United States, Canada and Japan.

In addition, recent statistics show that more and more enterprises are using advanced manufacturing technologies. Diffusion appears most rapid in the non-metallic minerals and basic metal products industries.

The final outputs of innovation are the innovations themselves. Australian firms that undertake R&D have become markedly more innovative. In 1971–72, 68 per cent of the manufacturing output studied involved no innovative products and processes at all; by 1990–91, this proportion was only 38 per cent. In the

1990s, 22 per cent of sales were said to derive from 'totally new' products and processes compared with only 9 per cent, twenty years before.

The picture that emerges from the discussion in this chapter is that Australia is devoting more resources to R&D, obtaining more output from its growing research effort and taking up and using innovations. However, increasing innovation is only useful if it results in higher productivity and ultimately, higher output growth. The links between innovation, productivity and economic growth are examined in the next chapter.

A4 R&D, COMPETITIVENESS AND ECONOMIC GROWTH

A4.1 Introduction

Both economic theory and empirical analysis suggest that technological progress has the potential to be a major contributor to economic growth in any country. The extent to which it actually does contribute to growth varies from country to country.

'Technological progress' is a rather vague term which, at its broadest, includes any contribution to economic growth that is not derived strictly from quantitative increases in physical inputs. R&D has a significant role in driving technological progress but, as we have seen, is only one element in the system of relationships linking science, technology and the production of economically valuable goods and services. R&D is induced by changes in markets as well as bringing about such changes itself.

Most innovation-related decisions that are motivated directly to serve market needs are made by business firms. The competitiveness of a firm in any market is determined by how well it serves its customers in terms of the quality of the product and the price it charges.

When technology is fixed, as it is assumed to be in many models of economic activity, firms can compete only by making better use of existing technological knowledge or by resorting to non-technological weapons such as advertising. But when technology is changing, firms will need to invest directly or indirectly in new knowledge, whether they wish to be industry leaders, or merely to keep up.

Inter-firm rivalry thus drives important (and particularly close-to-market) elements of the innovation process. At the same time, the success with which firms participate in the innovation process has an important bearing on their competitiveness.

No fully satisfactory analysis yet exists to account simultaneously for the micro-level decisions of firms, industry-level outcomes and economic growth rates. Indeed, attempts to explain these relationships have resulted in controversy at the most fundamental levels in economics. The Commission, while recognising that central issues in the area remain unsettled, draws on the debate to see what general lessons might so far have been learned.

In doing so, the Commission accepts that conventional statistical measures of rising GDP are a reasonable approximation to increases in national welfare. This chapter also focuses on technologically related R&D rather than other forms of research activity undertaken in the arts and humanities. The Commission recognises, however, that national welfare is affected by the state of the physical, social and cultural environment and by activities not captured in national accounts (like household production). And it acknowledges that research of all kinds may have value to add which is not adequately reflected in conventional economic measures of growth.

A4.2 Competitiveness

'Competitiveness' is one of the most frequently stated objectives of government industry policy. Yet it is not easy to define unambiguously and may not, in itself, be easy to defend as a policy goal. Particularly at the national level, competitiveness is a slippery concept. Krugman has argued:

> ... competitiveness is a meaningless word when applied to national economies. And the obsession with competitiveness is both wrong and dangerous (1994, p. 44).

This may be an extreme position. But the notion of competitiveness does appear to be more difficult to deal with, the higher is the level of aggregation at which it is made to operate.

At the level of the *firm*, competitiveness has a relatively clear meaning and operational content. A firm is competitive if it 'competes successfully'; that is, if it can maintain or expand its market share while making at least enough profit to induce it to stay in its existing line of business. This is a somewhat conservative definition since the most successful firms in some industries will be achieving rapidly increasing market share at the same time as building up their long-term market value. In other industries market conditions will prevent any firm from making profits beyond the normal level required to keep them in the business.

Economic theory has often viewed firms as having similar technology and comparable skills in exploiting it. Technological advance has frequently been incorporated as a productivity- or product-improving change from which firms may benefit at no cost to themselves. Analysis in the tradition of Schumpeter, however, emphasises that product and process innovations are investment activities, costly to firms, and at the heart of competitive strategy.

Because technological knowledge is partly tacit and always built on each firm's specific history of production, each firm is different. Some firms will have technological knowledge and competences which are better suited than others to given economic conditions and as a result find they have a competitive edge. In addition, some firms will be better than others at predicting how economic conditions will change and invest in new technology to position themselves most effectively to take advantage of the change. Heterogeneity among firms, based on firm-specific knowledge accumulation, is thus an essential component of technological competition.

Variations in the 'core competences' of firms in developing and deploying new production methods are in this view central to understanding why some firms do better than others. On the other hand Freeman recalls Winter's (1987) warning that:

> ... we hardly ever know precisely what we are talking about ... (quoted in Freeman 1994, p. 473),

when we try to *measure* knowledge, competence and skill.

Putting measurement issues on one side, the government has a potentially important role in funding research and educational institutions, and providing an incentive structure to encourage R&D, the mobility of skilled labour, and so on — and thus may indirectly affect firms' competitiveness through those channels. It is therefore unclear how much a firm's competitiveness reflects its own decisions and efforts independently of government policy.

Firms interact with other research performers in a variety of ways and we should expect that firms operating in the context of some countries' innovation system might perform as more effective innovators than those working in the systems of other nations. As a result, we might also expect firms in some countries to be more competitive than those in others. That said, however, firms can and do build up competitive advantages more or less independently of the national innovation system in which they operate and can draw globally on physical and human resources to do so. Multinationals are even less tied to the specifics of a given national innovation system.

The 'competitiveness' of an Australian industry can be thought of in two ways:

- the extent to which the firms comprising it are exposed to the forces of competition from within and outside the industry, domestically and internationally; and
- the extent to which it is able to capture and increase its share of the world market for the goods or services it provides.

Much recent analysis of international competitiveness (OECD 1992a; Porter 1990) has stressed the importance of macroeconomic features or 'structural factors' in creating a national environment which assists firms in a given economy to be globally competitive. This was noted above in relation specifically to the national innovation system. The OECD argues firms' competitiveness stems not only from their management practices but also from 'structural competitiveness' related to:

- the strength and efficiency of an economy's productive structure;
- long-term trends in the rate and structure of capital investment; and
- technical infrastructure (OECD 1992a, p. 243).

Porter uses the concept of a competitive 'diamond' to provide a perspective on the determinants of industry competitiveness. The four points of the diamond represent factor conditions; demand conditions; related and supporting industries; and firm strategy, structure and rivalry. From industry to industry and from country to country there are differences in the relative importance for competitiveness of each of these conditions and in the ways in which they interact.

An Australian industry's competitiveness reflects the degree of pressure on firms within it and the success of those firms in winning global market share. But the concept is ambiguous to the extent that firms' performance may vary from one country to another because of direct and indirect government support.

A4.3 Innovation and firm competitiveness

As noted in chapter A1, firms are at the cutting edge of the innovation process: they are the main agents in the economy for *converting* new technological knowledge into improvements in living standards. To gain a better appreciation of their innovating activity, their motivations are considered first, and then their operations.

Why firms innovate

Given that innovation is costly for firms, why do they do it? The answer lies in the sources of inter-firm competitiveness: lower costs; better products; better delivery and after-sales service. Each of these can be achieved by firm-level innovation involving processes, products and organisational innovation.

Left to compete in terms of price alone, with given products and technology, there is little scope for individual firms to enhance their profits even temporarily — unless they receive legislative protection, or gain unique access to a vital input, or find a way of colluding with rivals over price setting. If a firm can *change* the products it sells or the technology it uses, this gives it a whole new range of competitive weaponry. In this sense, the prospect of undertaking R&D

is a spur to competition because it provides a major extra dimension within which firms may compete with each other. This was recognised by participants in the inquiry. The Australian Industrial Research Group said:

> ... you do R&D to get a competitive advantage ... getting a competitive advantage can manifest in various ways ... it is not R&D alone but it is the innovation-technology transfer and R&D is part of that (transcript, p. 1903).

Similarly, Critec Pty Ltd said:

> Firms (as distinct from public sector bodies) do R&D as part of a business plan in an attempt to gain competitive advantage through product and process differentiation within their industry (Sub. 249, p. 1).

In many industries R&D is an essential continuing requirement simply to maintain competitiveness in the face of rapid technological change and increasingly sophisticated consumer needs. The Nucleus Group stressed that there was a need for ongoing investment in R&D in its industry:

> In the area of medical equipment and sophisticated high technology prosthetic devices it is essential to maintain high levels of expenditure on both concept and product innovation to maintain market presence, let alone market leadership. Obsolete products do not sell in the highly sophisticated, competitive and well informed world of the medical equipment market. R&D therefore is a *sine qua non* for a company such as Nucleus which specialises in medical electronic equipment (Sub. 93, p. 8).

As the Nucleus comment makes clear, competition is a spur to firm-level R&D as much as R&D broadens the front on which competitive battles are fought. Firms not only undertake R&D to steal a competitive advantage. They are also forced to innovate to survive.

Firm size and R&D

Where R&D has a high threshold cost, perhaps because of high fixed laboratory or equipment costs, small firms may find it very difficult to compete with large firms who may use R&D to gain competitive advantage. This argument was put to the Commission at its Business roundtable. Most Australian companies were said to be too small to have the critical mass necessary to undertake R&D and thus needed to collaborate with other firms.

But the argument that size drives R&D does not apply in general.

- R&D costs need not necessarily be very high: two-thirds of Australian R&D falls into the $50 000–$500 000 range per year (BIE 1993a).
- R&D activity need not involve a large element of fixed costs. Table A3.5 showed that only a small proportion of R&D expenses could be attributed to capital and buildings, and while some labour might be regarded as a

fixed cost element, many R&D staff are capable of performing other functions.

- Firms with fewer than 100 employees ('small' and 'very small') undertook 23.5 per cent of all R&D, and 'medium' size firms (200–499 employees) 25.8 per cent. The implication is that far more small and medium sized enterprises (SMEs) do R&D in Australia than larger firms.

Small size is an observable characteristic of many 'hi-tech', start-up companies, some of whom participated in the inquiry — often to report chronic cash-flow problems associated with ploughing profits back into expensive new rounds of R&D. Martin Communications told the inquiry:

> ... we run on the edge all the time, and we never have enough money — ever ... because we spend all our money on R&D, and then there is nothing left. This is typical ... (transcript, p. 554).

In a recent survey of the literature, Cohen and Levin argued that:

> ... the most notable feature of [the] considerable body of empirical research on the relationship between firm size and innovation is its inconclusiveness (1989, p. 1069).

Strategic use of R&D

Another feature of R&D activity which firms may attempt to use to competitive advantage is the sunk cost aspect of R&D expenditures. Sunk costs are non-recoverable costs and may be used strategically by firms to create protection for themselves (or a form of barrier to entry) against potential rivals. The asset which the innovating first mover obtains is new technological knowledge. While such knowledge may sometimes be patentable, both Australian and United States firms have indicated that secrecy and moving first are generally regarded as more effective ways of appropriating the gains from R&D than gaining patent protection. (The pharmaceutical industry is an exception.) Once a lead has been established it may, moreover, be reinforced by various forms of learning (learning-by-doing, learning-by-using, etc).

The perceived importance of moving first, and the scope for doing so offered by technological innovation, is clear from table A4.1. This shows that moving first to create a competitive advantage was the most important factor motivating Australian firms to undertake R&D.

Table A4.1: **Factors influencing R&D expenditures by firms**

	percentage of firms ranking factor as important or very important:		
Factor	*small (< 100)*	*large (100+)*	*All firms*
Create a competitive advantage	84.3	87.8	85.3
Exploit technological strengths	75.5	76.6	75.3
Changes in market opportunities	72.0	76.9	73.4
Changes in technological opportunities	63.6	68.9	65.0
Tax concession for R&D	66.8	58.7	63.1
Keep up with competitors' products	58.1	73.4	62.8
Cash flow position	70.2	46.2	61.7
After-tax cost of R&D	49.3	46.5	47.9
Retained profits	50.6	42.7	47.4
Pre-tax cost of R&D	48.0	41.6	45.5
Maintain a given ratio of R&D to sales	17.6	7.7	14.0
Level of competitors' R&D	10.8	10.8	10.8

Note: The data for the 'all firms' category relate to 847 respondents which performed R&D in at least one year since 1989–90. The number of respondents in the two size categories are: small (546 companies) and large (286).
Source: BIE 1993c.

The importance of speed to market was emphasised by a number of participants in the inquiry. CRA, for example said that 'speed of development work is important' (Sub. 44, p. 11).

This led it to try, where appropriate, to draw on the skills of outside organisations and hence foreshorten learning times.

But the opportunity to be a first mover is not always a guaranteed inducement to innovate:

- a firm *already earning profit from a previous innovation* would have to abandon these profits if it substituted a new product for its existing product (Arrow 1962),
- the *timing* of innovation is often as important as speed to market (Barzel 1968), and
- firms may deliberately choose to let others go first in order to *learn from their experience.*

Moreover, Teece (1986) has emphasised the importance of *complementary assets* in generating a profit from innovation. A firm which possesses a well-developed distribution network for a product innovation may prefer to let another firm bear the heavy costs of development — in the expectation that the latter will not be able to market the product effectively at the end of the day. The former may then plan to imitate, or buy out the first mover — and consolidate its advantage by building on the assets it already has.

It could be argued that a lack of complementary assets has hindered Australian firms in export markets in the past, as they have often lacked effective marketing and distribution networks. On the other hand, the fact that moving first neither guarantees success nor exclusivity leaves open to Australian firms the opportunity to act as ‘fast seconds’, diffusing, adapting and building on the experience of firms that have led the way.

Firms use technological information to provide themselves with competitive weapons in addition to price. Innovation enables them to cut costs, improve and change their products and offer better delivery and after-sales service. It also offers firms the prospect of taking a strategic advantage if they move first to pre-empt potential or emerging opportunities. Moving first is not, however, a sufficient condition for commercial success: profitable innovation also calls for the use of complementary assets to ensure rapid and sustained market penetration.

How firms compete through innovation

In order to compete effectively through innovation firms must:

- know about and be responsive to changing conditions in the markets;
- develop, where appropriate, the knowledge base, competencies and complementary assets required to undertake either research, development or commercialisation on its own account; and
- know about and have the ability to absorb from external sources relevant new technology in all its forms — knowledge, human capital and equipment, including collaborative effort and outsourcing arrangements.

Market orientation and producer/user interaction

Product innovating R&D, and the process innovation accompanying it will be misdirected and ineffective unless linked to market conditions.

The OECD identifies as a major factor contributing to firm level competitiveness:

> ... the capacity to incorporate closer definitions of demand characteristics and the evolution of markets into design and production strategies ... the successful organisation of effective interactive integrating mechanisms between market planning, formal R&D, design, engineering and industrial manufacture (1992a, p. 239).

Users have a critical role in influencing suppliers' R&D in a wide range of product fields according to von Hippel (1978). And in their study of Australian product innovators, Dwyer and Mellor (1992) discovered that the most successful strategy calls for a new product program which is proactive in identifying market needs and in which the firm's new products fit well with its production and R&D skills.

To some extent the value of aligning production and innovation with identified market need has become more apparent simply because it has been recognised that firms which do this are reducing the market uncertainty associated with product R&D — and hence enhancing the risk-return trade off for their shareholders.

In addition, computer-aided manufacturing methods and, more generally, flexible manufacturing systems enable suppliers to operate profitably with very short production runs. This puts them in a position to tailor or customise products much more precisely to user or consumer needs.

Internally generated innovation activity

Firms cut costs and/or produce new products by extending and refining their command of technology in all its dimensions. This is achieved internally by:

- deliberate, formal R&D (generating new knowledge and devices);
- learning-by-doing, learning-by-using, learning-by-learning (generating new knowledge, mainly of a non-documented and often of a tacit form); and
- formal and informal in-house training, on and off the job.

The value of resources allocated to generating innovation internally could in principle be calculated by comparing expected marginal benefits with expected marginal costs for each type of activity involved.

In practice, it is difficult if not impossible to apply precise cost-benefit analysis to industrial R&D. Firms which have formal research laboratories generally have to justify their existence in terms of the perceived qualitative success with which they enable the firm:

- to understand the potential value to them of advances in science;
- to respond effectively to feedback from users when solutions to fundamental problems are required; and
- to solve fundamental problems raised in connection with technological development.

The modern managerial literature emphasises not rate of return calculations on R&D expenditure so much as the establishment of a corporate *culture of continuous learning and improvement* in and among all elements of the firm — the ‘learning organisation’ (Senge 1992). While it plays down the role of R&D *per se*, a recent BCA study suggests that applying methods of continuous improvement in management and production practices underlies many of the recent competitive successes seen in Australian business.

At the Commission’s Business roundtable discussions, the point was made that research is sometimes undertaken specifically with a view to developing international linkages and understanding and learning from the patent literature.

Following the work of Cohen and Levinthal (1989) and others, the role of R&D in enhancing the firm’s ability to exploit and evaluate external knowledge (absorptive capacity) is now widely accepted. Academic research (Tilton 1971; Allen 1977; and Mowery 1983) has shown that firms which conduct their own R&D are better able to use externally available information and that the ease of learning within the industry is directly affected by the level of expenditures on R&D. Dosi summarises this by saying:

> One needs to have substantial in-house capacity in order to recognise, evaluate, negotiate, and finally adapt the technology potentially available from others (Dosi 1988, in Freeman 1990, p. 119).

Thus, although knowledge from research performed by other firms, public research institutions and other sources is often freely available, it can require substantial investments in R&D to make successful use of it.

External sources of technology

Acquisition of knowledge from external sources involves *market* transactions (such as the purchase of intellectual property rights, the hiring of technical and management experts, and acquiring a stake in another company) and *non-market* transactions (occurring through informal interaction at conferences and the information gleaned from reverse engineering). Somewhere between the two lie informal but important exchanges of technological knowledge between engineers and researchers working on similar problems in different firms (von Hippel 1987).

The sources from which firms acquire external technology are:

- universities,
- government research agencies, and
- other firms,

each of which may be located either in Australia or abroad.

Universities and government research agencies

Universities and public research agencies conventionally disseminate much of their research in the form of information which can be acquired by firms at low cost through standard devices such as journals and seminars. Such research often has its justification in producing results that can be shared among all potential users, and these forms of dissemination are often appropriate in those cases.

However, research in public institutions can also have more firm-specific applications. It is desirable that mechanisms are created for firms to tap in to research capabilities where research projects are undertaken in institutions which have, or could have, spin-off benefits for firms. For example, the Australian Pharmaceutical Manufacturers Association said:

> Strategic alliances between the commercial partners in the pharmaceutical companies and research institutions associated with universities, teaching hospitals and organisations such as CSIRO, provides the pattern for collaborative public sector/private sector R&D directed towards commercialisation of research outcomes (Sub. 131, p. 4).

In relation to the Cooperative Research Centres (CRCs) scheme, the Nucleus Group said:

> Breakthrough technological advances are likely to arise through the CRC scheme. Nucleus companies are involved as commercial partners in three CRCs. Networking with research bodies in Australia will be essential for future strategic development (Sub. 93, p. 7).

Firms also look at secondments to and from institutions to achieve the transfer of person-embodied information. For example, Biotech Australia encourages the secondment of staff from the universities and government research organisations into its industrial R&D laboratories, while measures taken by the Electric Supply Industry (ESI) include:

> ... sponsorship of university professionals and academic staff positions, sponsoring of scholarships and the joint development with universities of R&D programs and facilities (Sub. 120, p. 13).

However, the AIRG noted that universities and CSIRO sometimes lack an appreciation of the market approach to technology and at the Commission’s roundtable on business R&D some participants observed that time horizons in public institutions were longer than business finds acceptable. At inquiry hearings, Dr Clive Summerfield said:

> They’re not exposed to the commercial realities. They have their projects, they have their agendas in place, and we come along with requests and we don’t get much opportunity to do business with them (transcript, p. 1078).

Between 1989–90 and 1991–92, collaborative research by business with higher education institutions and government research agencies both fell by almost a half — but in each case there appears to be an upward trend in *contracted* research (Chapman and Shaw 1993).

Collaboration with other firms

Firms can sometimes have common interests in research, the results of which they can share though joint projects. Two situations in which this can occur are:

- among firms in the same industry, which share generic research on which they can independently build; and
- between suppliers and purchasers, who have a common interest in producing a better quality input to the purchaser for joint gain.

In Australia, some collaborative research is undertaken through brokerage mechanisms such as industry associations (see part D) and rural R&D corporations (see part E). The Australian Mineral Industries Research Association (AMIRA) manages more than 80 collaborative contracts worth about $35 million (transcript, p. 572). AMIRA believes collaborative work makes up something less than 10 per cent of the total R&D spending of the industry. The Association said:

> In some cases companies can gain benefit from sharing inputs and outcomes of research and tackle problems collaboratively. The industry set up AMIRA specifically to manage this collaborative work and much of it is contracted into the publicly funded R&D infrastructure such as universities and CSIRO (Sub. 32, p. 1).

The effect of collaboration is to share risk and return. This can be particularly important for small firms (MTIA, Sub. 133, p. 10). Uniquest (Sub. 94), similarly indicated that one of the options available to firms which have developed a new product or process and who wish to market the research results, is to enter joint ventures with organisations having a common interest in developing the technology. The Nucleus Group said:

> Collaborative research has also been a major factor in the company’s success ... Pacific Dunlop’s involvement has been critical in funding defibrillator technology and developments in cardiomyoplasty (Sub. 93, p. 7).

A survey by DITAC (1990) reveals that for Australian firms (in communication, software and services, and computer hardware), more than 70 per cent of all alliances were concerned with marketing.

Acquiring technology from overseas

Reflecting on the potential for drawing on new technology developed abroad, the MTIA noted that:

> ... since the development of new or improved technology is not confined to any one country, it follows that the economic progress of all nations is influenced by the processes by which technological changes are diffused, imitated and adapted. In other words, the economic growth of all nations is inextricably linked to the successful international transfer of technology (Sub. 133, p. 19).

Use of foreign technology is common throughout the world. EPAC observed:

> Japanese firms regard global scanning for technological insights as an integral part of their business strategies. This includes sending researchers, engineers, and technicians to international conferences and trade shows or to visit their global competitors; systematically scanning their scientific journals and newspapers published in other countries ... Japanese government agencies also gather technological information from around the world and make it available to industry (1991, p. 25).

A similar approach is taken by the Koreans. The Samsung Advanced Institute of Technology is the Samsung group’s R&D centre, which has as one of its objectives to search for useable ideas in the rest of the world. Mechanisms it employs include literature and patent searches and seeking feedback from foreign affiliates. Foreign researchers are also encouraged to work at the Institute on 3–5 year contracts.

In both Korea and Taiwan, the Commission heard that many students go to the United States, subsequently reaching senior level positions within American firms (for example, in Silicon Valley) before returning home. This provides them with information about foreign technology and, perhaps more importantly, knowledge of how technology may be successfully exploited. In Taiwan, it is apparently not unusual for those who return to set up new businesses in competition with their former employers.

The BIE (1988) identified the proportion of technology acquired from overseas in three industry case studies (agricultural and veterinary chemicals, telecommunications and related equipment, and medical scientific equipment). Its findings suggest that the extent of Australia’s reliance on overseas technology has been somewhat overstated, although imported technology was found to be significant in each of the industries considered.

When firms gain access to imported technology, restrictions are often applied. In the BIE study, overseas technology suppliers generally stated that they would be reluctant to transfer technology, particularly their latest technology, to other countries unless they could nominate the territories in which resultant products could be sold. Participants expressed concerns about these restrictions. The MTIA said:

> Quite often R&D must be local if the product is to be exported. If a design is to be purchased overseas for manufacture of the product in Australia, the territory in which product can be exported is restricted, almost invariably to Australia (Sub. 133, p. 10).

AMRAD Corporation Ltd said that:

> ... if R&D is not progressed by indigenous firms there will be severe restrictions on the use to which the internationally acquired R&D can be applied. These restrictions would include territories and fields of endeavour (Sub. 43, p. 5).

The internal/external balance

Broadly speaking, the balance between internally and externally sourcing technology will reflect:

- the firm's existing level and composition of technological skill and capability relative to what is available externally; and
- the costs of searching for and negotiating to obtain new technology generated externally.

Firms are most likely to outsource R&D, where their existing skills are most limited and where it is relatively cheap and easy to find and negotiate with an external contractor. They are at least likely to do so where they already have an established research and technological competence and where search and negotiation costs are expected to be high.

A number of participants underlined the importance of in-house research:

> Access to such facilities [in-house R&D capabilities] provides closer contact with operations together with a higher level of security and development of the necessary expertise to better manage external programs (CRA, Sub. 44, p. 11).

> New technology is done in-house if it is perceived to relate to the core competence of the organisation (Leeds and Northrup, Sub. 167, p. 3).

Innovating firms are creative, learning organisations. They learn about the need to change from the users of their products, their own experience of production, the activities of their rivals and their exposure to externally generated technological opportunity. They respond by incremental adaptation and informal experimentation, internally generated formal R&D and interaction with external institutions. Firms' decisions are driven by perceived costs and benefits (including transaction costs) when they can be identified. But given the uncertain nature of R&D outcomes, largely qualitative judgments are often made.

A4.4 How valuable is R&D to firms?

The benefits for an individual firm from making investments in R&D are best judged by the firm itself. But studies of the returns earned by firms from investing in R&D have been widely used to attempt to gain information about the value of different types of R&D. For example, studies of returns to R&D can, in principle, reveal the value of:

- transfers of knowledge among firms in the same industry;
- transfers of knowledge among firms in different industries;
- public sector research; and
- access to foreign R&D.

A key question is the extent of knowledge transmission that occurs without full payment to the originator, indicating the presence of knowledge spillovers.

As part of this inquiry the Commission undertook an extensive survey of the empirical work undertaken on a large number of countries relating to the returns from R&D (appendix QA). These studies fall into two broad categories: those using econometric (statistical) methods and those using case studies.

Econometric methods relate outputs of firms to inputs (usually labour, capital and R&D) and separately identify the contribution of R&D. Case studies track the benefits of particular R&D investments and calculate the internal rate of return to the investment.

Econometric studies have the advantage over case studies of being non-selective in their examination — they analyse all expenditure in a firm or industry on R&D rather than particular technologies or innovations.

Case studies seek and quantify each of the sources of benefit and, as a result, are in some ways better suited to identifying uncompensated spillovers. For example, they can measure explicitly the benefits to consumers from price reductions.

Econometric studies

These studies use two main methods to identify the contributions to output made by firms' own R&D and by R&D from elsewhere.

One method is statistical — by including as explanatory variables data on R&D in the firm or industry under consideration, together with data on R&D from other firms, industries or countries, the independent contributions of R&D from 'inside' and 'outside' the firm or industry under consideration can be identified. For example, the R&D of individual pharmaceutical firms might be compared with the total returns to R&D in the pharmaceutical industry. In this way it can be possible to identify any additional returns at the industry level that might arise from knowledge spillovers among firms.

A great number of these studies have now been completed (see appendix QA). It is hard to draw definitive conclusions from such a diverse range of studies, but in broad terms:

- Estimates of returns to individual firms undertaking R&D vary considerably, but are broadly in the range of 15 to 50 per cent (appendix QA). These are relatively high returns. They are of the order of 1.2 to 4 times the return to physical capital in studies which allow such a comparison to be made.
- At the industry level, the rate of return appears to be little different from that at the firm level, with most in the range of 10 to 50 per cent (appendix QA). This is true both for studies which consider such transfers directly, by including other firms' R&D in production relationships, and from a simple comparison of returns to individual firms in a given industry with returns to the industry as a whole. This appears to imply that knowledge transfer between firms in the same industry are relatively small.
- Knowledge transfers among industries appear to be identifiable in some studies which indicate that the rate of return in other industries to R&D carried out in a particular industry may be around 75 per cent (appendix QA), and about 20 to 100 per cent of the within-industry rates of return to that R&D (appendix QA).

Econometric tests of publicly financed research are less common. However, studies reported in table QA9 appear to show that for research undertaken with public funds (that is, not necessarily performed only in the public sector) returns are significantly lower than privately funded R&D.

The returns to overseas research are considered later in this chapter.

There are a number of methodological and statistical reservations that need to be made about this type of work, in addition to the usual reservations in econometric work about possible misspecification of the true relationship and data quality. These are explained in detail in appendix QA, but include:

- measurement of the amount of R&D 'used' in production is problematic (should it be expenditure on R&D or the stock, and if it is the stock, at what rate does it depreciate?);
- benefits from R&D tend to be spread over many years and this process is difficult to capture in models;
- there are factors such as trade and other liberalisation which can affect productivity over time which are not usually included in the measurement but may be related to R&D and so bias the results; and

- R&D in one industry may be wrongly attributed to another if improvements in input quality are not fully reflected in statistics that measure input quantities or prices.

It is also necessary to be careful in interpreting the results that are produced from this work. One possible cause of misinterpretation is to assume that indications of returns being influenced by R&D outside the firm or industry are simply fortuitous spillovers. In some cases, for example, such relationships are a consequence of explicit contracting of research by firms in one industry from firms in other industries. In other cases, as Geroski (1994) stresses, such relationships can be a consequence of implicit contracts between firms such as those between purchasers of inputs and their suppliers. In these cases firms undertake research at the behest of the purchasers and in the expectation of rewards in the form of continuing contracts or better prices for their products. In addition, insufficient account is taken of the complementary costs incurred in converting R&D into a commercial innovation.

Notwithstanding these reservations, however, the evidence does appear consistent with the view that knowledge transfers occur (probably without explicit or implicit contracts) and are significant, especially among firms in different industries.

Case studies

Case studies focus on particular innovations that arise from the R&D process and identify the benefits and costs for firms and society that flow from them. The general procedure is to estimate private returns from a technology and then estimate additional benefits to those outside the originating firm or organisation. These include benefits to other firms and consumers.

Broadly, the results of such studies confirm the econometric work. Returns to firms are high, as are returns to society more generally (appendix QA).

There is significant element of Australian work in this tradition. It has been historically concentrated in agriculture, but has more recently included studies in manufacturing. The technique has been used especially to examine returns to public R&D such as that performed by the CSIRO. Results have so far broadly supported the viability of the research projects which have been measured.

Like the econometric work, these studies also have methodological drawbacks. They cannot, for example, in their nature capture all of the returns to R&D because some channels will be too difficult to identify. The BIE noted that:

> Unfortunately the practical impediments to rigorous measurement of R&D are very severe, especially problems of corporate memory and confidentiality, and inherent

> difficulties in tracking knowledge flows between firms to link R&D causes with economic effects (1994b, p. 12–13).

In that sense they will tend to underestimate benefits. However, they will also overestimate benefits to the extent that innovations themselves build on uncompensated transfers of knowledge.

More fundamentally, these approaches can suffer from what can be generally called ‘selection bias’. They are said to concentrate largely on innovations that have been successful — both because of pressure from organisations which have produced the innovation to appear successful, and because successful R&D makes for more interesting publications by the evaluators.

Like the econometric work, however, they generally point in the direction of high returns to R&D. In the work which concentrates on public sector projects, they confirm that many projects that are undertaken do appear to produce genuine and valuable uncompensated spillovers.

A4.5 Technological competition, industry-wide R&D and innovation

An important strand of the analysis of innovation claims that there is a causal relationship between the degree of competition in an industry and R&D. Industries with undifferentiated products, low barriers to entry and no scale economies in production are said to be unlikely to do much R&D because competition will erode the profits they need to finance it. On the other hand, monopoly industries protected by regulation or technological advantage from the threat of having to contest their market are more likely to have the profits to fund R&D — but many innovate little, given the costs of doing so which include the potential for displacing existing product lines which remain profitable. Various forms of oligopoly have thus been regarded as the most likely forms of market structure to promote innovation.

Recent advances in the theory of industrial organisation suggest, however, that this view is simplistic and static. At the heart of modern thinking is the recognition that the market structures within which firms compete and the amount of innovation which they carry out are jointly determined by more fundamental factors — importantly technological opportunity, appropriability conditions, the nature of market demand and market size. Governments may influence any of these.

Technological opportunity is sometimes taken to be related to the ‘closeness’ of industry to rapidly expanding areas of scientific knowledge. It is also sometimes defined as the responsiveness of production costs to additional R&D (Dasgupta and Stiglitz 1980) or, put more crudely, as 'bang for the R&D buck'. It makes good sense that research intensity should be positively related to it.

The importance of technological opportunity in capturing inter-industry differences in R&D intensity ratios has reappeared in a wide range of empirical analyses. In a leading text on industrial economics the authors, Hay and Morris, conclude an exhaustive review of the empirical literature with the comment:

> If the 'technological opportunity' variable (is a) reasonable proxy for the underlying R&D technology, then (it) should be sufficient to explain R&D intensity without recourse to market structure or firm size variables (1991, p. 489).

If spillovers are introduced, another dimension of complexity is introduced with influences in a number of directions. On the one hand spillovers enhance technological opportunity: an extra $1 spent on R&D in any firm in the industry gives rise to knowledge which can be used by all its rivals to cut their costs by more than would otherwise have possible. Since 'bang for the R&D buck' is now larger than in the absence of spillovers, R&D intensity should be increased. On the other hand, spillovers create a disincentive: the more a firm believes its rivals will capture of the benefits of the R&D it undertakes, the less it will be induced to undertake the R&D in the first place. This effect, as noted earlier, may be offset by firms undertaking R&D in order to absorb spillovers.

The evidence

Empirically, the influence of spillover effects on the R & D intensity within and across industries has yet to be clearly verified. A Commission survey of the evidence reveals that further research is required to establish whether intra- or inter-industry spillovers are more significant. Another major survey by authorities in the area concludes that empirical findings (up to 1989) do not establish whether the net effect of appropriability on R&D incentives is positive or negative, nor how the balance of effects varies across industries (Cohen and Levin 1989, p. 1094).

Levin (1988) observes that spillovers seem to be large in US industries producing computers, communication equipment, electronic components and aircraft — industries which are also among the country's largest R&D spenders. Geroski generates similar findings for engineering and chemicals in the United Kingdom when examining sectoral sources of major innovations. He comments:

> One obvious explanation of this puzzle is that high R&D spending occurs in these sectors despite spillovers because rich technological opportunities make the productivity of R&D high in these sectors (1994, p. 22).

Alternative explanations might be that a firm's own and its rivals' R&D are complementary; and that R&D intensive industries may do so much R&D in order to absorb spillovers.

'Evolutionary' theories

Evolutionary economics (see box A4.1) allows for uncertainty in analysing innovation and takes as a foundation stone diversity among firms. It is also centrally concerned with the process of competition itself. Inter-firm diversity springs naturally from analysis of how and why firms innovate. They innovate in order to create a competitive advantage for themselves — by definition not shared by other firms — and they build on any initial advantage they achieve through learning-by-doing in a way simply inaccessible to firms which are not actually using that type of technology.

In a nutshell, evolutionary economics argues that performance-enhancing competition *requires* diversity, but diversity can be maintained only if innovation is occurring. As Metcalfe puts it:

> ... competition consumes its own fuel; it eliminates variety and if it is to be sustained that variety must be regenerated (1994, p. 939).

From an evolutionary perspective a clearly defined role for policy is thus to contribute to regenerating enough technological diversity within industries to maintain economic growth and development (see chapter A5).

When firms use technology to compete, the fierceness of the competition reflects existing inter-firm diversity, and the generation of variety across the industry drives competition. Industry structure and research intensity are interconnected. An important explanation of inter-industry differences in research intensity is variation in technological opportunity.

A4.6 Implications for business R&D performance

Technological competition of the kind briefly sketched in the last section is competition among firms. Analysis referred to there can be used to explain Australia's recent history of BERD. This in itself is of interest, but because R&D has been shown to have an impact on economic performance, and in particular growth, it also has wider implications.

The recent Australian history of BERD can be characterised by three features:

- the ranking of R&D to sales ratios by industry is much the same in Australia as in most industrialised countries;

- almost without exception, industry-level BERD intensities in Australia are below those found internationally, and
- almost without exception, R&D intensities have risen over the last 10–15 years.

Box A4.1: **Evolutionary economics**

Evolutionary economics is the name given to the analysis of processes which bring about developmental changes in economic structure. Analysis focuses on the generation of novelty and variety through technological innovation and selection processes which determine which products and processes will come to dominate. The father of evolutionary economics is in many ways Schumpeter (1934) but Nelson and Winter (1982) have played the major role in pioneering modern analysis from this perspective. Evolutionary economists emphasise the importance of variety in understanding the drivers of system-wide change, and the potential for technological change to be trapped on paths which may not (with the benefit of hindsight) have been the best available. These and related issues are discussed in a paper prepared for this inquiry by Tisdell (1994).

Some of the main insights from evolutionary economics are as follows:

- inter-firm diversity (or variety, or asymmetry) is central to *initiating* the dynamic process of technological competition. In its absence, each firm would see the potential gains from moving by itself but would recognise that if all firms moved together, none could individually profit. None would therefore move at all unless at least one of them believed itself superior to the rest. The trigger for one to move first is the prospect of profit from innovation based on an asymmetric advantage (Dasgupta 1988; Silverberg, Dosi, Orsenigo 1988).
- inter-firm diversity is central to *maintaining* the process of technological competition. The greater the range of performance is among firms, the more the survival of laggards is threatened and the greater are the opportunities for them to profit by playing catch-up. Competition is thus driven by diversity.
- catching-up is a time-consuming and costly business — because technological knowledge is highly specific to particular lines of production, has significant tacit elements and calls for the accumulation of considerable experience before it is mastered.
- the process of technological competition results in lower industry average costs and/or higher industry-average product quality as uncompetitive firms are eliminated or imitate industry leaders well enough to be able to approximate their performance.
- industry-average performance will improve only until all firms have caught up with the industry leaders. For industry-average performance itself to improve in the long run, at least one firm in the industry must be innovating successfully, at any one time.
- only when continuous innovation is combined with imitation and selection (ie weeding out the least competitive) is it possible to explain familiar long-run patterns of differential inter-firm performance observed in practice (Iwai 1984). Innovation thus generates variety.

According to recent theory, BERD intensities are likely to reflect technological opportunity. Technological opportunity derives from scientific advances bred outside industry and cumulative innovating experience built up by firms within industry. Scientific knowledge tends to be widely disseminated internationally and there is good evidence that Australia is active in the processes and networks through which scientific knowledge is diffused (see chapter A2). To the extent that science creates technological opportunity to differing degrees across industries it should be expected that the ranking of BERD intensities across industries in Australia would therefore largely mimic rankings found elsewhere. This accounts for the first observation.

Given that access to the results of scientific research is at least equivalent to that found internationally, factors specific to the innovating competence, capability and experience of Australian firms look as though they must be important in explaining the observation that BERD intensities here usually lie below those overseas. The same factors should also be relevant to explaining the surge in BERD over the last decade and a half (chapter A3).

In this connection it is crucial to emphasise the *cumulative* nature of technological knowledge: understanding about how to generate and use new production methods has substantial tacit elements and can be only acquired through actual experience of innovation. In other words, learning about new technology and technological innovation requires time.

Innovation, because of its inherent technological and market uncertainties, need not always be successful. It will only occur in the first place if firms have either a strong incentive to undertake it or are under threat of extinction if they fail to do so.

The Australian market for locally produced goods is small and was, until the 1980s, heavily protected. This environment encouraged the emergence of protected monopolies and collusive oligopolies in many parts of manufacturing industry. Inter-firm diversity within industries was therefore limited, undermining the scope for competitive pressure, and the threat from external competition was stifled. There was little inter-firm variety to drive competition, and limited competition to drive innovation. Monopoly profits which could have been used to innovate were, in the absence of competition, used for other purposes. Moreover, Australia’s structure of production was skewed towards technologically ‘simple’ production and, in addition, many local producers were subsidiaries of international companies which performed most of their R&D in the United Kingdom or United States. And, while CSIRO played a dominant role in generating the scientific basis for technological opportunity, local producers were under little pressure and faced few incentives to grow their own innovating skills.

It can be argued that during this period Australian firms simply failed to develop the skills of innovating which less protected, more open and sometimes larger countries abroad were forced to build up. They also made relatively poor use of existing technology.

Since the early 1980s there have been substantial changes. The Business Council of Australia, in a study of 70 businesses said:

> Common to many enterprises was the imperative to respond to the challenges of an economy opening to the world. Opening the Australian economy by floating the exchange rate ..., substantially lowering the levels of industry protection and deregulating a number of service industries created a new environment of more immediate opportunities and threats. These changes in the business environment will remain drivers of change for at least the 1990s; consequently innovation will be an essential response for many ... businesses (1993, pp. 63–4).

The internationally low BERD intensity ratios across the board shown in figure A4.1 in all probability reflect a widespread perception, well founded in the past, that poor innovating skills imply lower potential ‘bang for the R&D buck’ in Australia than elsewhere. But this is now changing.

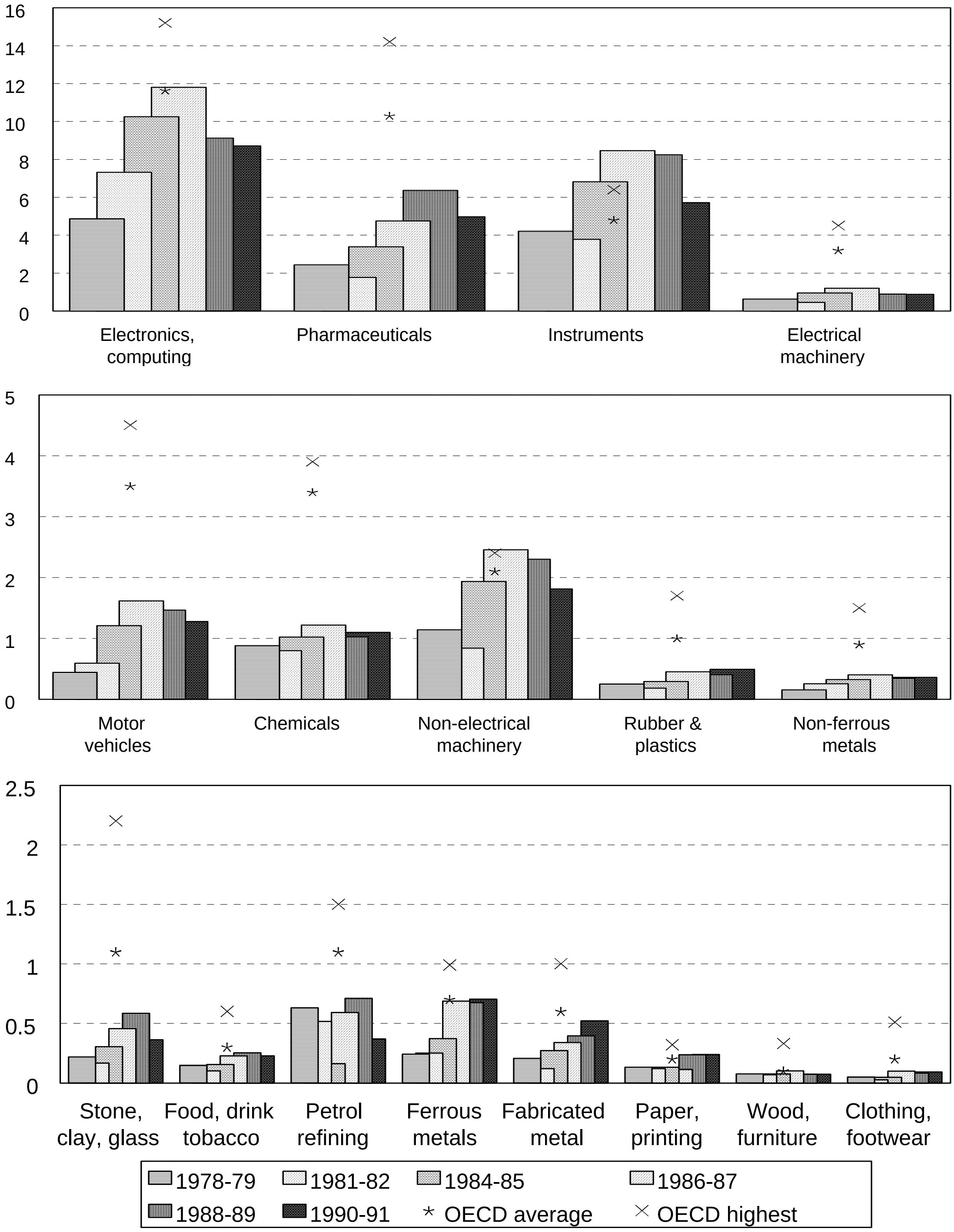
The effect of opening the Australian economy has been to propel Australian firms into competition with a much greater diversity of firms — to move them into global industries. As the Business Council quotation makes clear, this presents both opportunities and threats. Opportunities for firm growth and profit arise from successfully playing catch-up in a global environment. For consumers there is the promise of enhanced benefits from lower prices and better products. Threats relate to the prospects for firms which fail to respond effectively to the new environment.

The rising BERD-intensity ratios are in part a response to the new conditions. While the increase has occurred at the same time as the introduction of the 150 per cent tax concession, the BIE found this induced only 10–17 per cent more R&D than would otherwise have taken place. It seems at least as likely that as increased competition has driven the search for new and better products and processes, it has also facilitated learning about innovation, which in turn has made investment in R&D look more attractive. As noted above, it should not be a surprise that this process is a gradual one — but the fact that the upward trend has survived a long recession suggests that it is becoming deeply rooted.

Opening the economy has contributed to increasing its innovative effort and, as a result, its dynamic efficiency — though much remains to be achieved. It is also encouraging more effective firm-level use of existing technology: a point stressed by the BCA.

Any potentially negative effects for innovation of eroding monopoly profits are therefore being swamped by the positive inducement effects of competition. Increased openness is also diverting resources from low to higher-productivity uses as the economy restructures to specialise more in its areas of international comparative advantage.

Figure A4.1: **R&D intensity in Australian manufacturing**[a,b]



a R&D intensity refers to the ratio of R&D to the value of production (or turnover) in each industry.
b The Commission has adjusted the figures for petrol refining.
Source: DIST 1994a.

All of this is reflected in increasing international competitiveness, visible as the increasing proportion of GDP now accounted for by trade and in the rise in manufactured and service sector exports. The Commission believes increased innovative activity is a response to the opening of the Australian economy, but successful innovation is also contributing to increasing Australia's participation in international trade. This in turn will enable the economy to draw more extensively on equipment-embodied technological advance in future as its imports of capital and material inputs continue to rise.

This chapter has shown how complex the links are between technological innovation, and firm and industry performance. Much of this complexity is usually ignored at the aggregate level in the interests of obtaining insights into the more general implications of innovation for growth.

A4.7 R&D and economic growth

'Old' growth theory

What have conventionally been known as growth theories essentially arose from economists' concerns to describe how the accumulation of physical capital could improve living standards in the presence of population growth.

The conclusions were in one sense pessimistic. They suggested that while increases in per capita output could initially be achieved by savings and investment, the rate of growth in per capita output must eventually decline, and output per head reach a plateau. In the end investment would gradually take place in less and less productive opportunities and an economy would reach a point at which per capita increases in output were no longer possible.

It is important to realise that, while constituting, in their own way, important advances, these models were being developed in response to particular problems. They did not represent the sum total of economic thinking on growth and technology questions. As Dowrick (1994) points out, mid twentieth century economists such as Schumpeter and Kaldor also theorised in a quite different way about the importance of innovation, knowledge, increasing returns to scale, learning etc. Even nineteenth century classical economists such as Ricardo and Marx emphasised the role of capital accumulation in growth.

Nevertheless, 'old' growth theory models had implications which were widely accepted. In particular they implied that less developed countries, through investment, would eventually catch up to the more advanced countries as growth in the advanced countries slowed down.

In these models (such as those in the Swan-Solow tradition) technological change happened quite independent of the growth process. The Victorian Government described the process in the following way:

> An economy could sustain long-run per capita growth in the Swan-Solow model only if it was continually subject to beneficial shocks to its technology. Such shocks could involve workers learning to be more productive in their work, or in the discovery and introduction of improved products or production processes. For most of the 1950s and 1960s growth was thus an exogenous phenomenon in the Swan-Solow model: it was determined outside the model as technological manna from heaven (Sub. 241, p. 5).

This was a rather unsatisfactory approach, if technological change is, as economists in other branches of the discipline such as Schumpeter had stressed, one of the fundamental drivers of growth.

'New' growth theory

The so-called 'new' or 'endogenous' growth theories attempt to grapple with these unsatisfactory outcomes by capturing in formal models a range of other factors that influence growth, while at the same time encompassing the capital accumulation considerations that so concerned early theorists.

The new growth theories have a number of branches, not all of which are concerned with R&D itself (for example, some focus on capital goods investment and investment in public infrastructure). However, an emphasis on the role of R&D and knowledge in influencing growth is a central theme. The essence of this approach is to recognise that technological innovation is a process that responds to economic incentives such as the rate of the return. Growth is thus endogenous because it can be influenced by the incentives that exist to undertake R&D and, unlike in earlier theories, technological change is not outside the processes being modelled. RIRDC summarised the approach as follows:

> Instead of assuming that knowledge and technological progress just happens, in modern explanations of growth — known as the *new growth theories* (Romer 1990; World Bank 1991) — knowledge is another factor of production which like capital has to be built and paid for by forgoing current consumption. In this construction economies have to invest in knowledge on the same way as they invest in machines (Sub. 124, attachment 1, p. 6).

The point is made frequently that such theories are in some ways simply formalising what was always obvious to practical and policy-oriented analysts. While this is in one sense true, in another sense the change of perspective has brought about a general change in attitudes to growth processes. For what these theories clearly imply is that countries can, by employing appropriate policies towards R&D, maintain a growth path that remains above countries which employ inappropriate policies. In other words, a country which has a low level of output per head may not just catch up with more advanced countries, it may, with the right policies, overtake them. Alternatively, with the wrong policies, some countries may never catch up, despite the accumulation of capital.

At the heart of new growth theory is the idea of the production of new knowledge which can be used repeatedly in different applications. It thus concentrates on the knowledge transfers which are of benefit to other firms through non-market transactions. Many firms and industries can use the knowledge simultaneously, and the more it is used, the greater the economic growth resulting from it.

In his survey of R&D and the new growth theory, commissioned as part of this inquiry, Dowrick (1994) identifies two different channels through which R&D interactions influence long-term growth.

The first channel he calls *R&D feedback*. Dowrick puts it thus:

> Crucially, the larger the stock of knowledge, the easier it is to increase it. Better educated and more knowledgeable people learn faster and develop new ideas more easily. The underlying idea is appealing, that existing knowledge and understanding, combined with further education and research, generate further knowledge. This is an example of a feedback effect (1994, p. 9).

The second channel is *R&D spillovers*, which involves the notion of transfers of knowledge among firms for which no payment is made. These models are most closely associated with Romer who:

> ... emphasises the non-rival nature of disembodied knowledge as a primary source of growth. He uses the metaphor of knowledge as a blueprint for the production of goods. Once a design or a blueprint has been created it can be used repeatedly at no extra cost (1994, p. 13).

Both mechanisms provide a means by which the limits on growth otherwise imposed (in the 'old' models) by decreasing opportunities for valuable investment may be pushed back. Multiple opportunities for the use of knowledge give opportunities for sustained increases in living standards.

As a result of the existence of these effects, there is no guarantee that such knowledge will be produced in appropriate quantities if incentives to undertake R&D are left unaltered. Individual producers are unlikely to take into account the benefits for others when making decisions about how much research to undertake. The question of ways in which this problem might be overcome is considered in greater detail in the next chapter.

R&D and growth in a small open economy

Knowledge spillovers are not necessarily confined within the borders of a country. In the growth models of Grossman and Helpman (1991) a key determinant of patterns of growth is the extent to which skills and knowledge spill over national boundaries.

The Grossman and Helpman model assumes the extent of spillovers between any two countries increases with the volume of bilateral trade. This is because:

- a higher volume of international trade increases the number of contacts between domestic and foreign individuals and improves the exchange of information;
- imports may embody differentiated intermediate products which are not made in the local economy; and
- when goods are exported, foreign purchasing agents may suggest ways to improve the manufacturing process.

They state:

> Policies that serve to expand the level of trade (i.e., an import subsidy or an export subsidy) promote contacts between local and foreign residents. Policies that contract trade, such as tariffs and export taxes, reduce the number of contacts. The former type of policy accelerates the rate of knowledge accumulation and growth, while the latter type retards learning and growth (Grossman and Helpman 1991, p. 8).

The rate of growth of output will be higher in a skill-intensive country which specialises in innovative products. However, a crucial point in the Grossman and Helpman analysis is that ‘high tech’ countries will not necessarily be better off than labour- or resource-intensive countries. In the long run, their model predicts similar rates of growth of real consumption for all countries.

The point made here is that with free trade in goods and free transmission of knowledge, it makes no difference to consumers whether they live in a labour-intensive or a skill-intensive country. They will enjoy the benefits of innovation in either case. A faster rate of growth of output in the skill-intensive country is offset by deteriorating terms of trade. High technology goods become relatively cheaper in direct proportion to the faster rate of innovation (Dowrick 1994).

Dowrick considers that these conclusions change if knowledge is not transmitted freely across national boundaries. If knowledge is a *national* public good, rather than an international public good, the more technologically advanced nations will have a comparative advantage in the production of further knowledge. Hence they will tend to extend their technological lead and their share of world production of the innovative products.

Nevertheless, even in such a situation gaining a technological lead will not necessarily make a country better off. International trade in assets and goods may still allow the residents of the country which specialises in the production of labour-intensive goods to invest their savings in foreign assets and to import the new and cheaper innovative products.

This has implications for suggestions that countries can benefit by ‘creating’ comparative advantage through fostering development of high-technology goods. Dowrick summarises:

> The point of the Grossman and Helpman analysis is that if private incentives for accumulation of human and knowledge capital reflect social costs and benefits, then although it may be possible to accumulate output growth by intervening to change the pattern of dynamic comparative advantage, doing so will reduce welfare (1994, p. 19).

Empirical evidence of the impact of R&D on growth

The contribution that R&D makes to national GDP can be measured using econometric techniques very similar to those used at the firm and industry level. These approaches consider the contribution of R&D (together with other factors of production such as capital and labour), to either growth in gross output (normally measured as GDP) or growth in productivity (often measured as Multi Factor Productivity — MFP). Reservations noted in the earlier discussion about methodology, data and interpretation also apply to these measurements.

Productivity growth provides a key link between R&D and output growth. The Commission’s work on Australian market sector growth between 1975–76 and 1992–93 suggests that multi-factor productivity accounted for about 40 per cent of all expansion in that part of the economy.[1] The relative sizes of the contributions of labour, capital and multi-factor productivity growth are shown in figure A4.2.

The relationships are based on past average growth trends. They do not necessarily indicate how expenditure on additional R&D would effect economic growth. Indeed, under the estimation methodologies adopted, an efficiency improvement in the delivery of R&D would lead to higher returns to R&D as fewer resources are used in innovation per unit of growth.

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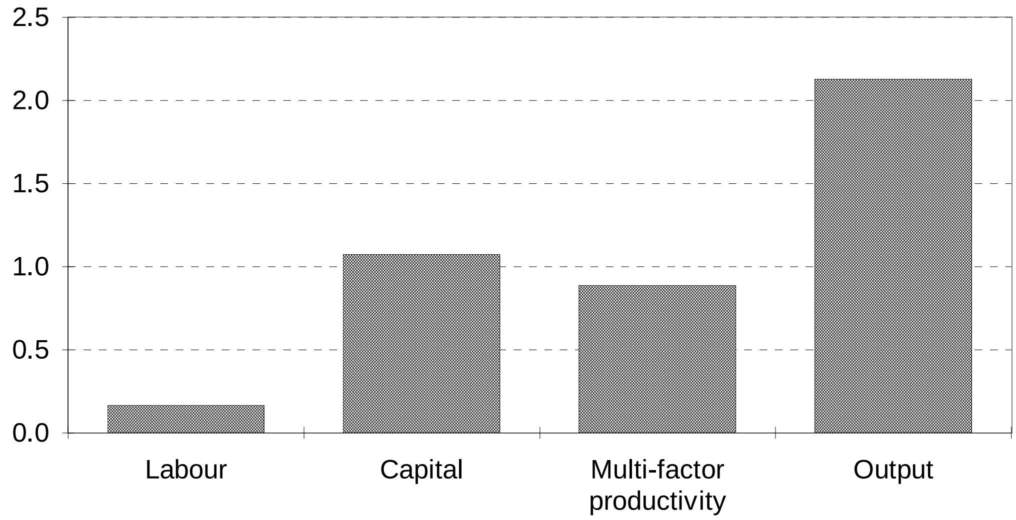
[1] The market sector comprises the agricultural, mining, manufacturing, utilities, and transport and distribution industries. These industries combined, contributed a little over half of all measured output growth in that period. Data inadequacies prevent analysis of the sources of growth in the non-market sector. The non-market sector includes finance property and business services, public administration and defence, community services and ownership of dwellings (appendix QB, table QB.1).

Overseas studies

One group of studies attempts to measure the contribution of R&D to economic growth across a range of countries. By comparing productivity growth directly with R&D stocks it is possible to derive a measure of the social returns to R&D.

The evidence that is available suggests that at the national level, measured returns to R&D are high. This is consistent with an hypothesis of the existence of spillovers under which returns to the nation exceed the returns earned by individual investors. For example, Coe and Helpman (1993) estimate returns at over 100 per cent for larger (G7) countries and 90 per cent for smaller (15 non-G7) countries (see appendix QA, table QA6).

Figure A4.2: **Average annual contribution of labour, capital, and multi-factor productivity to market sector output growth, 1975–76 to 1992–93** (per cent)



Source: Commission estimates based on ABS data.

The returns take account of the total capital stock of R&D knowledge employed in a country and the responsiveness of productivity to changes in that capital stock. In their study, Coe and Helpman found that a one per cent increase in R&D would provide a 0.23 per cent increase in MFP for the G7 countries and 0.08 per cent increase for non-G7 countries. Patel and Soete (1988) have also estimated these elasticities for a range of countries and obtained somewhat higher estimates: the United Kingdom (0.82), United States (0.61) and Canada (0.26) (see appendix QA, table QA.7). While such differences may indicate differences in methodology and data problems, they can also reflect a myriad of economic differences. For example, the responsiveness of productivity to domestic R&D may vary with the extent with the benefits a country obtains from international spillovers, the level of international trade exposure of a country, improvements in education and training and capacity utilisation.

In their analysis Coe and Helpman (1993) provide information on the likely extent of international knowledge transfers. They found evidence that the stock of knowledge in one country, approximated by cumulative R&D expenditures, raises productivity in foreign countries as well as in the home country. For the large G7 economies, the return from international spillovers is approximately one-quarter of the domestic return.

A further interesting result was that spillover benefits are larger for countries with a relatively high ratio of trade to GDP. However, Dowrick said:

> Since trade shares are strongly correlated (inversely) with population, it is not clear whether it is really trade which enhances technology transfer or whether it simply reflects the fact that a country with a small population and a small domestic R&D stock will rely disproportionately on spillover from the international stock of knowledge (1994, p. 26).

There appears general support for the existence of substantial international transfers of knowledge. The mechanisms for the transfer may differ between countries, nevertheless.

Australia

Studies for Australia are rare. In recognition of this the Commission, conducted its own investigation of the relationship between R&D, productivity and growth.

A first approximation to estimating possible returns to R&D can be obtained by comparing annual rates of productivity growth with the annual investment in research and development. Over the period 1974–75 to 1992–93, total factor productivity made an average annual contribution to growth of around 0.9 per cent, while the average ratio of R&D to GDP was 1.2 per cent. The social rate of return to R&D spending in Australia using this methodology is therefore approximately 50 per cent (see appendix QB).

This simple measure does not take account of other factors which could influence productivity growth, including education and training, learning by doing, the possibility of spillovers from international R&D efforts — all of which would tend to lower estimated returns to domestic R&D. It is also based on the (very conservative) assumption that productivity growth in the non-market sector is zero. The Commission found that the rate of return to domestic R&D varies around the average from a conservative 25 per cent (by taking into account the effects of education and time on productivity growth) up to

90 per cent (by assuming productivity growth in the non-market sector to be the same as in the market sector).

The direct approach adopted to obtain these initial measures of productivity growth and the returns to R&D depend on an estimate of the residual growth of output not accounted for by growth in labour and capital inputs. The growth accounting model employed also makes a number of restrictive assumptions about the relation between labour and capital inputs, and output over time. The Commission has attempted to relax some of these assumptions and in doing so obtained rates of return as high as 150 per cent. However, since the Commission's draft report was released a new study has been published suggesting that such an estimate may be biased upwards (appendix QB, p. QB22).

Each of the methods considered in estimating the returns to R&D is concerned with measures of productivity growth so that, essentially, returns to R&D depend on an estimate of the residual growth of output not accounted for by growth in labour and capital inputs, and possibly other factors. However, the frameworks take no account of induced economy-wide effects on growth as productivity improvements raise saving and investment, inducing further rounds of output growth. Hulten concludes:

> In assessing the importance of technical change as a source of growth, the effects of induced capital accumulation must be allowed for; the conventional 'residual' does not take induced capital accumulation into account, and thus tends to misstate the importance of technical change as a source of growth (1975, p. 956).

For a small country such as Australia, a potentially important influence on productivity and output growth is the effect of improvements over time in the quality and technical content of imported inputs (technology transfers) and other research spillovers from other countries. Benefits of foreign R&D are likely to flow to Australia through the import of improved machinery, equipment and supplies from overseas and the interaction of foreign and Australian researchers. After taking both of these factors into account, the Commission found that a one per cent rise in foreign R&D stocks would raise Australian multi-factor productivity by between 0.028 and 0.08 per cent yielding an economy-wide rate of return to foreign R&D of between 8 and 23 per cent. This is lower than for other countries, which Dowrick considered might reflect a combination of factors:

> ... geographic isolation from most OECD countries; a different industrial structure from other OECD countries, reflecting Australian comparative advantage in resource intensive industries which may be less innovative than other industries; a structure of business organisation less attuned to imitating successful overseas innovations (1994, p. 30).

As discussed earlier in this chapter, a further likely reason is the legacy of the traditionally ‘closed’ nature of the Australian manufacturing sector.

Overall, the Commission’s analysis indicates strong and positive returns to R&D investments. International studies also provide evidence consistent with this assessment. Nevertheless, data problems and differences in economic structure between countries and within countries over time, limit the extent to which the actual level of returns can be tied to a narrow range of values.

In sum it is clear that firms benefit from R&D and that they have many avenues of access to it. These avenues form a complex map which is only partly understood at the aggregate level. But R&D appears to make a significant contribution to national growth and, as far as measurement can reveal, provides social benefits which extend beyond those who undertake the R&D.

The analytical task remaining is to examine the way in which, if left to themselves, normal investment decisions by firms would fail to deliver all of the potential benefits from undertaking R&D. When the source of spillovers can be identified there is scope to consider remedial action. The following chapter considers rationales for government intervention to support R&D.

A5 RATIONALES FOR GOVERNMENT INVOLVEMENT

> In formulating a rationale for public investment in research and development, it is clear that general theoretical analyses and the ambiguity of empirical observations offer incomplete guidance to appropriate policies and their benefits ... In looking at intervention, the question is not only whether the economy works satisfactorily, but whether government intervention can achieve a better result. Total laissez faire (or laissez innover) is not a real alternative, because market failure is ubiquitous and a presumption that policies inherently have a net cost may not hold. Notwithstanding this, there are significant constraints on government intervention, notably as one moves to the commercial end of the research and development spectrum (ASTEC 1985, p. 87–8).

A5.1 Introduction

While R&D plays a central role in advancing living standards and the quality of life, the extent of improvement depends critically on making the right decisions about its direction and use. Like any other input in the innovation system, R&D is valuable in the right quantity in the right place, but misdirection of effort can mean a loss of potential benefits and can involve significant costs. Too little R&D can steer the country onto a lower growth trajectory than is possible, while too much can consume resources which might be invested to better effect elsewhere. And if the wrong R&D is supported, the results may produce little of lasting benefit.

Government policy towards R&D can be crucial in making the most of our economic potential. The Victorian Government summarised its significance well when it said that the:

> ... process of accumulating new knowledge and expertise does not typically occur by serendipity; it flows from the incentives which face individuals and the actions of governments in encouraging efficient resource use. Identifying policies which aim at creating an environment in which the right level and quality of resources are employed in R&D activities is therefore, an important component of economic management (Sub. 241, p. iii).

This chapter is about why government should intervene in R&D; the next chapter considers the different forms of intervention and some guidelines for policy.

Analysis of individual government programs is provided in subsequent parts of the report. Those parts build on the principles discussed in this chapter.

Why should governments intervene?

A key element in economic theories about growth, and in the measurement of the returns to investment in R&D, is the transfer of knowledge from one economic agent to another (chapter A3). These transfers are important because they can effectively permit knowledge to do double duty — to improve the products and processes of several providers of goods and services at once.

Such transfers are broadly labelled ‘spillovers’. But ‘spillovers’ is a term which can take many meanings. As it is often used, it covers a wide variety of knowledge transfer mechanisms (artefacts, documents and people), a wide variety of sources of knowledge (among firms, out of public institutions and from overseas), and various priced and unpriced transactions in knowledge.

Much economic theorising has gone into attempting to specify exactly those circumstances in which these transfers may be relevant to economic policy; that is, when private incentives to undertake R&D, and innovation more generally, may be inadequate. A large and evolving economic literature exists. A survey of recent developments in this literature was commissioned as part of this inquiry (see Tisdell 1994).

As a small open economy, the international dimension of knowledge transfer is particularly important for Australia, and a number of measures can be taken to increase our access to the large body of overseas technology that exists. Opening our borders to foreign products is one such measure, as is the extent to which we provide protection to foreign intellectual property.

At the most fundamental level, however, reasons for government action in supporting and undertaking R&D rest on the economist’s distinction between public and private goods.

A5.2 R&D has ‘public good’ characteristics

In the absence of government action, some socially valuable R&D would not be undertaken. The source of this problem is that knowledge — the product of R&D — often exhibits the characteristics of a ‘public good’, namely:

- non-rivalry — it can be made available to a number of users simultaneously, at no extra cost to the supplier; and
- non-excludability — users cannot be denied access to it.

Discoveries which are public goods may be readily copied and used by others. As a result, the incentives to invest resources in making such discoveries is low — an inventor who uses the discovery to produce cheaper or better goods and services and obtain a competitive advantage may find others immediately eroding that advantage by using the same discovery.

This is the source of the paradox of the existence of apparently high social returns to R&D which no one wishes to undertake. Where the cost of a newly invented technology to a competitor is low, rival producers do not need to recover the cost of acquiring the invention in their cost structures. They may therefore use the new technology to produce better or cheaper goods or services, while charging prices which are sufficiently low to eliminate the component of the price that was necessary to provide a return to the original inventor.

Public goods thus are characterised by ‘spillovers’ of knowledge in their purest sense — transfers of valuable information from its original producer which cannot be prevented and for which there is no payment (see box A5.1).

Box A5.1: **Spillovers**

Spillover is another word for the economic term externality. The terms are used to denote the existence of various forms of interdependence among producers, or consumers or between the two groups. Spillovers may be broadly divided into *knowledge* (or research) *spillovers* and *pecuniary spillovers*. The first type include:

> ... any original, valuable knowledge generated in the research process which becomes publicly accessible (Cohen & Levinthal 1989),

and usually relates to disembodied knowledge transmitted through formal and informal professional communication in journals, at conferences, through other interpersonal contact, and through the movement of human capital around the economy. As noted earlier, a significant reason for a firm to undertake R&D is to position and equip itself to be a good detector and absorber of knowledge generated elsewhere.

The pecuniary type of spillover usually relates to knowledge embodied in equipment or material products supplied by one firm and used as inputs in production elsewhere. When users achieve higher productivity, lower costs and/or enhanced product quality as a result of their suppliers’ innovation activity, there will often be cases in which some of the resulting benefits flow either to the user or the final consumer, but not back to the supplier.

The distinction between technological and pecuniary spillovers is blurred by the fact that firms often acquire new technological knowledge without compensating its originator financially but instead through offering other information in return (von Hippel 1987).

There will, however, often be some provision of public goods even when others can benefit in the ways described. This will occur if, despite the benefits to others, a private producer still gains sufficient benefits from provision. Sometimes goods are also provided for philanthropic reasons. In these cases benefits, in the form of spillovers, will flow to others and will be enjoyed without government action.

Thus the central policy question for public goods provision is often not whether action should be taken to ensure that a good is provided at all, but rather whether action should be taken to augment private provision. Here there are some difficult questions which centre on the impact of government policy itself. For government action can have costs, even when it has an effect in countering market failure. These costs include those associated with raising revenue and any impact public provision has in crowding out private provision. And the extent of spillovers is hard to measure and judge.

The 'public goodness' in R&D varies

In practice, goods and services are not always classifiable into discrete public and private categories. There is a continuum in the extent to which goods and services possess the characteristics of non-rivalry and non-excludability. This continuum applies especially to knowledge created by R&D.

In an address to the Commission's conference on economic growth, Professor Paul Romer stressed that if goods are sorted into those that are rival and non-rival, both groups will contain goods which vary in the degree to which people can be excluded from their use (see table A5.1; and Conference Transcript, pp. 25–28). An encoded television broadcast, for example may simultaneously be made available to all, but those who have not paid may be excluded from enjoying it by being denied the technology to unscramble it. It is both fully non-rival and fully excludable. Basic research results, however, can be made available to all who want them at minimal cost, but are denied to some only with great difficulty. They are both non-rival and non-excludable.

Consistent with this, not all R&D leads to the creation of knowledge that could be considered a pure public good. Romer gave the example of Wal-Mart, a company which has revolutionised the process by which goods move from a factory to the home. He said:

> There is an enormous amount of knowledge that has built up within this corporation about how you actually do that. They generate a lot of value from that, so they have some control over it, but other firms are copying it so they can't completely control it (Conference transcript, p. 26).

Performers of R&D are, naturally enough, well aware of the potential for erosion of their returns and take measures, where possible, to exclude rivals from the benefits of their research. For some activities, this can be readily accomplished by maintaining secrecy about the source of the improvement in product or process. For example, some production techniques can be hidden from view and some products (like some chemical compounds) may, by their nature, be difficult to reverse engineer.

Table A5.1: **Economic attributes of various goods**

Degree of control (per cent)	*Rival goods*	*Nonrival goods*
100	Private goods: for example, a piece of unimproved land	An encoded satellite television broadcast
		A digital music recording The design for a microprocessor Computer code
	A car	The operations manual for Wal-Mart stores
	A worker's labor effort	General principles of chemical engineering Principles behind window-based graphical user inter-faces The do-loop in computer programming
	Fish in the sea Clean air	
0	Sterile insects used for pest control	Public goods: for examples, basic research in physics

Source: Romer 1993, p. 354.

The importance of 'tacit knowledge'

The nature of knowledge itself can also vary and affect its ability to be transferred. An important distinction in this respect is between 'codified' and 'tacit' knowledge.

Codified knowledge is typically organised and expressed in a way that can be readily disseminated. This includes information contained in papers, patents and blueprints. However, this codified knowledge often will not be sufficient in itself to allow the findings of research to be implemented. Other knowledge or complementary know-how, is required.

This other type of knowledge or know-how, often generated through production or R&D experience, is known as tacit knowledge and by definition is difficult to articulate — though it is shared by individuals with similar experience. This might be the case where the tacit knowledge is obtained by a researcher during the conduct of research. A firm wishing to obtain access to that knowledge must either obtain access to the researchers involved in the discovery or undertake a parallel process of R&D. In either case the public good characteristics are much less evident.

The implication of the existence of tacit knowledge is that researchers (and the firms and other organisations that employ them) can have more control over the dissemination of the knowledge they create than might first appear. Mowery has observed:

> Although the public good conceptualisation is partially correct, it overlooks the high costs of transferring and exploiting technological knowledge. These costs often affect the success or failure with which such knowledge is utilised, and mean that much technological knowledge is a private good (1993, p. 7).

Tacit knowledge may be more prevalent in knowledge which is technologically based. For example, scientists involved in basic research may learn much about what each is doing (and communicate this knowledge to firms and other users) through journal articles and books. However, learning about actual technologies to be used by firms is likely to require more informal information about likely deadends, applicability in particular situations, compatibility with other technologies and processes and so on.

Public good attributes are arguably more characteristic of basic than applied research. Of the two public good characteristics, non-rivalry and non-excludability, it is particularly the latter which is an essential component of basic research. Basic research is predominantly a shared activity, with each discovery building on previous ones and many minds contributing to the evolution of knowledge. It is rarely completed without interaction by the principal researcher with colleagues from institutions elsewhere and exposure of the results to external examination and modification. The test of its success, at the time of its completion, is the degree to which it passes the scrutiny of others.

Applied research on the other hand can be completed more readily by groups of researchers without interaction with outsiders. The test of its success tends to be whether or not a product or process works better as a result of the research and, because such a test is to some degree independent of the views and judgments of others, the research can be undertaken in a more self-contained fashion.

Cooperative action can also enhance R&D incentives

When the number of potential beneficiaries of research is small, there is more incentive for firms to cooperate or to undertake research that can benefit them all.

Typical of such cooperative arrangements are those between firms supplying capital or material inputs and the firms using these inputs (see also chapter A4).

Apparent gains from research in the using industry can be the consequence of implicit contracts in which suppliers act as agents for the user. According to Geroski:

> ... it is almost certainly the case that some of the gains realized by innovation users are just a reward for their own inputs into the innovation process. Von Hippel, 1988, for example, examined more than 1000 innovations in the scientific instruments sector, and discovered that users dominated the process in about 80% of the sample innovations. They often perceived the need for the innovation, built the prototype and then transferred the knowledge which they had accumulated to producers. In these circumstances, it is hardly surprising to find that they seem to have realized most of the benefits of innovation (1994, p. 9).

Similarly, firms in the same industry may cooperate to undertake research of mutual interest (see, for example Weder and Grubel 1993). More formal arrangements to achieve this include the cooperative research funding arrangements in the mining industry through the Australian Mining Industry Research Association (AMIRA), and specific purpose research undertaken through various organisations, including the Tax Research Foundation, industry associations and philanthropic organisations.

When the potential beneficiaries of research constitute a large group, however, such cooperative and contractual solutions become difficult to implement on a voluntary basis. There is more scope for individual beneficiaries to consider that they can free-ride on the contracts and understandings of others. Unfortunately, in a large enough industry this can become the dominant strategy of all and research with public good characteristics will not be undertaken.

Pecuniary spillovers

Pecuniary spillovers occur when benefits from R&D flow on through the price system. There are two issues about them:

- do they constitute a net benefit from the innovation?; and
- do they provide grounds for encouraging additional R&D by the government (are they ‘policy relevant’)?

This was an important issue in the inquiry. In commenting on the draft report, the Rural Industries Research and Development Corporation said:

> ... ample supplies of higher quality, lower cost food products throughout the year might be considered pecuniary benefits under the Commission’s definition but are a very definite public benefit to Australian food consumers resulting from research, development and international marketing of food products (Sub. 367, p. 3).

In formal benefit-cost analysis, pecuniary spillovers are not considered to generate sources of benefit additional to the underlying technological spillovers of knowledge. Rather, pecuniary spillovers are thought to indicate distributional effects which, if included as external benefits, would constitute double counting. The conventional approach is discussed by Prest and Turvey in the following terms:

> ... progenitors of public investment projects should take into account the external effects of their actions in so far as they alter the physical production possibilities of other producers or the satisfactions that consumers can get from given resources; they should not take side-effects into account if the sole effect is via prices of products or factors. One example of the first type is when the construction of a reservoir by the upstream authority of a river basin necessitates more dredging by the downstream authority. An example of the second type is when the improvement of a road leads to greater profitability of the garages on the other, which are now less used as result of the traffic diversion. Any net difference in profitability and any net rise in rents and land values is simply a reflection of the benefits of more journeys being undertaken, etc., than before, and it would be double counting if these were included too. In other words, we have to eliminate the purely transfer or distributional items from a cost-benefit evaluation: we are concerned with the value of the increment of output arising from a given investment and not with the increment in value of existing assets. In still other words, we measure costs and benefits on the assumption of a given set of prices, and the incidental and consequential price changes of goods and factors should be ignored (1965, pp. 76–7).

They go on to point the practical difficulties associated with the application of the distinction:

> No one can pretend that this distinction is a simple one to maintain in practice; there may well be results from investment which are partially technological and partially pecuniary. Nor is the task of unravelling made easier by the fact that some of the transfers occasioned by investment projects may affect the distribution of income significantly, and hence the pattern of demand. But as a general guiding principle the distinction is most valuable.

What is clear is that pecuniary externalities should not be included as benefits *additional* to those associated with the creation of new and better products and processes. However, they can represent an alternative way of measuring the social benefits of the underlying technological improvement, providing double counting is avoided (see box A5.2).

If policy measures are in place to address the underlying technological spillovers then further action to address the distributional consequences of these spillovers, occurring in the form of pecuniary spillovers, probably will not be necessary. For example, there may be a subsidy in existence for the performance of R&D, but benefits of that R&D occur through reductions in the price of products. In another instance, a research association may be formed among all firms in an industry which effectively charges consumers for research performed by levying its members — rural research corporations in Australia are one example. If research is fully charged for by these firms, any pecuniary externalities that eventuate need not suggest the need for further intervention as a general matter, but could indicate the presence of an additional gain from particular pieces of research — a surplus — which accrues to consumers.

Box A5.2: The measurement of spillover benefits and costs

The BIE notes a number of empirical examinations of the costs and benefits of R&D which have adopted the following approach:

- add the profits that other firms make by outright imitation of the innovation, or by otherwise applying the new knowledge to improve their own products and processes;
- subtract losses (including forgone profits) of firms whose products are displaced by the innovation;
- subtract an appropriate share of the cost of uncommercialised R&D of firms other than the innovator to allow for the fact that the selected innovation may pre-empt similar developments by other firms (‘duplicate’ R&D);
- add savings to consumers that benefit through lower-priced or better value products;
- subtract the lost earnings of technologically displaced labour; and
- add an estimate of the value of broader community benefits (eg environmental, health and safety) for which the innovating firm is not compensated — and subtract any such costs for which the innovator does not pay compensation.

Source: BIE 1994b, p. 12.

A5.3 Other rationales for intervention

There are a number of other rationales that have been given for government intervention to promote R&D. These are summarised in box A5.3. They range from traditional ‘market failure’ arguments, to more recent economic analysis drawing on new growth theory and ‘evolutionary’ economics.

Risk and uncertainty

An important argument for intervention relates to risk and uncertainty.

There are two sources of risk and uncertainty associated with R&D for an investorı (Treasury, Sub. 236, p. 27). First, research is inherently uncertain in its outcomes. Second, technical risk is augmented by the market or commercial risk associated with the exploitation of the outcomes of R&D.

Arrow’s (1962b) seminal work on the case for government intervention in R&D, rested in part on the particularly risky nature of these activities. Tisdell observed:

> R&D and innovation (technological change generally) are by their very nature uncertain activities, and often the uncertainty involved is greater than for most other investment opportunities available in society (1994, p. 4).

Box A5.3: **Rationales for intervention**

Many reasons have been advanced to support the idea that private investments in R&D would not, without government intervention, accord with desirable levels for society.

Externalities: External benefits from R&D accrue to those other than the innovator without adequate recompense. These are spillovers under another name and are characterised by the same attributes of non-rivalry and non-appropriability. They can result in inadequate incentives for private investment in R&D.

Risk and uncertainty: R&D is claimed to be an activity which will be avoided by private investors because of its high risk and the difficulties in determining likely outcomes from investment in R&D.

Information: Trading in the results of R&D (knowledge) is limited by the fact that to be fully informed in advance about a purchase is to acquire the R&D itself. The seller of information therefore necessarily has information that the buyer cannot have.

Indivisibilities: Many research projects require large investments to produce results. This is thought to discourage investment in R&D, especially if the research has applicability to many firms.

The common pool problem: New ideas are said to be like fish in the sea — incentives exist for each individual to exploit them more quickly than would otherwise be desirable in order to prevent anyone else from doing so. This leads to over-investment in R&D.

Evolutionary theories: R&D is seen as a process of evolution to different products and processes. Evolution requires the creation of diversity and a principle of selection. Evolutionary theorists argue that governments can assist in these processes to obtain a better evolutionary path.

New growth theory: New growth theory stresses the role of R&D in assisting nations to achieve their path of maximum growth.

The policy relevance of this derives from the potential for underinvestment if individuals or firms are too risk averse, or lack the capacity to spread risk. In these cases there is a theoretical argument for pooling projects or for using government assistance to overcome reduced R&D investment caused by the hesitancy of individuals to accept risk.

The question of whether risk induces market failure turns on whether it deters individual investors to a greater extent than is socially desirable. If so, then there could be a case for government to assist R&D to achieve more socially desirable levels.

A range of market mechanisms exist to reduce risk. The stock market is one vehicle by which individuals can take small shares in risky ventures. Superannuation funds and banks are other vehicles. Furthermore, firms themselves share their exposure to risk through futures contracts, insurance and various forms of hedging against financial risk. For especially risky activities, venture capital funds pool the risks from a number of different activities and provide the means by which a large number of investors might share in the returns.

The Commission's Report on the Availability of Capital (1991b) noted the large number of specialist intermediaries that existed to take shares in small speculative ventures. Financial deregulation has also increased the range of financial instruments available for risk pooling, especially in providing immediate access to the financial markets of the world.

Nevertheless, there are still many small businesses in which individual entrepreneurs take large shares and accept a large amount of risk. Although sometimes such risks are accepted by the entrepreneurs willingly, more often it reflects an inability to attract funding from other sources.

One reason for this can be that outside investors are unwilling to back projects in which the entrepreneur does not have a large stake, for fear that this might reduce the incentives of the entrepreneur to succeed. This barrier to risk sharing was once thought to be a market failure itself because it implied that government intervention could achieve a greater reduction in risk than that which eventuated in the private market (see Arrow 1962b). It was recognised by Demsetz (1969), however, that 'coinsurance' can be a necessary part of obtaining maximum value from scarce investment funds. Without a large interest by the entrepreneur in the venture's success, the incentive to succeed is diminished and the return to outside investors placed at greater risk.

Investment by government is another mechanism that allows risks to be spread among all citizens. It thus can achieve many of the gains that are achievable from reducing individual exposure to risk. But the issue then turns on the ability of governments to identify where markets have failed to provide socially beneficial risk pooling and spreading. In practice, governments often have neither the inclination nor skills to assume such a risk-taking role. If anything, there is a tendency for governments to avoid taking risks in case there are political repercussions.

The Treasury (Sub. 236, p. 28) said that the arguments that governments should intervene to spread risk is highly contentious because:

- large diversified firms may have more opportunities to do so than governments;

- the argument would require government intervention into many fields of economic activity, not just R&D; and
- governments often have rather short time horizons, especially when elections are anticipated.

Information problems

Research is largely concerned with the provision of information, the transmission of which is subject to some well-known deficiencies. These arise from the public good characteristics of discoveries.

On efficiency grounds, information which can be useful to others should be made available at the social cost of doing so. Where knowledge can be codified, this is simply the cost of transmission. Producers of information, however, need to recoup the cost of producing and disseminating their information. Without that prospect incentives to produce are greatly diminished.

This is an example of the information dilemma: price incentives need to be provided to have information created but once it is created it would be optimal to eliminate the very same incentives. Unfortunately, it is not possible to resolve this dilemma readily. Patent systems attempt to do so, but imperfectly.

Another problem with information can arise when parties to a transaction have different levels of knowledge about the trade. This can be a problem for owners of information seeking to sell at a profit, because to allow a full assessment of the benefits of the information, it is necessary to reveal the information itself. Conversely, potential buyers do not fully know beforehand what they will receive. This is not a problem just for the products of R&D; similar problems apply to the purchase of services such as car repair or medical services. There too, it is not always possible to know what is being received until it has been received. In practice, however, such services are evaluated on reputation and past service and these can also be employed in the purchase of the products of R&D.

Information can also be underused, somewhat perversely, in situations in which it is freely supplied. Providers of information will only have incentives to seek out users of information if they are in a position to profit in some way from it. This will often not be worthwhile where information is made publicly available. For recipients, the task of sorting and assessing available information can itself have the characteristics of a public good which can be shared among a group of recipients with similar interests, but which no single recipient may have sufficient incentives to create. While producer cooperatives can sometimes overcome this market failure, it has also been used to justify agricultural extension services.

Indivisibilities

The problem of indivisibilities in the production of new technology was summarised by the Treasury as follows:

> ... it has been argued that a threshold (indivisibilities) often exists whereby R&D projects require a minimum level of investment in order to be technically and/or commercially successful. Potential problems arise where this threshold is beyond the financial capacity of individual firms. Where firms cannot afford to invest in R&D, valuable projects (from a social perspective) may not be undertaken (Sub. 236, p. 29).

Pavitt (1990) quotes a range of studies to argue that there is little evidence of economies of scale in basic research, although he notes the need for further analysis if the conclusion was to be of broad generality. In applied research and in development, specific examples can be quoted where large investments are required. However, many of these examples are where firms are cooperating on a very large scale to share the costs of at least pre-competitive research and sometimes also the commercial development of the new technology. These include development of new aircraft, sophisticated automobile technology and new semi-conductor products and designs. Others are where many small innovative firms individually undertake particularly promising aspects of a much larger research problem. For example, the biotechnology industry is characterised by many small firms specialising in research and development and funded by venture capital.

It is not clear, however, that government could bring to bear any greater resources than would be available from large private enterprise firms. Nor is it clear that there would be any greater market failure in the research and development process itself associated with the size of the research problem. Whether research results are rival or non-rival would not seem likely to be influenced by the size of the research project.

The problems associated with indivisibilities are in many ways symptomatic of underlying public good characteristics rather than additional rationales for intervention. Large projects of any type are not in themselves usually difficult to finance when returns are high enough. But the problem comes when one firm requires research which is also beneficial to others. In such situations it may either:

- not invest because its own share of the returns is inadequate (even though the project may provide total benefits to all firms which exceed its cost);
- invest and then either exclude other users or charge excessively high prices for access to the information which have the effect of excluding some potential users.

These are classic spillover problems.

The common pool problem

In many circumstances, the benefits from research accrue largely to those who are first to the market with the research results. This might be in product markets where lead time and 'learning by doing' are important in protecting the competitive advantages of new or improved products and processes (Levin, Klevorick, Nelson and Winter 1987). It is also the case where patents are used to protect property rights or in academic research where rewards are based in some way on priority of discovery:

> A common implication of priority-based reward systems is that they give rise to competition — whether among reputation-seeking scientists or among patent-seeking inventors — that is fuelled by the winner-takes-all structure of the payoffs for those who participate (David 1992, p. 229).

This is sometimes described as the 'common pool problem' where there are too many contestants entering the race for priority in discovery and invention (Dasgupta and Stiglitz 1980). As a consequence, private profits tend to be dissipated in the race for priority. In addition, David (1992) argues that the effort to win patent or other races leads researchers to shroud their ongoing efforts in secrecy, reducing the scope for society to realise benefits from the cumulative, interactive process through which ideas proliferate and generate still more ideas. He also refers to Fölster's (1985) results that there might be potentially even more wasteful failure to coordinate the research efforts of rival researchers.

The magnitude of this problem depends on how secure the property rights are thought to be. To some extent this is within the scope of governments to influence through patent and other intellectual property law.

Recent advances in thinking

Among more recent developments in economic thinking about R&D have been two major strands. One is the analysis of technological change as a process of evolution; the other, new growth theory, is concerned with the factors that produce differential rates of growth within and between countries.

Evolutionary theories of technological change (see chapter A4), stress factors that produce variation in the types of techniques available and the way in which they are selected. Production of variety is seen to be desirable, as is having appropriate mechanisms for selection.

Technological evolution builds on itself through time, that is it is path-dependent. As a result, the technology selected can sometimes be less than perfect. Tisdell gave the following example:

> Suppose that two close substitute products are developed eg different types of video systems, but one is somewhat better than the other. Due to chance or other circumstances, the inferior form may be used first commercially. Large economies of scale may be generated and complementary products developed. This is likely to provide insuperable barriers to the better technique and it may fail to survive (Arthur 1990). Furthermore, the earlier adoption of an inferior technique may lead to further innovations improving it. Hence the development process reduces the initial superiority of the superior technique and may eventually reverse the ordering of the techniques. This may happen even if the superiority of the initially superior technique would have been even further enhanced by its use. Thus under competition, the fittest do not always survive and prosper, even if they are 'born'. Selection mechanisms can sometimes be inefficient even in a bounded rationality sense (1994, p. 30).

Similarly, the arrangement of keys on a typewriter (the 'QWERTY' keyboard) was originally devised as a way of preventing early typewriters from locking up and is not as well suited to rapid typing on modern computer keyboards as other possible arrangements.

To ensure that better techniques survive much of the time, evolutionary economists have offered various suggestions to guide government policy. These revolve around ensuring technological variation occurs, that ideas are transmitted, perhaps via networks and clusters, and that firms are economically competent to choose among techniques.

What is difficult in giving precision to these suggestions about the role for government in promoting worthwhile technological evolution is knowing how much would occur anyway simply because they are in firms' own interest. Clearly many of them would occur and it is likely that the role for government would in practice boil down to those cases for intervention which satisfy conventional (spillover etc) rationales.

Moreover even when selection mechanisms are inefficient in the sense described in Tisdell's example, it is not clear how they could be improved or what additional information a government might bring to the problem if it were to attempt to influence the technology adopted. Substituting selection processes which did not rely on the commercial judgement of firms would appear to run the risk of even more errors that would become apparent with hindsight. (An exception to this might be when the government itself is the principal customer for products embodying the research, for example defence and aerospace).

The substance of *New Growth Theory* has been discussed in the previous chapter. A central conclusion is that R&D is a crucial determinant of growth and that inappropriate levels of R&D (either too little or too much) can have the effect of constraining economic growth.

Other than in a purely theoretical way, however, new growth theory provides only limited guidance for policymakers about how and when to intervene to achieve optimal growth.

A key feature of new growth theory is the scope for individual discoveries to serve a number of different purposes. In this it relies on the public good nature of R&D and the spillovers that this entails. A logical conclusion then is that while new growth theory gives some new insights into the gains and losses associated with different investments in R&D, the policy conclusions about how to fine-tune the level of R&D fall back to the conventional implications from market failure.

This was also the conclusion of Dowrick who said:

> From the point of view of public policy, then, the question of whether or not the production technology and consumer preferences satisfy the conditions for endogenous growth is not as important as the question of whether there are identifiable market failures which public policy can attempt to correct (1994, p. 1).

Dowrick went on to make a number of other points about the implications of new growth theory for policy which are summarised in box A5.4.

Box A5.4: **New growth theory: implications for policy**

In a study commissioned for this inquiry, Dowrick (1994) drew out a number of implications of new growth theory for public policy:

- Market failures may result in substantially lower than optimal growth.
- Temporary public intervention has the potential to affect the economy’s growth path. But countries should not ignore their own strengths by attempting to imitate other high growth countries whose advantage lies in innovative activities.
- Evidence of Australian R&D effort lagging behind that of other advanced industrial economies is not sufficient to prove that more R&D would necessarily improve national welfare.
- To the extent that Australia can benefit more from imitation of overseas innovation than from its own innovation, there is less likely to be substantial domestic market failure.
- Public policy measures to encourage innovative activity should not be confused with measures to promote innovative firms or industries.
- Private institutions may provide better mechanisms than direct government provision for correcting failure in the market for knowledge.

R&D and broader economic objectives

Encouragement of R&D has sometimes been thought to be the way to change the Australian economy into one less reliant on agricultural exports and more oriented towards high-technology manufacturing.

There is no doubt that R&D can be a means to establishing high-technology industries. However, support is worthwhile only if the industry is one to which the nature of the economy is suited. Here the judgment of firms in assessing the commercial success of potential high-technology ventures is central. Government attempts to alter the industrial structure through fostering particular technological alternatives can be very costly even if some attention is paid to natural strengths — simply because these strengths are so difficult to identify, especially in conditions of rapid change. Dowrick (1994), for instance says:

> It is not easy to judge whether dynamic comparative advantage lies in resource based rather than knowledge based industries. For instance, Engelbrecht (1992) finds that Australian manufacturing industry in 1980 revealed a comparative disadvantage in R&D intensive sectors.

He goes on to say that things may now have changed:

> It would be interesting to see whether the same result would hold for the pattern of exports in the 1990s, following the claimed success of new and innovative exporters. Although our natural resource base is our most obviously distinctive economic feature, it seems likely that our less tangible but nevertheless very real human capital base may be equally important for development, especially if our trading future lies primarily with Asia.

More generally, assistance for R&D is sometimes seen as a way to encourage the establishment of a more competitive industry sector. However, while subsidies can always improve the position of particular industries they do so at a cost to others. This cost cannot be justified except in the presence of identifiable spillovers of the type that have been discussed. Unless these are present, a subsidy will have the effect of making Australia worse off even though subsidies continue to make particular industries become more competitive.

It has also been argued that R&D can, through achieving lower cost production and assisting the creation of innovative products, redress imbalances in the current account. While R&D can be a means to this end, it is not one that is costless in terms of resource use. When R&D is given excessive assistance, benefits achieved will fall short of the costs created. In these circumstances, assistance for R&D will create lower levels of economic welfare.

Moreover such a policy could act perversely. Resources used to assist R&D are raised at the cost to others in society, including those who may be engaged in exporting and import replacement activities. The net effect on the current account is difficult to determine.

In general terms concerns about macroeconomic phenomena such as the balance of payments are better addressed through macroeconomic measures, such as monetary and broad fiscal policy, which act across all industries. In that way impacts are made in areas of the economy which can most readily adjust.

Summing up

Analysis of R&D has been undertaken from many perspectives for many different purposes. Out of all these approaches, however, the concept of spillovers, itself defined in terms of the more esoteric characteristics of non-rivalry and non-excludability, remains the central justification for intervention on the part of governments to change the course of technological development.

Spillovers create benefits for others which do not figure in the decision making of the originators of the R&D giving rise to them. Where they exist, there is a *prima facie* case that not enough R&D will be performed.

Tackling this market failure involves, in principle, the creation of an environment in which more R&D will be undertaken. When this is done projects may go ahead which have worthwhile total returns (benefits to the originator plus spillovers) but which would fail to get approval on the basis of their benefits to the originator alone.

A5.4 Market failure may not require intervention

The rationales as presented thus far have focused on market failure, but ignored the equally important issue of whether government intervention can improve matters. This requires consideration of (a) how much information is needed for interventions to address market failures and (b) what the 'side-effects', and other costs of intervention, are likely to be. Policy choices need to be based on a realistic appraisal of real-world alternatives, given the constraints and limitations within the processes of both the market and government administrations.

As the RIRDC observed:

> In practice, there is always a choice between a range of imperfect market responses and a range of imperfect government responses and there is no general basis for presuming that the imperfect market responses are more imperfect ... (Sub. 124, attachment, p. 26).

The dilemma confronting government policy was characterised by one participant at the BIE/ANU 1994 Conference of Industry Economics as the 'blind giant' problem:

> This is because governments have bounded rationality...In an early stage of the process the government is a giant, but it is blind, so it doesn't really know what it ought to be doing. And by the time it has any sight, it is too late in the process to actually change anything – even a giant could not change the result (BIE 1994e, p. 83).

Commenting on Arrow's neglect of the 'bounded rationality' of governments, Demsetz observed that:

> The view that now pervades much public policy economics implicitly presents the relevant choice as between an ideal norm and an existing 'imperfect' institutional arrangement. This *nirvana* approach differs considerably from the *comparative institution* approach in which the relevant choice is between alternative real institutional arrangements. In practice, those who adopt the nirvana viewpoint seek to discover discrepancies between the ideal and the real and if discrepancies are found, they deduce that the real is inefficient. Users of the comparative institutions approach attempt to assess which alternative real institutional arrangement seems best able to cope with the economic problem; practitioners of this approach may use an ideal norm to provide standards from which divergences are assessed for all practical alternatives of interest and select as efficient that alternative which seems most likely to minimize the divergence (1969, pp. 237–8).

Apart from the prospect of government making mistakes through lack of information, or the impossibility of analysing it to the necessary extent, additional costs can derive from the incentives created by the very existence of government support. Analysis of these incentives has been the preoccupation of another relatively new strand of economic theory — at least since the arguments for intervention in R&D were first made — known as 'public choice'.

The additional incentive-related costs of intervention include:

- effects on economic activity of any additional taxation needed to finance R&D assistance, including its administration (estimates of the 'cost of public funds' range from around 20 cents for each dollar raised to around 50 cents); and
- diversion of the firm's managerial and other resources into: complying with rules; finding ways of organising production activities to qualify for support, and lobbying government to obtain support (or for changes to the rules or administrative mechanisms to make support more likely). This source of cost, while highly relevant to R&D policy, is obviously very difficult to estimate. As discussed later, it will vary depending on the form of intervention and its administrative arrangements.

When these potential limitations on government action are taken into account, the pre-conditions for intervention become more complex, requiring answers to the following questions:

- is there a valid market failure present?
- what are its costs?
- what are the benefits of the proposed intervention?
- what are the costs of the proposed intervention?
- is there a better way of achieving the same result?

Answers to these questions may not always be able to be given in money terms or even very precisely. Policy makers will in practice answer them using approximations and rules of thumb. But they do constitute a checklist which helps define worthwhile interventions.

In practical terms, of course, we are not starting with a clean slate. There is a substantial apparatus of government support for R&D already in place. Making changes to it can produce costs of its own and at times it may be appropriate to consider whether the extent of gains from changing some measures would justify the possible disruption, even though some gains may be in principle achievable.

A6 POLICY APPROACHES TO R&D

Having examined why government needs to take action to facilitate and contribute to appropriate R&D in the economy, this chapter now looks firstly at *how* governments can intervene — the instruments available and their applicability — and then at some broad guidelines for policy design in this area.

A6.1 Forms of intervention

Where R&D has public good characteristics which lead to its undersupply, it is appropriate to examine alternative institutional arrangements to improve the situation. However, the nature of the intervention considered by government may need to vary with the nature of the R&D concerned and the market incentives for its supply. Intervention can be direct (involving financial incentives) or indirect (facilitating the R&D process).

In some circumstances, the appropriate policy may build on private incentives to undertake research. The patent system takes this approach by allowing researchers to exclude those who might otherwise use results without recompense (itself not without cost, as discussed below).

In other circumstances the benefits from the research may be more diffuse and the demands of those likely to gain from it unable to be explicitly harnessed to guide project selection. If such research is to be encouraged, more direct government assistance may be required. For example, industrial research is currently subsidised across-the-board through a tax concession. This is consistent with the idea that there are leakages of the results from most research, but that the nature of these leakages cannot be specified in advance, nor all the benefits captured by the performer.

The third approach to intervention in R&D involves government sponsoring it within the public sector itself, and includes research agencies like CSIRO and research in universities.

Each of these approaches is now considered in more detail.

Creating and strengthening markets

Intellectual property rights

Firms protect the results of their research in many ways. These include manufacturing and researching in secret, focusing effort where there are 'first mover' advantages, contracting researchers not to work with competitors, disguising their products in ways that make reverse engineering more difficult and so on.

Where such mechanisms are ineffective, however, the use of intellectual property rights can permit researchers to appropriate additional benefits from their research. Through such protection, researchers can exclude other users of the results unless they are prepared to purchase them. The incentives to undertake research are thus restored to a value which, depending on the effectiveness of property rights, could approximate the value of the possible discoveries to consumers.

Australia has a range of policy instruments designed to provide intellectual property rights. The best known is the patent system, but others include design rights, trademarks, plant breeders rights, copyright, circuit layouts and the legal protection of confidential information. These instruments vary in the nature and scope of protection provided. For example, a patent confers the inventor with the exclusive right over the commercial exploitation of the invention, but copyright only provides protection to the expression of ideas against copying. Information on applications and granting or registrations of patents, designs and trademarks in Australia are shown in table A6.1.

Intellectual property rights work better for some goods than others. For chemicals and pharmaceuticals where formulas may be precisely specified, they are, in the form of patents, relatively effective. (As Professor Paul Geroski observed at a Commission seminar, 'patents work best when they deal with molecules'). In Australia, the sector 'chemicals and drugs' attracts a quantity of patents greatly out of scale with its research effort (table A6.2).

For other industries in which good ideas may be implemented in a number of forms, patents are less useful — indeed in some industries, researchers choose not to patent at all because it merely serves to advertise their discoveries to competitors. And even in industries in which intellectual property rights have some effect, there are likely to be elements of research that will inevitably leak and cannot be protected.

Table A6.1: **Patents, designs and trademarks**

	Patents		*Designs*		*Trademarks*	
	Applied for	*Granted*[a]	*Applied for*	*Registered*	*Applied for*	*Registered*
1980–81	17 209	7 501	3 049	2 165	14 091	4 335
1981–82	18 579	5 415	3 214	2 111	15 566	6 177
1982–83	17 180	6 638	3 544	1 998	15 847	7 122
1983–84	17 993	7 445	3 693	2 030	17 577	7 594
1984–85	18 244	7 101	3 601	1 523	17 802	7 515
1985–86	18 711	7 355	4 037	1 903	18 594	5 366
1986–87	20 241	8 785	4 636	4 376	20 195	5 685
1987–88	21 905	10 753	4 647	3 859	22 417	8 501
1988–89	23 354	11 671	4 364	3 579	23 746	11 584
1989–90	25 232	12 104	4 135	3 760	23 005	11 466
1990–91	27 592	11 405	4 009	3 342	21 478	11 370
1991–92	27 217	14 294	3 774	3 029	22 870	12 416
1992–93	28 736	13 447	4 018	3 129	24 391	13 820
1993–94	31 598	11 855	4 149	3 204	27 775	15 147

a Includes the total of petty and standard patents sealed by the patent office.
Source: AIPO various years.

Even where property rights are effective in protecting discoveries, they remain imperfect solutions to the problems associated with the public good nature of knowledge. For, to the extent that R&D results are non-rival, they remain so after the issue of a patent or similar device. Results thus could be disseminated at very low cost were the owner of the right prepared to allow this to occur. The issue of the property right thus discourages dissemination of knowledge, because its owner can charge a price for the information which is not related to its cost of transmission.

The Centre for International Economics in a report included in a submission by the RIRDC said:

> In resolving the problem of diminished incentive to invent, patents may create another. This problem relates to the fact that discovery of new ideas is expensive, whereas the transmission of new ideas among possible users is usually relatively cheap. Thus there is a tension between the social goals of achieving efficient use of information once produced and providing ideal motivation for production of that information in the first place (Sub. 124, appendix 1, p. 34).

This is a fundamental dilemma in policy — property rights help to provide incentives to have worthwhile knowledge created, but once it has been created they hinder its spread.

Table A6.2: **Sectoral distribution of business R&D expenditure compared to subject matter of patent sealed**

Industry or subject area[a]	*Percentage share of Australian business R&D*	*Percentage share of total patent sealed*	*Percentage share of patents sealed by residents*
Agriculture	1.4	2.2	5.1
Mining	7.0	3.0	4.2
Food processing	3.9	2.4	1.5
Textiles and clothing	0.4	1.7	1.3
Paper and printing	1.7	2.9	2.3
Chemicals and drugs	11.8	29.7	8.3
Metal and mineral processing	6.7	5.3	4.7
Transport equipment	8.8	6.2	11.0
Mechanical engineering	10.7	11.7	28.3
Instruments	2.9	10.7	8.1
Electrical and electronics	40.0	10.2	10.5
Miscellaneous articles	4.7	14.0	14.7
Total	**100.0**	**100.0**	**100.0**

a The patent classification of subject matter does not accord with the ASIC classifications. See BIE 1994d for more details.

Source: BIE 1994d, based on ABS and AIPO data.

The difficulty of resolving this dilemma is illustrated by the divergences in view (expressed on separate occasions) between two leading US economists who visited Australia while this inquiry was in progress. Oi (1994) saw patents as the preferred instrument, because they increase incentives to innovate, whereas Romer (1994), being primarily concerned about the dissemination of information, cautioned against patents because they discourage widespread use. Both economists were critical, however, of the use of subsidies to support R&D. On this they were in similar company, though for different reasons, to Geroski (see box A6.1).

A related complication is that because intellectual property rights have the effect of protecting particular knowledge while at the same time making it known that such knowledge exists, they set up competing incentives for those in possession of new knowledge. From society's point of view this has some attractive aspects — while there is some protection for inventors, dissemination of the broad tenor of the research is actually enhanced.

Box A6.1: **Visiting scholars on the role of government**

In the course of 1994, while this inquiry was underway, Australia was visited by three leading mainstream economists who expressed views about the government's role in encouraging R&D. As if to illustrate the difficulty of some of the questions at issue here, there were marked differences among them.

Walter Oi was a strong advocate of patents, stressing their role in stimulating invention:

> When we know so little about the costs of invention and innovation, I would prefer a policy that promotes invention by increasing the returns by changing the regulations on patents (BIE 1994e, p. 50).

He did not favour subsidies:

> The subsidisation of research and development through tax credits for R&D expenditures will allegedly lead to a faster pace of technical progress by encouraging more inventive activities. This policy tacitly assumes that a R&D dollar spent on developing sugar substitutes [when sugar is already protected by tariff barriers] is as valuable as a R&D dollar allocated to degradable plastics. Expenditures for test marketing a new brand of kitty litter gets the same subsidy as outlays for building a new research laboratory (BIE 1994e, p. 50).

Paul Romer, however, argued against granting patent rights for many classes of goods:

> You would not want to establish the strongest property rights that you possibly could ... because we face this trade-off with monopoly power. One example ... is the idea of the transistor. In effect the government in the United States gave very weak property rights over the transistor to the inventor, Bell Labs, for a variety of historical reasons having to do with the fact that they were a regulated monopolist. You can make a case that that was a very useful thing (Conference transcript, p. 26).

He invited his audience to think about:

> ... what the world would look like if everybody who had wanted to improve on the transistor had had to negotiate [over patent rights] ... if you had given an infinite life patent to the transistor and that patent had been held by some organisation (Conference transcript, p. 26).

He saw the challenge for policy to provide incentives for invention and incentives for dissemination:

> ... in a way that doesn't lead to rent-seeking or inappropriate behaviour in the political process' (Conference transcript, p. 28).

Paul Geroski suggested that much of this sort of dispute was beside the point because spillovers were more apparent than real:

> The diffusion of knowledge is a very serious policy problem, but not, I think because spillovers inhibit the production of innovations.

He suggested that:

> ... if competition is strong enough, firms will have to innovate to survive (BIE 1994e, p. 24).

The alternative of abolishing intellectual property rights or diminishing their role to increase incentives for dissemination is, however, not attractive. As Demsetz has argued:

> The partitioning of economic activity into the act of producing knowledge and the act of disseminating already produced knowledge is bound to cause confusion when the attempt is made to judge efficiency. It is hardly useful to say that there is ‘underutilization’ of information if the method recommended to avoid ‘underutilization’ discourages the research required to produce the information. These two activities simply cannot be judged independently (1969, p. 249).

While government subsidies could to some extent make up for reduced incentives to innovate, they cannot substitute for the incentives that property rights provide to individuals with particular market and technical knowledge to exploit particular opportunities to provide useful advances. In this sense property rights are ‘incentive compatible’.

The design of an ideal patent system has many complications including the likelihood that if patent protection is made too tight, there is a danger of incurring social cost through ‘patent races’ (akin to the common pool problem — see chapter A5) as there would be a substantial monopoly prize for the winners, and further incentive to join the race because of negligible scope for spillovers to outsiders. Nevertheless, it seems desirable to provide incentive for knowledge of this type to be created even if this implies that it will sometimes absorb too many resources and will be disseminated only slowly.

In a small open economy such as Australia’s, there are also issues about the extent to which our intellectual property rights should be integrated with those in the rest of the world.

The suggestion is sometimes made that Australia could make maximum use of knowledge generated in the rest of the world by revoking all intellectual property rights in Australia. This strategy, which some developing countries appear to have adopted at some stages of their development, could allow low cost dissemination in Australia of knowledge created under incentives, including patent systems, existing in other countries. However, while theoretically possible under some assumptions, the dangers to Australia’s standing in the world (including with respect to GATT obligations) and the likelihood of retaliation obviously make such a policy undesirable.

Even if it seemed desirable for Australia to offer protection for different periods from those elsewhere, in most circumstances it would be undesirable to get out of step with those in the rest of the world (BIE 1994d). The likelihood of this occurring has diminished with the outcome of the recent Uruguay Round of the GATT under which countries have agreed to uniform standard patent protection of 20 years.

Collective industry research arrangements

An alternative mechanism which channels the demands of those likely to benefit from the research is to find a mechanism to allow all (or most) of the potential beneficiaries to make a joint decision to undertake it. By assisting what are in some senses ‘contracts’ among those in the industry, levels and types of research come closer to the market model in which producers invest on the basis of their individual assessments of the costs and benefits

Where numbers in the industry are small this can and does occur without government assistance. But in industries with many firms, agreements are more difficult to reach because of the costs of contracting with individuals who have incentives to free-ride (ie gain the benefits of the research but not contribute to the cost).

The government can assist by creating an institutional framework under which members of an industry can make decisions about research priorities and the extent to which research is to be financed.

Inevitably there is an element of compulsion about such arrangements because many participants would prefer to have the benefits and not pay the costs. But such arrangements can lead to research of benefit to the industry as a whole being undertaken and to its being prioritised by those in the best position to know what is needed.

Australia’s rural research corporations provide one model for industry-based arrangements. Broadly, the model employed in this case involves a levy on the output of all producers which is used to fund research. Producers vote on the size of the levy and have a say concerning the composition of the board itself (see part E). Similarly, in manufacturing, research associations exist for firms in such industries as bread and sugar milling. Some received government assistance under the old Research Associations program (set up in 1947 and terminated in 1988), but now operate without additional assistance.

Such arrangements are also common in other countries. In Korea, businesses are required to join an industrial research association for firms of their type (classified by the standard four-digit industrial classification) under the Technology Development Promotion Act. The United States has a system of agriculture research funding based on industry levies, and associations for research in the electricity and gas industries. A number of research associations were also set up with government assistance in the United Kingdom, but now function as self-supporting organisations.

Industry research corporations or associations are less likely to suffer from problems associated with restricted dissemination than patents. But they face difficulties in detecting the potential usefulness of particular R&D projects because, at base, they must rely on collective (majority) decisions rather than individual purchases of R&D by businesses in the industry.

Such costs can be reduced by making the design principles for setting up and running industry research associations as flexible as possible. This means maximising industry participation within the constraints of the costs of decision-making procedures. This might involve allowing industry members to exercise individual decisions (through ballot) on:

- whether the industry should have a research association;
- the level of the levy rate; and
- the composition of the board.

A major issue in considering collective research of this kind is the extent to which it should be financed by industry levies as against public subsidies. While there are a number of technical considerations about what rate of levy will produce efficient research generation and dissemination, perhaps the most telling arguments in favour of a levy relate to the effect that it would have in the longer term on the behaviour of:

- producers, in preventing the industry organisations from becoming vehicles for lobbying the government for funds without limit;
- producers, in being encouraged to focus on the research program undertaken with their contributions; and
- consumers, in having the long-term average cost of research incorporated in the cost of products and being required to modify their consumption in response to changes in such costs.

A levy to support collective industry research organisations has the useful feature that its cost can be shared between users and producers in similar proportions to their benefits from the research (see part E in which these questions are discussed further in the context of rural research and part D which discusses the possibility of introducing such arrangements more widely in non-rural industries).

Assisting the market

R&D in the firm

Some commercially motivated research performed by business could also produce benefits for others. These public benefits would not afford the business a direct commercial return and therefore would not be taken into account by the performer in their financial appraisal of research alternatives. Potentially valuable research from the community's point of view therefore may not be performed. In order to encourage business performers of R&D to extend their research efforts, governments frequently subsidise the research of businesses. In this way, businesses performing eligible R&D are given some compensation for the public benefits that they would not be able to appropriate through the market.

The likelihood of public benefits flowing from business R&D effort is recognised in the outcome of the recent Uruguay Round of trade negotiations. Under the Agreement on Subsidies and Countervailing Measures, assistance to R&D is permitted and non-actionable by other signatories to the Agreement.

In Australia, one means of providing assistance of this type is through the 150 per cent tax deduction for expenditure on R&D, which provides assistance to all companies undertaking research, so long as they have taxable profits against which to claim the deduction. The Discretionary Grant Scheme has played some part in providing assistance for similar reasons to companies in tax loss although, as its name suggests, it has not been a universal scheme. Assistance given to the rural corporations can be interpreted as having the same rationale.

Are spillovers uniform across activities?

A key issue is the extent to which broader public benefits of such research relate to the type of private research which is subsidised. Benefits accruing without full compensation to the originator of the research can include:

- the use of productivity raising techniques in firms other than those in which they were first generated or developed;
- the use of cost-reducing or quality-enhancing new products as inputs into production elsewhere;
- the migration of researchers, their skills and human capital to firms other than those where they were acquired; and
- price reductions that provide consumer benefits from research that cannot be captured by the firms that undertook the initial R&D.

The extent of these benefits is likely to vary according to the industry and the firm involved. If there is a large amount of variation in R&D spillovers by firm or industry, then a uniform rate of assistance will result in:

- some firms with high rates of spillover not producing sufficient research; and
- some firms with low spillovers producing additional R&D with low social value.

To the extent that such research is stimulated, uniform assistance is inefficient. However, to reduce such inefficiencies it is necessary to have a strong basis for distinguishing the characteristics associated with spillovers of different strengths and to relate the size of subsidies to those strengths. Unfortunately, empirical work does not give clear guidance as to how that might be done, nor does it appear likely that such distinctions can be readily made. Research spillovers are difficult to identify *a priori* and occur in unexpected ways. The Commonwealth Treasury said:

> A practical problem with market based incentives is that it is often difficult to determine whether particular projects warrant assistance or whether the most efficient provider has been selected. Problems in identifying and measuring externalities and other market failures ... may mean that is hard to evaluate requests for assistance and to compare or rank them (Sub. 236, p. 41).

The government has, in the past, undertaken some selective assistance for R&D under the Industry Innovation Program. A full evaluation is in appendix E. In general terms, many of the subsidies have gone not for research with generic benefits to a range of firms, but to technologies with benefits to specific (typically, larger) firms. The Commission also argued that grants under the National Procurement Development Program had not targeted projects with externalities, in its 1992 report on the program (IC 1992).

Should R&D support be based on potential for commercialisation?

In comment on the draft report, the IR&D Board stated its belief that it was necessary for assistance to be targeted at R&D which was likely to be commercialised. It was, the Board argued, only through commercialisation that benefits for consumers were created:

> ... none of the customer spillovers occur unless and until the product is commercialised. No spillovers from R&D go alone to the customer and hence a failure to commercialise will usually decimate the spillovers from R&D (Sub. 363, p. 15).

In the Board's view, support for R&D is best directed to firms likely to be successful in the market with their technology.

The Board's argument, however, fails to acknowledge the complexity in the way in which spillovers occur. Spillovers are generated from the discoveries inherent in the R&D. So long as these are spread to other potential users, benefits from the R&D can occur. The transmission of knowledge may occur in a variety of ways, including interaction among researchers, and their migration from one activity to another.

While therefore, commercialisation of some R&D is a necessary condition for benefits to be achieved, a particular piece of R&D can create benefits even if it does not itself directly produce a commercialised product or process. So long as it contributes a product or process that is eventually commercialised, benefits will have been achieved.

Do spillovers decline as R&D increases?

In attempting to determine the level of support to be given to encourage the production of R&D, a key parameter is the level of spillover generated and the extent to which spillovers vary with the amount of R&D produced.

As appendix QA makes clear, there are many estimates of the level of externalities associated with particular projects or for given broad level of R&D production in the economy. But do these externalities become less significant as R&D investment increases? Unfortunately the econometric and other evidence is not able to shed much light on this question.

A standard observation about investment more generally is that, at any point in time, expected returns to investors decline as investment increases. This is also so for investments in R&D, and is no more than common sense, as the most productive opportunities are exhausted first.

One view about spillovers from R&D is that they also decline as private returns from R&D decline. This is the assumption made by the BIE in its evaluation of schemes such as the 150 per cent tax deduction and syndication (BIE 1993c and 1994a). However, it is not the only possibility.

Another view is that spillover benefits from R&D do not necessarily decline as private returns decline. Projects with large public good characteristics may have low expected private returns.

The Commission has reviewed the empirical evidence on this matter, including Mansfield et al. (1977) and considers that it provides little support for either position.

In evaluating the benefits and costs of subsidy measures for R&D, the measurement of spillovers assumes a central role. Uncertainty about the extent of spillovers at different levels of investment adds an extra element of imprecision to evaluation.

Costs of across-the-board schemes

One clear drawback of across-the-board subsidies is that they inevitably produce costs because they assist projects which would have gone ahead anyway. As the BIE (1993c) has demonstrated, this creates costs to the economy at large because:

- raising the revenue to provide the subsidy imposes a cost (the cost of public funds) through affecting the behaviour of those who must be taxed to provide it (for example, taxation reduces work effort); and
- some revenue from the subsidy accrues to foreign shareholders and, because the research would have been done anyway, amounts to a direct, and in a sense gratuitous, payment overseas.

To overcome this problem some have suggested the use of schemes which provide assistance only for R&D that is incremental. Although this approach is followed in other countries (including the United States and Japan), it faces inherent difficulties related to defining an incremental project. In particular, fixed costs associated with R&D can be high and spread over a number of projects and a number of years. To limit subsidies to so-called ‘incremental projects’ would be to risk deterring R&D by some firms for which the entire operation of R&D is borderline.

An even more significant objection in the Australian context is that it appears that firms would be able to manipulate their structure to bring new firms into existence to ensure that a large amount of R&D appeared to be incremental (BIE 1993c). In principle, each new firm’s R&D would be entirely incremental even if it were simply a continuation of research conducted by the firm’s predecessor.

More generally, discretion brings with it additional costs associated with strategic behaviour by firms and costs of compliance and administration, as discussed previously.

Government financing of public sector research

In situations in which market incentives for research are weak, where spillover benefits are likely to be pervasive or governments seek to ensure dissemination of the results, governments have tended to provide direct support for research in government-funded institutions.

The rationale for public sector research at the broadest level is that it should (a) enable research to be undertaken and disseminated in a way that advances social welfare by more than alternative uses of the public’s funds, and (b) achieve results which would not otherwise occur. The role for government is not clear cut, and can change over time. It depends on:

- the private incentives and arrangements for doing research (whether ‘crowding out’ is likely);
- the ability of government to identify the appropriate areas of research;

- the scope for and benefits from wider dissemination of results from public compared to private research; and
- the cost of undertaking the research within the public sector relative to contracting it to the private sector, which should also include transaction costs and issues to do with control.

Government financing of public sector research has taken a range of forms in Australia, including:

- block funding of universities to undertake research;
- selective funding of research in universities through the ARC on the basis of (mainly) excellence;
- selective funding for medical research through the NHMRC;
- funding of research through the block funding of CSIRO, AIMS, ANSTO, and State agricultural research departments;
- funding of projects with particular merit directly through the government (eg programs for funding AIDS, aboriginal health, breast cancer, and nanotechnology); and
- direct funding of institutions which undertake research relevant to the government’s own functions (for example economic policy research, and defence research).

No single approach is best

The design of particular R&D programs is clearly a complex matter involving competing considerations. The considerations also vary from program to program, with approaches needed for support for research in universities for example, being very different from those relevant to support for industry research. There is, as a result, no ‘one size fits all’ approach to assistance for R&D.

Part of the reason for this is the very strong information requirements in some areas for identification of projects that meet criteria for support. An important implication of this deficiency of information is that programs should be designed to make the most of the information that is available. If targeting of support requires the use of people with technical knowledge about particular types of research projects (for example in university or business), then ways should be found to employ that specialist information. If governments themselves take on selection of that type, there is scope for significant misallocation.

At the same time responsibilities should not be allocated only to technical experts where broad judgments about social benefits are required. There was, for example, concern on the part of some participants that selection of projects in some areas was too science-driven, and not enough attention was paid to the economic payoffs to society (the CSIRO was frequently the target of this type of criticism).

Difficult judgments need to be made about how far selection processes, with their attendant costs of administration and compliance, can be taken. When the necessary information for choice is too difficult or expensive to obtain, governments must make choices between the costs of broadly-based assistance, which (necessarily) supports some inappropriate research, and offering no assistance at all, which implies that some projects of value will be missed.

A6.2 Some guidelines for R&D policy design

> One of the key weaknesses of public sector R&D in Australia is the lack of a clear and consistent set of policy principles adopted nationally by both Commonwealth and State governments. Such policies should address issues ... of contestability, priority setting, accountability, the separation of policy, funding and service provision (Victorian Government, Sub. 241, p. 330).

Both theoretical and empirical analysis suggest that there will typically be under-investment in R&D in the absence of government intervention. But it is also evident that no definitive answers can be given to the question of the optimal scale and mix of intervention. The theory (and theoreticians) remain equivocal on the relative merits and applicability of different instruments (illustrated in box A6.2).

In principle, support should be targeted by reference to the future relative returns to society from different areas of policy-induced R&D — taking into account costs associated with the government's actions — but in practice there is insufficient information to allow such precise calculations to be made. The information problems are especially pronounced for basic research, the impacts of which spread through diffuse channels over a prolonged period.

The problems of information and uncertainty that confront government intervention in this area mean that a robust policy strategy for R&D must involve a combination of approaches. And, perhaps more than in any other area of government policy, measures that are implemented need to be recognised as experimental, and designed and reviewed accordingly.

Box A6.2: Some guidelines for R&D policy design

- **Diversity should be encouraged.**
- **Private incentives should be built on where possible.**
- **Assistance schemes should be simple and transparent, with well-defined criteria.**
- **Research should be monitored and evaluated.**
- **Assistance levels should be consistent in comparable circumstances.**
- **Contestability should play a major role in funding R&D.**
- **Government's objectives and roles should be clear.**

In this section, the Commission draws on available theory and recent experience (overseas as well as in Australia) to devise a number of general principles that should inform R&D policy design (summarised in box A6.2). Despite their generality, they are of course not immutable. Some of them may also be difficult to apply in practice. But the Commission considers that, collectively, they constitute a useful frame of reference for examining the various aspects of governments' current involvement in R&D.

Diversity should be encouraged

Pervasive uncertainty and information difficulties confronting public policy on R&D mean that the optimal forms, levels and destinations of intervention cannot be known. In these circumstances, a policy approach with the best chance of maximising the expected payoff from R&D support, should not be too specialised. There are dangers in putting too many research eggs into one policy basket.

There are several aspects of the R&D support system for which some diversity would seem desirable.

- *Instruments*: A combination of interventions will generally be needed — not only because some may be more suited to particular circumstances, but also because their relative efficacy is uncertain. Thus support for business R&D, for example, should not rely on the patent system alone. For reasons outlined above, some combination of property rights and other support will generally be preferable. And in the case of university research, not all funding should be by block allocation or by competitive processes.

- *Funders*: Selecting the best research is a difficult task. Even the most competent assessors inevitably make mistakes. They may even make them systematically. Having more than one potential funder available to a given researcher or research institution reduces the risk of rejecting projects that should have been accepted ('Type II errors'). Of course there are costs involved in having potentially overlapping funding arrangements. A balance needs to be achieved.
- *Centralised vs. decentralised*: Centralised decisions can have the advantage of breadth of perspective. Broad tradeoffs can be made. But decentralised decisions have the advantage of more complete information about the merits of the researcher and the local infrastructural and other circumstances of the proposed project. (As some participants observed, the ARC may well not fund a promising young researcher because he or she is just that.)
- *Levels of government*: Different levels of government all play a role in innovation. While acknowledging the Commonwealth's primary responsibility in R&D policy, for example, the Victorian Government noted that:

  > State Governments have an important role to play in some aspects of research in Australia, particularly research related to native resources and the environment. Such research is more regionally based ... because of variations in climate, geology and geomorphology (Sub. 241, p. 34).

  The States are well placed to assist in the dissemination of technological information, facilitate the establishment of research infrastructure, and contract research to be applied to local needs and problems.

  The involvement of different governments needs to be complementary and based on an awareness of the policies of other governments. This implies a need for nationally accessible data, as well as processes of consultation among governments (ASTEC 1991b).
- *Research performers:* Critical mass can be very important to the success of some R&D projects. But for other projects it can equally be said that 'small is beautiful'. What is important is that funding arrangements promote the best research and research institutions, regardless of their size. An advantage of competitive funding is that it can allow greater scope for the emergence of new research teams in different institutions, including within the private sector, than with block funding of established institutions. Australia appears to be less well endowed with private research institutions than some other countries.

Private incentives should be built on where possible

As earlier analysis has illustrated, not all R&D activity is impeded by market failure. Because R&D varies in the extent to which individual projects produce knowledge with public good characteristics, normal market incentives are adequate to induce much R&D activity. Indeed, as Levin (1988) has observed, the most R&D intensive industries — computers, communication equipment, electronic components and aircraft — are those where spillovers appear greatest.

Policy to promote R&D for the benefit of producers of goods and services should generally allow producers themselves to choose and initiate their own research. Research done outside firms, without their direct involvement, is rarely an adequate substitute for that done within firms (or done extramurally under contract). This reflects not only the better targeting of firm-initiated research to real needs and opportunities, but also the fact that the learning associated with R&D is of value in itself.

What can stop firms from proceeding with some research projects is the diminution in the expected returns from research that result from other firms taking a free ride. But free-rider problems can be addressed by legal and organisational arrangements, without necessarily requiring public subsidy. Patents and other forms of intellectual property are one traditional means. Government enforcement of industry research levies is another.

Assistance schemes should be simple and transparent, with well-defined criteria

The need for some administrative discretion and judgement is inevitable in financial interventions to support R&D. This is true even for the most broadly-based assistance measures, where judgments must be made about whether a given project constitutes R&D. The scope for administrative discretion increases for more selective schemes.

In principle, there are arguments on the side of allowing targeting of assistance where possible. This is because of the likelihood that the responsiveness to incentives and the level of spillovers will vary significantly from one institution, firm or project to another. In practice, there are some considerations that tilt the balance in favour of simple and easily-administered measures, which limit the extent of discretion.

To begin with, there is the reality that in most cases there is not adequate information to allow fine judgments to be made between research proposals in terms of their likely net social payoff. This applies not just to basic research (where academic merit can be a reasonable proxy, as already discussed) but also to assistance for private sector research. The critical determinants of net social payoff from assistance to firm R&D — namely, whether it would occur anyway and the value of any spillovers from induced R&D — are not directly observable.

In particular, when activities attract assistance, it is in potential recipients' interests to define as many activities as possible as being in the assisted category. (It is frequently claimed that this effect was noticeable after the tax concession was introduced.) Where activities which do not produce spillovers are encouraged, there are likely to be social costs.

The more straightforward and well specified the criteria for giving support, the easier it is to make unambiguous decisions about eligibility and the less incentives firms will have to attempt to manipulate and get around them. The Treasury said:

> There are likely to be indirect costs associated with the private sector response to incentives. These costs arise from private sector rent seeking and strategic behaviour. For example, firms may exploit opportunities to capture profits through government subsidies since it is often difficult to determine whether the private sector would have undertaken a particular R&D activity without subsidy (Sub. 224, p. 41).

When rules are complicated, applicants have more scope to argue that they should be changed in particular ways that would benefit them. This type of lobbying is socially costly as it can absorb the effort of senior managers and administrators.

Moreover, administrative costs are reduced for both the funder and the applicant when rules are simple and broadly based. For example, the tax concession has administrative costs of about 0.7 per cent of the value of assistance; the Discretionary Grants Scheme (which involved a significant element of assessment) had costs of about 4.7 per cent. In addition, there are the costs to firms in applying, which also tend to be higher for more selective schemes with complicated rules.

Research should be monitored and evaluated

Research should be evaluated both before projects begin and after they are completed.

The analysis of potential benefits is already quite common. The Tasmanian Government noted that some Departments have been preparing ex ante analyses of research projects since 1990. Although some problems had been encountered, it proposed that 'economic analyses be used as an integral part of assessing the potential returns to industry and the wider community' (Sub. 254). The Queensland Government gave details of a proposed benefit-cost procedure to be employed in the Department of Primary Industry based on formal benefit-cost analysis (Sub. 253, attachment 1, p. 2). A number of rural research corporations are using formal procedures for assessment of projects.

Such evaluation provides a degree of confidence not only that projects are being funded in order of merit, but that they are being funded for the right reasons. It is important, for example, that assistance serves as a mechanism for increasing the benefits to society from research (that would not be captured otherwise) and not simply become output assistance or income support.

Because specific outcomes from research are so difficult to specify in advance, retrospective analysis is essential. By looking at the characteristics of successful and unsuccessful projects, better judgments can be made about what is likely to succeed in the future. The Tasmanian Government noted that:

> *Ex post* analysis will always be more effective than *ex ante* analysis because there is better knowledge as to whether the project was a success and whether industry has adopted the innovation (Sub. 254).

Many organisations conduct evaluations of past research. The ARC examines the research it has funded under its large grants program. CSIRO has conducted, or commissioned, benefit-cost analyses of selected research projects and programs (see appendix QA).

The nature of evaluation will obviously differ depending on the type of research, and the capacity of funders to specify outcomes. Basic research is not generally amenable to benefit-cost analysis although it can have important long-term economic benefits (often flowing through applied research which has used basic research as an 'input').

To be most useful, evaluation must be conducted against objectives that are specified beforehand, and should encompass all projects that are funded — 'successes' as well as 'failures'. While evaluation can be costly, these costs can be regarded as an investment in knowledge about where resources are best allocated (or reallocated).

Assistance levels should be consistent in comparable circumstances

R&D support is provided across a range of programs and to meet a range of objectives. Where assistance is given in different places or sectors with a likelihood of inducing similar social benefits, however, it is important that assistance levels correspond. For example, assistance to encourage the production of research with broad, non-specific spillovers in one area of manufacturing should be given at broadly the same rate as assistance for similar research activities in another. And assistance for firms able to take advantage of the tax concession should not be different from assistance to firms in tax loss if the essential rationale is, or should be, the same.

That much is necessary to ensure that potential social benefits from additional expenditure are equalised across programs.

A problem with current funding arrangements is the potential for ‘cascading’ subsidies. For example, a subsidised rural research corporation may purchase research from a government research organisation which is itself subsidised. Or firms may use the 150 per cent tax deduction to purchase research from a university researcher who charges only the incremental cost.

Contestability should play a major role

The social benefits from research depend on its quality, cost effectiveness and the extent to which it meets needs and creates opportunities. It is important that government funding arrangements help ensure that, within the limits of available information and choice, taxpayers can get most value from the research that governments fund on their behalf.

That means that where practicable funding should potentially be open to all researchers who could do the job (that is, ‘contestable’) rather than being reserved for particular groups. Such competitive arrangements are quite common. The Australian Mining Industry Research Association (AMIRA) and the Rural Research Corporations shop around for those who might best deliver the research which meets the needs of their industry constituents. The ARC and NHMRC seek proposals for research of the highest standard and fund only the best (a small proportion) of those they receive. And, in the private sector, companies have a responsibility to shareholders to seek the best value from their expenditure or research, whether performed internally or contracted out.

Contestable funding can occur at different levels — from funding projects proposed by individual researchers, to the block funding of research institutions over specified periods of time (such as the CRCs). The choice among forms of contestable funding — and between them and other forms of funding — depends on:

- the ability of the funder to evaluate the relative merits of competing proposals against the objectives of the funding program;
- the costs of conducting the ‘contest’ — both administrative costs and the costs of researchers’ time in applying and reviewing the applications of others;

- whether there is a need for significant 'sunk costs' (like a nuclear reactor) which may make it risky or wasteful of resources to have competition;
- the potential for 'capture' of the funder by particular interests and the incentives for those seeking funds to take strategic action to obtain preferment.

The ability of a central funder to distinguish among projects will differ according to the nature of the research and its objectives. In the university sector, there is a long tradition of funding according to academic merit (excellence), as determined by peer review. This is appropriate to the educational role of university research and the diffuse nature of the benefits from basic research. In the business sector it is much more difficult to devise criteria by which a government agent can reliably distinguish among proposals according to their social benefits, and strategic behaviour by applicants can as a result be more prevalent.

There may also be limits to the competition that is desirable in some cases. For example, if some ARC funding were seen as a method of funding research which was an essential complement to the teaching role of universities, it may be inappropriate to extend competition for those funds to institutions which are not involved in teaching, even though they may be capable of research of equivalent merit and meet ARC criteria in other ways.

Some argue that researchers need certainty of funding to pursue long-term research with slow payoffs. This is clearly true in some cases and such research should not be penalised. However, funding can be provided in a way that supports institutions or long-term programs (rather than discrete research projects) but leaves open the possibility of such funding being allocated elsewhere after a fixed term. Some funding through the ARC for institutions (for example that for Research Centres and Centres for Teaching and Research) is currently funded in this manner. And some participants have raised questions about whether greater contestability among block-funded medical research institutions may be desirable.

It is also argued that, unlike in other areas of activities, competition can be destructive in the field of research, because it may inhibit productive cooperative arrangements among researchers. In some cases this may be a problem. However, contestable funding arrangements should not preclude collaborative proposals and indeed can be designed to encourage them, by allocating funds specifically for this purpose or giving priority to such proposals. The ARC currently provides grants for collaborative research on a competitive basis and funding for CRCs is also competitively awarded.

Government's objectives and roles should be clear

As well as acting to ameliorate problems associated with the provision of R&D in the economy as a whole, the government has a particular role as a sponsor of research associated with its own role as a policy-maker, provider of services such as defence, and custodian of community resources such as environmental amenity and public health. It is also generally better placed to fund research into Australia-specific needs and problems that cut across interest groups. In many of these areas, government sponsorship can also allow wider dissemination of research results of public benefit than would otherwise occur.

When government sponsors research activity, it is important that its objectives are clearly articulated and that the nature of its involvement is appropriate to the most effective attainment of those objectives.

In practice, the nature and extent of government involvement in R&D varies significantly, including:

- intervening in a relatively light-handed way, either by establishing conditions for private research or through across-the-board assistance (tax concessions for business investment) and untied block grants (for example, block grants for universities);
- using intermediaries to make decisions about support according to specified criteria (for example, the ARC for universities, the IR&D Board for the Industry Innovation Program);
- relying on research performers with only limited explicit guidance (for example CSIRO, where external earning targets apply as well as some earmarked allocations for small business and so on); and
- allocating funds to particular activities as it sees fit (for example some health projects such as aboriginal health and breast cancer, and some industrial research projects such as nanotechnology).

Governments choose different approaches according to the objectives they wish to achieve. Even when objectives appear to be quite similar, however, there can be marked differences in the extent to which government is overtly involved. In analysing this it helps to consider the three dimensions of R&D activity in which government can play a role:

- first is the determination of priorities: this ranges from decisions about the broad allocation of R&D funding in the economy, to the socio-economic priorities applicable to research within particular components of the system;
- second is the allocation of funds among research projects and research performers; and

- third is the performance of the research.

An important question for government is the extent to which responsibility for these elements of the R&D process should be separated.

A clear separation of roles is evident in some funding of university research, where the selection of projects is the responsibility of the ARC. Performers in institutions compete for grants. In effect there is a delegation of selection powers to an expert funder, which then offers contestable grants to performers of research which are again separate.

In contrast, government provides some support for R&D through block grants to institutions based on the numbers of students of particular types. In effect the government makes a policy decision about the level of funding and then leaves the allocation among (competing) research projects to the institutions themselves to carry out. The institution both allocates and performs the research.

In this case the government either implicitly considers that the priorities of the universities as funders are well suited to achieving national goals, or that decisions are best made in close proximity to the researchers, or that the amounts involved in project grants do not warrant the transaction costs of centralised allocation.

However, in the case of government research agencies such as CSIRO and the State departments of agriculture, the grounds for the lack of separation are not so clear. These appear to be precisely the circumstances referred to in the Rothschild report's basic principle that:

> ... applied R&D, that is R&D with a practical application as its objective, must be done on a customer-contractor basis. The customer says what he wants; the contractor does it (if he can); and the customer pays (Rothschild 1971, p. 3).

CSIRO in effect combines the roles of priority setter, purchaser and performer of research. This would be appropriate if it were clear that the incentives for project selection by the institution were likely to accord with those which would best progress the government's objectives (as the block grants to universities may do for teaching-related research).

In practice, the selection of projects by government research agencies faces difficulty first in discovering the relevant set of government objectives and second in selecting a set of projects consistent with any expressed objectives. Added to this is the question raised by many in industry as to whether researchers inevitably have their own agendas, which may or may not accord with wider priorities. The problem for the policy maker, however, is to know what research *would* best meet the needs of a diffuse set of stakeholders in industry and the community.

What all this suggests is that the role of government needs to be carefully thought through and decisions of different types delegated and separated where appropriate. Considerations raised previously in relation to the appropriateness of contestability — including skill and information requirements, and the relative costs — are equally relevant here.

In sum, the processes by which objectives and funding allocation criteria are determined play a critical role in determining the effectiveness of the research system as a whole. At the 'coal face', within particular research or funding institutions, decisions must be made and priorities will inevitably be set (or emerge by default). One question raised in this inquiry, however, is the extent to which priorities can be more effectively set at a higher level — that is, whether a 'national strategy' can be institutionalised to establish greater coherence in government's various roles. We return to this issue at the end of the report, after a more detailed examination of key components of Australia's innovation system.

PART B

GOVERNMENT RESEARCH AGENCIES

PART B GOVERNMENT RESEARCH AGENCIES

B5 DSTO

PART B GOVERNMENT RESEARCH AGENCIES

This part of the report focuses on the activities of CSIRO, which is by far the largest Commonwealth research agency. However, the Commission's proposals in respect of CSIRO should be applicable to many of the other agencies. The DSTO is considered separately, reflecting its special status as a provider of research services to Defence.

Chapter B1 describes briefly the structure of CSIRO and a sample of other government research agencies. It points out that while government research institutions play major roles in research, two agencies dominate — CSIRO and DSTO. It briefly discusses the rationale for government research and lists the main issues examined in subsequent chapters.

Chapter B2 is an overview of CSIRO. It lists participants' views about CSIRO's role, and the appropriateness and usefulness of its research. It then describes in more detail its functions and objectives, organisational structure, the type of research it carries out, and the way it is funded by Government and other users. Finally, the chapter outlines CSIRO's priority-setting procedures and the allocation of its funds to the priority areas selected by it for research.

Chapter B3 looks at some key issues related to CSIRO's research in more detail, including its role and its research agenda. It examines closely CSIRO priority-setting process, its effects, limitations, and the possible links between CSIRO's own priorities and external earnings. CSIRO's funding arrangements are described and their impact on the type of research undertaken. The value of CSIRO's research, the way the results are disseminated, and questions about CSIRO's size, structure and efficiency are then discussed.

Chapter B4 takes up the implications of the issues discussed in Chapter B3 and looks at some options for reform. It takes on board comments made by participants on proposals in the draft report for more contestable funding arrangements and examines alternatives for CSIRO and some other government research agencies.

Chapter B5 examines DSTO — its role, funding arrangements, priority-setting procedures, the extent of contracting out, and industry links. It also comments on the relevance of contestability and an external earnings requirement for DSTO.

B1 FEATURES OF GOVERNMENT RESEARCH AGENCIES

It has been observed that Australia stands out internationally in the proportion of its total research and development activity that occurs within the public sector. About 55 per cent of overall R&D expenditure is by government research agencies and higher education institutions. Over half of the public sector research is conducted within government departments and research agencies

Government research agencies exist and receive their substantial public funding because they seem to meet research needs which would not be accommodated by other research performers. To make the best use of public funds, government research agencies may have to interact closely with actual and potential users of their research findings and with other research performers. Interaction with other performers will in many cases also involve interaction with users. Firms undertaking their own research, for example, may also be potential users of government research agencies' work. Through their interaction with such firms, these agencies may learn how best to ensure that their contributions are a useful complement to private research effort. In other cases, research performers such as higher education institutions may have complementary research skills and expertise which offer the prospect of beneficial collaboration with government research agencies.

Getting the best out of government research agencies involves seeking mechanisms to achieve the best match between research done at public expense and the need for such research. It also requires putting in place arrangements to ensure that research is done cost effectively. These are the central concerns of this part of the report.

B1.1 A variety of government research agencies

There is a range of different types of government research agencies (see table B1.1). They include 'stand alone' agencies such as CSIRO, AIMS and ANSTO, established under Acts of Parliament and with their own boards, as well as in-house research bureaus which generally have some degree of independent research status, such as the BIE (within DIST), and the research bureaus (eg ABARE, and the Bureau of Resource Sciences) of DPIE. Agencies embedded in departments include DSTO (Department of Defence), and the Antarctic Division (DEST).

Table B1.1: **Selected government research activities, 1992–93**

Agency	*Status*	*Annual government appropriation ($ million)*	*Number of staff*	*External earnings requirement*	*External income ($ million)*
CSIRO	Stat. Corp.	456	7407	30% of income	237
DSTO[a]	Defence Dept	231	2600	none	na
ANSTO	Stat. Corp.	68	851	30% of approp.	27
Antarctic Division	DEST	65	282	nil	2
AGSO[b]	DPIE	55	522	25% of approp.	6.9
BRS[c]	DPIE	23	182	nil	2.8
ABARE[d]	DPIE	16	278	30% of its funds	4
AIMS	Stat. Corp.	14	147	30% of approp.	2
BIE[e]	DIST	3	67	nil	0.5
Victorian Govt. agencies[f]	Mostly State Depts. Some State Corps	127	830	na	na
Queensland Govt. agencies[g]	Includes most State Depts.	115	2292	na	50
Dept of Agriculture of WA[h]	State Depts.	40	500	na	13

a Staff number applies to 1995.
b The external earnings target is for 1993-94.
c Actual 1992-93 expenditure from appropriations, staff data are for 1994, and BRS does not have any official external earnings target, but its appropriation will be reduced by 30 per cent by 1996.
d Budget funding (net appropriation), ABARE staff are permanent full-time employees.
e Staff number is current, and external incomes also include revenue from publications (small).
f See Sub. 241 for various departments and staff details.
g Staff covers all Queensland departments employed in research, development and application (see Sub. 253).
h Staff data are for 1994.

Sources: Cook 1994a; DPIE, *Annual report* 1992-93; DITARD *Annual report* 1992-93; Submissions (241, 253); Marinova 1994; McKinnon 1993 and information from agencies.

Some of the research agencies do scientific research while others do social/economic research. Some have charters to do independent research while others directly underpin the policy function of the parent department (see table B1.2).

Table B1.2: **Key research functions of selected Commonwealth research agencies**

Agency	*Key functions*
CSIRO	Carry out scientific research to assist Australian industry and further the interests of the Australian community; and to encourage or facilitate the application and use of the results of its own or any other scientific research.
DSTO	Undertake research and provide scientific and technological advice to the Department of Defence to meet Australia's defence and security needs.
ANSTO	Undertake R&D in nuclear science and associated technologies.
Antarctic Division	Research on the Antarctic region.
AGSO	Undertake national geoscientific mapping effort to encourage economically and environmentally sustainable management of Australia's minerals, energy, soil and water resources.
Bureau of Resource Sciences	Provide technical advice to government, industry and the community to support sustainable development of agriculture, mineral, petroleum, forestry and fisheries industries.
ABARE	Undertake policy research, projecting and forecasting developments in commodity markets, and collect data to provide economic information of relevance to primary and energy industries.
AIMS	Generate new knowledge in marine science and technology, promote its applications to industry, government and ecosystem management; and disseminate the knowledge, collaborate effectively, and assist in the development of a national marine science policy.
BIE	Undertake applied research on policy issues affecting industry.

Sources: Derived from Cook 1994a; Annual reports (CSIRO, DITARD); and Sub. 196.

The government research agencies are organised in various ways with different degrees of autonomy. Some have external earning targets and some do not. Even those external earning targets are based on different starting points — CSIRO's external earnings target was set at 30 per cent of total income, while ANSTO's and AIMS' are at 30 per cent of appropriation funding.

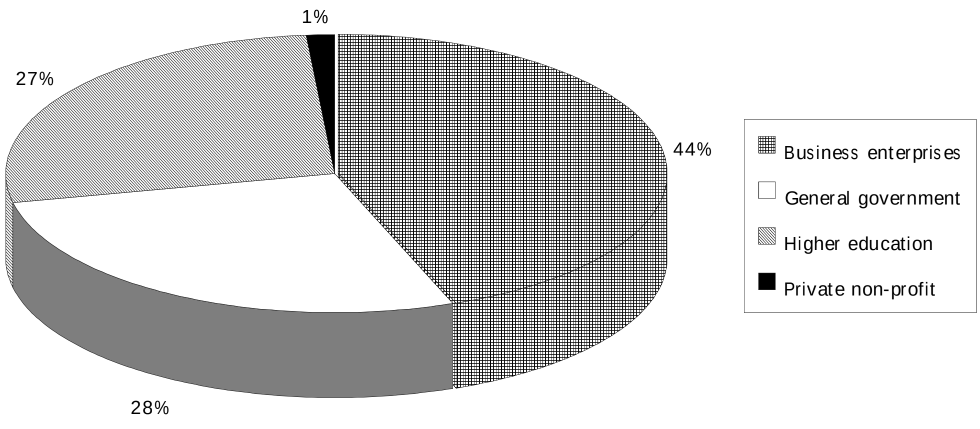
Some of these agencies undertake similar research in the same field, or have the capacity and expertise to do so. For instance, marine science research is undertaken both in CSIRO and AIMS. Minerals resources research is undertaken in both CSIRO and AGSO and also by State geological survey offices. CSIRO and all State departments of agriculture undertake agricultural research. Even from these few examples, it is clear that CSIRO has the widest charter among these agencies.

B1.2 Government research agencies have a major role

In 1992–93, Government research agencies' (Commonwealth and State) expenditure on R&D amounted to some $1 744 million; this was around 28 per cent of overall R&D expenditure in Australia (see figure B1.1). Government research agencies and higher education institutions accounted for 55 per cent of all R&D expenditures. This is high by international standards. State governments play a major role in agricultural R&D.

Of the general government R&D expenditure, around 65 per cent was attributable to Commonwealth agencies and 35 per cent to State agencies. The key research functions of certain Commonwealth agencies are given in table B1.2.

Figure B1.1: **R&D expenditure by sector, 1992–93**

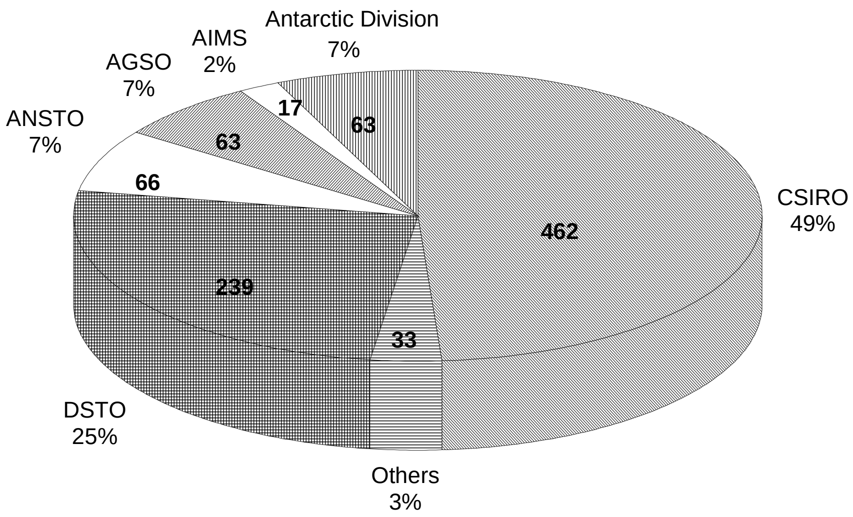


Note General government consists of Commonwealth (18%) and State (10%).
Source: ABS, Cat. No. 8112.0.

CSIRO and DSTO dominate

CSIRO and DSTO are the largest of the Government research agencies involved in R&D. Their dominance is evident from figure B1.2, with CSIRO taking up nearly half and DSTO[1] about 25 per cent of the Commonwealth's budget outlays for research agencies in 1994–95. The largest five organisations (CSIRO, DSTO, AGSO, ANSTO, and Antarctic Division) together accounted for 95 per cent of the total outlays.

Figure B1.2: **Major Commonwealth scientific research agencies – estimated budget outlays for 1994–95** ($ million)



Source: Cook 1995a, Table 4, p. 3.14.

There is, however, a large number of other Commonwealth and State government agencies involved in R&D. The Commonwealth's R&D involvement includes investments in or through the Bureau of Meteorology Research Centre (budget estimated outlay for 1994–95 was $3.7 million), Supervising Scientist — Alligator Rivers Research Institute ($6.4 million), Anglo-Australian Telescope ($3.0 million), Australian Institute of Health & Welfare ($8.1 million excluding grants), Nuclear Safety Bureau (0.8 million). In addition, the Commonwealth funds the Bureau of Resource Sciences, ABARE, and the BIE (see table B1.1).

1 DSTO expenditure estimates for 1994-95 include an attributable superannuation component from other Defence appropriations.

While there is a very large number of Commonwealth and State government agencies involved in R&D, expenditure is highly concentrated within a few of these agencies (see figure B1.2).

B1.3 Sources of funds

Since 1987–88 there has been a significant move away from government funding (especially in CSIRO, ANSTO and AIMS) to greater dependence on external revenue sources. However, the Government remains their main source of income, which is allocated in the form of a block appropriation.

The Government has set specific external earnings targets for some Government research agencies. CSIRO was set a target in August 1988 (to achieve 30 per cent of total income by 30 June 1991), ANSTO in November 1990 (to achieve 30 per cent of appropriation funding by 30 June 1994), and AIMS in November 1990 (to achieve 30 per cent of appropriation funding by 30 June 1996). AGSO also had an external earnings target of 25 per cent of appropriations for 1993–94, and the target is 30 per cent for 1994–95.

These requirements have led to a steady increase in external income earned by these Government research agencies. CSIRO's external earnings, for example, increased from about 23 per cent of total income in 1987-88 to about 33 per cent in 1992–93, and ANSTO's from 23 per cent of total appropriations to 39 per cent[2] over the same period. While AIMS' external earnings for 1992–93 was 15 per cent of its appropriations, ASTEC noted that AIMS expects to meet the target by 1995 (ASTEC 1994e).

While termed 'external earnings', in the case of CSIRO and AIMS, the bulk of it nevertheless comes from other government or government funded agencies such as Commonwealth departments, CRCs, State Governments, and RDCs. CSIRO's direct receipts from the Australian private sector remain relatively small but have shown the most rapid increase of all the categories, growing from about $20 million or 4 per cent of total funds in 1988–89, to about $75 million or 11 per cent in 1992–93. For AIMS, 2.5 per cent of total income in 1992–93 came from the private sector (including overseas sources).

Recently, there have also been pressure on some research bureaus to obtain funds from external sources. For example, in 1993–94, ABARE has been set an external earnings target to obtain 30 per cent of its funds from external sources. The amount of external funds ABARE generated in 1992–93 was 20 per cent of

2 If expressed in the same way as the CSIRO target, that is as a percentage of total expenditure, external revenue for ANSTO would be about 19 per cent for 1987-88 and 28 per cent for 1992-93 (ASTEC 1994e, p. 17).

its total budget. These funds, however, were not linked to any explicit government targets (Sub. 196, p. 52). The Commission understands that no official target has been set for the Bureau of Resource Sciences, but its appropriations will be reduced by 30 per cent by 1996.

B1.4 Why government research?

The rationales for and approaches to government intervention in R&D in general (that is whether to sponsor or perform research) were outlined in Part A of this report. It was noted that, in general terms, governments should only sponsor or perform research when there is likely to be a sufficiently high social payoff, and the research might not otherwise take place. Reasons for this might be:

- the research is socially beneficial, but would not otherwise be performed because of lack of privately appropriable benefits;
- the potential social benefits are such that it is better to have public provision and wide dissemination than private provision and restricted diffusion; and
- it is more cost effective to do it in the public sector.

The first two reasons relate to the public good nature of research. One dimension of a public good is that it is impossible or very costly to exclude additional users from enjoying the benefits of the good. This makes it very difficult for a private producer to appropriate financial rewards for supplying the good — and they are therefore unlikely to supply it. Pure basic research is a commonly cited example. But, as noted, there is no line which delineates the boundary between public good research and research whose results are appropriable by the private sector. And, in the absence of private interest, the question of what particular research topics should be pursued by government (having the highest net social payoff) is very difficult to answer. Nevertheless, governments need to find ways of choosing, and a fundamental issue is whether it is sufficient to allow the research agency itself to choose what research it does.

Where it is clear that government must sponsor research — whether for its own policy-related needs or to meet its responsibilities for the environment or natural resource management or industry development— a question remains as to whether it should do the research itself or simply fund others to do it.

By performing R&D in-house, the government may reduce (by internalising) a number of potential transaction costs. For example, in some instances the costs of contracting out (relative to in-house R&D) may be large due to the costs of obtaining information about potential R&D producers, assessing bids, determining prices and the timing of the research work, working out the finer details of the contract and monitoring the provider's research output and quality.

Some types of research require large capital investments and may have natural monopoly characteristics. In a relatively small market like Australia, having one producer in such cases may well be efficient. And if that producer were to be a private company it might fail to disseminate the results of its research fully in order to increase its market value. For some forms of research it may be that undertaking it in one large multi-disciplinary organisation creates the necessary critical mass and reduces transaction costs. In other areas, smaller multi-disciplinary (public or private) organisations may still be able to reap economies of scale and scope, while bringing extra flexibility and cost efficiencies.

Issues in assessing government research agencies

Having considered the threshold question of their role, or rationale for existing, the next issue is whether government research agencies are likely to be doing the most appropriate research. This in turn depends on two interrelated issues: how their research agendas or priorities are established, and how they are funded.

Most agencies have traditionally been block funded and some have received little guidance from government about research priorities, so that they have determined their own priorities. CSIRO has recently adopted a sophisticated priority-setting process and ANSTO has followed its lead.

Nevertheless, concerns about the 'relevance' of these and other agencies' research has led government to impose external earnings requirements on them. Whether the external earnings requirement is desirable can only be answered in the context of the agency's primary role. ASTEC has conducted a recent review of this requirement, which the Commission has drawn on in making its own assessments.

An advantage of the requirement to obtain external earnings is that it ensures that at least that part of the agencies' research is responding to a specified need. A possible problem with this approach is that government may end up doing research with privately appropriable benefits that would have been conducted anyway. However, not all external income is derived from the private sector. Indeed a substantial proportion comes from government contracts. There is a question as to whether more of the government funding of its agencies could be tagged for defined research needs on the community's behalf.

Another related issue is the cost-effectiveness of the research performed by government agencies. Within the private sector, competition creates an obvious incentive to be as productive and low-cost as possible in producing goods and services. In recent years, the benefits of extending competition to the public sector have been recognised by governments and reform is now being pursued systematically. Chapter A5 of this report discussed why competition or contestability may also be beneficial in relation to the R&D activities of government. And indeed, as noted, government agencies already compete for a proportion of their funding. Questions that need to be addressed include how to ensure that any such competition is productive — that it does not suppress necessary cooperation (eg between CSIRO, universities, other agencies and companies) — and, for a given agency, what balance should be struck between contestable and non-contestable funding.

A further issue in assessing the role and performance of Government research agencies is the extent to which there is dissemination of the results of their research activities. As already suggested, one of the justifications for government research is that it can be made widely available. The avenues for dissemination include:

- ‘encoded knowledge’ in papers, articles, patents;
- exchanges of and communication among researchers (moving among organisations, but also meetings, workshops, conferences and joint projects); and
- production of goods and services.

The first two mechanisms will generally be the most appropriate for the direct involvement of these agencies, but an important outcome from some research will also be better delivery of services by government, and the formulation of new or reformed policies. Indeed, in the case of DSTO, its rationale relates primarily to a key government service — defence (which is itself a public good), precluding dissemination of much of the knowledge it generates.

The following chapters consider these and other issues in relation to the two agencies that dominate public sector research, CSIRO and DSTO (the operations of some other Government research agencies are described in appendix C).

B2 CSIRO: AN OVERVIEW

B2.1 A unique Australian institution

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a unique Australian research institution. It is by any measure a major research establishment. In 1993–94, it spent just over $700 million, funded by Government appropriations of about $461 million and non-appropriation funding of about $246 million. It employs about 7400 people, including 3300 professional and 2300 technical staff.

It has an important role in Australia's national innovation system, providing research services to the community and to industry, and scientific advice to governments.

CSIRO's roots go back to 1916, when the Commonwealth first assumed responsibility for scientific research and established the Advisory Council on Science and Technology (Currie and Graham 1966). The Council was set up after the Imperial Government in Britain established an organisation for scientific research in July 1915, to assist in its war effort. When news of this reached Australia later in the year, scientists in Melbourne sought to establish a similar scheme in Australia.

The Advisory Council on Science and Technology became the Council for Scientific and Industrial Research in 1926, and its objectives were:

> ... to promote scientific research for the benefit of primary and secondary industries, and to encourage the pursuit of 'pure' scientific research ... (Schedvin 1987, p. 1).

At that time, State departments of agriculture carried out some scientific research to support agriculture, and all States had universities with at least some research capability (although the first Australian PhD was not conferred until 1946). Among the arguments put forward for the Council were the perceived need for an organisation to:

- coordinate scientific research beyond State boundaries to tackle common cross-State problems such as cattle tick, prickly pear and bunchy-top of bananas; and to
- undertake applied research (and thereby avoid the need to rely on the universities, which were perceived as having primarily teaching responsibilities as well as undertaking some 'pure science') (Schedvin 1987).

CSIRO was created as an independent statutory authority in 1949 to succeed the Council.

CSIRO's role, structure and operations have changed somewhat since then. Similarly, while some other countries also set up government research organisations at about the time CSIRO's predecessor was established in 1916 — New Zealand, South Africa, Canada, India and Pakistan, for example — these have since been reorganised following various reviews. Indeed, the original British Department of Science and Industrial Research no longer exists.

As a result, CSIRO is now somewhat unusual in the world. Many governments fund their research agencies on a program or project basis (and may also provide scope for competition in the supply of research). In contrast, Australia has, in CSIRO, a research agency which dominates the supply of government funded research across a wide range of fields, and which is largely funded by way of a single appropriation. The advantages and disadvantages of this have been matters for debate among participants.

It has been the subject of many reviews

CSIRO has been the subject of several inquiries since the 1970s, and successive Government decisions have shaped and reshaped the organisation:

- A review in 1977 by Professor A. J. Birch concluded that its main role should be scientific and technological research in support of Australian industries, community interests and other perceived national objectives and obligations. He stated the principal type of research conducted by CSIRO should be strategic mission-oriented, but that fundamental and tactical problem-oriented research should be undertaken when related to CSIRO's main role.
- In contrast, an ASTEC review in 1985 concluded that CSIRO should be more active in applied research and experimental development than its counterpart bodies overseas, that its main role should be in applications-oriented research (with more emphasis on the effective transfer of research results to end users), and that research groups conducting pure basic research not linked to CSIRO's major objectives should be considered for transfer elsewhere.
- In 1986, following the Birch and ASTEC reviews, the legislation governing CSIRO's activities was amended to establish a formal Board structure with a Chief Executive appointed by the Governor-General reporting to it, as well as allowing for the establishment of up to six Institutes.

- In 1987 CSIRO commissioned McKinsey & Co to review its top management structure. The review, commonly referred to as the *Model Institute Study*, provided a blueprint for the Institute and Division-based refocussing of CSIRO.
- The McKinsey report recommended a further review of the division of corporate functions between central administration and the Institutes and Divisions. This was carried out in late 1987 and early 1988 by Pappas, Carter, Evans and Koop (1988), and implemented during 1988.
- In 1987-88 the Government reduced its funding of CSIRO. In August 1988 it set a target for CSIRO to obtain 30 per cent of its total funding from external sources (to be achieved by 30 June 1991, the end of the first triennium funding period), ‘to promote linkages between CSIRO and its potential users’. Since 1986-87 Government appropriations to CSIRO have decreased in real terms on average by about one per cent per year.
- In a 1991, report the Auditor-General reviewed the 30 per cent requirement, noting the increased emphasis which CSIRO had given to commercial activities. It expressed concern about the use of appropriation funds to further subsidise externally–funded research activities.
- The effects of the earnings target were again reviewed in a 1994 *Review of the Operations of External Earnings Target for CSIRO, ANSTO and AIMS* conducted by ASTEC.
- In 1994, the Auditor-General’s report, *CSIRO — Follow-up of an Efficiency Audit of External Funds Generation*, recommended some changes to improve CSIRO’s external funds generation activities.
- The inquiry into rural research funding by the Senate Standing Committee on Industry, Science, Technology, Transport, Communications and Infrastructure made comments about and recommended on the adequacy and appropriateness of this funding, as well as CSIRO’s structure and administration (see box B2.2).

Community views on CSIRO’s role and performance

Over recent years, the research requirements of governments and industry have changed, and CSIRO has endeavoured to respond to those changes. In part this has occurred as a result of internal decisions about the appropriate direction to take; in others the pressures from outside the organisation have been more direct. For example, faced with budgetary constraints governments have required CSIRO and other government research agencies to earn more external revenue and to become more ‘relevant’ to the marketplace, while at the same time continuing to undertake research of a ‘public good’ nature. The objective of the external earnings requirement is to promote links between government research agencies, industry and other research agencies (ASTEC 1994e, p. 2).

But notwithstanding many reviews — some external and others initiated by CSIRO itself — there continues to be debate about CSIRO’s appropriate role and the directions its research should take. Indeed, it has become clear to the Commission that confusion about CSIRO’s role exists both within the organisation and in the broader community. It arises partly because, in the absence of direction from outside, CSIRO is required to set its own research priorities, and partly because of differing perceptions about its role in assisting industry and the success of its endeavours to meet the external funding requirement.

Participants expressed a variety of views about the usefulness of CSIRO to industry, and about the appropriateness of its research. Many praised the high quality of CSIRO’s research work in, for example, agricultural and minerals research. The Wool Research and Development Corporation said that CSIRO had, over the last 40 years or so, developed outstanding specialised knowledge and ability (transcript, p. 466). In 1992–93 CSIRO performed 60 per cent of the research commissioned by the Corporation.

Similarly, the Cattle Council of Australia said:

> CSIRO is an extremely valuable resource to Australian agriculture. The fundamental scientific research undertaken by this body has led to a host of new technologies and helped to lift the performance of the beef industry (Sub. 183, p. 6).

It listed some notable CSIRO research successes (some jointly funded by the Meat Research Corporation) — the introduction of stylo legumes and disease resistant lucerne in Queensland, the development of the Belmont Red cattle breed, tick research and electrical stimulation for carcases. In 1992–93, CSIRO performed 20 per cent of the research commissioned by the Meat Research Corporation. Box B2.1 lists some recent CSIRO scientific discoveries and achievements.

CSIRO’s work for the mining industry was also praised by participants. Dr Hickman stated:

> ... the Australian mining industry is regarded worldwide as being technology leaders ... a significant reason for that has been that there has been a tradition in the tertiary institutions and in CSIRO, going way back, of working very closely with industry which has never existed in many other faculties ... We’re only starting to get that now in other disciplines (transcript, p. 878).

Box B2.1: Some recent CSIRO discoveries and achievements

1. *Gene shears* technology that can 'switch off' genes that produce harmful or undesirable characteristics and has large implications for plant, animal and human health.

2. An anti-influenza drug which is now undergoing clinical trials and has the potential of treating all strains of the flu.

3. The *multibeam antenna* which can communicate with up to 20 satellites at once, making communications links more cost-effective.

4. *Active packaging* techniques to keep flowers, fruit and vegetables fresher for longer.

5. CSIRO technology to process magnesium into a range of value-added products, including lighter engines and components for cars.

6. *Sirosmelt* technology that is a cleaner, cheaper and more efficient method of producing tin, copper, lead and zinc.

7. *Microbrain* software system which processes satellite images to monitor erosion, crops, forests and other vegetation.

8. The *Smart Battery Tester* which rates a battery's condition quickly and simply, and is now selling in the international marketplace.

9. *Coalscan* - a set of instruments for analysing minerals and coal.

10. Waste management technologies like *Plascon* (for destroying toxic wastes) and *Sirofloc* (for cleaning water, sewage and industrial waste) that improve the environment.

11. Development of vaccines that treat cattle tick, the sheep blowfly, worm parasites, and other livestock and poultry diseases.

12. The *Synchro-Pulse welder* which has won an Australian design award.

Source: Information provided by CSIRO.

However, some participants drew attention to the difficulty in determining exactly what CSIRO's role is (or should be). For example, Biotech Australia said:

> ... hardly any western country now has such a large single research organisation aimed at so many different objectives ... the problem ... is knowing exactly what their objectives are, and how ... each one is managed.
>
> Obviously there are objectives with the CSIRO which are academic research objectives [which] ... they can do ... more efficiently than a university.... There are objectives in the CSIRO which are ... like social objectives that no industry would really want to get involved in that kind of R and D - it may be very long-term, very speculative, but

> needed for social and maybe longer-term economic reasons, and that's a completely new set of objectives which should be clearly defined.
>
> But it's hard to know why the CSIRO should be involved in ... industry research — if it's not actually being controlled by industry (transcript, pp. 999-1000).

Several participants criticised CSIRO's ability to respond quickly to industry's changing research needs. Techniche Ltd said:

> The window to market opportunity is exceedingly short. You have to do things terribly quickly. Our experience with CSIRO ... is that by the time they just get organised and decide what to do the market window is often closed (transcript, p. 1746).

The Meat Research Corporation said:

> ... a big structure such as the CSIRO which has strong centralisation is reasonably good at doing strategic research, but poor at responding to things that need sudden attention, with little incentive for the people within it to go out and work for industry. CSIRO researcher(s) get their reputation out of international recognition; they don't get much recognition - although I think it's changing in CSIRO - they don't really get much reputation within CSIRO for doing a good job for Joe Bloggs' abattoir down the road.
>
> So the incentives are wrong, the structure is wrong and [relevant research] just wasn't happening (transcript, pp. 1555-6).

Some participants (eg Cattle Council of Australia) questioned the value of an artificial external earnings target, while others expressed concern about its impact on CSIRO's research agenda. For example, the Department of Commerce and Trade (WA) said that:

> The 30 per cent external funding requirement is clearly leading to problems in terms of the direction of CSIRO ... The result of that seems to be a Board which is increasingly anxious and increasingly interventionist in its approach to the management of CSIRO, which I think is detracting from the capacity of the various institutes to run their own business and to define their own business in a way which is really effectively interacting with their client group - because there is this high level of intervention from a board level (DR transcript, pp. 2000-1).

Some CSIRO staff are said to have concerns that CSIRO's role has been changing to become a short-term consultant to industry because of the 30 per cent external earnings requirement. The Australian Coal Association said that some CSIRO staff:

> ... are very concerned that they may finish up - using their own words - being contractors to the industry, rather than independent researchers. They really feel very strongly that they don't want to just become contractors a la the New Zealand Crown Research Institutes and they want to maintain a certain independence and always have a role in doing basic research (transcript, p. 1707).

CSIRO management recognises the difficulty of changing staff attitudes in becoming more responsive to industry's changing needs:

> Changing the culture of any organisation can be a slow process, and this is certainly true of a scientific research organisation that depends on the expertise of highly trained staff. These staff often have to enter and operate in an entirely new world.

But it added:

> Further effort is needed to convince many potential users of CSIRO's services of the changes that have already occurred, as their perceptions have not been keeping up with the pace of change (Sub. 113, p. 20).

These concerns were also evident in public discussion prior to the 1994–95 Budget, when the possibility emerged that the $20 million per annum of infrastructure allocation expected by CSIRO for its second triennium funding may not be approved. Such difficulties may be interpreted as indicating uncertainties within Government about CSIRO's role and the benefits from funding its research relative to meeting other community needs. In the draft report submission, the Australian Industrial Research Group (AIRG) said that:

> The 'confusion' about CSIRO's role derives largely from the lack of a clear statement or direction from government about its expectations and vision for CSIRO. Customer orientation falls off as one moves down through the organisation (Sub. 329, p. 2).

The University of Adelaide said:

> The University has found the confusion over the CSIRO role to be a problem in negotiating with CSIRO with regard to CRCs (the university is in a number of CRCs jointly with CSIRO) and the Waite co-location (Sub. 287, p. 2).

In 1994, the Senate Standing Committee on Industry, Science, Technology, Transport, Communications and Infrastructure conducted an inquiry into the adequacy and appropriateness of the operations, funding and resourcing of CSIRO's research relating to rural industries (see box B2.2 for the main recommendations on structure, funding (including external targets), and commercialisation. (Also refer Senate Economics References Committee 1994 for full recommendations.)

The Senate inquiry was set up in the wake of dissatisfaction by some scientists, users of CSIRO's research and members of the community with the likely effects on CSIRO's operations of:

- the $20 million per annum cutback from the triennium funds that were expected by CSIRO;
- reduced external earnings available from some external sources (for instance the wool industry); and
- the higher priority CSIRO was giving to activities such as research into manufacturing, information and communication industries, relative to that for rural research.

The terms of reference of the Senate inquiry suggest a wider concern about other CSIRO issues, such as its management structures and private funding impacts on rural research, although they do not seek a review of the broader rationale for CSIRO's research. There was wide interest in the Senate inquiry — it received 166 submissions, of which about half were from CSIRO staff — many expressing concerns about CSIRO's current operations and role. The views expressed by participants to the Senate's inquiry and to the Commission's broader inquiry point to CSIRO performing well in some areas of research, but not in others, where its research relevance and performance are questioned. In addition, participants raised concerns about the extent CSIRO is able to perform its role well under the current arrangements and with its current structure. The Commission reviews some of these concerns in Chapter B4.

A CSIRO Board Evaluation Committee recently conducted an evaluation of CSIRO's management and its structure. It examined ways to better define its goals with government on a regular basis, and to establish better processes to determine its other customers' expectations, as well as develop measures to assess its performance. The Board Evaluation Committee published a discussion paper on 3rd April 1995 (see chapter B4 for further details).

In sum, despite the many reviews of CSIRO and continuing evidence of its capacity to produce research of high quality in a range of areas of importance to Australia, there remains pervasive uncertainty and confusion about its proper role and its performance. These are closely related, and the Commission, like many others, has given some consideration to CSIRO's role, as a necessary requirement for evaluating aspects of its performance and how its contribution might be enhanced. Before considering what that role might be in Chapter B4, the remainder of this chapter sets out the key features of CSIRO's existing arrangements.

B2.2 How CSIRO operates

Its functions and objectives

CSIRO's role has evolved over time. In its early years it had a narrower scientific focus, concentrating mainly on agricultural research. But it has been subject to many changes in structure and focus, and it now has the widest range of research responsibilities of any government research agency in Australia or overseas. CSIRO is not active in research in some areas (such as clinical medicine), and only marginally involved in nuclear science research (which is primarily an ANSTO responsibility).

Box B2.2: **Some recommendations of the Senate Committee**

Structure and administration:

The Board of CSIRO must take a stronger role in the leadership of CSIRO. The Board's current review of the management structure should, as a priority:

- restructure CSIRO to reduce the layers of management, including modifying or eliminating the institute structure;
- introduce a 'business line' model of the structure based on having direct communication with workplaces within CSIRO;
- institute a similar mechanism for staff appointments to the CSIRO Board as applies under the *Australian Broadcasting Corporation Act 1983*.
- set up a new administrative structure around the CEO to replace the Executive Committee based on the Board, leaving internal administrative matters to the CEO and such new structure;
- introduce a world best practice program of management across the organisation, including industrial participation;
- clarify its formal reporting mechanisms to the Minister; and
- as part of this process of streamlining of administration, report on how excessive accountability can be reduced.

Funding and the external earnings target

- CSIRO re-instate the high priority ranking of rural research and ensure that the share of appropriation funding of rural research is increased to commensurate with that ranking;
- the Government commission an independent study of the system of rural levies, which would focus on how they are applied to research in both on-farm and post-farm sectors, and how the system could be expanded to include industries not currently contributing to, but benefiting from, CSIRO research.
- the CSIRO Board conduct an assessment of the way in which the 30 per cent funding target has altered the ratio of fundamental to applied research.

Commercialisation

- the CSIRO Board commission a study to determine further ways in which CSIRO can limit its legal liability arising from commercialisation of its research;
- CSIRO clarify its respective roles in 'commercialisation' and 'development' and make its policy in these areas clear to its staff and its stakeholders; and
- CSIRO examine ways in which its research results can be transferred to the rural sector, given the demise of State extension services.

Source: SERC 1994.

CSIRO operates as an independent statutory authority under the *Science and Industry Research Act 1949* (amended in 1986, following the ASTEC review). Its primary functions are:

- to carry out scientific research
  - to assist Australian industry and to further the interests of the Australian community;

  - to contribute to national and international objectives and responsibilities of the Commonwealth Government;

- to encourage or facilitate the application and use of the results of its own or any other scientific research (CSIRO, *Annual Report 1992-93*, p. 9).

CSIRO's primary functions require it to meet the broad research needs of industry and the community generally, as well as to encourage the diffusion and use of its research results.

Its secondary functions include international scientific liaison, training of research workers, publication of research results, and the dissemination of information about science and technology.

The discretion given to CSIRO under the legislation is wide. Specific direction is not given as to the type of research and development or mechanisms for diffusion of technology.

However, the powers and functions of CSIRO are subject to the regulation and approval of the Minister, who can refer any matter to CSIRO for action, or give specific direction on priorities for research, by way of Ministerial directions. The current Ministerial guidelines for CSIRO include directions that:

- CSIRO will ensure that research activities in areas of significance to national economic development receive preferential support;
- CSIRO's research priorities will be planned with due regard to the industry and research policies and priorities of the Government;
- CSIRO will maintain a distribution of effort in accord with the Government's policies and priorities in relation to research in support of existing industries, and research which will contribute to future balanced national development; and
- CSIRO will establish procedures to identify promising areas of research as part of its strategic planning process.

(CSIRO 1994a *Submission to Senate Inquiry*, attachment 3).

The guidelines clearly place emphasis on the need for CSIRO to follow the priorities of the Government. At issue, however, is the extent to which such priorities are adequately articulated under current arrangements. This is a central consideration and is addressed later in this report.

To carry out its functions, CSIRO has established five corporate goals for its research programs; namely, to:

- improve the competitiveness of Australia's primary and manufacturing industries;
- develop ecologically sound management principles and practices for the use and conservation of Australia's natural resources;

- achieve sustainable development in production systems and develop technologies to protect the environment;
- improve the competitiveness of the information and communications industries; and
- enhance productivity and effectiveness in the provision of infrastructure and services (CSIRO, *Annual Report 1992-93*, p. 8).

Organisational structure

Figure B2.1 shows CSIRO's organisational structure and its main areas of research activity as at April 1995.

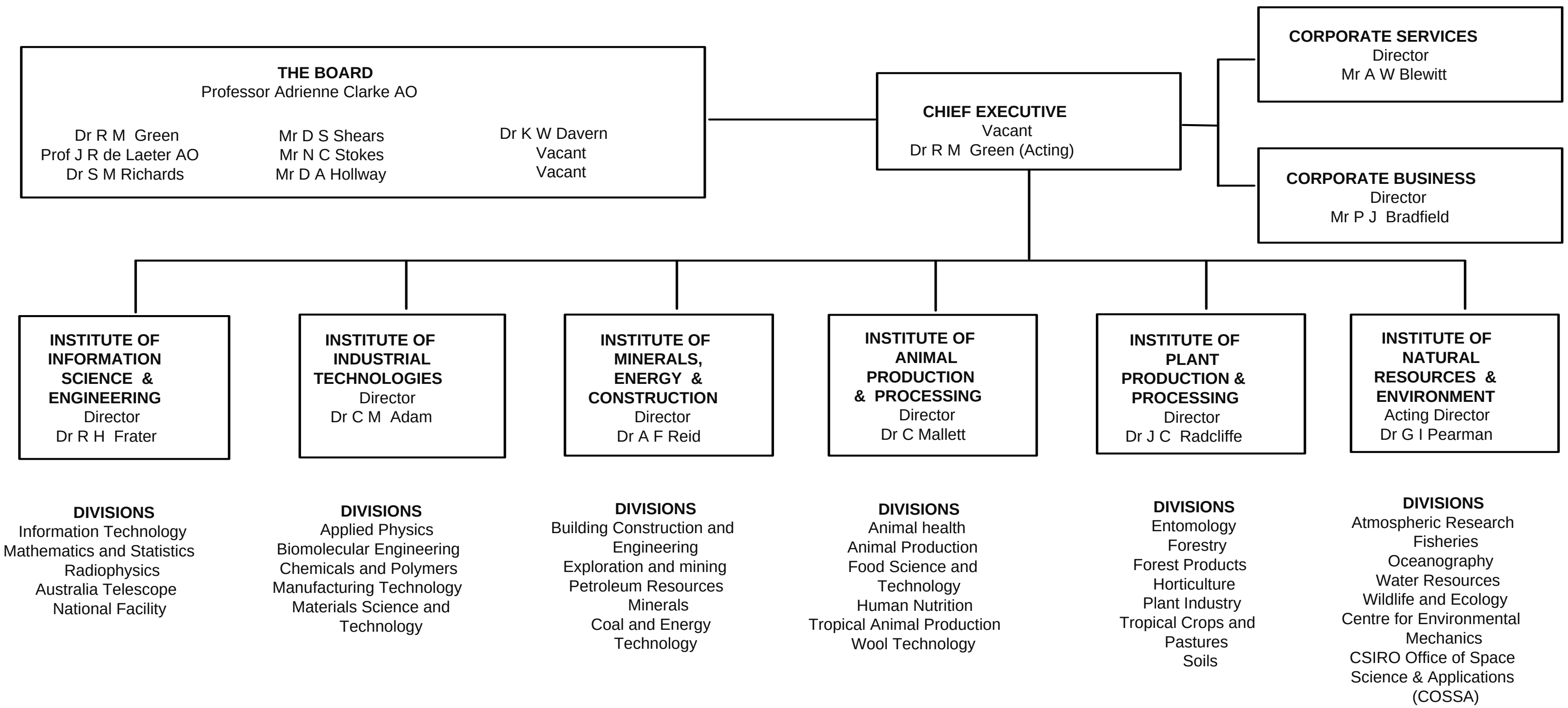
The current structure reflects the impact on CSIRO of two key reports — the Birch (1977) and ASTEC (1985) reports. The Birch report recommended that the Divisions be grouped into Institutes, the number of which should not exceed six (Birch 1977, recommendation 27, p 49). The legislation was accordingly changed and five Institutes were established initially, predominantly along scientific discipline lines. The subsequent ASTEC report recommended a more commercial and customer orientation for CSIRO, with a structure which retained Institutes but related primarily to existing and emerging industry sectors rather than to scientific disciplines (ASTEC 1985, p. 51). A Board was recommended to replace the Executive with leadership provided by a part-time Chairman and a full-time Chief Executive. All other Board members were to serve part time and to be drawn from outside the Organisation (ASTEC 1985, p. 47).

A study by McKinsey was commissioned by the new Chief Executive at that time, Dr Boardman, to identify a revised Institute and Division structure. This study confirmed the placement of the Divisions into the six Institutes along commercial, customer and socio-economic alignments resulting in the current six Institutes and 32 Divisions (reduced from 41) as shown in figure B2.1.

What R&D does CSIRO do ?

In 1993–94, CSIRO spent about $705 million on its research programs, equal to about 11 per cent of Australia's total R&D expenditure. Its activities comprise about half of the Commonwealth's total funding for its own research agencies, and a significant part of the Commonwealth's total spending on R&D.

Figure B2.1: **CSIRO's Organisational Chart, as at 26 April 1995**



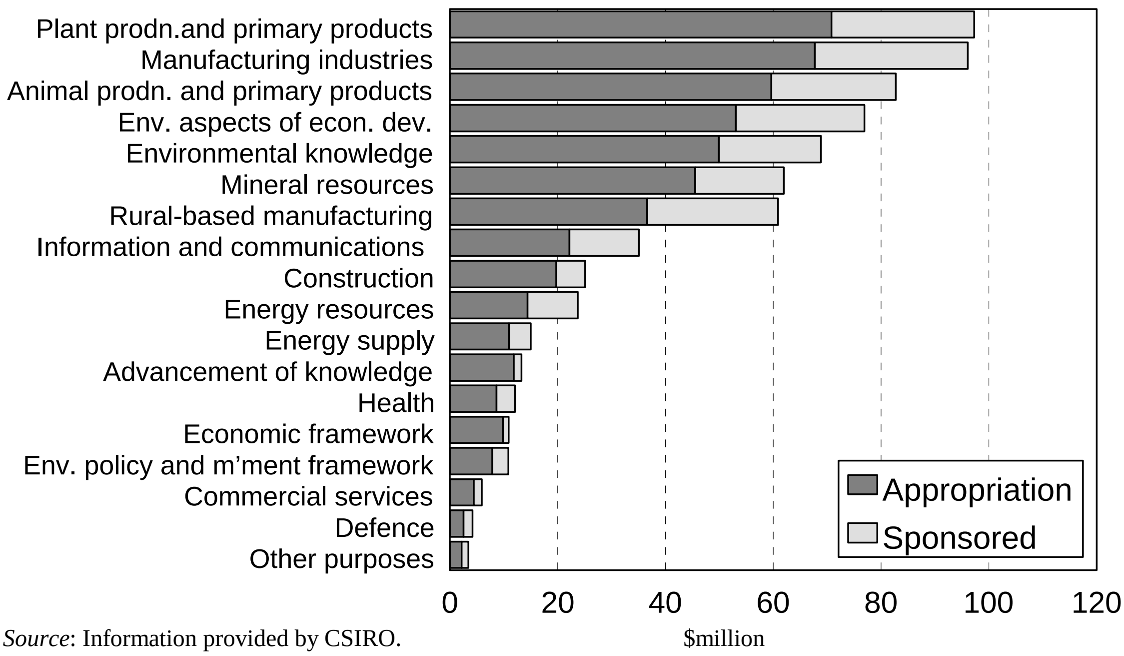
Source: CSIRO, April 1995.

CSIRO's research by socio-economic objective

For use in planning and reporting its research, CSIRO has adapted the *socio-economic objectives* classification of the Australian Standard Research Classification, produced by the ABS. This classification identifies the purpose for which the research is carried out. Figure B2.2 shows the main areas of CSIRO's research effort classified in this way for 1993–94.

Figure B2.2 shows that a significant portion of CSIRO's research continues to be in the agricultural sector. About 14 per cent of its total research is directed to research in plant production and primary products, and about 12 per cent to animal production and primary products.

Figure B2.2: **CSIRO distributrion of research effort, 1993–94**



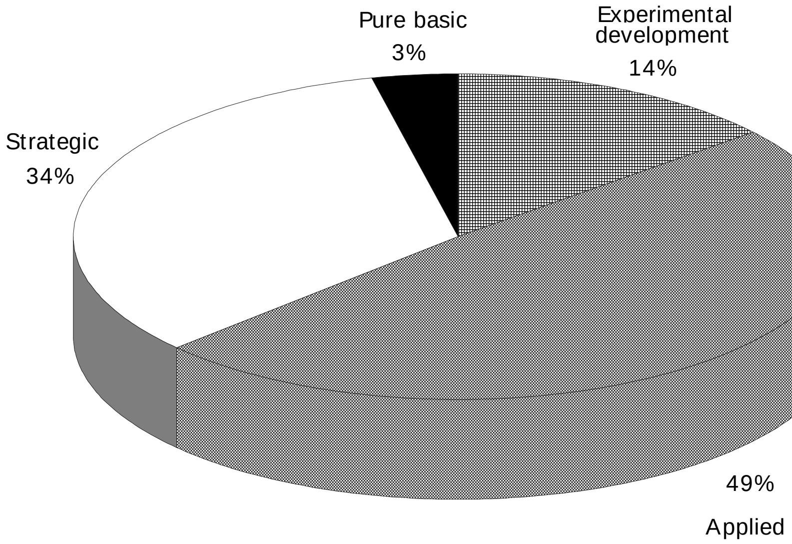
Source: Information provided by CSIRO.

CSIRO's research by type of activity

CSIRO estimates that about 49 per cent of its research could be categorised as applied research, and 34 per cent as strategic basic research. Experimental development research (14 per cent) and pure basic research (3 per cent) are smaller activities (see figure B2.3).

There was a reduction in emphasis on reported pure basic research (a proxy for CSIRO's longer-term research effort) after 1986, when CSIRO started to take a more commercial approach and seek external funding. In August 1988, the Government set a target for CSIRO to obtain 30 per cent of its total funding from external sources. (The effects of this decision are discussed later in this chapter.) However, as table B2.1 shows, the changes in the proportion of expenditure allocated to each research type have not otherwise changed significantly.

Figure B2.3: **CSIRO R&D by type of activity, 1993–94**



Source: CSIRO 1995c, Data Book, figure 1.4.

The data in the table are based on estimates by CSIRO researchers of the types of research done. The table suggests a fall in the relative importance of pure basic research and greater emphasis on applied research. This is broadly in line with the views put to this inquiry by participants (for example, the PSU (now the CPSU).

How is CSIRO funded to do this research?

Current funding arrangements and recent changes

Most CSIRO funding is by way of a single block grant under a triennial funding arrangement with the Commonwealth.

Of the $707 million received by CSIRO from all sources during 1993–94, about 65 per cent came as appropriation funding from the Commonwealth, and about 30 per cent from competitive granting schemes, CRCs, and from research funded by industry and other users. The remaining 5 per cent came from such sources as royalties, fees for services such as calibrations, sales of publications and sales of assets.

Table B2.1: **CSIRO R&D effort by type of activity for selected years** (per cent of total)

Type of R&D activity[a]	*1986–87*	*1988–89*	*1990–91*	*1992–93*	*1993–94*
Pure basic research	8.5	4.6	3.7	3.4	3.4
Strategic basic research	32.4	37.4	32.9	34.0	33.5
Applied research	45.0	44.5	48.8	48.6	49.1
Experimental development	14.1	13.5	14.5	14.0	14.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

a The research types are as defined by the ABS. Expenditures are subjectively allocated to the categories by respondents to ABS surveys, and the ABS makes every effort to ensure correct and consistent interpretation and reporting.
Source: ASTEC 1994e, p. 34; CSIRO 1994b and 1995c, *Data Books*.

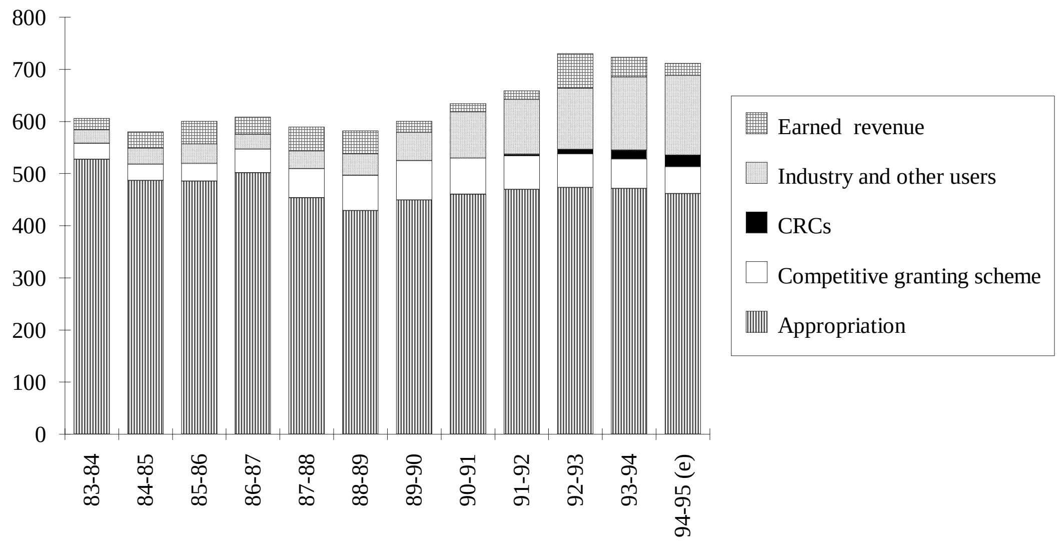
Over the past decade, government appropriations to CSIRO have fallen in real terms (notwithstanding some increases since 1988–89), while external sources of revenue have increased in importance (see figures B2.4 and B2.5). In particular, research funded directly by industry and other users has increased dramatically since the late 1980s, to an estimated $153 million in 1994–95. Revenue from competitive granting schemes has fluctuated in relative importance over the decade, but remains a significant source of revenue for CSIRO. More recently, research contracts from CRCs, while still relatively small, have become an increasing source of external funding.

External funding and links with industry

Following the 1985 ASTEC review, CSIRO was directed to focus more explicitly on research in support of existing and emerging industries. In June 1988 the Government directed CSIRO to increase the proportion of its overall expenditure funded from non-budgetary or external sources.

In August 1988, the Government gave CSIRO a target of attracting 30 per cent of its total annual funding from external sources by June 1991. It set this target to encourage CSIRO to increase its earnings from external sources, to increase the relevance of its research to the marketplace and to provide an impetus for closer interaction with industry. This reflected concerns that CSIRO was not ‘relevant’ enough in its research agenda.

Figure B2.4: **CSIRO's sources of funds, 1983–84 to 1994–95** ($ million)[a]



a Adjusted to $1994–95. Appropriation includes both capital and annual appropriations. Industry and other users include funds earned from Australian private sector and government agencies. Earned revenue, among other things, includes interest on appropriation, royalties from patents/licence fees, sale of publications and revenue from sale of assets. The 1994–95 data are estimates. e=estimate.
Source: CSIRO 1995c, *Data Book*, table 2.2.

In its recent review of external earnings requirements, ASTEC observed that:

> ... external earnings targets have been a strong focus for beneficial change within CSIRO ... [they] have value in promoting links with research users and as a catalyst for organisational change and the report recommends that they be retained (Chairman of ASTEC, covering letter to the Minister, 22 February 1994).

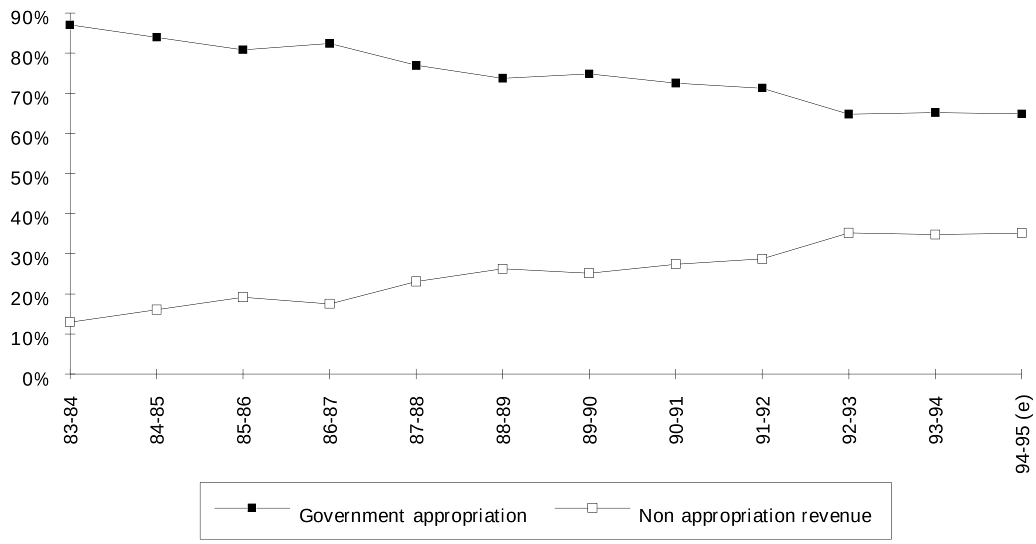
In May 1994 the Government announced that it would retain the target, noting ASTEC's view that, despite a number of adverse consequences, it provided an incentive for CSIRO to develop links with the users of research.

CSIRO now retains all external income, including that from the sale of assets. These arrangements are intended to give CSIRO an incentive to make its research more relevant to industry.

Each Division within CSIRO has an external funding target, although this varies depending on 'the unique environment in which each Division operates, including the degree to which its research outputs are of a public good type' (CSIRO 1992a, p. 77). In addition, the variations are related to differences in the nature of the Division's R&D and differences in funding sources. In 1993–94, high proportions of external earnings were achieved by the Divisions of Wool Technology (60 per cent), Minesite Rehabilitation (59 per cent) and Animal Health (52 per cent). At the lower end were the Australia Telescope National Facility (20 per cent), and the Divisions of Materials Science and Technology (20 per cent) and Forest Products (25 per cent).

Figure B2.5 shows that there is a downward trend in the proportion of CSIRO appropriation funds, while the proportion of external income is rising. Box B2.3 breaks up the external income by sources.

Figure B2.5: **CSIRO's sources of funds, 1983–84 to 1994–95** (per cent of total revenues)[a]

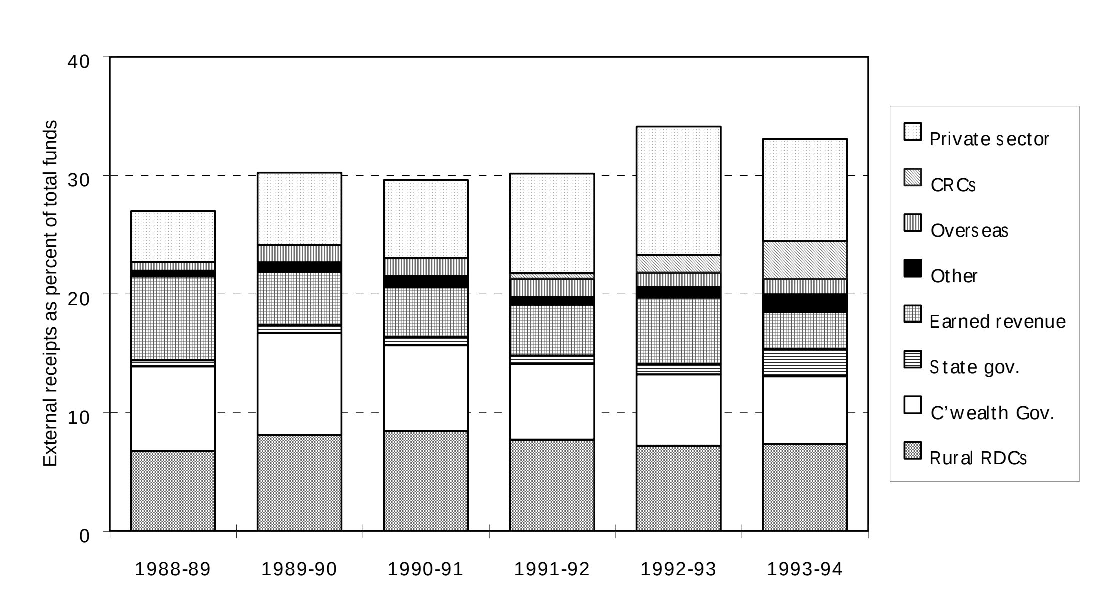


a Funds adjusted to $1994–95.
Source: CSIRO 1995c, *Data Book*, table 2.2.

In 1993–94, CSIRO's total receipts from external sources were $225 million or about 33 per cent of total funds (see box B2.3). Funding from the Australian private sector has grown rapidly, from about $20 million or 4.3 per cent of total funds in 1988–89, to about $58 million or 8.6 per cent in 1993–94. Nevertheless it accounted for only about 26 per cent of total external receipts.

Much of the rest came from government departments or agencies, or government-sponsored bodies such as the CRCs and the rural R&D corporations.

Box B2.3 **CSIRO's external earnings by source** (per cent of total funds)



Earned revenue, among other things, includes interest on appropriation, royalties from patents/licence fees, sale of publications and revenue from sale of assets.

In 1993–94, the components of the external receipts and their shares (of the total CSIRO funds) were:

- Rural R&D corporations and councils ($50 million – 7.3 per cent);
- Australian private sector ($58 million – 8.6 per cent)
- Commonwealth government ($39 million – 5.7 per cent);
- State governments ($16 million – 2.3 per cent)
- CRCs ($22 million – 3.2 per cent);
- Earned revenue ($21 million – 3.1 per cent) ;
- Overseas organisations ($9 million – 1.3 per cent); and
- Other ($10 million – 1.5 per cent).

Source: Information provided by CSIRO.

Income from patents, royalties and licence fees has varied from $0.9 million in 1987–88 to a high of $10.4 million in 1988-89 (see table B2.2). Between 1987–88 and 1993–94, CSIRO generated income of $30.3 million from these sources.

The average earnings from patents, royalties and licence fees over the last seven years ending 1993–94 was about $4.3 million dollars per annum. This represents less than one per cent of the total receipts. The net annual income from these sources is considerably smaller, however, when account is taken of legal and other costs in defending the associated intellectual property rights (see later in this chapter).

Table B2.2: **CSIRO's earnings from patents, royalties/licence fees, 1987–88 to 1993–94**

Year	*Total CSIRO receipts* *$m*	*Patent, royalties and licence fees* *$m*	*Fees as percent of receipts* *%*
1987-88	410.5	0.9	0.2
1988-89	476.8	10.4	2.2
1989-90	537.6	2.0	0.4
1990-91	588.7	1.9	0.3
1991-92	638.7	2.4	0.4
1992-93	686.1	10.2[a]	1.5
1993-94	681.4	2.5	0.4

a Includes a dividend of $7.65 million from restructuring of the Dunlena joint venture between CSIRO, Du Pont (Australia) and AIDC.

Source: CSIRO 1995c, *Data Book*, tables 2.6 and 2.10.

How CSIRO sets its priorities

CSIRO has a very wide charter of responsibilities, and in the absence of explicit national research priorities set by Government, CSIRO chooses and sets its own research priorities with the help of an internally-developed methodology.

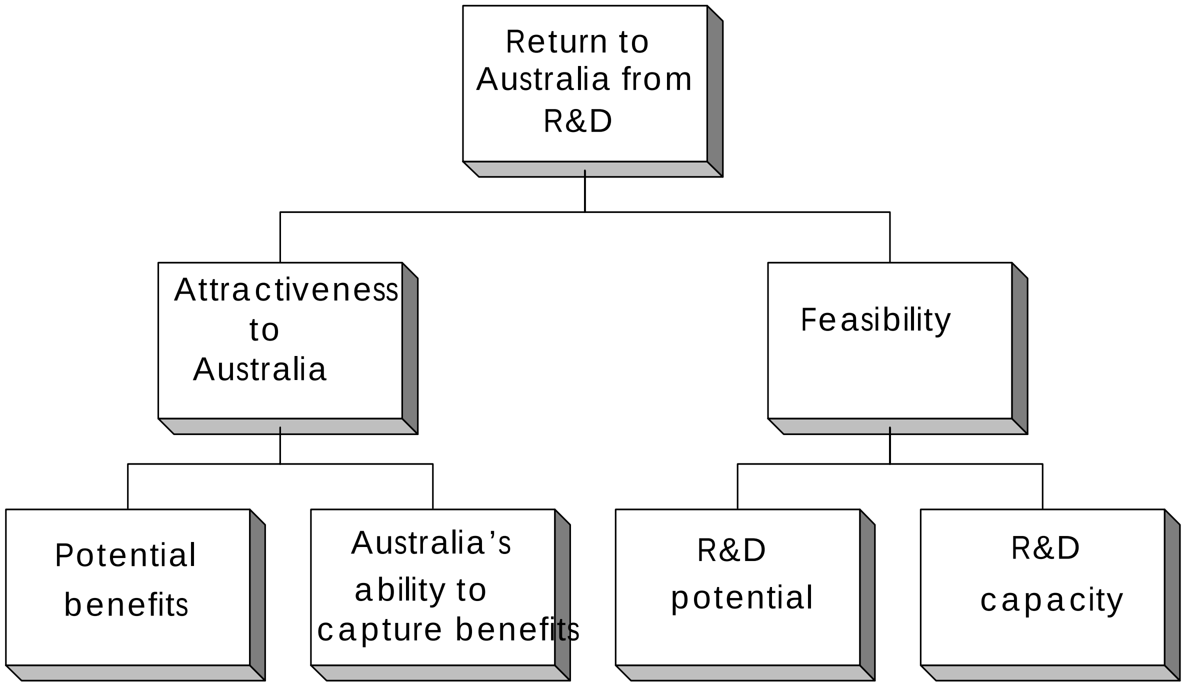
Because of the external earnings requirement, the research priorities for about 30 per cent of its work are largely determined (and paid for) by industry and other users. To the extent that the 30 per cent external earnings revenue drives more than 30 per cent of the research work, part of the remaining 70 per cent of CSIRO research is also influenced by the priorities of these users.

Attractiveness and feasibility assessments

When assessing the prospective return to Australia from a research project, CSIRO evaluates the net benefit of each research purpose against two major factors (adopting an assessment framework derived from that of the Industrial Research Institute in the United States) (Foster et al. 1985):

- **attractiveness**, combining the potential economic, social and environmental benefits for Australia, and Australia's ability to capture the benefits by converting technological progress into commercial or other gains; and
- **feasibility**, combining what technological progress research could potentially accomplish, and the nation's and CSIRO's ability to achieve the progress in a timely way (see figure B2.6).

Figure B2.6: **The CSIRO assessment framework**



Source: CSIRO 1991b, p. 4.

CSIRO judges that Australia should place ‘strong emphasis’ on research which scores highly against both criteria, should provide ‘selective support’ for that which ranks moderately well, and ‘limited support’ for that research which scores relatively poorly.

CSIRO has developed the priority-setting process essentially in-house with some input from stakeholders and others (see appendix B). As Blyth and Upstill (1994, p. 11) of CSIRO point out, the process canvasses fairly extensively the views of CSIRO’s top management and Institute and Division officers, using an iterative process. The resultant report is sent to the CSIRO board for approval.

Comments made by participants to the Commission and the Senate, however, indicate some community concern about the impact of the priority-setting process. Julian Cribb, reflecting his experience as an adviser to CSIRO on three advisory panels, stated at the Senate inquiry:

> CSIRO should make far greater use of its 350+ external advisers for the identification of strategic goals in R&D and communication with industry. This is probably the most powerful advisory force in Australia but its talent and scope (are) not being properly exploited (CSIRO submission to Senate Inquiry, p. 2).

Using its dual criteria, as well as judgments about its own R&D capability relative to that of other research performers — and about the extent to which research for a particular purpose should be publicly supported — CSIRO has drawn up a Strategic Plan for 1994–95 to 1998–99. The plan sets out CSIRO's corporate goals, its objectives and priorities for that period (see appendix B), and the strategies which CSIRO research managers and research support managers can use to align their activities with the organisation's priorities.

The plan is scheduled for review every year with a major review planned every three years.

Allocation of funds to priority areas

CSIRO formally targets up to 3 per cent of its appropriation to priority areas (see appendix B). For other research, managers are encouraged to take those priorities into account.

Each CSIRO Institute is required to commit funds at an agreed level (1.5 per cent of appropriation in the first instance) to support research in priority areas. In addition, those Institutes which carry out that research are expected to identify additional (generally matching) funding to be redirected from lower priority areas to the new initiatives.

B3 CSIRO - THE KEY ISSUES

CSIRO is a major research institution, with a long history and a proud record of achievement. Despite this, its role and contribution continue to be matters for dispute, both within government and amongst the community at large. The Commission has attempted here to shed some light on why this is so, as a basis for considering changes that would allow CSIRO not only to continue to do good work, but also to be seen to be doing the work that Australia needs it to do.

This section begins therefore with the vexed question of CSIRO's role. It then looks at the key issue of whether priority setting and funding arrangements are adequately supporting this role. Related questions about the value of CSIRO's research, its record in disseminating the knowledge it creates, and some organisational issues are then raised in turn.

B3.1 What is CSIRO's role?

CSIRO has evolved considerably since its origins in 1916. An important part of its early role was to find scientific solutions to the challenges facing Australia's farmers, who lacked the scale and the incentive to undertake the R&D needed by their sector.

Over time, CSIRO's responsibilities widened to include other sectors, and research needed by government and the community in relation to natural resource and environmental management as well as shifting towards more fundamental science.

More recently, CSIRO has moved away from undertaking basic research and has been making greater attempts to meet industry needs. Partly as a consequence of reviews and government directives in recent years, its role and functions have again been changing. The external earnings requirement, set in place in 1988 and reviewed several times since, has clearly had an impact on CSIRO's activities.

But this shift towards more commercial activity has also brought some problems and attracted criticism. Some participants saw CSIRO as a major research asset which added to Australia's standing in the international scientific community. But others criticised it as being too science- or scientist-driven. Those less critical suggested that its choices of research topics do not line up well with Australia's research needs. Its use to Australian industry was also debated — some firms or industries benefit significantly from its research; others argued that it was not adequately responding to the day-to-day problems of industry, or that small firms were missing out.

There is also lack of agreement about what exactly CSIRO should be doing and why. Should it be a 'university without students' or 'an industry outpatients clinic' or something in between?

Government directions to CSIRO on the types of research it should do are not clear, and such messages as do emanate from government change over time, contributing to the general expectation that CSIRO should be all things to all users. It is questionable whether any organisation could (or should) meet these very wide expectations.

Moreover, the broader environment within which CSIRO operates has changed significantly.

- There are now a number of other government research agencies (some with overlapping fields of interest) as well as a burgeoning university research sector.
- The rural community has been organised to fund research through the rural R&D corporations, with similar (voluntary) arrangements also existing for mining companies.
- Some private research facilities have emerged (although much less so than in other countries).
- And the capacity of companies within the manufacturing sector to perform or sponsor others to do R&D has increased, with government support programs having further increased the incentive to do so.

In other words, demand for industrial R&D has increased, and so have alternative sources of supply. More than at any time in the past, CSIRO now needs to define its separate niche relative to universities and other public (and private) research organisations and corporations.

The Birch Report (1977) concluded that CSIRO's main role should be:

> ... to fill a gap in national research, with what we call strategic mission-orientated work, which would otherwise remain unfilled. This is the kind of rather long-term work for the community benefit which cannot be, and is not being, carried out by industry or other organisations (p. xxvii).

ASTEC's 1985 report on CSIRO concurred with Birch that CSIRO should undertake strategic basic research of a longer-term or high risk nature, for which private appropriability is unlikely, but also saw a greater role for more applied, firm-specific research.

> There is, however, a significant difference in the research capability in the private sector in Australia. Whereas most applied research and experimental development takes

> place in the private sector in other countries, in Australia the level of activity is relatively low in all major industry sectors. It follows that, for CSIRO to fill a complementary role in the Australian infrastructure, the organisation will, in general, have to be more active at the applied ... end of the R&D spectrum than its counterpart bodies overseas (ASTEC 1985, p. 13).

ASTEC's concern to balance CSIRO's 'longer term and more broadly applicable research' with 'shorter term, more directly applicable activities' was ultimately reflected in the 30 per cent external earnings requirements (discussed later). This shift in orientation of CSIRO was characterised as follows in a press interview with one of its Institute directors:

> ... the CSIRO is a national resource for all local companies to use. If they look at CSIRO as their research laboratory, available for a fraction of the cost of establishing one in-house, they can produce results comparable to those achieved by much larger companies off shore (*Australian Financial Review*, 11 October 1994).

At least notionally, the potential research field for CSIRO can be divided into three different categories:

- Research whose benefits accrue to the community generally and whose outcomes by their nature cannot be captured by one group in the community to the exclusion of others. Examples include research into broad environmental issues such as soil erosion and global warming. Sufficient of this research would not be done if it were left to private interests to finance — even with subsidies from government — as they would not be able to keep for themselves enough of the benefits to justify undertaking or commissioning the research. In CSIRO's case, some is undertaken because of judgments made by CSIRO as to its importance; in other cases it is commissioned by, for example, a government department.
- Research whose results primarily benefit the client who commissions CSIRO to undertake the research; that is, where the client (often a private firm) will be able to gain much of the benefit and prevent or impede others from having access. In such cases, getting CSIRO to undertake the research is a commercial decision and a substitute for the firm doing it in-house or contracting out elsewhere. There is usually a need for the ownership of the resultant intellectual property to be settled beforehand.
- Research which contains elements of both — which benefits particular private interests but also has a substantial 'public good' component. Examples include research which is industry-wide in its benefits such as may be commissioned by the rural R&D corporations.

In the first category, university researchers undertake a great deal of basic and some other research motivated mostly by the prospect of advancing knowledge for its own sake. In the second, firms are driven by commercial motives to sponsor or perform R&D work principally directed to their specific short-term needs. Attempts by CSIRO to occupy that (potentially very large) field could simply succeed in displacing privately performed R&D, including the emergence of contract research firms within the private sector. Since ASTEC's 1985 judgment that CSIRO had to make up for the inadequacies of Australian firms, there has been a significant increase in firm expenditure on R&D (whether carried out within firms or contracted out).

This leaves a range of research work — in the first and third categories — which might have substantial benefit to the community but would not be undertaken by others. University researchers would not do it because they would not regard it as original or interesting enough, or likely to enhance their academic reputations; individual firms would not do it because they would not foresee themselves appropriating enough of the benefits of the work. Such research has strong 'public good' characteristics, with the potential to generate knowledge which may bestow benefits on many groups and individuals.

This is CSIRO's niche. As emphasised by Birch (1977), it lies between firms and universities in the area of research loosely described as 'strategic'. Such research has always been performed by CSIRO and comprises a wide range of activities. Box B3.1 includes some examples which generate benefits widely within the community.

There are also some areas of industry applicable research which are 'generic' or 'precompetitive' in nature and which would not be initiated by firms individually. While CSIRO will always have a role in this research, it could also be picked up by groups of firms, such as collective research associations within the manufacturing sector, although such arrangements remain the exception thus far.

Many participants agreed with the Commission's views in the draft report as to the type of research CSIRO should carry out. They agreed that CSIRO's role should involve predominantly public good research (although some found such a role as too restrictive). For example, the Cattle Council of Australia stated that:

> ... CSIRO should remain basically focused on public research (Sub. 370, p. 12).

CRA Ltd said that:

> [CSIRO] should concentrate more on longer term research rather than carrying out money making functions for industry (Sub. 296, p. 1).

CSIRO — although agreeing with the Commission's identification of its niche in 'public good' research — considered the Commission's position on its interactions with industry to be much too restrictive.

> To constrain CSIRO to this role, even with the addition of some full-cost contractual research, would have the effect of isolating the Organisation from its clients (Sub. 356, p. 1).

Similarly, CSIRO's Division of Tropical Crops and Pastures contended that to confine CSIRO to a *pure* public good role was too narrow and restrictive, and this would jeopardise linkages with industry:

> To confine CSIRO to this role alone would cut off the closer and extremely fruitful linkages with industry which have been painstakingly developed, particularly in the last five years (Sub. 293, p. 3).

It added further that:

> If CSIRO is to fulfil one of its primary functions - to carry out scientific research to assist Australian industry ... it needs a two-way interaction and co-learning which inevitably occurs. CSIRO's research would again be in danger of being irrelevant or impractical to transfer to either the industry or the community (Sub. 293, p. 3).

Australian Academy of Technological Sciences and Engineering agreed with the Commission in general terms, but argued for more contract work for industry:

> ... the contract work for private firms should be actively encouraged rather than passively permitted. The present level is not optimal and the case for a special relationship with small start-up enterprises (SSEs) will be advanced (Sub. 337, p. 11).

In regard to dissemination of CSIRO's research, the AIRG said that:

> ... the suggestion that [CSIRO] research should be available to all including our overseas competitors is not in the national interest (Sub. 329, p. 2).

The Commission would emphasise that its view about CSIRO concentrating on research of a long-term, strategic nature, yielding wide benefits to the community, is entirely consistent with CSIRO working with and for private industry. Indeed, the Commission sees the connections with industry as providing an important 'relevance check' for CSIRO's work as well as triggering public good research grounded in practical problems. Nevertheless, industry sponsored work should not be allowed to drive CSIRO's agenda in a way which has it mostly doing work of a more applied nature that is largely appropriable by its clients.

The Commission considers that CSIRO's principal role is to undertake research which has direct value to industry generally and the community, but lacks sufficient private returns to be sponsored by firms ('public good' research). The results of such research should be widely disseminated.

Box B3.1: **Some examples of CSIRO's broader public good research**

Most CSIRO work has a real or potential customer. For example, for environmental work, departments and agencies might be the customers, on behalf of the public and of their own policy and management work. Departments or rural RDCs may be the funder of rural sector work. Nevertheless, many CSIRO projects have diffuse beneficiaries within industry and the community generally. Examples include:

- radioastronomy
- prevention of exotic animal diseases
- global climate change
- environmental decision systems — computerised aids to environmental policy and management
- assessment of natural areas, for example, conservation values and wildlife habitats
- coastal zone management techniques
- measurements and standards
- research into ocean systems
- fish stock measurements
- bushfire research
- forest management systems
- waste-water treatment, sewage treatment, water purification in artificial wetlands
- non-splatter welding
- optical research into design of pedestrian lighting.

Source: Information provided by CSIRO.

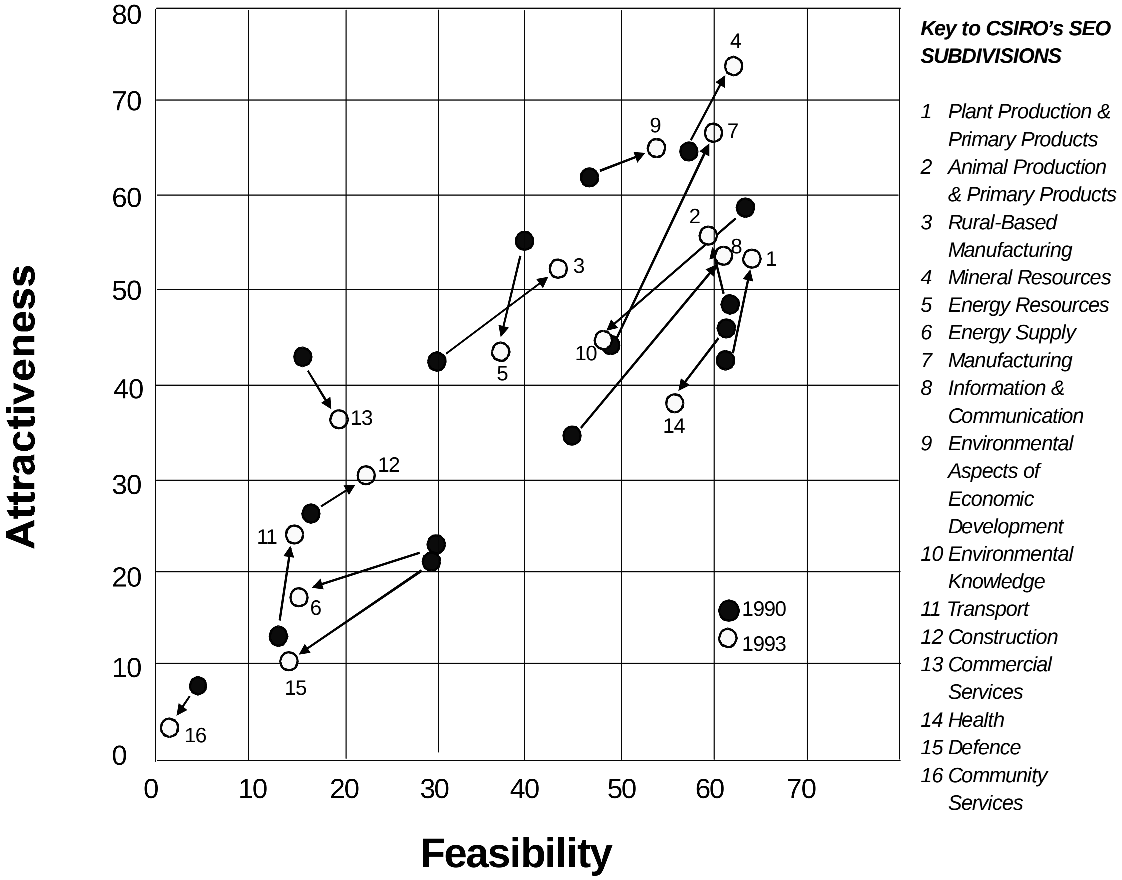
B3.2 Setting priorities

CSIRO's priority-setting process has much to commend it. In the absence of nationally-determined priorities for research, it provides a useful discipline on the agency to translate the requirements of the community into research programs. Figure B3.1 shows CSIRO's assessment of the return to Australia from R&D in key SEO subdivisions, and how the ranking of the research in the SEOs changed between 1990 and 1993.

The BIE observed that CSIRO's rules for selecting areas of research are simple and cost effective relative to detailed cost-benefit studies, and provide some consistency of approach. It added that, while the way in which the factors are combined is not well-defined and might not coincide with a theoretically based benefit-cost analysis:

> Various techniques are used to ensure all their relevant experience and knowhow is *made available* to the group (eg debate between product champions and advocates of outlier solutions) a*nd assimilated* ... The lack of formal adherence to the theoretical principles of [benefit-cost analysis] might be offset by the other properties of this R&D direction-setting process (ie consistency, use of all relevant information, and the close relationship between decisions and their implementation) (BIE 1992, p. 27).

Figure B3.1: **CSIRO's assessment of the return to Australia from R&D, 1990 and 1993**



Source: CSIRO 1993c, *Annual Report*, p. 64.

What effect has priority setting had?

To date, while there has been a reallocation of some funds to identified priority areas, the impact of the priority setting process in reallocating resources within CSIRO has been limited. The bulk of CSIRO's appropriation income is not directly affected — the focus is largely on reallocating about 3 per cent of the appropriation income and on the persuasive power of the priorities exercise.

Assessing its effects is made difficult by the changes in CSIRO's funding which have occurred in recent years. Appropriation funding has risen only slowly relative to funding from external sources, and so the allocation of research resources is increasingly influenced by the requirements of outside bodies. This factor alone has heavily influenced the changes in the pattern of research undertaken.

The priorities exercise has led to an explicit redistribution of some research funds within CSIRO (see table B2 in appendix B). While the amounts are small, the allocation of these funds indicates the CSIRO Board's view of priority research areas. *Mineral resources*, *environmental aspects of economic development*, and *manufacturing* rank highly in both the priority fund and the Board's allocation of certain non-recurrent funds (allocated to CSIRO in the May 1994 Statement).

More broadly, an indication of the effect of the priorities exercise may be obtained by examining the extent to which changes in the pattern of appropriation expenditures — that is, funding over which CSIRO has direct control — have occurred in the direction of priority areas.

The evidence is mixed. While total appropriation spending (in constant dollar terms) increased by 7 per cent between 1990–91 and 1993–94, significantly bigger increases were recorded over that period in the priority areas of *mineral resources* (up 34 per cent) and *environmental aspects of economic development* (up 19 per cent, although most of the increase occurred in the first year). But both areas recorded reductions in funding between 1992–93 and 1993–94, when appropriation spending fell in aggregate (see table B4 in appendix B).

Manufacturing, which has middle ranking in priority terms (see table B2 in appendix B), attracted only 2 per cent more appropriation funding in 1993–94 than in 1990–91. In contrast, a lower priority area, *animal production and primary products*, recorded a 13 per cent increase over that period (but only 1 per cent in the most recent year). Appropriation funding has decreased for *plant production and primary products* and for the *information and communications industries* since 1990–91.

Growth in externally-funded (or sponsored) research over the three years averaged 33 per cent. Higher growth was evident in the priority areas of *mineral resources*, *environmental aspects of economic development* and *manufacturing*, although *mineral resources* fell in the last year. But significant growth was also evident in some non-priority areas, such as *energy resources and supply*.

An examination of changes in funding broad categories of research (which suggests that the total reallocation of resources within CSIRO has been relatively small) could disguise significant changes that might have been made at a lower level of disaggregation.

In response to the draft report, CSIRO stated that major human and capital resource adjustments are occurring across CSIRO and that:

> ... the influence of the priority setting process has been much greater than acknowledged by the Commission in its draft report. The 'priority setting' methodology and rationale is influencing decision making throughout the Organisation, and has

> fostered substantial cultural change. It is widely accepted and used to assess priorities not only at a corporate level but at Institute, Division, program and project levels (Sub. 455, p. 5).
>
> ...
>
> The magnitude of change which is occurring at the program/project level will not be revealed by an analysis of SEO data at a broad subdivision level (Sub. 455, p. 6).

However CSIRO cautioned that:

> ... major shifts across subdivisions over a period of a few years would be inappropriate ... the type of research it delivers requires relatively stable funding over time, and that stability is not available through external funding sources; and external funding of projects limits the flexibility to shift appropriation funded resources between laboratories and research groups.
>
> The annual corporate shift at SEO sub-division level (approximately $5.5 million per annum, plus matching funds) has a considerable cumulative effect.

CSIRO quoted examples of priority-setting decisions and the resource adjustments at the Institute and Divisional level. From 1990–91 to 1993–94 the Institute of Animal Production and Processing (IAPP) has had a small net reduction in appropriation funds. CSIRO stated that IAPP has in turn shifted substantial resources internally over the same period in response to a number of factors, including the priority-setting exercise, reduction of funds from RDCs, particularly wool but also meat. It stated:

> In response to priority determinations at the Institute level, IAPP decided in 1991-92 to shift 9 per cent of its appropriation funds between the major SEO groups on which its research is classified. Three per cent were shifted over the triennium between Divisions and the balance between programs and projects within Divisions (Sub. 455, p. 7).

Similarly the Division of Animal Production (DAP) has also had substantial reductions in appropriation funds, resulting in changes in research programs between 1989–90 and 1992–93 as a consequence of changing priorities and funding levels. Programs in a number of research areas have been eliminated, including reproductive technologies and fertilisers.

The Sugar Research and Development Corporation also indicated that CSIRO's priority-setting exercise was having an impact. It said that the CSIRO priority-setting process had resulted in redirecting more resources into the sugar industry. At the draft report hearing, the Corporation said:

> The major provider that we have in the sugar industry from CSIRO is the Division of Tropical Crops and Pastures and we clearly have seen them in their own priority-setting process asking the question, 'Are we doing the right things?', determining that they in fact could see opportunities to deliver benefits to both the sugar industry and the community on the coast of Queensland and New South Wales and shifting their own resources from 5 per cent a few years ago up to about 20 per cent now into the sugar

> industry and we see that as a very positive shift to our benefit, but also to the benefit of the community (DR transcript, p. 2307).

It went on to say that:

> Our current deputy chairman is a member of the CSIRO Tropical Crops and Pastures Advisory Committee ... but they went through the similar process you describe for the total CSIRO, the feasibility and attractiveness set, and found that sugar didn’t appear in their existing program and placed it well up in the right-hand corner, and therefore wished to further investigate how they would get into the sugar industry ... I saw the decision that they felt that there were benefits that could be gained from the sugar industry and they moved in that direction. (DR transcript, pp. 2307-8).

CSIRO Division of Tropical Crops and Pastures itself said that:

> We’re in sugar R and D not just because the funds are there, but also because on the basis of the priority-setting mechanisms within CSIRO we see it as a very attractive area to be in, and we need to increase our investment to increase the feasibility in line with the attractiveness (DR transcript, p. 2392).

As stated in the draft report, the impact of priority changes on some specific activities appears to have been significant, and some dissatisfaction has been expressed. For example, the Chief of the Division of Entomology (part of the Institute of Plant Production and Processing, for which appropriation funding has been reduced), argued that CSIRO’s rural research had yielded excellent returns:

> ... because we are dealing with problems that are unique to Australia. They are problems that are of a generic nature to the industries and, when we seek solutions, those solutions are normally taken up by the industry ... However, that model has been uncritically applied to manufacturing and information technologies to say that, because we have got it right in one sector, one therefore can have successful publicly funded R&D in these other areas ... the resources for the manufacturing and information technology exercises have been largely drawn from the funds that have traditionally gone to the rural sector and to the environment (Senate Hansard 1994, p. 249).

The Pastoralists’ and Graziers’ Association of WA argued:

> The CSIRO’s strategic plan shows that agricultural research, mining research, and research on the environment are all highly attractive and highly feasible, and according to CSIRO’s own criteria should be receiving strong emphasis.
>
> Areas such as manufacturing are less attractive to the national good, largely because Australia has a lower chance of capturing the benefit. Despite this, funding for agriculture particularly has received a low priority over recent years (Senate Hansard 1994, p. 1150).

The Western Australian Farmers Federation added:

> The Federation is concerned that funding allocations made by CSIRO are not consistent with their own national research priorities.

Priorities and external earnings

CSIRO has now decided upon priority areas for the second triennium from 1994–95 to 1996–97 (see table B1 and box B4 in appendix B). For example, CSIRO said that *manufacturing* is to be allocated increased appropriation funding:

> ... for defined areas of the strategic research base with the expectation that this will produce substantial increases in external earnings in these areas.

All three research areas picked for increased allocations from the priority fund in the second triennium (*manufacturing, mineral resources* and *information and communications industries*) had above average growth in earnings from external sources in the first triennium.

For example, between 1990–91 and 1993–94 the greatest growth of external income (205 per cent from a small base) was for research in the *information and communications industries*. The CSIRO priority decision for 1994–95 to 1996–97 for the information and communication SEO was to:

> ... increase appropriation subject to maintaining CSIRO target for external earnings (see box B4 in appendix B).

This could suggest that the capacity for particular research to generate future external income influences its priority ranking. CSIRO has a financial incentive to use appropriation funds to generate external income and this may affect its views of national research priorities as well as its own priorities — preferring areas of research which have the potential to earn it external income. To the extent that this occurs, it reinforces the view that the external earnings requirement drives a lot of CSIRO's research.

Some limitations of the current priorities process

CSIRO is well placed to assess the *feasibility* of research in different fields. It combines judgments from a range of experts as to the appropriate balance of the underlying factors affecting the feasibility of researching different fields, and does so relatively efficiently and consistently, and in a way that generates fairly robust and reliable results.

It is less certain, as CSIRO itself has acknowledged, whether CSIRO scientists are best placed to evaluate the *attractiveness* of research alternatives. While non-CSIRO people are involved in this process, it is not clear how representative they are of broader community needs. CSIRO said that:

> ... [assessing] the potential benefits of environmental research involves a subjective comparative judgment (in relation to the economic benefits of things like a competitive minerals industry) of the potential benefits of improved capacity to adapt to climate

> change, preservation of endangered species, etc. Both personal and community values must come into play ... (CSIRO 1991b, p. 9).

Under the *attractiveness* criterion, weight is given to:

> ... Australia's ability to capture the benefits by converting technological progress into commercial or other returns.

Read in isolation, this suggests that the higher the appropriability of the research outcomes by Australian organisations, the more attractive the research will be. This may lead to some bias in practice towards research which can be used by Australian organisations to generate commercial returns. But this may be at the expense of other (public good) research that might benefit the community more.

The case for public funding of research largely turns on the existence of net spillover benefits to others in the community. Selecting which research should be given higher priority on the basis of 'ability to capture the benefits' could limit the diffusion of the benefits of publicly-funded research.

Taken alone, the criterion may not adversely affect priority setting within CSIRO, but combined with the 30 per cent target it has the potential to skew its research priorities towards areas of greatest potential future gain to CSIRO from external income. Whether this gain equates to that for the community as a whole is less clear. Participants' submissions and discussions at the hearings emphasised that at least two forces were at work driving CSIRO's research efforts — CSIRO's own priority-setting exercise and the need to earn 30 per cent or more external income.

CSIRO has made significant progress in establishing a priority-setting process based on identified national needs and opportunities. However, its procedures are mainly in-house and heavily influenced by its perspective as a performer of R&D, as well as the potential for external earnings.

B3.3 Funding arrangements

Since 1986–87 government appropriations to CSIRO have decreased by an average of about one per cent per year in real terms, and CSIRO is relying increasingly on 'external' sources of funding. These now amount to some 33 per cent of its total income. Nevertheless, the largest slice of funding it receives is by way of its annual appropriation of about $456 million (including a separate capital appropriation of about $38 million).

The Commission has not reviewed the adequacy of CSIRO's appropriation. But it notes that providing some 'block' funding in this way has significant advantages for CSIRO, which has the flexibility to allocate that money among competing activities within the organisation. It gives CSIRO the ability to plan longer-range research programs, and freedom to choose the areas on which it will focus. From a broader viewpoint, however, it has the disadvantage that it limits the scope for outside involvement in how those funds are spent. This has implications for the pattern of research undertaken, and for CSIRO's accountability to the community.

The external earnings requirement has meant that CSIRO has been increasingly responding to the needs of industry. At one level, this is likely to have led to some beneficial outcomes by focusing attention (and high quality research resources) on problems specific to Australia. But there is a downside. The external earnings requirement sets up incentives which have led to outcomes which were not planned (see box B3.2). In particular, it is said to have led to:

- a shorter-term focus in CSIRO's research work;
- greater emphasis on the needs of large firms;
- increased commercial exposure — CSIRO has become embroiled in intellectual property disputes with industry partners; and
- some cross-subsidisation of externally-funded work from appropriation funding.

These and other issues are considered below.

A shorter-term research focus?

A concern expressed by the Parliamentary Public Accounts Committee (JCPA 1992) and some scientists about the external funding target is that it pressures CSIRO staff to chase revenue from short-term research, leading to reduced priorities for longer-term research. An earlier report by the Auditor-General stated that:

> ... Divisional chiefs (in CSIRO) have estimated that between 50 to 90 per cent of the total resources of CSIRO are being used to support externally funded work. ... [This] results in increasing portions of CSIRO work being driven to meet the needs of outsiders, and a shift in research focus from strategic to tactical and fee-for-service consultancies (ANAO 1991, pp. 35, 40).

The Public Sector Union (now the CPSU) said that the external earnings requirement for government agencies:

> ... has led to very substantial changes in their culture and activities [and] have placed very considerable stresses on the organisations. These include:
>
> - a devotion of most of the resources of the organisations to obtaining this external funding, although it is supposed to represent only 30 % of the total; ...

- a fall in strategic or background research, and an increase in short-term or tactical research (Sub. 178, p. 3).

In August 1994, the Auditor-General, in a follow-up to its 1991 report, said:

> The management of appropriation and externally funded research has seemingly put pressure on [CSIRO] to undertake more applied research, such as solving industry problems at the expense of more fundamental research funded through appropriations (ANAO 1994b, p. 17).

CSIRO accepts that there has been some distortion of research effort:

> In a small number of Divisions, as researchers sought to increase earnings rapidly to achieve their external earnings target, the balance (between strategic research to underpin future developments and sponsored research with an applied focus for shorter term outcomes) became distorted. This matter was examined by CSIRO senior management in 1991-92 and in most cases Divisional management had already taken corrective action. Adequate costing and pricing, and attention to recovering appropriate costs from rural funding bodies are important principles for maintaining balance. The issue is now satisfactorily addressed but will require continual attention (CSIRO submission to the Senate inquiry, 1 July 1994, p. 10).

Greater emphasis on large firms

One advantage of the external earnings requirement is that it encourages CSIRO to focus on what the user wants or needs (although participants argued that CSIRO is not set up to be an effective consultant to SMEs). ASTEC (1994e) argued in favour of the requirement on the grounds that it gave a focus to CSIRO's research and promoted links with users. Without the target, it is likely that less sponsored research would be done.

Notwithstanding this, some participants expressed concern that CSIRO research is still not sufficiently responsive to commercial needs. The McKinsey report said that, since the introduction of the external-funding requirement, the number of SMEs involved in collaborative research had increased, but at a lower rate than large firms. For example, while in 1988–89 (before the requirement was introduced) 40 per cent of the resources of CSIRO's Institute of Industrial Technologies were allocated to collaborative research with SMEs, this had fallen to 10 per cent by 1992–93 (CSIRO 1993d, p. 84).

The Public Sector Union (now CPSU) said:

> Because [SMEs] in general cannot fund research, and because almost all research is now directed towards externally funded projects, there is little or no research capacity to conduct research for their benefit (Sub. 178, p. 5).

Box B3.2: **Problems with external earnings**

ASTEC listed some industry concerns about research agency management of external targets (ASTEC 1994e, box 3.1, p. 25). The agencies are:

- encouraging contract relationships at the expense of other forms of collaboration such as secondments and collaborative research arrangements;
- causing agencies to focus on large companies and government grants to the detriment of other industry users, especially SMEs;
- favouring one-to-one arrangements with companies, rather than broader industry-based agreements;
- tying up core knowledge by non-disclosure agreements with single companies;
- seeking funding by a small number of larger-scale agreements, preferably ones that run over a period of several years, eg from large companies or government funded schemes;
- maximising cash returns by insisting on the use of agency facilities even if a client has them available;
- extending activities beyond the R&D phase when they could appropriately be done by the partner;
- carrying out R&D that could more effectively be done by industry and acting as a disincentive for government research agencies to contract work to industry;
- retaining cash-flow generators that should be spun-off;
- providing services that are in direct competition with private sector research providers;
- adopting restrictive positions in intellectual property negotiations; and
- adopting an inflexible approach to costing.

Some other concerns include the following:

- Some RDCs and government users argued that Government research agencies should not charge for use of infrastructure because they are publicly funded. Only marginal cost pricing was seen as appropriate.
- Other science agencies were concerned about a decline in the traditional emphasis on scientific cooperation and scientific data exchange.
- University users expressed concern that:
  - direct CSIRO-university collaboration through the CSIRO grants scheme has been reduced significantly;
  - the preoccupation of agencies with intellectual property or assessing financial return have deterred cooperative research;
  - the increased cost of access to research and research products has had a negative impact on interaction with universities; and
  - even the larger universities find it difficult to compete against CSIRO for industry funding.

Source: ASTEC 1994e.

Under the external-funding requirement CSIRO has an incentive to generate external revenue at the least cost to itself. The costs of attracting research funding by arranging research and transacting business with smaller firms per dollar spent by CSIRO is generally higher than the same arrangement with larger firms. This could be expected to lead to a change in the emphasis CSIRO gives to assisting smaller enterprises relative to larger ones.

Some participants said that CSIRO's responsiveness to the needs of SMEs was better before the introduction of the 30 per cent target. For example, Australia's Technology Industries Exporters Group stated:

> Historically the CSIRO has interacted well with SMEs. It was possible to telephone scientists and obtain quick and succinct advice from specialists in a relevant field.
>
> However, with the advent of the 30% funding requirement, the situation has changed. Companies report that scientists are reluctant to talk on a casual basis as they had done in the past. The 'meter' would often go on almost immediately and companies were required to pay consulting fees (Sub. 204, p. 5).

The Group further added that:

> John Stocker admitted in a recently published interview that it is far easier to obtain external funds from a small number of larger companies (which frequently are overseas owned, eg Boeing) rather than a large number of smaller companies (p. 5).

The Department of Commerce and Trade (WA) also expressed concerns in this regard. It said that:

> ... 30 per cent external funding has actually proved an impediment to CSIRO to actually work in with those smaller companies, [so] that almost by default they have had to go to the bigger industries to actually get the sort of returns that they need to justify this external funding (DR transcript, p. 2006).

In April 1993, it commissioned McKinsey and Company to investigate how the organisation could strengthen its support to SMEs. McKinsey found that CSIRO was working with only about 10 per cent of SMEs and with mixed impact. It recommended that it establish industry outreach groups in each of its Institutes, and strengthen its secondment program by integrating it into the career paths of research staff.

In August 1993 it decided to double its interaction with small firms over the following five years within the constraints of its overall budget. The importance of explicit strategies for interaction with SMEs was also highlighted by ASTEC in late 1993 when it found that the external earnings targets have tended to focus government research agencies' efforts onto large business and that SMEs appeared under represented in linkages with agencies (ASTEC 1994e, p. 26).

As part of its 1994–97 triennium funding negotiations, it requested additional appropriation funds for a number of initiatives, including its SMEs program. This additional allocation to CSIRO's appropriation was aimed to help it to implement its SME program more quickly and without cutback in other areas.

In May 1994 the Government announced that:

> ... CSIRO will spend $10 million over the next three years to improve the access of small and medium enterprises to CSIRO technology and expertise ... [it] will also allocate some $7 million over the next three years to improve company access to state-

> of-the-art ‘smart’ manufacturing technology, to enhance their market responsiveness (Senator Peter Cook, *News Release*, 4 May 1994, p. 2).

CSIRO informed the Commission that the provision of these additional funds for SMEs will enable it to maintain some of its existing activities which may have otherwise had to be cut back or ceased to enable resources to be redirected. It advised that the additional funding had certainly enabled CSIRO to expand some aspects of its SME initiative and to speed its implementation.

CSIRO drew up a detailed list of R&D programs in line with this broad research direction by Government. In its paper explaining the technology support for SMEs, CSIRO said that the funds were for the provision of generic support for SMEs, and that these activities will become focal points for improving their links with CSIRO. SMEs will be able to obtain access to expertise in areas such as quality improvement, instrumentation and electronic systems, irrespective of the industry sector to which they belong. The activities to be supported are targeting and screening of potential companies, analysis of technology needs, technical advice and short term consulting services, and some in-plant assistance.

The activities being established through this program will be networked with AusIndustry and NIES, and should lead to improved access by SMEs to sources of technical expertise throughout CSIRO, universities and the private sector.

To meet these objectives, CSIRO is to recruit staff with particular business skills to complement its existing skills base. The draft resource summary for the use of additional funds provided under Working Nation specifically for CSIRO’s small and medium sized enterprises program is shown in table B3.1. Programs identified for support are:

- technology support for SMEs in the manufacturing and food processing industries;
- quality improvements for SMEs (by developing tools and infrastructure);
- SME outreach group in electronics systems (designed to provide access to a pool of advanced electronic engineering skills);
- corporate business department strategy (to deliver front line service to SME enquirers and to develop and deliver training courses on quality management of commercial practices to all CSIRO staff, and to subsidise appropriate secondments).

Australia has over 700 000 SMEs (defined as enterprises with less than 100 employees). Clearly there are limits on the extent to which CSIRO could meet their individual needs. Indeed, it is likely that, if CSIRO were required to be a research contractor to private firms, it would make better use of its resources by concentrating on a smaller number of large firms, given the transactions costs. As noted previously, however, the Commission does not consider that the main benefits which CSIRO can provide to the community are to be derived from firm-specific research in itself.

Table B3.1: **Support for SMEs**[a]

Component	*Staff*	*Redirected staff*	*Annual funds ($ 000)*
Industry liaison managers (IIT)[b]	7		1 000
Outreach program and information service (food science and technology)	3		500
Quality improvement (mathematics and statistics)	2	4 (1st year) 5 (subsequently)	750
Electronic systems (radiophysics)	3	2 (1st year) 2 (subsequently)	750
Corporate business strategy on SMEs	1		300
Total	16	6 (1st year) 7 (subsequently)	3 300

a The information in the table applies to each of 1994-95, 1995-96, and 1996-97, as $10 million has been provided over 3 years.
b IIT = CSIRO Institute of Industrial Technologies.
Source: Information provided by CSIRO.

Increased commercial exposure?

The external earnings target is said to encourage CSIRO to enter into exclusive collaboration with an industry partner (at the expense of other firms in the same industry), and to treat as commercially confidential the findings of the jointly-funded project. The partner generally has preferential access to the resulting intellectual property. As a result, while CSIRO may have some limited rights to its use, others in the community are likely to be excluded. Australia’s Technology Industries Exporters Group stated:

> It is also more difficult to access the appropriate scientist. They are now tied up in collaborative research with other companies and tightly restricted by Non Disclosure Agreements. Thus although it may be ‘core’ knowledge (paid for by appropriation funds for generic research) access to it is denied to Australian companies whilst the collaborative research partner (who may be foreign) effectively has sole rights to the knowledge at that juncture (Sub. 204, p. 5).

Some industry submissions to the ASTEC inquiry expressed similar concerns and that the target favours one-to-one arrangements with companies, rather than broader industry-based agreements. ASTEC said:

> Concerns were raised about the inequity of using public funds for projects that generate competitive advantage for a single sponsor, especially where core knowledge is tied up by non-disclosure agreements with the company (ASTEC 1994e, p. 24).

There is a financial risk for a research organisation entering into intellectual property agreements. The cost of disputes is high. CSIRO has been sued by some former commercial partners over rights of ownership of technology arising out of collaboration. It has paid $13 million to settle one dispute. In another, concerning the development of pixelgram anti-counterfeit technology, it has agreed to give its partner, Charter Pacific, rights to 50 per cent of the royalties (to up to $35 million, after which Charter Pacific's share of royalties will drop to 30 per cent) until 2006. In addition, CSIRO will advance to Charter Pacific $2 million against future royalties, as well as pay them up to 25 per cent of any royalties from new developments of the technology within the next five years. In addition to these disputes, CSIRO is involved in another 20 or so minor intellectual property disputes.

Apart from the implication that government research agencies can face organisational and cultural difficulties in coming to grips with the difficult role of successful entrepreneur, such legal tangles — involving negotiating and establishing property rights and perhaps defending them in court — distract the research agencies from their main role. While this is not a problem confined to CSIRO — it is common to government research agencies around the world — it has implications for the way in which agencies such as CSIRO carry out their broader public good roles.

In the Commission's view, government research agencies, including CSIRO should keep their commercial exposure to a minimum by avoiding joint-equity projects. This does not preclude collaborative research when each partner's responsibilities, liabilities, and the allocation of benefits are clearly understood and well defined. Agencies should not enter into arrangements for which the commitment (or potential liability) is open ended.

In particular, joint-equity ventures are generally high risk, have intellectual property ownership problems, generate results which are appropriable by private investors, require flexibility and entrepreneurial skills which are more suited to roles of the private sector, and divert agencies from the main focus of their work — public good research.

Intellectual property

Settling on the appropriate approach to intellectual property issues, including the ownership of intellectual property, is not a simple matter — which may explain why CSIRO has encountered the problems referred to above in managing its intellectual property. A number of factors are relevant to its resolution:

- CSIRO’s statutory responsibilities to assist industry and further the interests of the community, and to encourage the use of the results of its research (see section B2.2).
- The need for certainty. If intellectual property ownership is not clearly specified, all sorts of difficulties can arise, especially if the research generates a valuable property right to fight over, or if partnerships cease.
- CSIRO engages in different types of research. Much of it is of a public good nature and so is unlikely to create intellectual property ownership problems. But even a planned public good project may — by serendipity — offer the prospects of privately appropriable returns (for example via patents). Collaborative and commissioned work will typically create both public and privately appropriable goods. At the other extreme, contract research for a private firm may be intended to generate private benefits to that firm. Even then, however, the work may build on much public good research that was previously undertaken by CSIRO and others.
- Research outcomes are unpredictable. Although the objectives of a particular research project may be agreed to beforehand, the eventual outcomes of that research might be quite different to what was planned, or there will be some additional unanticipated benefits generated.
- CSIRO’s research is increasingly being externally funded. Should external funders have some say in the ownership of the intellectual property created by the research that they pay for — either fully or partially?
- CSIRO’s expertise is in doing research, not in managing a portfolio of intellectual property.

In considering all of the above, the Commission has concluded that the simplest approach would be for the ownership of any intellectual property to be allocated to only one party.

In principle, and reflecting its statutory role, the owner of all property rights should be CSIRO. This would enable it to benefit from any serendipitous research outcomes arising from self-initiated or commissioned research, and would avoid any appropriability of public good outcomes generated in the course of privately funded research. But it would also provide less incentive for private firms to commission research from CSIRO. This problem could be overcome by allowing CSIRO to cede its entitlements to the intellectual property rights arising from the research, provided that the research is fully paid for.

CSIRO should also have a clear and public policy for the management of its intellectual property. A research project funder should have a clear idea of what its entitlements to any intellectual property would be, including ownership of, right of first refusal, or preferential access to the ensuing intellectual property, and the relationship of that entitlement to what it has to pay for the research. Intellectual property management should also avoid joint ownership of any intellectual property.

In many instances the appropriate policy would be to allow patentable results to be widely accessed at negligible cost. Where the results of research are unlikely to be utilised unless property rights are exclusively assigned, CSIRO should auction those rights to the highest bidder.

CSIRO's principal responsibility is to ensure that the research results it generates benefit Australia to the greatest extent. To achieve this objective at minimum cost relating to intellectual property rights, CSIRO should not enter into contracts promising shared revenues from such rights, but should ensure that all relevant intellectual property rights are allocated unambiguously and exclusively *either* to itself *or* to other parties at every stage of any contract or partnership arrangement.

Some cross-subsidisation has occurred

Current funding arrangements provide an incentive to cross-subsidise research to increase external sources of funds, and the large appropriation funding of CSIRO provides an opportunity to do so. Australia's Technology Industries Exporters Group stated that appropriation funds are used to subsidise collaborative research:

> For every dollar spent by a company with CSIRO for collaborative research, it takes at least another dollar to support it from appropriation funding. McKinsey's figures gave it as 60% of appropriation that is used to support external funds.
>
> This is regardless of whether the company is Australian. For example, Boeing, spending about $25m with the CSIRO, is apparently getting a dollar for dollar subsidy on that research (Sub. 204, p. 6).

In 1991, the Auditor-General said:

> Some of the discrepancy between external funding and expenditure on external funded research is due to the fact that certain funders, especially granting bodies, do not support the overhead costs of research. Some of the discrepancy is due to the weakness in costing and pricing ...
>
> In order to meet external commitments, CSIRO is often forced to supplement the external funds with resources funded from Budget appropriations (ANAO 1991, p. 35).

In that report, the Auditor-General found evidence of discounting, observing that CSIRO did not have a uniform approach to pricing for its research services across its divisions. It added:

> CSIRO does not measure the human and financial resources used in generating external funds ... it is unable to produce the economy and efficiency or productivity indicators related to generating its external funds and to managing its funded activities.

The Coordination Committee on Science and Technology (CCST) also found discounting, stating:

> A large proportion of CSIRO external funds is earned from competitive grant schemes, which provide little or no overhead costs. Consequently, overheads associated with these projects are borne by CSIRO ... (CCST 1992, p. 35).

CSIRO agreed that it is essential to have accurate costing, adding that:

> ... to enable a more accurate attribution of overhead costs and asset utilisation charges to specific activities, CSIRO is implementing full accrual accounting, down to project level (CCST, p. 54).

It expected this would:

> ... improve the Organisation's capacity to fully cost projects, including the attribution of overheads and utilisation charges; better support the analysis and setting of priorities at all levels within CSIRO; and facilitate the development of more commercial pricing/funding policies (CCST 1992, p. 57).

In its 1994 follow-up report, the Auditor-General confirmed:

> CSIRO was not adequately identifying or measuring through current management information systems the costs of external funding, nor the level of subsidisation of externally funded projects from appropriation funds.
>
> There was no mechanism in place to ensure consistent costing practices across the Organisation (ANAO 1994b, p. vii).

ASTEC (1994e) concluded that cross-subsidisation was still continuing and that:

> ... a significant portion of appropriation funding has been diverted to achieve the external earnings targets; contracts with large rather than small organisations have been preferred; and free consultations (eg for small businesses) have become rarer (p. xv).

At the draft report hearing, AMIRA, in response to the question of whether the work CSIRO does is subsidised, said :

> ... it varies ... at one end of the scale it's paid for a hundred per cent by the individual company. At another end, there's a fair degree of appropriation funding. It might be on a fifty-fifty basis (DR transcript, p. 2978).

To the extent that cross-subsidisation of research from appropriation funds to obtain external income continues, it can:

- cause the costs of undertaking the research funded from appropriations to be overstated;
- under-price external research and thereby discourage the supply of lower-cost substitute private sector R&D. Some firms may be induced to substitute subsidised CSIRO research for their in-house research efforts, such that their capacity to use knowledge and benefit from learning-by-doing and by watching is reduced; and
- facilitate ‘double dipping’ by subsidising external funders, some of whom are also eligible for the 150 per cent tax concession or are otherwise publicly-funded.

Costing and pricing of research

The previous section on cross-subsidisation suggests that CSIRO does not include all costs in the work it does on contract to, for example, rural R&D corporations. This is perhaps done in the belief that there are significant public good aspects to that work.

This is also consistent with the view that it under-prices, relative to its own costs, so as to win outside work and thereby help meet its external earnings requirement.

In January 1992 the Coordinating Committee on Science and Technology (CCST 1992) examined the question of costing and pricing public sector research. Its main views are listed in box B3.3. Subsequently in the same year, the Government issued ‘principles for costing and pricing of research’ for government agencies (see box B3.4).

CSIRO issued a formal (confidential) *CSIRO Commercial practice manual* in February 1994 covering costing and pricing guidelines for its staff. The Commission has been given extracts of the manual, under commercial-in-confidence cover. In general terms the pricing guidelines take into account the potential value of the research to its client (depending amongst other things, on the exclusivity and appropriability of benefits); the community as a whole (which depends upon spillover benefits); and CSIRO itself (how it fits in with the organisation’s research plans).

The Commission is precluded by confidentiality requirements from commenting on the guidelines.

The Commission considers that CSIRO’s costing and pricing guidelines should be reviewed and explicitly agreed with Government and be made publicly available.

Box B3.3: **CCST's views on costing and pricing of public sector research**

Costing and pricing of research services are different issues. Accurate costs based on comprehensive accounting are essential parts of the information base on which managers and other decision makers rely for improved resource allocation decisions, including the appropriate level of prices, but pricing decisions are based on the 'market' for the research service and depend on various circumstances (p. 1).

Full costs are defined as the value of all resources consumed or utilised in an activity, including those not directly caused by the additional output. It generally comprises the cost of capital assets and the cost of funds employed, as well as labour, consumables and corporate support.

Full cost pricing includes a recognition of all costs, including those associated with infrastructure. Since the funders of research benefit from public infrastructure through making use of the infrastructure, it is appropriate that they contribute to its maintenance. Excluding infrastructure from pricing would provide an unwarranted subsidy. This would distort the use of government research facilities and may constitute a disincentive for private sector research organisations to undertake research.

Pricing decisions should be based on knowledge of all relevant cost components. Pricing of applied research with business needs to take account of factors other than the costs of actually conducting it, including consistency of the research with the overall objective of the research performer and funder; knowledge of market conditions and what the market will bear; costs of negotiations and administering the research; the value to the performer of conducting the research (eg to establish a market reputation or train staff); the degree of risk or uncertainty involved; and the degree to which the funder may fully appropriate the benefits the benefits.

There are circumstances when it is not appropriate to charge full cost, for example in areas of research that deliver benefits to the wider public or to the research performer, which the funder cannot capture (and therefore should not be charged for). Concessional pricing should, of course only be considered where there is insufficient subsidy offered by government through other schemes (such as tax concessions and grants) to pay for these wider benefits.

While external funding targets are an indication from the government that research agencies should perform a portion of their overall research for external users, they do not imply that research should be performed at below full cost and draw on appropriation funds.

The setting of a price for a research service between performer and funder depends on a range of factors, of which cost is only one; the others have to do with the objectives of both agencies, the nature of the market, and the capturing of benefits. The major considerations in such negotiations should be — the degree to which the funder can appropriate the benefits of research; the presence of public good benefits resulting from research; and whether the research would have been undertaken by the researcher or research agency in the context of its research priorities. Where the funders wish to fund research that is not closely connected to the core programs of research providers they would expect to provide a greater proportion of the funds.

Source: Based on CCST 1992, pp. 1-6, 22.

The Government's position on the costing of research is indicated in box B3.4. The Commission agrees with the Government's views that CSIRO:

> ... develop and maintain accurate accounting systems, recording all of the costs associated with any research project/program, with the best balance of accuracy, transparency and cost-effectiveness in doing so (Budget Related Paper No. 6, 1992-93, p. 1.33).

At a minimum, it is important that CSIRO adopt a consistent policy of fully costing all externally-initiated research.

Drawing firm conclusions on pricing, is however, more difficult. As the CSIRO Institute of Industrial Technologies has noted:

> CSIRO has sought to generate benefit for the manufacturing sector through its interactions with groups of companies and industry sectors but also through interaction with individual companies through two means:
>
> - **contract research,** where the required outcome is generally well defined in advance and which is usually conducted on a full-cost recovery basis with transfer of intellectual property, and
> - **collaborative research**, which is longer term in character with less precisely defined outcomes, and in which a collaborative firm shares the costs, risks and expected benefits (Sub. 445, p. 10).

Box B3.4: **Established principles for costing and pricing of government research**

In the Government's view:

- all research performers should develop and maintain accurate accounting systems, recording all of the costs associated with any research project/program, with the best balance of accuracy, transparency and cost-effectiveness in doing so.
- pricing decisions should be based on knowledge of all relevant cost components, to ensure the long-term viability of the research enterprise and to meet the need for accountability for publicly-provided resources.
- decisions on price should be based on an understanding of the respective objectives and responsibilities of the research performers and funder, and the extent to which the benefits from the conduct and results of the research can be captured by each party.

Source: Budget Related Paper No. 6, 1992-93, p. 1.33.

The Institute stressed the value of collaborative research:

> Collaborative research is seen as critical to maintaining a strong relevant core research base within CSIRO and to its role in helping generate national wealth via Australian companies, large and small. It accounts for about two-thirds of total company-related research in the manufacturing area. Collaborative research provides an efficient and cost-effective way for companies to access CSIRO core capabilities, link researchers to the market through practical feedback, and enables funding of significant projects that would otherwise not take place (Sub. 445, p. 10).

Case 1 - pricing fully appropriable external research

For research carried out for private firms where the benefits are fully appropriable by the firms, the client should pay for the full cost of the resources used in producing the required research output. If the client can buy the research more cheaply elsewhere, then it would be more efficient for CSIRO's resources to be used in other work. This position was supported by a number of users of CSIRO research.

The Cattle Council of Australia said:

> ... CSIRO should be fully charging for its contract research (Sub. 370, p. 12).

The Wool Council of Australia added:

> Full cost recovery of research conducted by CSIRO on behalf of R&D corporations is acceptable to Wool Council providing this does not preclude the joint funding of research programs. Joint funding has the potential to encourage cooperative research efforts and thereby improve research efficiency (Sub. 371, p. 7).

The NSW Farmers' Association, however, argued that:

> The high overhead costs associated with research carried out by CSIRO, and the continued scope for achieving internal cost efficiencies, means that pricing to fully recover costs will see CSIRO unable to compete with other research providers (Sub. 315, p. 17).

AIRG agreed with this assessment and stated that:

> Full cost recovery at the current CSIRO rate of overhead charges makes contract research unattractive to industry (Sub. 329, p. 2).

The CSIRO Division of CPSU stated that:

> In addition to its [full-cost recovery] impact on CSIRO's financial viability, this would jeopardise the organisation's current efforts to establish closer working relationships with industry, and ignores the need for flexibility in those relationships (Sub. 342, p. 6).

The Australian Academy of Technological Sciences and Engineering did not support the idea of full cost recovery of CSIRO research, as, in its view, there is a case for free assistance to small start-up enterprises and SMEs. In fact, it recommended an allocation of 5 to 7.5 per cent of CSIRO funds to work for these enterprises free of charge (Sub. 337, p. 3). It added:

> Full cost recovery should not need to be a rule as there are many forms of benefit which can flow to the institutional research party from contract work (Sub. 337, p. 1).

Case 2 - pricing research with spillover benefits

Other participants have argued that full cost recovery is not always appropriate, especially for collaborative research, where there are sometimes large net social benefits from working with industry. However, part of the problem of pricing collaborative research is often the inability to predict the presence or extent of likely future spillover benefits (see box B3.5). The CSIRO Institute of Industrial Technologies acknowledged this problem, stating that decisions on longer term research need both informed judgment and risk taking, as outcomes are often not obvious at the start.

The above example from the Institute shows how difficult it is to identify public and private benefits and the extent of any spillovers in advance. The Commission notes these comments and considers that where additional spillover benefits are foreseen, these need to be listed, evaluated and allowed for in the pricing policy when the research is being arranged. Where departures from full cost pricing are proposed they should be fully justified and documented. Where such benefits are not foreseen but the research later generates large social benefits, the subsequent evaluation may help influence future priority decisions.

It should also be noted that many CSIRO clients are often already subsidised by Government through other programs. For example, because of the existence of spillover benefits, firms are already supported by the 150 per cent tax concession or grants to undertake R&D. CSIRO should only depart from full cost pricing of research for firms if there are expected to be some demonstrable spillover benefits which are not compensated for by such subsidies.

Box B3.5: **Payoffs from strategic research**

An example from Division of Biomolecular Engineering helps illustrate the way the outcomes of strategic research are not always obvious from the start, and dates back to employment in 1978 of a plant pathologist to work with protein chemists to develop new approaches to the detection of viruses using microscopy and antibodies.

Fundamental studies of the structure and variation in potyviruses began in the early 1980s, and a decade later the research team, composed of about a dozen individuals over that extended period, has solved a plant classification puzzle that will enable scientists to detect, identify and control the largest group of plant and crop viruses, leading to significant savings. Potyvirus plant diseases account for about $10B of crop damage each year. Even more significant perhaps, in working out the methodology for potyvirus classification, new light has been thrown on viruses in general, including human viruses with, as a first step, a discovery concerning Hepatitis C that has important implications for its detection and control.

Source: Reproduced from CSIRO Institute of Industrial Technologies, Sub. 445, p. 7.

Similarly, research commissioned by rural R&D corporations or other government-supported research funding agencies should also be full cost priced to avoid a double subsidy, unless additional social benefits not already subsidised by government are identified. While there may well be some public good component in such research, this is often taken into account through assistance to the funding agency, so there may be no cause for the public, through CSIRO, to further subsidise that work. The advantage of this approach is that the research is user-driven, and the public good component accounted for in the subsidy to the R&D corporation.

The Commission recommends that CSIRO research be priced to recover full costs unless additional social benefits not already subsidised by government are identified.

If there are further exceptional public good benefits arising from the research, perhaps which extend beyond the industry or interests for which the research is commissioned, a further subsidy may in some circumstances be justified. In such cases, the benefits would need to be identified and explicitly funded.

Later the Commission examines some alternatives by which funding of those broader public benefits might be achieved.

B3.4 The value of CSIRO's research

Participants expressed a variety of views about the value of CSIRO's research to their activities. While many considered that CSIRO had many good people who were undertaking worthwhile research, and that the benefits to Australia from CSIRO's research were very high, the view was often put that this was of little use to industry in a day-to-day sense, because of the different working 'cultures' involved.

For example, the AIRG suggested that a major problem for CSIRO is to manage the interface with industry and to cope with a market approach to technology. Other participants suggested that there is a large time cost (slow response, much paper work, confidentiality agreements and so on) in dealing with CSIRO. This can disadvantage a firm which is seeking to get a differentiated product to the market quickly. Critec Pty Ltd said:

> ... our experience with public research organisations with collaborative R&D has been poor, primarily because of the unrealistic expectations of worth by those organisations when only the R phase has been completed, a near total lack of customer focus, and because of excessive demands for cash royalties at early stages of the projects (Sub. 194, p. 2).

Dr Summerfield said:

> We have talked to CSIRO on a number of occasions. At one point we were actually simulating a chip design that we had implemented, and we went to them for assistance on getting some computing resource to ... complete that simulation. In the end we plugged our computer in for 3 months and did the simulation ourself ... trying to gain access to CSIRO was very difficult for us as a small company. We needed to move

> quickly. They tend to concentrate on their in-house pet projects as such that they had, and we have not found the collaboration with CSIRO to be useful at all ...
>
> They're not exposed to the commercial realities. They have their projects, they have their agendas in place, and we come along with requests and we don't get much opportunity to do business with them (transcript, p. 1078).

In a recent study undertaken for the (then) Department of Industry, Technology and Commerce, none of the Australian communications firms surveyed regarded research institutions such as CSIRO as important sources of technology. In contrast, 27 per cent of respondents in the food processing industry rated cooperative research with universities and CSIRO as important sources of technology (TASC 1990, pp. 39, 42).

These views do not directly help to answer questions about the value to Australia of the research which CSIRO is producing. One way of looking at this is to ask what are the returns to Australia — irrespective of to whom they accrue — from CSIRO's research. To shed some light on this, we can turn to those benefit-cost studies which have been undertaken of particular CSIRO projects or programs.

Many selective studies have been undertaken over recent decades into the benefits to Australia of research, particularly into rural research. CSIRO cited a private sector consultant's study (McLennan Magasanik Pearce 1988)[1] on the *Coalscan* discovery as yielding a national return of eight times the cost of the R&D (Sub. 113, p. 22).

Estimates of the rates of return on some of CSIRO's rural, industrial and environmental R&D are provided in table B3.2. These selective studies are of R&D projects that account for a relatively small portion of CSIRO's total research effort.

The particular studies in rural research have estimated the benefit-cost ratios ranging from 4:1 to 60:1, with a median of 15:1 (at a 5 per cent discount rate). This suggests high returns for investment in those areas of rural research (about $15 for every dollar invested on average). The studies suggest that investment in research into other industries yielded an average return of about $4 for every dollar (at a 10 per cent discount rate). In environmental research the average benefit-cost ratio for the selected studies was about $6 for every dollar invested.

It is very difficult to identify and measure the extent to which parties other than those directly involved receive net benefits. In addition, errors in methodology can lead to some costs or benefits not being taken into account. And

1 Also see table B3.2.

assumptions have to be made about future benefits — often based on the perceptions of those involved in the research projects.

The studies listed in table B3.2 generally estimated the benefit-cost ratio of *selected* projects — excluding those which had been abandoned as failures — which tends to bias the assessment. Moreover, successful projects tend to be the ones for which data are more readily available. It seems likely that net benefits would be lower if all projects were to be taken into account.

For example, a joint Industries Assistance Commission/CSIRO 1980 study of the returns to 13 selected research projects completed between 1960 and 1975 by the Division of Entomology found that a small number of projects generated significant net benefits (one, the biological control of skeleton weed, had a benefit-cost ratio of over 110:1), while for most the net benefits were negligible. In aggregate, the 13 projects returned a benefit-cost ratio of 4:1 when using a discount rate of 5 per cent, and 2:1 when using 10 per cent (IAC and CSIRO 1980).

The studies indicate that CSIRO has had good returns in those areas examined, especially in agricultural research. Similar benefit-cost outcomes from investment in agricultural research have been found in studies undertaken in the United States and Europe.

Nevertheless, given the shortcomings of the selected case studies approach and benefit-cost estimates, it is difficult to generalise from them about the net benefit of research done by CSIRO.

Whether or not this research is better undertaken within CSIRO or elsewhere depends in part upon the return on the marginal research dollar within CSIRO, as well as other research agencies competing for research funds, and more generally a comparison of the marginal return on alternative publicly funded activities. More importantly, perhaps, it does not exclude the possibility that other institutional arrangements might achieve better outcomes and/or lower costs. Some of the questions that the studies do not answer are:

- could some of the research have been done more efficiently by others, yielding greater net benefits, under different arrangements?
- would different projects have been chosen? and
- would the speed of completion of the projects have been faster and the diffusion of knowledge greater to the economy under different arrangements?

Table B3.2: **Estimated benefits of selected CSIRO research projects**

Nature of project	Discount rate %	Benefits ($m)	Costs ($m)	Benefit-cost ratio
Rural research				
10 projects in the Institute of Plant Production and Processing [a]	5	2371	161	15:1
13 projects in the Division of Entomology[b]	5	475	107	4:1
Sirospun	5	964	16	60:1
8 projects in the Institute of Animal Production and Processing [c]	5	662	41	16:1
Biological control of echium species[d]	5	57	7	8:1
Research into other industries				
8 minerals projects[e]	10	359	133	2.7:1
50 aluminium projects[f]	np	600	102	6:1
4 manufacturing and communications technology projects[g]	10	np	np	3.6:1
Environmental research				
Environmental projects[h]	5			5.8:1

np not provided

a CSIRO 1992, *Rural Research - The Pay-Off*, Occasional Paper No. 7, May. 10 selected projects were studied.

b IAC-CSIRO 1980, *Returns on Australian Agricultural Research*. This reviewed the research undertaken in the Division of Entomology from 1960 to 1975. It took account of all costs of the Division and all benefits from 13 projects completed during that period (there were a total of 40 or so research programs undertaken by the Division during the period).

c CSIRO, *Animal Production and Processing Research - The Pay-Off*, 1993. Eight selected successful projects were studied.

d IAC 1985, *Biological Control of Echium Species (including Paterson's Curse/Salvation Jane*, Report No. 371.

e McLennan Magasanik Pearce Pty. Ltd. 1988 *Economic Evaluation of Selected Research at the Division of Mineral and Process Engineering.* Eight selected minerals research projects were studied by a private sector consultant.

f ABARE 1991, T*he Economics of CSIRO Aluminium Research, a report to the CSIRO Institute of Minerals, Energy and Construction*, vol. 1. The study examined 50 CSIRO projects relevant to the aluminium industry.

g BIE 1992, *Economic Evaluation of CSIRO Industrial Research*. This paper examined four manufacturing and communication technology projects.

h Carter M. and Young R. 1993, *Environmental Research - The Pay-Off*, CSIRO Occasional Paper No. 8,, April. This paper examined six research projects.

Source: CSIRO, Sub. 113, pp. 21-3 and original studies listed above.

One means of generating better information on this issue is to carry our more comprehensive evaluations of research projects. This is not to say that all projects need to be subjected to formal benefit-cost scrutiny. But if ex-post evaluations were to be made part of routine reviews of research programs, any possible bias in the findings should be reduced, and a more rounded picture should emerge.

Evaluations should include reviews of unsuccessful and prematurely terminated projects, as well as those which provided successful outcomes.

Part of the difficulty in evaluating much of CSIRO's research is that there has been no external customer. As a result, it is difficult to know whether CSIRO is carrying out the kinds of research which would best meet the community's needs.

B3.5 Dissemination of CSIRO's research

Much of the knowledge produced by government research agencies such as CSIRO should have widely applicable benefits and relatively low costs of dissemination. Such knowledge should be disseminated widely, and, indeed, the Act under which CSIRO operates requires it to disseminate its scientific findings widely in the community. CSIRO said that it seeks to:

> Increase recognition by Government, industry, and the general public of CSIRO's contribution to the nation [and to] improve Australia's ability to interpret and disseminate scientific and technical knowledge for the economic benefit of our industries (CSIRO 1993c, p. 76).

Not all knowledge or research produced by CSIRO is predominantly long-term strategic research of public benefit. Some has appropriability characteristics and it will benefit the user to exclude others from its use. To the extent that CSIRO enters into exclusive agreements with selected firms/users, it will in most cases limit the speed and extent of knowledge and technology diffusion in the economy. The costs of slowing the technology diffusion rate by exclusive agreements may be higher than the gains from the earlier development of the technology through collaboration.

As noted in part A, dissemination can occur in a number of ways — embodied in goods and services, through people talking to one another or changing jobs, or through 'codified' knowledge (publications, patents, consultancy reports and so on).

For CSIRO, the last of these is the most important. The production of goods and services is not a major contributor to dissemination of its research, and while its people do a lot of networking — attending professional gatherings and the like — mobility in an employment sense is not high. The mobility of people is sometimes regarded at the most important of these.

CSIRO uses a number of channels to disseminate its scientific findings to the community, such as publications, conferences, information networks, secondments of research personnel, and collaborative research links. More broadly, it provides information to the community through the media, school programs and public events. These advertise CSIRO's services and achievements, and encourage an interest, particularly in students, in matters scientific.

Publications

Over the last decade, the volume of CSIRO's publications output has changed little — from 3380 documents in 1984 to 3300 in 1993. But there has been some change in the type of document produced. Table B3.3 shows that the relative importance of journal articles and books (or chapters in books) has fallen since 1984. Many of the increasing number of confidential consultancies undertaken for the private sector are not included in this table.

Table B3.3: **CSIRO publications by document type** (percentage of total)

Year	*Journal articles*	*Conference papers*	*Technical reports*	*Books/book chapters*	*Other*[a]	*Total*
1984	53	26	10	9	2	100
1993	49	28	7	6	9	100

a Includes newsletter articles and some unpublished material.
Source: CSIRO 1994b and 1995c, p. 18.

Staff movements

CSIRO stated that it encourages staff secondments to the private sector. It said that while employment terms and conditions do not in themselves constrain staff from undertaking secondments, superannuation and workers compensation may become complicated, and the terms of secondment and the degree of support offered by the receiving party also influence outcomes.

If the secondment is related to technology transfer, then the benefits are more obvious and the secondment is more likely to be paid for by the recipient organisation. In some situations, staff have been allowed leave without pay to seek positions outside or establish their own businesses. In some cases, new businesses involved CSIRO technology transfer and were seen as an appropriate means of technology transfer.

An alternative to secondments that has sometimes been used by CSIRO to encourage technology dissemination is for CSIRO staff to branch out and set up their own companies or company with CSIRO short-term equity. There are some examples of this occurring (such as the Preston Group), but not many.

Over the past year or so, 7 staff were seconded from the Institute of Minerals, Energy and Construction, and 13 from the Institute of Industrial Technologies — two of the Institutes most likely to second staff to the private sector. These numbers are comparatively low, given that there were 1161 and 989 staff respectively working within these Institutes.

This low level of secondment may reflect the fact that professional careers may be better advanced working within CSIRO. But the scope for mobility also depends on the individual's field of research and degree of speciality. In some fields, there is little opportunity for secondments to the private sector, especially in Australia. Indeed, a relevant question is whether the sheer size of the subsidised public research sector is not limiting the extent the private research capacity can grow (and, incidentally, thereby create external opportunities for CSIRO scientists).

At the draft report hearings, the South Australian Government said that:

> ... after a certain period of time .. people [are] ... locked in for other reasons - superannuation ... the portability of entitlements and ... employment conditions.
>
> ... sometimes you wish to attract people from other agencies, from other areas, because it's appropriate in their career or the particular program ... but you can't bring them because you can't match and equal the same package of remuneration, vehicles ... (DR transcript, pp. 2279-80).

In the context of staff mobility, Mr John Stephens (a former CSIRO employee) said that:

> ... it all gets down to really four factors: one is the opportunity to get out there, and there are not very many of them really. The other one is reward. The other one is security, and if you are going to go into some part of private industry which is naturally regarded as a high-risk area such as research and development, then security is the other side of the coin, the start. The fourth is job satisfaction (DR transcript, p. 2574).

Comparison with other countries is difficult. However, the Commission was told in Taiwan, that ITRI (Taiwan's equivalent to CSIRO) has a high staff turnover (up to 10 per cent annually), with staff moving into industry or in some cases setting up spin-off companies to commercialise research results.

There may be scope for more secondments by CSIRO to industry. CSIRO's own experience with SMEs points to providing more secondments (both inwards and outwards) as an effective way to transfer skills and to encourage an appreciation for the ways in which technical R&D may be used.

As pointed out in the Commission's 1993 report into *Impediments to Regional Industry Adjustment*, while the current regulatory framework does not inhibit portability of superannuation entitlements, superannuation funds have their own design features that may, in some cases, discourage the mobility of staff. These design features include eligibility conditions and vesting rules. Many funds require the employee to work with the employer-sponsor for a minimum period before being eligible for membership, or for employer contributions.

Vesting refers to the process whereby workers become entitled to contributions made on their behalf by an employer. The vesting scale, referring to the rate at which employer contributions vest to the worker, is dependent on the length of the membership period. Funds which have long vesting scales require employees to remain with the employer for a long period before they are eligible for the full employer-financed benefits. This could constrain mobility. This applies to some private sector employers and could limit the attractiveness to CSIRO staff of transferring to the private sector.

In addition, the report noted that in the private sector, long service leave is not portable between employers. CSIRO employees seeking secondment or long-term employment with the private sector are constrained in this respect (see also part F).

B3.6 Size, structure and efficiency

Suggestions that CSIRO research is expensive are sometimes made in tandem with complaints that it is too large and that its organisational structure is inflexible and unwieldy. Several participants in this and the Senate inquiry have suggested that CSIRO as an organisation is too large and not structured to be able to meet the needs of its different clients.

Cost of research

The costs of CSIRO's research relative to that conducted in the private sector has been raised as an issue by some participants, including the MTIA and Techniche. These participants and the Australian Industrial Research Group (Watson and Smith 1991, p. 256) claimed that CSIRO's charge out rates were higher than those of equivalent private sector research laboratories. The Australian Industrial Research Group carried out a survey of eight industrial research laboratories and four government research institutes and found that CSIRO's:

> ... charge out rates[2] for contract research are often three times salary or more ...

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[2] AIRG defines total charge-out ratios or rates as the ratio of laboratory total budget (salaries, overheads, materials etc) divided by direct R&D labour salary costs.

compared with:

> ... the more efficient research institutions [that] cover all their costs (including salaries, travel, consumables, depreciation, rates, taxes etc) with a charge out factor of 2.0 to 2.2 times the salary of their research personnel ... The mean charge out factor was close to 2.5 which is similar to figures quoted internationally (Watson and Smith 1991, p. 255).

MTIA said that charging rates by CSIRO's and some universities make some R&D more expensive than if undertaken in-house (Sub. 133, p. 21 and transcript, pp. 1492–3).

CSIRO said that the ratio of total costs of a research agency to the total costs of its research personnel for CSIRO is acceptable at 3.0 compared with 2.0 to 2.5 in the private sector. CSIRO cautioned against such cost comparisons because of the different methodologies and cost accounting practices used (Sub. 113).

To the extent that private sector charge out rates are lower, it may be that CSIRO costs are higher, or that CSIRO is trying to get the private sector to pay for public good research in addition to the R&D of direct benefit to industry. It could also suggest that CSIRO is using its market power to extract the highest price. Alternatively, it could be that CSIRO has made the wrong R&D investment decisions (such as overinvesting in a particular area of research) relative to the demand for the research from industry leading to industry not being prepared to pay the full costs. It is quite possible, however, that some customers for CSIRO research might feel that charges are excessive while others obtain research cheaply. For example, it could be that CSIRO is high cost generally and, as discussed previously, may cross-subsidise to compete in some cases. Without cross-subsidisation the charge-out rates would be even higher relative to the private sector.

Based on the evidence, it is difficult to assess the cost effectiveness of CSIRO's research, especially where there is scope to cross-subsidise. In the Commission's view, competitive pressure is the most effective incentive for cost minimisation. The bulk of CSIRO activities involve no such pressure.

Is CSIRO too big?

CSIRO stands out, even internationally, for its size and the breadth of its research coverage. Its Chief Executive said that the location of multi-disciplinary skills in one institution was an advantage in that these various skills could be drawn upon quickly to meet needs (transcript, pp. 1378, 1384 and 1411). There would be potential economies of scope in such circumstances, and lower transaction costs when undertaking multi-disciplinary research.

The CSIRO Evaluation Committee (CSIRO 1995a, p. 16) has argued that it is important for it to maintain an institutional structure that will extract the maximum advantage from CSIRO's unique multi-disciplinary character. It proposes to achieve this through a structure and system that will allow the divisions to be clustered in flexible groups according to 'need and efficiency' (this is discussed further in the next chapter). The size and coverage of CSIRO were seen as problems by a number of participants, who variously suggested that:

- CSIRO is too big and involved in too many areas of research;
- CSIRO is too hierarchical — with the CSIRO Board, the Chief Executive, the Institute Directors, and the Division Chiefs. This is said to contribute to user remoteness from the researcher, and conflict between the line management and corporate responsibilities of senior managers; and
- CSIRO is inflexible and not interactive enough to respond to changing market needs.

Questions were also raised as to whether the large size, the range of CSIRO's functions, and the multiplicity of stakeholders it is trying to serve at the same time, is not making it too difficult to manage as a single institution. CSIRO supplies research outcomes for several interest groups — research for the community as a whole, and research required by particular firms or industries. According to the Australian Industrial Research Group, these differences can lead to problems:

> ... CSIRO has ... the broad public good or the more knowledgeable society base as a customer. It has got government departments as a customer and it has got industrial groups as a customer. And those customer bases are reflected somewhat in some of the institutes but not entirely. The customer's requirements are quite different, the way they operate are quite different, the drivers are quite different, yet the organisation itself is trying to run as a monolith so it has inherently got a problem (DR transcript, p. 1923).

Some considered that CSIRO should be split into several smaller autonomous research units. The Australian Industrial Research Group suggested that CSIRO be broken up into:

> ... a few separate groups to target customers in particular sectors (eg value adding to energy and minerals; agriculture and the environment; information and communications) with the only goal to ... [work] with that particular sector to innovate and transfer technology to support the aim of achieving world competitiveness of individual industries and businesses that make up that sector (Sub. 184, p. 52).

The approaches and cultures required to be an efficient producer of research for different groups within the community may well be different. Biotech Australia said:

> Are [CSIRO] there to do academic research, are they there to do industry's research for them, or are they there to do work of strategic research for the general good of the country? I think it would be easier if these objectives were split up a little (transcript, p. 1008).

It said that R&D is more efficiently carried out in industry than in government laboratories, and advocated the establishment of industry research institutes to enable small and medium companies to carry out R&D:

> This could be initially funded and resourced partly by the government resources currently spent on government R&D aimed at those industries. Such institutes should be managed by client companies so that in effect, member companies would use the resources and staff of the institutes to conduct their work as if it were 'in-house' R&D. (Sub. 81, p. 2).
>
> ... CSIRO could transfer some of its technology and expertise and personnel into - such institutes - to get them up and running ... it could actually be a group in the CSIRO which becomes such an institute, or it could be a group in the CSIRO which catalyses the setting up and getting such an institute going (transcript, p. 1008).

Some other countries have taken just this approach. In Korea, a number of separate research agencies have been 'spun-off' from KIST. And New Zealand split its CSIRO-equivalent body, together with other departmental research institutions such as MAFTech, into ten Crown Research Institutes. In Australia, a previous Minister for Science, Mr Schacht, proposed combining parts of CSIRO with AIMS, but this proposal was not taken up.

In the Commission's view, it is difficult to judge what CSIRO's optimal size and coverage should be. Ultimately decisions on these questions should depend on what CSIRO does best, compared to other public research institutions and private researchers. While the internal organisational arrangements for CSIRO can make an important difference to its performance (as in any organisation), the critical issue has more to do with the external environment, and in particular whether the organisation is receiving the right signals about what research is needed and faces adequate incentives to be cost effective in their delivery.

B4 CSIRO - OPTIONS FOR REFORM

The previous chapter suggested a number of reasons why, despite the high calibre of CSIRO scientists, the professionalism of its current management and the importance of its scientific achievements over the years, doubts and confusion persist about its contribution to the welfare of the Australian community that funds it.

First, in the absence of more explicit guidance from government — on the community's behalf — CSIRO has been obliged to develop its own national research priorities. Recently, it has adopted a relatively sophisticated methodology to this end, and it obtains input and advice from representatives of business and other community interests. CSIRO scientists are well qualified to judge the *feasibility* of various areas of research, but it is questionable whether current arrangements can yield the best assessment of the *attractiveness* or potential social payoff from the alternatives.

Such assessments are inherently subjective and are best made by the potential users or their representatives. Equally as important, this process has been largely in-house (albeit with some industry or customer advice), and therefore provides little scope for understanding or 'ownership' by the broader community. When priorities appear to have changed, those who feel disadvantaged seek to bring political influence to bear. Last year's Senate inquiry is only the most recent manifestation of this.

CSIRO has itself observed that:

> ... despite real improvements which have been made over the past few years, overall performance is still below customers' expectations in areas such as listening to customers needs, contractual responsiveness and timeliness and marketing our capabilities. CSIRO needs to respond better to the customer's requirements for service, particularly through more receptive listening (CSIRO 1995a, p. ii).

Related to this is the increased contractual and commercial orientation of CSIRO's activities with larger firms (local and foreign). The potential for the broader community to benefit from this work may be limited and CSIRO has sustained high costs from associated commercial disputes.

Moreover, there is evidence that CSIRO's external work has not only influenced the organisation's wider priorities (which has been an objective of the 30 per cent external earnings requirement) but has frequently not covered the costs of CSIRO resources devoted to it. This can:

- crowd out the more broadly applicable strategic research that CSIRO should be concentrating on;
- provide a double-dip R&D subsidy to private firms that are already benefiting from tax concessions or grants (CSIRO subsidises the work of RDCs and private firms which already receive government support for R&D, although it is not clear that there are always identifiable additional benefits); and
- crowd out a greater private research capability, which could also service the needs of Australian firms, including inhibiting the mobility of scientists from CSIRO itself.

In addition to these problems, it is very difficult to evaluate the cost effectiveness and net social benefits from CSIRO's research activities as a whole.

The source of the continuing controversy about CSIRO's role and performance is that it receives annually nearly half a billion dollars of public funds, but has essentially been left to itself to choose how to spend it and to monitor the benefits that come from it. CSIRO appears to stand out internationally in this respect, as well as in relation to its relative size and range of activities (see appendix H).

CSIRO itself has recognised that the lack of external guidance for its choice of work is unsatisfactory. In response to a question as to how CSIRO knew it was doing research which was attractive from the national point of view, Dr Stocker, the previous chief executive of CSIRO, stated:

> ... in an organisation like CSIRO which is overall a large agency but a small part of the total Australian research scene, it is quite difficult without a frame of reference of some kind of a national research strategy and a set of national research priorities, and in fact it's impossible for us to set any particular course without having a view of national research priorities (transcript, p. 1391).

More recently, CSIRO has been increasing its efforts to strengthen the involvement of the users of its research, and the broader community, in its priority-setting processes. It said that it is endeavouring to help articulate a 'whole of government' influence on its research agenda, and is:

> ... genuinely committed to the development with departments of an enhanced understanding of the Government's research needs ... Departments would grow in their capacity to articulate the government's needs and CSIRO would be able to bring to bear its considerable experience and expertise in the identification of national research needs and would be better informed in the determination of research priorities (Sub. 356, p. 17).

In its draft report, the Commission noted that a clearer articulation of government priorities, together with the development of some meaningful performance indicators and reporting, would improve accountability and increase the incentive for enhanced performance. But this would still leave CSIRO to allocate its appropriation funding, provide little scope to test CSIRO's research performance against alternative providers and not constrain the ability of CSIRO to cross-subsidise research for private clients.

The Commission sees benefits in achieving greater external influence over what CSIRO does, and in obtaining greater external input into the process of monitoring and evaluating the costs and outputs of that research.

B4.1 External priority setting and funding

The 30 per cent external earnings requirement has made CSIRO more responsive and accountable to users. But it is a blunt instrument and, on its own, carries the risk of diverting CSIRO into research of benefit mainly to those who commission it. Where clients are public sector agencies or departments, this is less likely to be a problem than where clients are individual private firms. While work for such firms is useful, and can yield results that are of general benefit, it is not the central reason for having a publicly funded research agency. Such research could in time be done by private firms themselves or by private research companies (such alternative sources are more significant overseas).

To prevent CSIRO's work being driven mainly by the interests of its scientists on the one hand, or of individual companies on the other, the Commission considers that government needs to exert more influence over the allocation of CSIRO's public resources (the 'appropriation') than has hitherto been the case.

Providing a greater role for government in priority setting and funding of CSIRO's research would, in principle, yield a number of benefits. It would:

- provide more scope to address perceived national needs and to achieve wider ownership of CSIRO's agenda;
- improve CSIRO's accountability and allow ongoing evaluation of its performance;
- allow CSIRO's performance to be tested against that of other researchers within government, universities or the private sector; and
- reduce the scope to cross-subsidise research performed for private clients.

In its draft report, the Commission accordingly recommended that government:

> ... increase substantially the extent to which it commissions CSIRO to do public good research on a project or program basis, according to priorities established outside the organisation (p. B.67).

The Commission nevertheless observed that how this principle might best be implemented is more problematic. It put forward for public consideration three options, based in part on approaches followed in other countries, noting that each had advantages and disadvantages. In brief, the options on which the Commission sought public comment were:

Option 1: For the Minister responsible for CSIRO, through the department, to fund specific programs of research, rather than provide a block allocation to CSIRO.

Option 2: To divide CSIRO's appropriation among the several portfolios covered by its work, to enable the respective departments to contract CSIRO to do research in the areas to which they attached priority.

Option 3: To create a separate and independent agency with responsibility for prioritising and funding public good research on behalf of the Government, drawing on wide community input.

The Commission emphasised that while overseas experience suggested that such options were practicable (see boxes B4.1 to B4.3), their applicability or relative usefulness in Australia would need to be assessed in the context of Australia's particular circumstances. A key determinant of their relative merit is whether they could lead to priority setting in a way that ensures CSIRO's agenda has wider 'ownership' and reflects national needs. The Commission considered the second and third options to be preferable to the first in those respects, as CSIRO's relevance extends beyond the particular interests and expertise of a single department.

The Commission also emphasised the need for any such change to be implemented gradually, to minimise disruption to CSIRO's research and researchers. Both the allocation of appropriation funding, and the extent to which such funds could be contested by other researchers (including other government agencies, universities and private firms), would be phased in. CSIRO would also retain some appropriation funding — which the Commission suggested could be 10 to 20 per cent of total government funding — to allow it to undertake research or to maintain facilities which it considered important and were not being otherwise funded.

Box B4.1: **Funding of government research agencies in Taiwan and Korea**

TAIWAN — Industrial Technology Research Institute (ITRI)

ITRI, which was set up in 1973 under the direction of the Ministry of Economic Affairs, has five major divisions to support the development of various industrial technologies (Industrial Technology Research Institute 1992). Two-thirds of ITRI's revenue comes from government, while one-third comes from industry and government agencies. ITRI's future directions re-emphasise that ITRI works for the benefit of private industry and aims to obtain half its funding from the private sector.

ITRI is funded on a *project or program basis* rather than by block allocation. The money that comes from the government is on a per project grant basis and has to be competed for. But in reality, ITRI has little competition in supplying research of the kind funded by the government. Money from industry has also to be competed for, but on a more competitive basis. This is because industry has its own research facilities.

ITRI tends to generate the research ideas for research projects to obtain funds from government. The projects proposed are subject to rigorous screening at several levels: internally (by the president and vice presidents of the Institute, providing something close to peer review): and externally (by the Ministry of Economic Affairs).

KOREA — The Korean Institute of Science and Technology (KIST)

KIST was established in 1966 as the first government funded research organisation. It has largely done applied research under contract, mainly to government but also to industry. However, KIST is now expanding its basic research capacity and has recently received $6 million from the government under the 'KIST 2000' program to enhance basic research.

KIST originally covered a wide range of research activities, like CSIRO, but (unlike CSIRO) has since been split up through the formation of separate 'spin-off' institutions: the Science and Technology Policy Institute (STEPI) and the Electronics and Telecommunications Research Institute (ETRI).

Block funding from the government does not cover all projects. Typically KIST puts proposals for such projects up to government which decides whether to fund them or not. KIST must compete against other, more specialised, research institutes for government funding.

Source: Overseas visits and appendix H.

B4.2 Response by participants

The Commission's proposals, as anticipated, generated considerable public debate. A variety of views were expressed by participants, with some key issues and arguments receiving a more open and sustained airing than has previously been experienced in Australia.

Box B4.2: Funding of government research in the United Kingdom

In 1991, total expenditure on R&D in UK was equivalent to about $A26 billion. About half was funded by industry. Almost 45 per cent of government-funded R&D is spent by the Ministry of Defence, while a further 20 per cent goes to other government departments, most notably the Department of Trade and Industry (seven per cent).

The remaining 35 per cent, designated as the ‘science base’, is divided equally between the Higher Education Funding Councils (HEFC) and the Research Councils. HEFC funds are distributed as block grants to universities to cover salaries, libraries, office and laboratory space and so on. Research Council grants are for specific R&D projects at academic institutions. The six Research Councils, headed by researchers, are the main route for government funding of academic R&D.

The Research Councils still control a significant proportion of government funds released through the Department of Education and Science, receive income for government-funded strategic research done for the functional Ministries/departments (which purchase research under the customer-contractor principle recommended by Lord Rothschild), as well as income from the private sector.

The Ministries use the R&D funds under their control for contracting research, either from laboratories located within the Ministry or from external laboratories. A surcharge of 10 per cent of contract funds is imposed to fund basic research. The UK White Paper in 1993 stated that Rothschild’s customer-contractor principle will be maintained and strengthened in relation to departmental applied R&D. Departments will continue to develop their role as intelligent customers for science and technology.

The Departments as customers purchase their research directly from research performers, or through the Research Councils, who act as contractors for departments. The Research Councils may undertake a defined program/project of research in their own research laboratory, or contract it out to a research institute or to some other organisation or individuals.

Sources: Congressional Research Service 1994; United Kingdom White Paper 1993.

Nevertheless, it is evident that there has been more support for the Commission’s assessment of CSIRO’s role, and its diagnosis of the problems with current administrative and funding arrangements, than there has been support for the prescriptions. And the broader principles of achieving greater external influence over priorities, making CSIRO more accountable and its funding more contestable, also received more support than the particular options for putting these principles into effect.

External priority setting

There was general agreement that CSIRO still needs to be influenced more by external perceptions of national research needs and areas of priority. For example, CRA Ltd said:

> ... the CSIRO priorities should be set by an independent body (Sub. 296, p. 1).

Box B4.3: **Funding public good research in New Zealand**

The management and organisation of government-funded science in New Zealand is separated according to government's involvement in science and technology *policy*, science *funding* and *the carrying out* of R&D.

Policy is decided by Cabinet. The Government is required by law to set priorities for public good science, and must issue a priority statement at least once every three years. The current priority statement sets out five-year funding targets for each of 24 science areas. It includes the setting of priorities for research by groups of output classes, funding levels by output class and priority research themes. Priority themes were at three levels - generic themes, such as sustainable development, applicable to a large number of output classes; cross-output themes, such as climate change, on specific topics and naturally linked groupings of outputs; and specific output class themes of key importance which have not been considered elsewhere.

The Foundation for Research, Science and Technology (FORST) is the Government's agent for the purchase of public good science outputs. It allocates the Public Good Science Fund (PGSF) so that the Government's strategic intentions for science as set out in the priority statement are most efficiently and effectively met. The PGSF is the largest source of public resource funding in New Zealand, and is the primary means whereby the Government invests in science. About 60 per cent of the Government's total research expenditure is channelled through the PGSF and allocated by FORST. For 1993-94 the Government had budgeted NZ$275 million for the PGSF.

A key element of the new system is the way funds are allocated through the PGSF. Competitive proposals in the different output classes are invited — funding is contestable. All eligible research organisations or researchers seeking to carry out public good research can apply for funds. The PGSF is accessible to all comers, including, progressively, the universities.

After communicating priority themes to FORST, the Government expects FORST to translate these into research strategies. It is required to consult extensively with a wide range of stakeholders. Information and technology transfer should be important considerations in every research proposal funded through the PGSF. Each strategy should include a consideration of the level of private sector and non-PGSF funding proposed or expected in that area of science. FORST is required to categorise funded programs into fundamental, strategic and applied research, and experimental development in each output class and the results are to be made publicly available.

In selecting research proposals, FORST has to ensure amongst other things that the proposals comprise priority public good science outputs that can be monitored; have scientific and technical merit; include collaboration between scientific providers (where practicable and appropriate); and that the proposed science output has a reasonable chance of being delivered to the standards required. Research proposals are extensively reviewed by peers before funding.

Some departments still carry out their own research where such research supports the development and effective implementation of policy and contributes to the performance of a regulatory function. This research is funded through direct allocations. Departments with substantial research capabilities are the New Zealand Defence Force, the Department of Conservation and the Ministry of Agriculture and Fisheries.

Source: Ministry of Research, Science and Technology 1993, *The Science System in New Zealand*, Wellington, New Zealand; and appendix H.

The Australian Academy of Technological Sciences and Engineering said:

> Public good research must be responsive to national policies and priorities and government department requirements (Sub. 337, p. 10).

The Cattle Council of Australia said that it:

> ... would hope that in future ... whatever process is devised, that industry or the ultimate end-users of what comes out of public good research have a very major say in what the broad priorities are (DR transcript, p. 3247).

The NFF said that:

> ... the best priority setting outcomes will be achieved through a process of consultation with people who have a range of skills and experience, who are collectively able to determine the appropriate mix of attractiveness and feasibility of research programs (in the same way that [the] RDC system is working) ... CSIRO must have responsibility for determining its research programs and allocation of resources, based on government's guidelines, its internal priority setting process and wide consultation ... the Government must provide clear guidelines to CSIRO on its priorities and expectations and develop performance indicators to evaluate CSIRO's performance (Sub. 379, pp. 12–14).

Many participants stressed that research priorities — even national priorities — cannot be meaningfully determined in isolation from the performers of research. While it was accepted that scientists may not be well placed to assess the attractiveness of different areas of research from a national perspective, it was noted that the expected national payoff from research also depends on its feasibility, and that scientists provide the main insights on that. The AIRG said:

> Priority setting should be done by relevant outside groups ie the stakeholders for the various areas of CSIRO research, in conjunction with senior CSIRO staff.

It went on to say that:

> ... we don't believe that [priority setting] should be done by a separate body completely outside of CSIRO and we don't believe that it should be just left to CSIRO to set its own priorities ... the ideal mechanism would be a joint group, be it say a board of directors for each sector or each target area ... a joint exercise between people with significant expertise in the sector outside of CSIRO, as well as the senior management within CSIRO (DR transcript, pp. 3318–20).

The Commission accepts that priority setting requires interaction between users and performers of research. However it is possible to have such interaction being driven from outside the research performing agencies. This is already happening where government departments commission CSIRO to do research. And the rural RDC experience shows that it is possible for an intermediary to set priorities and choose research by interacting with both users and performers.

Contestable funding of public good research

Most debate centred not on the role of government in setting broad priority areas for research, but on the merits of having the allocation of funds among research projects or programs being decided outside CSIRO. As noted, the potential benefits which the Commission sees in a contestable funding system include the discipline which it places on costs and quality, and the constraints it places on the scope for (unjustified) cross-subsidies. It can also facilitate a gradual rationalisation of research activities according to what CSIRO and other performers do best.

Dr Bruce Cornell said:

> ... I can see no reason why the competitive research approach suggested in the draft IC report should not be applied to all of the government-funded research organisations ... The use of external reviews comprising both technical and commercial assessment is the only way ... to circumvent the problems inherent in the reality of priority setting (Sub. 311, p. 3).

Some participants argued that CSIRO already performs research in a highly competitive environment. For example, there is internal contestability through the priority-setting process, and priority funding clawback arrangements. However the latter is limited in practice, and can provide only limited contestability because it is internal.

CSIRO researchers also face external contestability when they compete for the 33 per cent of funding which comes from outside the appropriation — through government departments, RDCs, CRCs and private companies. CSIRO Division of CPSU said:

> Research funding is already provided through processes in which contestability plays a very substantial part (eg through the Rural Research Corporations and the GIRD scheme) (Sub. 342, p. 5).

But as noted earlier, given the scope for CSIRO to cross-subsidise external work, there is some doubt as to the efficacy of this contest.

Other participants argued that a more comprehensive contestable funding system for CSIRO would be ineffective, too costly or actually counter-productive.

Identifying public good research

There was widespread concern among participants with the Commission's proposal that government should limit its funding of CSIRO to 'public good' research. Participants observed, as indeed the Commission itself had done in its draft report, that the public good element is manifest in varying degrees in most research. It was also argued that the most publicly worthwhile research is often that which is triggered by (or associated with) research for private users.

CSIRO stated that research for small and medium enterprises in the manufacturing sector often provides feedback which modifies its own basic research agenda:

> The highest growth in manufacturing is occurring in the small and medium manufacturing enterprises and these are companies that have sales from 20 to 200 million ... we have taken our charter essentially in the innovation cycle, putting research and development capacity into those companies to help them grow. But at the same time those companies provide some very, very interesting market feedback which modifies our basic research program. So were we to erect a barbed wire fence between a private company and CSIRO, we would not benefit from that feedback that comes from the market (DR transcript, p. 3145).

While the Commission does see CSIRO's role as being publicly funded principally to do socially beneficial research which would not otherwise get done, this does not confine it to 'pure' public goods. There will be worthwhile projects with some degree of private appropriability that would still need government sponsorship to proceed, and some which it might be preferable to do within CSIRO, to allow wider dissemination than if under private control.

The Commission also recognises that public good research can be undertaken as part of research sponsored by private interests. Where this involves public benefits that will not attract private funding (even with subsidies to the private interests) it is appropriate for CSIRO to allocate resources to it from its appropriation. The advantage of separating the funding decision from the performers of this research is that it allows greater scrutiny of the justification for providing public support. Joint projects would thus be more transparent in their funding arrangements than they are at present.

Information requirements

A fundamental issue is whether an arm's length funder can have enough information to choose among competing proposals. Vaughan *et al* said that:

> Adding more red tape by making scientists compete for funds on a project by project basis with the allocation decision being made by someone with little knowledge of the field can only worsen this situation (Sub. 344, p. 1).

A number of participants thought that a contestable funding system meant that the funder would be required to specify research tasks and merely commission particular researchers to perform them. This would require considerable technical expertise. While it could happen in some cases, the Commission rather saw such a funder choosing among proposals within particular priority areas. These could be defined quite broadly. Again, the RDCs provide one illustration of how this might be done — priorities are set 'top down' while project selection emerges from a 'bottom up' process.

Nevertheless, in choosing among proposals, judgments would still need to be made about the expected social payoffs from the alternatives. That remains a difficult task.

The main difficulty confronting contestable funding of public good research is that the 'product' is not well defined. Indeed, as Professor Ron Johnston has observed, it is rarely possible to define a transaction in simple market terms:

> In reality, knowledge is needed to articulate the problem, and the clarification of the precise nature of the problem commonly emerges through the research process, in interaction with the 'purchaser' (Sub. 401, p. 10).

Where the purchaser is not the end-user of the research, but in effect an agent for a diffuse group of end users, the difficulties multiply.

In effect, the purchaser of public good research will need to develop a close and ongoing relationship with end user groups and research performers. This is a quite different situation to that which would confront a purchasing agency for most other goods or services.

Competitors for CSIRO?

Some participants argued that, in practice, there were few alternative sources of supply of research services in many of the areas occupied by CSIRO. The CSIRO Division of the CPSU said:

> Research and engineering talents are in very limited supply ... Research practitioners normally direct their work in such a way as [to] create 'niches' of expertise, thus avoiding wasteful competition. ... the formation and maintenance of a team possessed of 'critical mass' is typically required (Sub. 342, p. 4).

The CSIRO Division of Water Resources believed that there is not much possibility that CSIRO will crowd out private sector research (at least in those areas with which they are familiar) given the relatively low number of researchers in Australia. (Sub. 425, pp. 4-5).

In circumstances where there are currently no other researchers, it could take a long time to put teams together. Nevertheless, in many areas of research it would appear that expertise already exists in universities, in other government agencies and internationally. For example, CSIRO said that:

> There is nothing to stop the crown research institutes in New Zealand from competing for contracts that CSIRO would compete for ... and many of them do (DR transcript, p. 3173).

Over time, it could be expected that the supply of providers outside CSIRO would increase, particularly in areas that involve lower fixed (or sunk) costs.

The costs of contestability

An issue raised by many participants (as well as by the Commission in its draft report) is the cost of external contestable funding arrangements. There are costs in diverting scientists' time and energies away from undertaking research and into applying for research funding (and refereeing the applications of others). The South Australian Government said that there is:

> ... an increasing outcry from researchers that because funding is becoming so contestable — I'm not arguing that it shouldn't be contestable — that they are just losing the capacity to do research because they are forever having to write grant applications ... it's a full-time job these days writing grants and contesting for funding (transcript, p. 2278).

Dr Colin Hansen (University of Adelaide) said:

> ... increasing contestability for research funds will result in poorer rather than better research as researchers will spend too much time writing grant applications and worrying about whether they will be able to obtain funds to continue their work for a reasonable time period ... the academic time used in peer review as well as in writing applications also needs to be included in any cost benefit analysis (Sub. 449, p. 3).

The costs associated with external contests are likely to be greater than would occur under an internal allocation process, where communication is easier and local knowledge greater, allowing scope for more informal procedures. Nevertheless, even internal funding generally requires (and, indeed, should require) scientists to put up proposals for scrutiny and peer assessment. Currently all significant research proposals are subject to formal and informal peer review evaluation and scrutiny processes at the CSIRO division and institute levels before resources are allocated. Subsequently, research programs are monitored and regularly assessed by line management, program leaders and division chiefs.

There are also costs in administering an external funding system, and these are likely to be higher with project funding than with program funding.

Wasteful competition?

Another argument is that contestable funding can lead to duplication of effort and waste of resources through competition rather than cooperation. CSIRO's Division of Water Resources saw:

> ... no problem with competition [for] research funds as long as the past performance of research is a major selection criterion both in terms of research capability and

> promulgation of the results of research. These should be considered more important criteria than cost.

It added that an issue which needs to be considered seriously in Australia given our low resource base in R&D, is the duplication that extensive competition may bring (Sub. 425, pp. 4-5).

The CSIRO Division of the CPSU said that:

> ... an essential function of scientific interchange — through conferences, journals and so on — is to allow scientists to plan their research in such a way as to complement the work of others working in the same fields, thus avoiding wasteful overlap (Sub. 342, p. 5).

The Australian Centre for Innovation and International Competitiveness said that:

> ... contestability in theory should ensure all the virtues of competition. However, if in practice it prevents the development of long-term capabilities, and long-term relationships, such competition may only ensure a continuing waste of research resource investment, as well as all the energy [that] goes to knocking off the competitors ... In this sort of environment, the competition for excellence may be a far more effective driver than the only lever available to the economist — the competition for money (Sub. 401, p. 10).

The Centre rather felt that:

> Promotion of more effective dialogue between the players, and significantly improved coordination mechanisms, seem to be the more pressing requirement for Australian R&D (p. 11).

Nevertheless, the ‘contest’ can be designed to encourage cooperative bids in certain fields by specifying that preference will be given to such proposals.

Contestable funding can actually prevent unnecessary duplication of effort, by only providing funds to a selected team, or by encouraging competing applicants with similar projects to combine forces. Indeed, this has been seen as one of the benefits of the Rural RDC scheme. The Rural Industries RDC said that:

> R&D corporations have the ability to establish joint ventures; a mechanism used more and more frequently by this corporation ... RIRDC has been very pleased with the level of collaboration which the Corporation has been able to generate between research agencies on industry R&D issues (Sub. 367, pp. 10-1).

Under current arrangements there is also scope for duplication of effort. One possible example is the overlapping activities of AIMS and CSIRO in the field of marine science. Contestable funding of marine science could lead to greater specialisation, rather than further duplication.

Impact on the nature of research

The Australian National University has pointed to the danger of centralised contestability processes selecting 'safe' (or incremental), rather than potentially pathbreaking, research (see Subs. 158 and 359; DR transcript, pp. 3291-6**).** This is a possibility, as pathbreaking research may be judged to have low feasibility even if highly relevant to national needs. Indeed, it is a reason why some appropriation funding would always be desirable alongside contestable funding. However, it should also be noted that 'incremental' research is where most of the benefits of research activity are likely to accrue, particularly for a small country like Australia.

A related concern is that contestable funding could lead to less emphasis on long-term strategic research in favour of more short-term applied research. Some participants considered that contestable funding arrangements would reduce the stability of funding and impede long-term research. The CSIRO Division of Tropical Crops and Pastures said that:

> The contestability notion makes it very hard for long term research if you want to have continuity (DR transcript, p. 2409).

Currently CSIRO receives block funding on a triennial basis, which appears to have brought greater stability than under the previous annual appropriations. Block funding also allows CSIRO to maintain a long-term resource commitment in some areas more easily than might be possible under external funding.

Nevertheless long-term funding is not precluded by a contestable funding system. Programs can be funded for longer or shorter periods or on a rolling basis, subject to reporting requirements. The seven year funding of the CRCs is one example. The breadth of long-term strategic research within predominantly program-funded medical research institutes, such as the Walter and Eliza Hall, is another (see subs. 15 and 233).

Whether distortions of research are likely, depends in part on the nature of the funding institutions, and the rules, incentives and objectives that constrain or shape their activities. For example, in New Zealand there was considerable concern that basic research would suffer under their new science funding arrangements. However, to date, this does not appear to have occurred. Dr Laurie Hammond, the chief executive of New Zealand's Foundation for Research, Science and Technology, has been reported as saying that:

> ... a recent survey by the NZ Association of Scientists found that scientists thought that the amount of basic research they were each doing was about right ... basic research does get funded within the PGSF as well — the fact that it is a strategically directed fund does not mean that you don't fund basic research (*Australian R&D Review*, December 1994/January 1995, p. 21).

Nevertheless, just as priorities set within CSIRO will be influenced by scientists' perspectives, those set outside CSIRO may be vulnerable to 'capture' or undue influence by particular groups. The question of institutional design may thus be critical to the outcomes from an external priority-setting and funding approach.

Views on the 'departmental' options

The first two options involved having either the Minister (through the department) responsible for CSIRO, or the various portfolios which essentially represent stakeholders for CSIRO's public good research, fund specific CSIRO projects or programs. The Commission expressed significant reservations about the first option, given the breadth of CSIRO's activities, and it received little support or comment from participants. However, option two generated more debate.

Option two envisaged that the relevant portfolios would be allocated a proportion of CSIRO's appropriation and would use those funds to commission research from CSIRO. They would determine priorities relevant to their portfolio responsibilities, seek proposals (in collaboration with stakeholders and community representatives, and with CSIRO itself) and enter into contracts with CSIRO.

Many Commonwealth and State departments and agencies are already purchasers of CSIRO research (and account for about 50 per cent of its external earnings). The intention in the draft report was to make that process more extensive and systematic. Departments would become the 'purchasers' of the bulk of CSIRO's research, acting as its direct customers on behalf of the community interests that each department represents. This approach would allow for considerable diversity in the external assessment of projects/programs.

This is similar to the approach proposed by Lord Rothschild and adopted by the United Kingdom in the early 1970s. Departments there have access to a number of research councils as intermediaries in the allocation of funds to specific research programs (see box 4.2). It is also similar to the contractual processes in the United States between government departments or agencies and 'federally funded R&D corporations', many of which are privately owned. Other governments also provide a substantial proportion of this funding for research agencies through the sponsoring of programs by government departments (see appendix H).

Either option would have provided an external 'customer', who would have been able to make judgments about priorities on behalf of relevant community interests and fund accordingly. Research groups within CSIRO would have had to convince the departmental customer, rather than the CSIRO hierarchy, of the merits of a particular program, although CSIRO could choose to coordinate and screen the bids. Decisions about funding, about continuation of research and about withdrawing support from unsuccessful projects would be made by the portfolio customer.

But the draft report acknowledged that there could be some significant disadvantages too. Many participants reiterated these points in submissions.

CSIRO argued against using departments as purchasers of research on the following grounds:

> - .... CSIRO performs research which applies to more than one portfolio, and arrangements would need to address the CSIRO's broad range of industrial, environmental and social responsibilities as well as cross-portfolio issues.
> - The ability of Government Departments to understand and articulate science and technology should be more widely considered.
>   - — Substantial additional resources would be needed in the department to enable informed decision-making by the Minister to take place.
>   - — Industry and other user input is essential. The Departments or Committees advising the Minister would need to establish new networks to obtain this input.
>   - — Departments are separated from daily interactions that occur between research providers and users (Sub. 356, p. 22).

CSIRO supported the development within departments of greater expertise in understanding and articulating government's research needs, but would prefer that this not involve changes in current funding arrangements:

> The structured exchange of advice does not require a transfer of funds or purchasing arrangements (Sub. 356, p. 17).

CSIRO's Division of Tropical Crops and Pastures considered that, while the departments do represent community interests, they would require substantial input from the general community, industry and research providers before making judgments, and this would require them to:

> ... recruit more staff and set up elaborate consultative mechanisms to provide this input. Coordination across Departments on cross-portfolio issues would represent major problems and require further staff and mechanisms. Moreover, partitioning CSIRO's funds to particular departments is bound to introduce new rigidity into sectoral resource allocations (Sub. 293, p. 6).

The NFF said that:

> ... there is no evidence that [government] officials would have superior expertise in identifying research needs to those already engaged within CSIRO. Indeed the poor understanding of business needs and of research linkages suggest they may be much

> worse at this task ... To put science appropriation funding and the priority setting process in the hands of Government departments would cause considerable duplication of effort in administration, record keeping and committee work (Sub. 379, p. 13).

The Australian Wool Research and Promotion Organisation supported the proposition that the Government should increasingly commission CSIRO to do public good research, but considered that:

> ... Commonwealth Departments do not have the required skills to develop R&D priorities of relevance to the industries covered by the particular departments (Sub. 355, p. 6).

The Australian Academy of Technological Sciences and Engineering argued against option one, noting that:

> It is enormously difficult for a single department to comprehend the complexity of the impact of technology in all areas (DR transcript, pp. 2835, and 2840).

But it did provide some support for option two, seeing advantages in using multiple departments as purchasers. The Academy also emphasised the importance of industry advice in helping to shape departmental views, but cautioned that departments should avoid becoming a obstacle between industry and researchers.

On a broadly similar point, the Australian Academy of Science said that:

> If departments are to fund specific projects and programs on the scale carried out by CSIRO, they would need to build yet another government bureaucracy, which would be further removed from the research practitioners who interact with the international scientific community and the Australian customers of research (Sub. 357, p. 2).

There was also some concern among participants about the likely adverse effects of short term political pressures on departmental priorities and funding. For example, CSIRO's Division of Oceanography feared that under the departmental option:

> ... there would be large-scale shifts in the amount of money that was being put into one particular sector or another that might change from year to year, or to activities that could not deliver - in other words, which might be attractive from the government point of view but not feasible.

Similarly, the Wool Council of Australia also said that the departmental proposal:

> ... would make allocation of appropriation funding vulnerable to political pressure from specific interest groups, industry and government departments at the expense of the government's national objectives (Sub. 371, p. 6).

CSIRO said that a similar scheme to option two which was implemented in the UK (based on the Rothschild report) 'did not produce the results anticipated' (Sub. 356, p. 22). At the hearings, Dr Keith Boardman, representing the

Australian Academy of Science, said that where the Rothschild model did work in the United Kingdom, it was due more to the interaction of particular individuals rather than the success of the underlying principles. He added:

> We would hope today ... that the customer more and more will be industry and more and more the managers of ... the environment and not necessarily the government departments ... [The Rothschild approach] ... put a government department between the research councils and the true customers of the research of the research councils (DR transcript, pp. 3453, 3456).

The Academy also argued that:

> Government departments are not the true customers of CSIRO research nor are they set up to represent users. The recommendations revisit Rothschild which is widely regarded in the UK as a failure (Sub. 357, p. 2).

During its visits to a range of relevant organisations and individuals in the United Kingdom for this inquiry (see appendix A), the Commission did not find that the customer-contractor arrangements were seen as a failure. Indeed, the recent and comprehensive re-evaluation of United Kingdom science policy, the 1993 White Paper stated:

> The Rothschild customer-contractor principle will be maintained and strengthened, in relation to Departmental applied research and development. Departments will continue to develop their role as intelligent customers for science and technology (para. 1.18(9)).

The Commission understands that, while some recent changes to policy in the United Kingdom have been announced, these do not amount to a wholesale rejection of the basic framework. That said, it is still too early to reach a conclusion on the success or otherwise of the United Kingdom model. The prestigious British science journal *Nature* recently observed that:

> Events this year will help to clarify the impact of the White Paper — in particular the new research council structures will be put in place and the government will publish the first conclusions of the technology foresight exercise (*5 January 1995*, p. 8).

The Commission accepts that a number of the arguments against using departments as purchasers of research have some force. Nevertheless, some of these concerns could be overcome. For example, cutbacks to research funding in departmental budgets could be prevented by attaching conditions to the use of any of CSIRO’s appropriation which is redistributed. And it would also be possible for departments to establish arm’s length purchasing units which could develop the necessary expertise and means of communication with researchers and users and be more immune to pressure. These could include representatives of industry or the wider community with an interest in R&D outcomes. Achieving coordination among departments on issues that cross boundaries would pose a difficulty, although interdepartmental mechanisms could be devised.

The CSIRO Board's Evaluation Committee said that its survey of the views of departments revealed that they were reluctant to assume such a role:

> Departments consulted in the preparation of this paper did not favour Departments being responsible for major allocations of CSIRO's existing appropriation funds (CSIRO 1995a, p. 5).

This is understandable. It requires some skills that most departments currently do not possess and new processes (although both can be addressed over time).

But such reluctance may also reflect a misunderstanding of what the purchasing role would entail. In the main, it is likely that such arrangements would need to focus on setting broad priorities and the funding and monitoring of *programs* of research, rather than individual projects. The programs would be jointly agreed with CSIRO and other providers, but (as in other countries that use this approach) would normally be initially developed and put forward by researchers. And external reviewers could be used to assist in the assessment of proposals.

Views on an independent research purchasing agency

The third option canvassed in the draft report envisaged the establishment of a separate and independent agency with the responsibility for prioritising and purchasing public good research from CSIRO on behalf of the Government and the community.

Such an approach, sharing some similarities with arrangements in New Zealand (box B4.3), would have several advantages over the 'departmental' model. For example, having one overarching body decide which programs of research to fund could ensure more consistency in the selection criteria used. It may also avoid the duplication which might otherwise occur under multiple funding arrangements. It would also be able to accumulate a knowledge base about the capacity of particular research bodies and researchers, and develop specialist skills in evaluation procedures.

The response of participants to this model was mixed. Some saw merit in the proposal and in the principles which lay behind it — more community-responsive priority setting, more external contestability and better accountability. Others opposed it, some on the grounds that it might be costly or that there was insufficient evidence that such a significant change in arrangements was warranted. Some participants had difficulty in envisaging how it might work in practice.

The Cattle Council of Australia suggested that such body would need to be constituted with care:

> ... the structure of this body would need to be carefully determined to reflect the wide spectrum of research interests, community end-user interest and skills necessary to ensure a truly independent and professional process (Sub. 370, p. 14).

The WA Department of Commerce said that the proposal to create an independent body had some merit, but it stressed the need for State representation to ensure that a national approach is taken (Sub. 283, p. 1). Other supporters included the Australian Wool Research and Promotion Organisation (AWRAP) and AIRG. The latter said:

> The separate and independent body is nominally attractive, but would need to have a wide and continuously changing membership for it not to become academically driven (Sub. 329, p. 2).

CSIRO's Division of Tropical Crops and Pastures considered that any new national science and technology agency might be costly and duplicate existing arrangements:

> [It] would be more bureaucratic and more costly than present arrangements, would cut across the functions of the CSIRO Board, ASTEC, and PMSEC, and would draw heavily on the already limited pool of scientifically trained talent available (Sub. 293, p. 6).

CSIRO's view was that:

- Australia already has bodies such as ASTEC, PMSEC, which so far have not come to a unified view on priorities; yet another body seems unnecessary.
- ... a separate body would incur considerable costs. The functions of the new body would also duplicate some of the functions of the CSIRO Board.
- ... proximity to users and researchers is important in assessing the directions of research. Decisions should not be made in isolation from the full range of factors impacting on the organisation.
- CSIRO has a priorities [setting] process which draws on wide community input and a network of Divisional and sectoral committees that influence priorities and other management issues (Sub. 356, p. 22).

The Nucleus Group said:

> To set up another body would add to the bureaucracy involved in the R and D benefit delivery mechanisms and I think we would feel there's already too much bureaucracy in terms of the various schemes that are available, and that in itself is a cost which probably needs looking at (DR transcript, p. 2493).

An independent purchasing agency would clearly need to cover a wide range of research areas and draw on a wide range of expertise in making judgments about funding directions.

But it would of necessity be a powerful and influential body, with some risk of reduced diversity and excessive centralisation of decision-making. It would involve more bureaucracy than current arrangements, although this may be partly compensated by reduced resource needs within CSIRO for priority setting and evaluation of projects. And there should also be some offsetting benefits in terms of the concentration of knowledge and skills and the better research funding outcomes which should result.

Giving such a body statutory independence should reduce the likelihood of ‘capture’ or undue influence by particular interests. Requiring a funding body explicitly to take a community-wide view of its responsibilities, and to put in place open, transparent priority-setting and decision-making processes, would help in this regard.

Because there is no established process for setting national research priorities in Australia, a purchasing agency would itself need to undertake some form of national priorities assessment, to inform its decisions about the broad funding of ‘public good’ research, and about the purchase of particular research projects or programs within identified priority areas.

To represent a clear improvement over current arrangements, this process would need to involve users, as well as research providers, in a more systematic way. In New Zealand there has been institutional separation between priority setting and purchasing, whereby FORST purchases science according to national priorities determined at a higher level (see box B4.3). But it is unlikely that Australia could adopt the very hierarchical model that has been followed in New Zealand.

B4.3 Implications for the Commission’s approach

The feedback from participants on the Commission’s draft options has highlighted the complexity of government’s role in public good research funding. The status quo presents a number of problems in this respect, but so too does an approach which involves external priority setting and purchasing of research.

The advantages in the ‘separation’ model include the scope it provides for a wider perspective on national research priorities, greater scrutiny and control over how public money is allocated to allow greater contestability, transparency and external accountability over the research funding process.

But there are some disadvantages, too. The remoteness of the funder from the research performers (and from individual users) brings informational difficulties and the costs of running the system — administrative and in researchers’ time — are likely to be higher. There are also some grey areas:

- Given the nature of research and lack of definition of the ‘product’, funders will inevitably have to depend on researchers when assessing proposals. With a close relationship developing between funder and research provider, the potential for reallocating resources among providers may diminish.
- There could also be more wasteful lobbying associated with external competitive funding, depending on the institutional arrangements.
- There is some tradeoff with ‘stability’ of the research environment. Significant uncertainty about funding would be likely to impact on the quality of research, although at the other extreme, complete security can mean little incentive to perform.

Other lessons from discussions on the draft report are:

- the need for extensive interaction between the ‘user’ or purchasing agency and performers of research; and
- program funding (or some block funding) will generally be preferable to project funding, because of the information requirements and the need to allow for flexibility, and because of escalation in transaction costs per dollar of research funding when dealing in small amounts.

Of the three options put forward in its draft report, and in the light of participants’ comments, the Commission considers that the third option — an independent body — has significant advantages over the other two. Such a body would need to be given statutory independence, and be accountable to Parliament. It could comprise a council or board supported by a secretariat. It should have a mandate to set national research priorities for public good research undertaken by government research agencies (after undertaking wide consultation, possibly through forums, workshops or other means), and to allocate funds. A possible model is outlined in box B4.4.

The Commission considers that on balance the advantages of such an approach are likely to outweigh the disadvantages. But it is conscious that there remains uncertainty about the net effects from what would amount to a major institutional change in Australia.

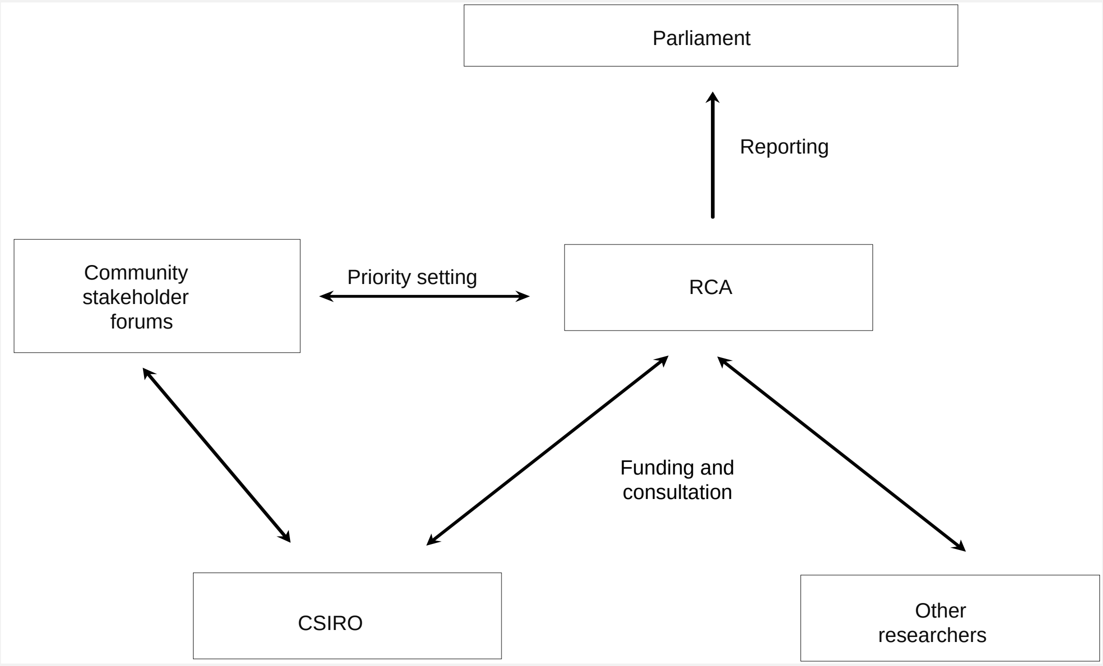
A number of participants argued that there was insufficient evidence of poor performance to warrant a reform of this magnitude. Treasury suggested :

> Rather than commit up front to an end point that involves a major change and phase to it, an alternative may be a ‘stepped’ approach involving commitment to a reform of lesser magnitude and then review the situation once the effects of the reform are better understood (Sub. 427, p. 6).

(The Treasury did not indicate what that lesser reform might entail).

Box B4.4: **Contestable funding of public good research — one approach**

This could involve an independent Research Commissioning Agency (RCA) informed by community stakeholder forums and reporting to Parliament. The RCA would report against the broad objective of getting the best social return from government investment in R&D.



The primary functions of the RCA would be to:

1. Set *broad* medium-term research priorities and allocate funds accordingly. It would focus on the attractiveness and feasibility criteria to determine the important areas of research, consulting widely through forums, workshops and other means. Programs within areas would be proposed by researchers and others - a ‘top-down, bottom-up’ model. The RCA would allocate funds to CSIRO and non-CSIRO research programs.
2. Evaluate and monitor the performance of the research against criteria such as the rate of return from the research investment as well as the extent of subsidy. The RCA would independently assess and report on the public good value of the taxpayer contribution to the various R&D programs/projects undertaken. This would increase transparency, information availability and influence future funding and decision making.

The Commission acknowledges the lack of adequate information about CSIRO’s performance as a public good research body. It argued in its draft report that the very difficulty of evaluating CSIRO’s performance under current arrangements was in itself a reason for changing its processes towards a more contractual approach. The question is whether reforms of a more incremental nature would yield benefits in the critical areas of priority setting, accountability and cost effectiveness, while providing better guidance about how CSIRO is performing.

B4.4 Other proposals

During the course of this inquiry, several proposals have been put forward to refocus the role and reform the structure of CSIRO. Some were discussed in evidence to the Senate committee hearings in 1994, or proposed to the Commission in the course of this inquiry. And since the preparation of the Commission's draft report, the CSIRO Board Evaluation Committee has released a discussion paper evaluating CSIRO's management and structure, and outlining some reforms it sees as desirable.

CSIRO Evaluation Committee proposal

The CSIRO Board began an internal review of CSIRO's management and structure in November 1994 and issued a 'discussion paper' on 3 April 1995 (CSIRO, 1995a). Elements of the discussion paper's proposals were included in CSIRO's submission on the Commission's draft report. In preparing the paper, CSIRO surveyed arrangements in other countries as well as surveying the views of government departments. Responses to the paper are to be reflected in a final version 'for the attention of the next Chief Executive'.

The Evaluation Committee's proposals were directed at improving CSIRO's links with government and industry and improving its internal flexibility (see box B4.5).

The Committee agreed that CSIRO lacked a 'whole of government' view on research priorities. But it considered that such priorities should not be *prescribed* by government.

> Any successful process for aligning Government priorities and CSIRO research interests and competencies will therefore need to be iterative. We suggest an annual workshop between senior government officers and CSIRO to reach consensus on priorities (CSIRO 1995a, p. 7).

The workshop model was seen as having relevance also to other government research agencies. According to the Evaluation Committee, the proposal was 'broadly supported' by government departments.

The Committee's proposals for restructuring the internal operations of CSIRO are intended to:

> ... break down demarcation between Institutes and maximise the benefit of CSIRO's multidisciplinary character (CSIRO 1995a, p. 16).

Box B4.5: CSIRO Evaluation Committee's preferred model

CSIRO will develop a 'whole of government' approach to priority setting. The Committee suggests that:

- an annual workshop be held between senior representatives of interested Departments and CSIRO, linked to CSIRO's strategic and operational planning cycle. The outcome would assist CSIRO to set out the objectives against expenditure in broad packages as part of the presentation of its Strategic Plan to the Minister for approval;
- customer involvement in CSIRO's priority determination processes be strengthened at strategic and sectoral levels;
- CSIRO strengthens its focus on meeting customer expectations, particularly in regard to understanding customer needs, delivery to schedule and budget, and more professional marketing and contract negotiation (p. ii).

In addition:

1. The six current Institutes would be closed down and their Directors replaced by a core of five Group Executives/Executive General Managers who would support and report to a Chief Executive. The executives would take a corporate approach in determining research priorities and the investment of resources to research needs.
2. The executives would maintain high level relationships with external stakeholders, lead task forces on specific research or management issues of strategic importance, lead top management teams on corporate tasks, be responsible for particular organisational functions (such as human resources development), maintain a general overview and coordination of a cluster/group of divisions focused on customers/stakeholders, market at a sectoral level and regularly participate in a significant part of each Board meeting to inform, advise and be advised by the Board.
3. The executives could change the clusters of divisions as well as marshal resources across divisions in multi-divisional programs to adapt to changing research needs.

Source: CSIRO 1995a.

The Committee considered the institute boundaries were restricting the flexibility of the organisation in managing its resources to respond to changing needs.

'Autonomous' institutes models

A number of other proposals differ significantly from that of the CSIRO Evaluation Committee in giving more autonomy to the operational levels.

The 'holding company' model

At the Senate inquiry, a detailed proposal for reform of the corporate structure of CSIRO was put forward in a personal submission from Mr Malcolm Robertson, Manager of Planning and Resources in CSIRO's Corporate Services Department, who observed:

> In spite of demonstrated improvements over the past few years, the organisation continues to be under pressure from critics who perceive it to be unresponsive to national needs, inflexible and poorly managed (Senate inquiry transcript, p. 231).

Robertson suggested abolishing the six CSIRO Institutes, combining the current 32 divisions of CSIRO with ANSTO, the Australian Government Survey Office (AGSO) and AIMS, and reorganising all of these resources into 15 or so corporate institutes under one umbrella corporation (see box 4.6).

Each corporate institute would be ‘semi-autonomous’, and organised around:

> ... [a] natural cohesion of research activity, disciplines and/or core technologies (Senate inquiry transcript, p. 227).

Robertson argued that some similar research is now being done within the different government agencies (for example, marine research in CSIRO and AIMS), and that under the new structure, the organisation would be able to gain economies of scale and reduce duplication in infrastructure provision (for example, by having centralised libraries, offices, laboratories and computer facilities).

The umbrella CSIRO group would concentrate on national research issues, including priorities and resource allocation, and develop appropriate policies and broad practices which would establish the parameters within which the ‘corporate institutes’ would operate. With the umbrella CSIRO taking over these functions, Robertson does not have a main CSIRO Board in his model.

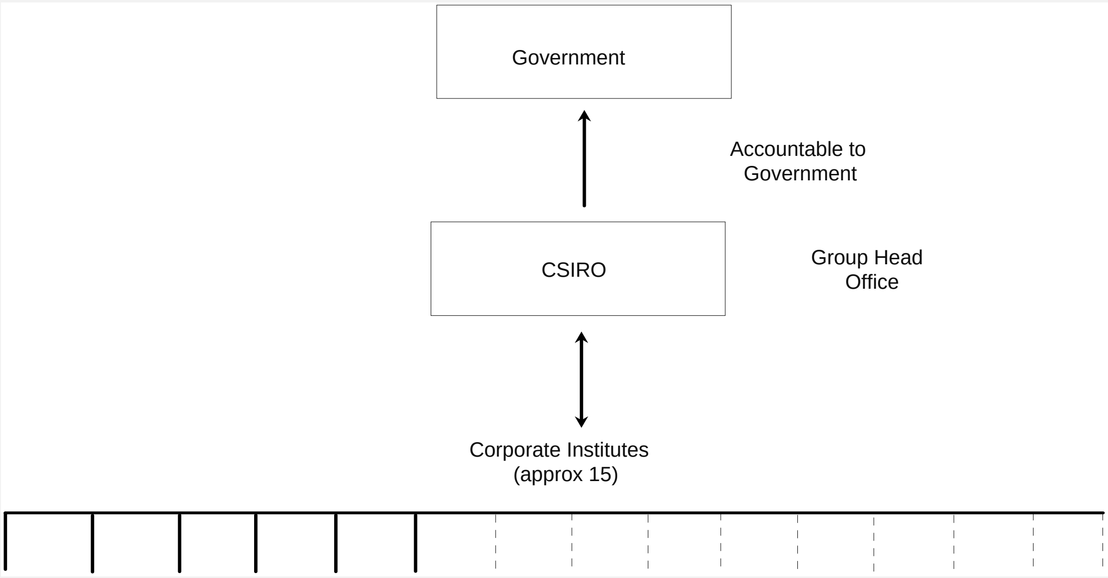
Each Institute would be headed by its own chief executive, who would be accountable to the Chief Executive of CSIRO for certain aspects of its performance, and to their stakeholder groups for achieving its research objectives.

The AMIRA ‘Institute boards’ model

The Australian Mineral Industries Research Association (AMIRA) supported the customer-contractor mechanism for allocating funds to CSIRO. It proposed an approach whereby each Institute would have its own Board, which would have the power to set priorities and allocate funds within their Institutes (see box B4.7). In this respect it differs from the previous model which is silent on funding; it also entrenches a wider role for the Board(s).

AMIRA argued that the main Board should meet three or four times a year and look at broad-ranging issues, and that the chairman of that Board would be responsible to the Minister, with the CEO responsible only to the main CSIRO Board.

Box B4.6: **A CSIRO manager’s model for reform of CSIRO**



Proposed corporate Institutes:

Animal Production (4 divisions)
Plant Industries (3 divisions)
Minerals and Energy Industries (5 divisions, AGSO)
Industrial Technologies (4 divisions)
Marine Sciences (3 divisions, AIMS)
Information Science & Engineering (3 divisions)
Building, Construction & Engineering (1 division)
Food & Nutrition (2 divisions)
Forest Industries (2 divisions)
Water & Soils (3 divisions)
Entomology (1 division)
Wildlife & Ecology (1 division)
National Facilities (Vessel, Telescope, Reactor)

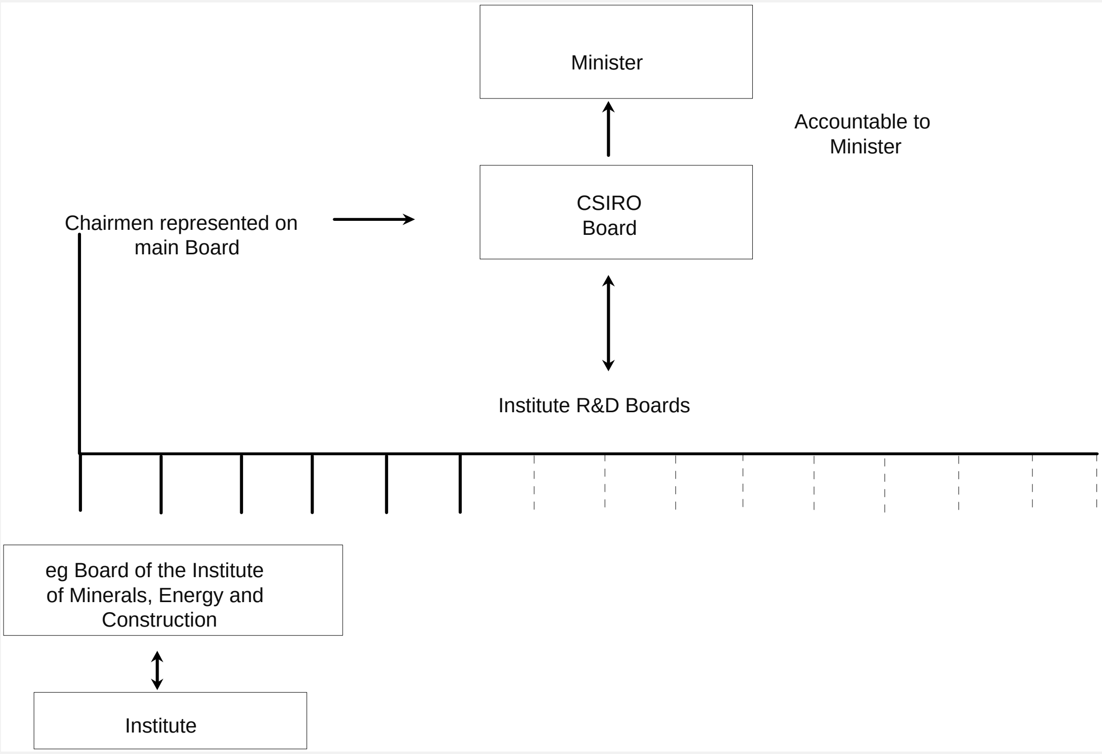
CSIRO would comprise about 15 semi-autonomous corporate research institutes which would bring together all Commonwealth strategic research agencies (CSIRO, AGSO, AIMS and ANSTO). The umbrella corporation, headed by the Chief Scientist, would be concerned more with national and strategic matters and less with day-to-day administration.

CSIRO's top management team would run corporate CSIRO but would not manage the institutes. The institutes would have their own chief executives. Each would be accountable to the chief executive of CSIRO for certain aspects of their performance, just as they would be accountable to their own stakeholder group (perhaps a board in some cases) for achieving their research objectives.

Source: Based on evidence by Mr Malcolm Robertson to Senate Standing Committee on Industry, Science, Technology, Transport, Communications and Infrastructure 1994, *Official Hansard Report*, pp. 226-7.

The composition of the Institute Boards would be a key determinant of the ensuing pattern of research undertaken.

Box B4.7: **The AMIRA model**



Source: Sub. 348 , p. 2; and DR transcript, p. 2971.

Mr Peter Laver of BHP (a member of AMIRA) supported the concepts behind the AMIRA model (see Sub. 348). In his view, arrangements whereby CSIRO is block funded, with the Board accountable to the Minister for its management and for overall outcomes should continue. However, he suggested several ways in which the AMIRA proposals for Institute Boards could be extended to improve decision-making.

He proposed that, each year, each Institute would submit to its own 'industry-driven' Board three lists of projects — an 'A' list of projects which are continuing satisfactorily and should continue to be funded; a 'B' list which should be terminated because they have been completed, are unsuccessful or are unlikely to be completed; and a 'C' list of new projects for which new funding should commence. The Institute Boards would review the lists, make suggestions and, with management, jointly prioritise projects on the 'C' list.

A 10 per cent 'clawback' plus any incremental funding would be allocated by the CSIRO Board between Institutes on the basis of the assessed quality of their management of existing projects.

The management and Boards would also have agreed on a priority ranking for list 'A' projects which could be wound down, reduced in scope, deferred or terminated in the event that the main Board decided to reduce funding to the Institute.

According to Mr Laver, these features would have several advantages:

- they would provide in-built performance monitoring;
- resource reallocation would be made on the quality of projects and outcomes, not on some perceived importance or political whim;
- the main decision making would be delegated to those best able to demonstrate informed judgment. (If the concept of Institute Boards were not accepted expert bodies such as AMIRA and the Rural R&D corporations could assume this role.)
- the process would be transparent, contestable, dynamic and capable of accommodating changes in the funding levels available.

Some proposals by other participants are listed in box B4.8.

Assessment

Most proposals for the reorganisation of CSIRO share in common the maintenance of appropriation funding, but differ in their processes for determining priorities and allocating funding within the organisation. Dr Cornell's proposal (see box B4.8) is the exception in providing for greater external contestability than the Commission itself had envisaged in its draft report. It would, however, also result in a highly centralised funding system, with loss of diversity in funding sources.

The CSIRO Evaluation Committee model retains the current powers and responsibilities of the Board, but provides a bigger, more centralised role for the top management group in priority setting and resourcing decisions for the organisation. It addresses the need for greater government involvement in priority setting through the 'workshops', which would be a useful innovation. It also proposes the strengthening of linkages between CSIRO and its stakeholders, by building on current arrangements, although the means are unclear.

The proposals would appear to enhance the potential to achieve synergies within a large multi-disciplinary research organisation by allowing greater flexibility in forming research teams. The implementation of changes in broad priorities could as a result be more readily effected.

Box B4.8: **Other proposals by participants**

Australian Wool Research and Promotion Organisation:

Under this proposal, the CSIRO Board would set broad priorities and allocate appropriation funds at that level. The Board would have responsibility to determine the relative importance of the wool industry compared to other industries and public good R&D which does not impinge on industry (such as radiophysics and some aspects [of] wildlife and ecology).

Appropriation funds for wool R&D would be managed within a wool industry R&D unit. The allocation of those funds to specific projects would be the responsibility of an industry-driven board comprising: woolgrowers; Australian wool processors; the Australian Wool Research and Promotion Organisation; the director of the wool industry R&D unit; and an independent chairperson (Sub. 355).

Dr R. G. Ward:

Each CSIRO Division would be run as a small medium sized business with its own Board. It would be free to develop its own internal mode of operation and R&D program in close cooperation with its sponsors, and be served by a small Secretariat and overseen by a Central Supervisory Board reporting to the appropriate Minister (Sub. 272, p. 1).

Dr Bruce Cornell:

Dr Cornell appeared at the hearing in a private capacity but had been a CSIRO scientist for 21 years. He suggested the pooling of ARC/NHMRC/CRC/CSIRO/AIMS etc funds, and the competitive bidding for funds by all corners with assessment [by] external review ... ‘My preferred form of the future Australian science and R&D is to pool the funding to allow a small quantity of peer-reviewed ARC-type work and national interest work requiring as far as possible the involvement of an end-user (even if it is a government authority) and have the rest of the funds available on a rolling basis to CRCs. The funding currently given to the major institutions would be rolled into this scheme and their present staff would compete along with all comers ... some grace period will be provided to allow researchers to get themselves organised into a new project should the one they are in fail’ (Sub. 311, pp. 3-4).

The AMIRA model — involving Institute Boards — and the variations on it (described above) are designed to strengthen the autonomy of research division groupings and their capacity to be influenced by external stakeholders.

This approach would seem to have a number of advantages, including more direct external influence and monitoring at the lower level within CSIRO; it would facilitate interaction with external users; it could also facilitate internal contestability and spinning off research activities to the private sector.

One possible disadvantage is that it might reduce the scope for collaborative and interdisciplinary work within CSIRO. The Board Review saw this as the main disadvantage:

> ... it runs counter to the idea of extracting maximum advantage from CSIRO’s unique multi-disciplinary character. Rather than loose clusters of divisions would be 15 effectively autonomous research ‘silos’ (CSIRO 1995a, p. 16).

How much of a problem this represents depends on the extent to which interaction across the different business units is needed and whether arrangements could be made to accommodate such linkages.

The Board Review also saw this approach complicating decision making within CSIRO and underutilising the capacity to establish priorities for the organisation as a whole. This would partly depend on the nature of the Board's own role. If the Corporate Board had responsibility for allocating funds among the business units, as envisaged, this would provide an important means of influencing their activities.

Another potential problem with the AMIRA model is that it could allow too *great* an influence of private industry over the allocation of CSIRO's resources. AMIRA, in its submission, observed that:

> ... the minerals industry would expect to be well represented on the board of the Institute for Minerals, Energy and Construction (Sub. 348, p.2).

If the composition of the Institute Boards were weighted too heavily in favour of industry representation, there is a danger that CSIRO's research agenda might be too narrow and include public funding of work which could or should be funded by industry itself. In this regard, the AMIRA model is different from the Robertson model which places less emphasis on external input into CSIRO's priority-setting process. Unlike AMIRA, the Robertson model also does not include industry board representation on the main Board for CSIRO.

In sum, the AMIRA model is likely to be better at sensitising the organisation to the needs of user groups; but the Board's own proposal might make it easier to ensure that the organisation is pursuing the public good research that provides its principal rationale.

B4.5 The Commission's proposals

The Commission sees significant advantages in moving over time to a funding and priority-setting system for CSIRO which provides a greater direct research contracting role for government and enhanced contestability. Given the uncertainties about some of the effects of such a major reform, however, other ways of achieving greater external influence on and information about CSIRO's performance have been examined.

Drawing on elements of the proposals just described, the Commission considers that significant 'incremental' improvements can be made. The key reforms relate to priority setting, accountability and, in lieu of greater direct contestability, monitoring of CSIRO's performance.

Priority setting

The Board Evaluation Committee, recognising the need for more governmental involvement in priority setting, proposed an annual ‘workshop’ between senior government officials and CSIRO (see box B4.9, reproduced from CSIRO 1995a).

The Commission considers that this has the potential to play a role in bringing a better government perspective to bear on CSIRO’s broad priorities, complementing the influence of industry through advisory committees and direct funding. To be most effective, it should be linked to CSIRO’s attractiveness/feasibility process and it should have tangible outputs — such as an agreed statement of priorities which feeds into CSIRO’s strategic planning and operational plans. It should also be used as an opportunity for government to be informed about and comment on CSIRO’s key research programs.

A yearly forum of this kind would create an incentive for government departments to think more systematically about their constituents’ needs from science, and to seek greater interaction with users. The Commission considers that, if successful, the concept should be extended to include other government agencies such as AIMS and ANSTO.

The Commission recommends that the Commonwealth Government establish an annual consultative forum with CSIRO for the purpose of achieving a whole of government view on broad priorities for public good research. As proposed by the CSIRO Board’s Evaluation Committee, the forum (or ‘workshop’) should include senior officials from stakeholder departments and be linked to CSIRO’s planning and funding cycles. In the Commission's view, such a forum should also:

- **provide an opportunity for government to examine key CSIRO programs;**
- **encompass other government research agencies; and**
- **result in a published statement of priorities.**

Within the broader established priorities for public good research, more detailed priorities within the different operating areas of CSIRO are influenced by the scientists’ interests and skills, and the views and requirements of those users with whom they are in contact. Advisory committees have been established at division and institute levels and provide a means of identifying detailed priorities separately from the influence exerted by CSIRO’s fee-paying clients.

A number of participants felt, however, that the advisory committees were often unable to exert much influence. Some models for organisational reform of

CSIRO saw them being replaced with industry boards having direct control over appropriation funds.

Box B4.9: **CSIRO's government 'workshop' proposal**

'A useful mechanism to achieve interaction with Government could be an annual workshop, held between senior representatives of interested Departments (which could include Finance, as well as Departments directly concerned with science) and CSIRO.

'The workshop would be linked to CSIRO's strategic and operational planning cycle. It would have particular importance in each third year, when triennial funding proposals were being decided. In other years the workshop might have more of an 'updating' role.

'The broad structure of the workshop could be:

- a 'scene setter' by the Minister following consultation with his or her colleagues;
- Departmental presentations indicating their priorities, concerns and views on national trends and the implications for the economic, environmental and social setting of CSIRO's work;
- a CSIRO presentation on progress in implementing the Strategic Plan and significant elements of the coming year's Operational Plan, and emerging technological challenges and opportunities of significance; and
- ensuring dialogue to help CSIRO frame its Strategic Plan and determine its Operational Plan.

'Following such discussions with Departments and Ministers, CSIRO could set out objectives against expenditure in broad packages as part of the presentation of its strategic plan to the Minister for approval.'

Source: Reproduced from CSIRO 1995a, p. 7.

There is a delicate balance to be achieved between making CSIRO more responsive to the requirements of users and creating circumstances in which CSIRO could end up doing research at public expense that should be funded by industry.

The Commission considers that the functioning of the advisory committee system should be enhanced, however, by:

- **committee members being appointed by the Board; and**
- **the committees' advice being documented and publicly available.**

Public reporting by the advisory committees would bring greater transparency to a process influencing spending decisions and also allow the committees to draw attention to any important areas in which they believe their advice to have been ignored.

Accountability

There are arrangements in place to ensure CSIRO's accountability in a public administration sense. It reports to the Minister of Industry, Science and Technology and is overseen by the Department. It produces an annual report, reporting against its charter of duties specified in its Act. More generally, DIST undertakes five-yearly portfolio reviews of significant government programs under its portfolio, including CSIRO. And the Auditor-General undertakes efficiency and project audits from time to time. Less formally, there is an exchange of information through CSIRO-government liaison committees (which generally meet twice-yearly).

There is also a more fundamental notion of accountability relating to CSIRO's role as a public good research body. Where CSIRO undertakes research commissioned by government or private clients it is clearly accountable for its performance. But a similar in-built accountability cannot apply to its appropriation funding. In the absence of a direct contracting relationship with government, it is important that instruments and processes to help evaluate its performance be developed.

It is only very recently that attempts have been made to move towards a more systematic process of reporting in this area. CSIRO and other agencies are currently negotiating 'resource agreements' with DIST and the Department of Finance. The Commission understands that they are to include a list of key performance indicators, which may draw on a larger set being examined by CSIRO (see box B4.10).

The Commission supports this initiative and considers it to be overdue. The absence of agreed performance indicators has compounded uncertainties about CSIRO's performance in what is already a difficult area to evaluate. The inclusion of external earnings as merely one performance indicator among others, as implied in the listing in box B4.10, would also be an improvement over the current reliance on it as a single target.

The Commission urges that the Resource Agreements and performance indicators for CSIRO (and other government research agencies) being negotiated with DIST and the Department of Finance, be concluded as soon as possible and be made publicly available.

As noted previously, an important determinant of CSIRO's performance as a performer of public good research is how it prices the research it does for or in collaboration with its individual clients. CSIRO has recently developed confidential guidelines for the costing and pricing of such research, but their importance is such that they should be formally agreed with Government and be open to public scrutiny.

The Commission considers that CSIRO’s costing and pricing guidelines should be explicitly agreed with Government and made publicly available.

Box B4.10: **Performance indicators under review for CSIRO**

Following recommendations in ASTEC (1994e), CSIRO is examining a number of performance indicators for possible implementation. Some of those being reviewed include:

- calculating the number of publications, patents, commercial reports and citation of publications, to assess the level and quality of publications and measure the flow of information between CSIRO and users;
- calculating external funds gained (from research for industry and other users) as a percentage of total funds, as well as the amount of non-cash contributions received, in order to measure the extent of collaboration and user responsiveness;
- listing the contracts successfully completed, to assess customer satisfaction;
- listing the adoption by users of practices, instruments and processes developed by CSIRO, to measure the research’s impact, the rate of technology transfer and communication effectiveness;
- calculating the number of licences gained by CSIRO, to measure the extent the technology developed by CSIRO is being exploited;
- listing the number of postgraduate students supervised, to measure the extent CSIRO’s expertise is transferred to present and future users and performers of research;
- calculating the shift of resources into priority areas as indicated by comparison with target profiles, to measure the extent that resources are being applied to areas of national priority and in response to customer needs;
- surveys of staff attitudes, to ensure CSIRO is aware and responsive to the concerns of staff;
- calculating the proportion of the budget spent on staff development to maintain a high quality work force;
- calculating the secondment of people to and from industry, to assess the mobility of staff and technology transfer; and
- evaluating the effectiveness of specific communication programs and undertake targeted surveys of the opinion of key stakeholders and the general public, to measure community awareness of CSIRO’s activities and contribution.

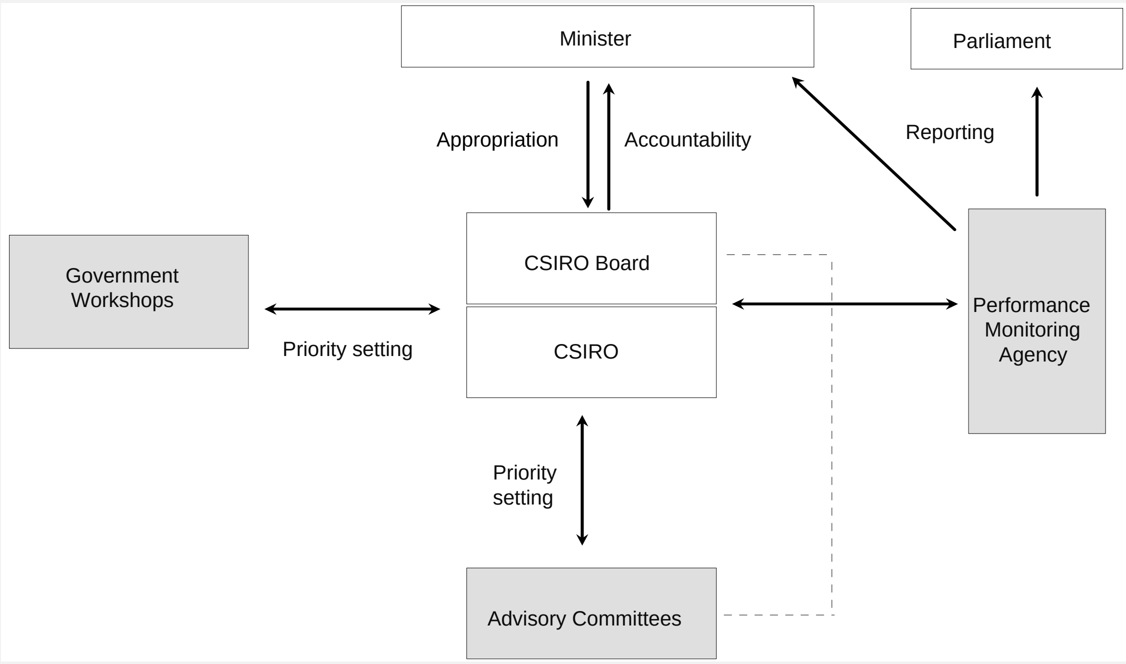
Source: Information provided by CSIRO.

Independent performance monitoring

The priorities endorsed through the ‘workshop’ process, the resource agreements, performance indicators and costing/pricing guidelines could be said to constitute a ‘contract’ between government and CSIRO that would go some way towards improving its broader accountability.

Its value would be greatly enhanced, in the Commission’s view, through arrangements to independently monitor CSIRO’s performance on a regular basis (see box B4.11). This is needed to enhance the transparency of the process, promote greater understanding within the Government of CSIRO’s operations and achievements, and provide greater discipline on CSIRO’s performance.

Box B4.11: **Proposed institutional arrangements for CSIRO**



In addition to verifying and presenting information on CSIRO’s allocation of resources against agreed priorities and performance indicators, the monitoring body should have the role of:

- verifying that CSIRO is costing and pricing its research according to agreed guidelines; and in particular
- examining the extent to which CSIRO resources are used to support projects for clients beyond what is paid for, and the justification.

The Commission also considers that it would be desirable for the monitoring body to initiate benefit-cost studies of selected programs. And, over time, it would review (and help refine) the performance indicators and the costing and pricing guidelines in the light of experience. This would provide better information to monitor research performance and underpin future decisions about priorities.

Given the breadth of CSIRO's research activities, the Commission envisages that such a monitoring and evaluation process should involve reporting to Parliament, rather than just to one Minister.

One approach would be to establish a small, specialist agency for this purpose. There are some advantages in this approach. It would have essentially only one task, and could build up a core of expertise and authority. In the short run it would at least provide information and facilitate scrutiny on what CSIRO was doing, how that accorded with its 'contract' with government, and what techniques might be used to evaluate that research. In the longer run it could develop expertise in public sector research evaluation.

An alternative would be to build on existing institutional arrangements. The Auditor-General's Office is an obvious possibility. The ANAO has undertaken some 'rolling' reviews of some aspects of CSIRO's work, such as the external earnings requirement (see ANAO 1991, and 1994b). Involving the ANAO has the additional advantage that the external monitoring function proposed here — and which has some similar features to the ANAO's 'efficiency' or 'performance' reviews — would be carried out by the same organisation which has ongoing responsibility for CSIRO's financial audits.

Further down the track the scope of the monitoring agency's activities might be reviewed. For example, it might extend its coverage beyond CSIRO to other organisations such as AIMS, ANSTO and AGSO. As well as providing similar benefits in terms of greater public scrutiny and awareness of the performance of those agencies, this might also provide a basis for comparisons. That may in turn influence future funding decisions.

The Commission recommends that an independent agency be designated to monitor and report publicly on CSIRO's performance against agreed priorities and performance indicators. (Among existing agencies, the ANAO could most appropriately take on this function.) The monitoring agency should also, among its tasks:

- **verify that CSIRO is costing and pricing its research according to agreed guidelines;**
- **examine the extent of CSIRO resources used to supplement projects for external clients, and the justification;**
- **initiate cost-benefit studies of selected programs;**
- **and over time, review (and help refine) performance indicators and costing/pricing guidelines in the light of experience.**

These proposals would greatly enhance external scrutiny of CSIRO and provide a better basis for influencing how it spends the appropriation. They would thus increase the potential for external earnings to enhance rather than detract from CSIRO's performance in public good research. By getting government more actively involved in priority-setting and generating more of the information necessary to evaluate CSIRO's performance, they should provide a better basis for funding decisions. They may also help identify whether a greater explicit purchasing role is needed to enhance contestability, and improve the capacity of government to assume such a role.

B5 DSTO

B5.1 What is DSTO’s role?

The Defence Science and Technology Organisation (DSTO) is responsible for the Science and Technology Program of the Department of Defence and conducts the bulk of Defence R&D.

It was established in 1974 as a separate organisation following the merging of the Australian Defence Scientific Service with elements from the Departments of Supply, Army, Navy, and Air. It is the second largest research body in Australia with about 2600 staff in 1995, including between 1200 and 1300 scientists and engineers. The Commonwealth budget outlay for DSTO was about $239 million in the financial year 1993–94 (Cook 1995a) — equal to about half of CSIRO’s budget outlay for the same period.

DSTO is one of the Department’s eight programs, and is seen as having a strategic role in enhancing Australia’s defence self-reliance. DSTO’s objective is to enhance the security of Australia through the application of science and technology. This is achieved by:

- participating in national security policy formation to position Defence to exploit future developments in technology which show promise for defence applications; assist Defence to be an informed buyer of equipment; develop new capabilities; and to support existing capabilities by increasing operational performance and reducing the costs of ownership, including through life extension programs;
- contribute to new defence capability through the provision of scientific and technological advice and assistance in relation to new or enhanced capabilities, including the development and evaluation of technology demonstrators to meet special Australian defence requirements;
- contribute to existing defence capability through scientific and technological investigations to extend the life of platforms and equipment and to solve operational problems associated with deficiencies in in-service equipment and operational procedures; and
- facilitate the timely transfer of the results of defence research to industry, and providing access to industry and other agencies to the research facilities and expertise of DSTO (Department of Defence 1994c, p. 217).

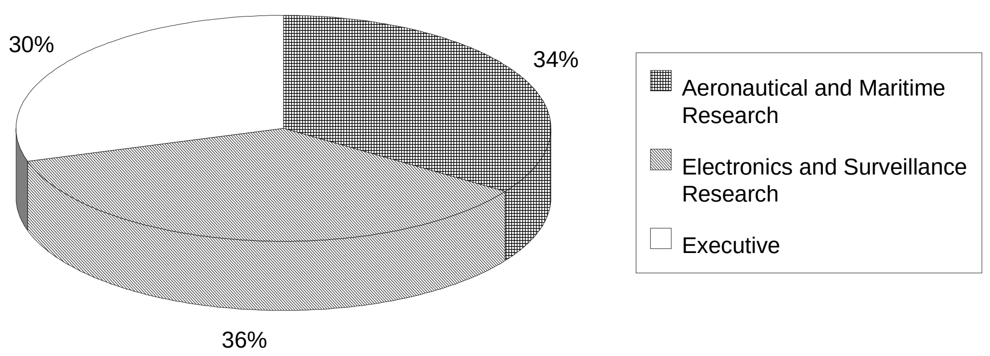
B5.2 Funding and outlays

The allocation of funds for the operation of DSTO is determined by the Department of Defence as an integral part of the Defence budget. Each year DSTO provides a forward budget along with all the other programs. Discussions between DSTO and the Forces Executive[1] then determine that year's allocation, in the light of defence needs.

While most funding comes directly from the Department's overall allocation in this way, some comes indirectly from some of the other seven Defence Programs. The Department said:

> Although DSTO's R&D work is funded almost entirely by a direct allocation from the Portfolio to the Science and Technology Program, a relatively small amount of funding comes from other Defence programs, payments received from industry and other external agencies for R&D services, and contributions in kind from the Cooperative Research Centre program (Sub. 148, p. 2).

Figure B5.1: **Estimated distribution of DSTO outlays, 1994–95**



Source: Budget Related Paper No. 4.3A, 1994, p. 201.

In 1993–94, DSTO's budget outlays amounted to about $239 million. Figure B5.1 shows the expected distribution of 1994–95 outlays (expected to be

[1] One of the eight Defence programs. Its objective is to provide an effective Australian Defence Force (ADF) operational command structure and policy direction in the areas of force structure and capability, personnel, reserve service, ordnance, health, public information, housing, emergency management, and superannuation.

$222 million) to its three sub-programs. Two of these concentrate on research and development. The third, the Executive sub-program, provides corporate direction to DSTO, policy advice on matters of defence science and technology to the Department and its Ministers, and corporate and administrative services.

B5.3 Issues

This section briefly raises some issues that relate to DSTO's research and development. They concern how priorities are set for DSTO research; the extent to which its research is contracted out; and technology transfer (including dissemination of research results) and other links with industry.

Prioritising research

DSTO priority-setting procedures are of a different character to those associated with other research bodies such as CSIRO and AIMS. DSTO's priorities are driven by its sole customer — the Department of Defence. The Department said:

> The major portion of DSTO's research priorities are determined and shaped by a process of consultation between DSTO and its clients — the three arms of the Australian Defence Force, and HQ elements of the Department of Defence. As a result, the R&D matches closely the current or anticipated needs of these clients (Sub. 148, pp. 6–7).

Factors used to identify priority areas include importance to national security, impact on the operational effectiveness of the Australian Defence Force (ADF), and forecast trends in defence technology (CCST 1994, p. 6).

The Department said that science and technology needs are planned forward for five years, but there can be priority changes according to changing circumstances (such as the Gulf War). It identifies likely future developments and defence strategic needs to help identify areas for research. In addition, the Department of Defence has to maintain the knowledge and ability to handle older technologies.

Current priority areas include intelligence, surveillance, maritime patrol and response, and rapid deployment ground forces:

> We need the most advanced capabilities in areas such as command and control, information transfer and integration, all-weather day/night operations and the ability to control and concentrate force rapidly and precisely. Judgements on the balance between technological quality and numbers of equipment will become increasingly important (Ray 1993, p. 48).

The Department said that it controls DSTO's budget to ensure that it responds to Defence's needs. Each of the three service arms (Navy, Army and Air Force) and the Policy and Command areas of the Defence Organisation has a scientific adviser, and in each command structure there is a scientist who identifies Defence's research needs. It said that its priority ranking is defence first, defence science second, and science last.

DSTO research activities must meet one of the following objectives:

- to add significantly to Australian defence capabilities in a priority area;
- to provide substantial cost savings in a priority area; or
- to contribute significantly to some higher Defence or national policy objective.

Each year the head of DSTO — the Chief Defence Scientist — is required to justify DSTO's R&D program. Each Defence program manager can ask for changes in the DSTO program. In addition, DSTO has to demonstrate value for money and argue for funds against other competing demands. If both DSTO and a customer program (for example, Navy) want more to be spent on R&D in some particular area than the DSTO program allocation allows, the customer may be required to help fund this.

A report by the Department's Inspector-General Division said that DSTO's customers within Defence (that is, the programs, including the services) have a significant influence on the allocation of DSTO's resources:

> If DSTO's priorities were in discord with those of the Services, sponsorship of tasks could be reassigned to areas of higher priority ... The Services have elected ... in specific cases to top-up DSTO allocations by redirecting resources from their own programs. This response by the Services reflects the importance placed on DSTO's work (Department of Defence 1993c, p. xii).

Contracting out of R&D

DSTO contracts out some activities under the Commercial Support Program (CSP). At present, activities such as Property Materiel and Media Operations have been contracted out — for example, a contract for the media operations of the DSTO Salisbury support services of $3 million over 5 years was offered to British Aerospace Australia, at a saving of 32 per cent or $0.3 million a year.

The CSP is a market testing program which allows for in-house bids in competition with outside firms. Under the program, the Department of Defence divides projects into core (which are crucial to the ADF and must be carried out in-house) and non-core (activities which may be supplied by outside agencies). Only non-core activities are being subjected to market testing. In the case of DSTO, the areas tested have been mainly in the support activities, and not in

R&D. DSTO argued that industry has not been successful in winning initial CSP contracts in research and engineering areas. It said:

> Such contestability of R&D as has been tried so far — [in] food research (Tasmania) and [in] engineering services (Salisbury) — has had mixed results. Both of these functions were won by the in-house bids, albeit with internal efficiency gains and, in the case of engineering services, the complication of transaction costs. While industry has some (but not all) success in winning CSP contracts in areas such as facilities and property management, stores and warehousing, it has not been successful in either of the research and engineering areas tested. It is not particularly realistic, therefore, to expect the private sector to be competitive in the more esoteric areas of DSTO's R&D work (Sub. 405, p. 5).

Nevertheless, DSTO had said it prefers to contract out research when other institutions have the necessary expertise, because this is more cost effective than conducting it in-house (JCPA 1992, p. 222). During 1992–93, DSTO contracted out R&D projects worth about $8.5 million to universities and industry. But in relative terms this is small — about 4 per cent of its expenditure.

In its submission to the Commission's Defence Procurement inquiry, the Department said:

> With regard to contracted research work, DSTO believes that it can increase the work placed with industry, and still maintain the principle of cost effectiveness (See Department of Defence's submission to Defence Procurement inquiry 1994, p. 70).

In this inquiry, the Department said:

> ... where value for money has been evident and security and other considerations have allowed, DSTO has regularly contracted R&D work to the universities and industry. Under the present (draft) four year [DSTO] forward program, DSTO will be looking at ways to increase the utilisation of external R&D from about 5% to 10% of budget within five years, that is, to about $20m (Sub. 148, p. 1).

In some other countries, the contracting out of defence research appears to be practised much more extensively than in Australia. For example, in the United Kingdom a report prepared by the Advisory Council on Science and Technology (ACOST 1989) recommended that the Ministry of Defence conduct its research extramurally wherever possible, preferably in an environment where both civil and defence work is undertaken. It also suggested awarding more R&D contracts to organisations (including universities and research institutes) with proven technology transfer mechanisms, and to small and medium sized companies.

The United Kingdom Government noted that:

> ... it is already [Ministry] policy to carry out research extramurally wherever it is practical and economic to do so, and this extramural element amounts to *approaching two-fifths* of all funded research ... it has to be recognised however that some elements

> of defence research and other support may have little or no civil relevance and/or may be best carried out in-house (ACOST 1989, p. 5).

In the United Kingdom, research is mainly provided by the Defence Research Agency, which has contracts with industry and the universities to procure some £200 million a year of defence-related research and associated products and services (United Kingdom White Paper 1993). The proportion of the Agency's research carried out in-house is expected to decline, and by 1997–98 about two-thirds of its research funds will be subject to contestability. Thus, over the next few years, industry is expected to play a greater part in meeting defence research needs.

In the United States, the estimated federal R&D obligations for the Department of Defence in 1993 was $36 billion. Of this, Federal laboratories (including federally funded R&D centres, many of which are privately-owned) accounted for $9.6 billion or about 27 per cent (National Science Board 1993). Much of the Department's R&D activities are contracted to outside companies and organisations.

While much defence-related R&D in Australia is undertaken in private firms in association with defence procurement, it appears that, in a comparative sense, DSTO contracts out very little of its own research to outside companies. It is difficult to make other than broad-brush comparisons, but DSTO appears to contract out a much smaller proportion of its defence research than the United Kingdom and the United States. While Australia's defence spending needs, and the ability of its industry to undertake defence R&D, are different, the reasons for this low level of outside contracting of specific R&D work are not wholly clear.

The experience in the United States and the United Kingdom suggests that DSTO may be treating as 'core' much more R&D activity than necessary, and thus the extent to which its research is contestable is low. One question is whether further contestability could be introduced into DSTO's research, either through the CSP or otherwise. Introducing some contestability might lead to more contracting out of Defence research, especially given the relatively low level of contracting of research to outside companies. However, the Department of Defence said that DSTO already faces pressure to contract out as much as is feasible and efficient due to budgetary pressures on DSTO and the demand for more services by other branches of Defence.

There would be little benefit in including DSTO in the Commission's reform proposals for CSIRO and the other research agencies discussed in previous chapters. DSTO must respond to defence priorities and its performance is monitored in terms of the benefits that it can deliver to Defence.

In the draft report, the Commission stated that there may be scope to modify arrangements so as to achieve greater contestability in the performance of defence R&D. It invited comments on these matters.

In response, DSTO took the view, as it did in 1993, that there was some scope to increase its external contracting, for example, to industry and universities and it has set a target for 1998 of 8–10 per cent of budget, doubling its 1993–94 level of external contracting out. However, DSTO is generally of the view that the majority of R&D needs to be carried out in-house. The key reasons provided were:

- DSTO must be able to provide impartial 'wise buyer' advice to Defence's acquisition process. This advice must not only be based on a thorough understanding of the underlying science, but also on the special needs of the 'Defence business'; and
- External organisations in Australia, especially industry, appear to be limited in their ability to undertake the majority of the kind of R&D that DSTO conducts. (there can also be further complication with respect to classified research, especially in relation to universities) (Sub. 405).

In addition, DSTO believes that the comparisons (in regard to external contracting out) between Australia and other countries such as USA and UK need to be approached with caution for several reasons:

- These countries' strategic circumstances are significantly different from those of Australia, as are their industrial infrastructures.
- Both the USA and the UK have designed, developed and manufactured the majority of the equipment needed for their respective armed forces. In contrast, Australia has tended to either import its defence equipment or, when manufactured here, has tended to base the product on overseas design.
- Where DSTO is involved in the design and development of equipment for the Australian Defence Force, it tends to be increasingly in those areas where Australia has a special need, related, for example, to the priorities of self-reliance or distinguishing features of its natural environment. In these cases, the trend is to get industry involved early. A complication is that not all of industry's involvement in such cases is funded by DSTO, but by other elements of Defence such as the Defence Industry Development (DID) funding (eg over-the-horizon radar).
- In the United States, the size of the defence science budget makes it possible to contract out a considerable amount of research to universities, private laboratories and industry, and still maintain an intramural defence

> technology knowledge, and hence, an impartial advisory capacity to government.

A number of participants considered the present level of contracting out by DSTO to be too low, and some saw benefits in more contracting out by DSTO. For example, in the draft report hearing, the Australian Academy of Technological Sciences and Engineering said that:

> ... much of the contracting out has been for the non-defence applications of that defence science and technology which has been developed, as distinct from contracting out of the defence applications per se, which again is in contradistinction to the practice which happens in say, America, where a lot of the defence applications are contracted out to private industry ... we agreed that DSTO had had an active program of contracting out but we still saw it as limited. Perhaps it was as far as they were able to go under present policies or as far as they had discretion as to what they could contract out. But we saw there a void really compared to other countries (DR transcript, p. 2857).

The Australian Electrical and Electronic Manufacturers' Association (AEEMA) said that:

> Australian industry in the past has had very little opportunity to contribute to Defence research. This contrasts with companies in the United States and Europe (Sub. 460, pp. 6-7).

Furthermore, the Association noted that there is no counterpart in Australia for programs such as the Technology Reinvestment Program (a US multi-agency, dual use technology investment program), consequently placing Australian industry at a competitive and technological disadvantage, explaining in part Australia's continuing reliance on defence imports. It said:

> ... to achieve self-reliance, we must encourage more research by Australian industry in the areas identified as being of strategic importance (p. 7).

The Association agreed with the Commission that more contestability should be introduced to defence R&D:

> Such [contestability] should focus in particular on the technology areas identified as being of strategic importance to Australia (Sub. 460, p. 7).

However, it considered that the Commercial Support Program, which is responsible for introducing contestability to a wide range of services in Defence, is not the most appropriate vehicle.

The South Australian Government felt that increased contestability would improve technology exchange and hence commercial opportunities available to Australian industry in the long term. If applied to Defence, this would result in more contracted R&D, at the 'exposed lower industrial rates' (at competitive prices), and should result in more R&D being completed within the DSTO budget (Sub. 289, p. 11).

The University of Queensland said:

> ... if more defence science were contracted out, it would allow greater input from university researchers, who may be able to offer needed requisite skills (Sub. 410, p. 3).

The Commission recognises some of the points made by DSTO including its ‘wise buyer’ advice role to Defence, but considers that there may be scope for a larger portion of the Defence R&D work to be done by private industry. Australian industry is more likely to build up capability to do defence work (ie defence applications) if given more opportunity to compete for contract work.

Under current arrangements — in which contracting out is done by DSTO — the Commission considers that the requirement set for DSTO to increase the proportion of its budget that is contracted out to a target of 8–10 per cent by 1998 is a useful measure.

An alternative to achieve greater contestability might be for the Department of Defence to review the possibility of providing a portion of research funds (as determined by the Department) directly to the users of DSTO research including the Army, Navy, Air Force and the Defence Headquarters for them to allocate to DSTO or others.

The Commission supports the target set for DSTO of contracting out 8 to 10 per cent of its budget by 1998. It recommends that there be a subsequent review by the Department of Defence of the attainment of this target and its effects, as a basis for assessing whether to vary it or implement alternative arrangements to achieve greater contestability.

Industry links

The Defence White Paper (Department of Defence 1994d) noted that effective and efficient collaborative links between the DSTO and Australian industry are essential to promote the adaptability and versatility of the Australian Defence Force. The DSTO’s interactions with industry will grow, particularly as commercial markets drive technological developments in fields such as communications and information technology, and as Defence looks increasingly for technology transfer from these markets.

DSTO said it recognises the benefits to itself from having partnerships and dialogue with other military and civilian researchers both within Australia and overseas (DSTO 1993a). It has identified a number of mechanisms to enhance the capability of Australian industry to support defence needs. These include R&D contracts with industry, consultative and engineering services, collaborative research, development of joint venture arrangements and involvement in CRCs.

For example, DSTO laboratories have partnerships with industry, tertiary institutions and other research agencies in the Cooperative Research Centres Scheme. DSTO is involved in seven CRCs and has cooperative research agreements with CSIRO and Telecom Research. As well, DSTO has several ‘strategic alliances’ with industry. It is also contracting work to the Australian Photonics CRC with a view to possible future membership and is negotiating to become an industrial associate of the CRC for Materials Welding and Joining. In 1991–92, DSTO had about $890 000 invested in research agreements with universities and a further $8.25 million was shared between universities and industry in technical service contracts.

In the context of CRCs, the Association of Australian Aerospace Industries (AAAI), in its submission to the Commission’s 1994 Defence Procurement inquiry, said:

> DSTO is involved in a number of Co-operative Research Centres, with program of interest to the aerospace industry. In particular ARL is involved in the CRC on Aircraft Structures. These links have (and, hopefully, will continue to be) most successful in the development of capabilities within the industry (See Sub. 14 of the IC Defence Procurement inquiry, p. 11).

The Defence White paper noted that industry is encouraged to become involved in Defence R&D in its early phases so that commercial opportunities can be identified and exploited as early as possible. Such involvement is facilitated through industry alliances, which are formal long-term relationships between Defence and external agencies to promote mutual objectives of technology transfer, the exploitation of R&D and the promotion of defence industries. These alliances encourage industry to play a greater role in defence science and technology.

Comments from some industry participants indicate that these long–term relationships (eg through joint undertaking of pre-competitive research) between DSTO and industry are quite valuable, and can play a vital role in commercialising DSTO’s research.

In a submission to the Commission’s Defence procurement inquiry, the Australian Electrical and Electronic Manufacturers’ Association said that:

> ... the Defence Science and Technology Organisation (DSTO), can play an important role by forming relationships with industry to commercialise its research. Unfortunately, the DSTO has proved unwilling in the past to accept commercial reality and enter into agreements on an equitable basis sharing financial and technical risk (See Sub. 22 of IC Defence Procurement inquiry, p. 14).

However, in this inquiry, the Association noted that it has been impressed by the manner in which DSTO in recent times has sought to strengthen linkages with the industry:

> DSTO has made it clear through its publications and in industry forums that it welcomes involvement of industry beyond the concept stage of a project (Sub. 460, p. 9).

Furthermore, a report prepared by the South Australian Centre for Economic Studies said that DSTO plays an important role in expanding business opportunities for the South Australian electronics industry:

> The DSTO currently is involved with some twenty six companies and four universities spanning approximately 45 technologies in the form of agreements to research applications, commercialise technologies, develop new products, or establish start-up companies (cited in Sub. 460, p. 10).

The AAAI, in a submission to the Commission's Defence Procurement inquiry (1994), said that:

> The linkages between the DSTO and AAAI are very strong and most effective ... But the DSTO can (and should) do much more to provide the generic technology base on which the Australian based industry will grow. AAAI believes that the best mechanism for achieving this is the formation of long-term strategic alliances between the DSTO and individual companies and/or groups of companies, to carry out this pre-competitive research and development work (See Sub. 14 of IC Defence Procurement inquiry, p. 11).

Nevertheless, a report by the Department's Inspector-General Division noted that there are few guidelines for establishing strategic alliances between DSTO and industry, and recommended that the principles underlying DSTO's interactions with industry be developed into a range of models to assist in the expansion of these alliances.

One of the DSTO's objectives is to facilitate the timely transfer of the results of defence research to industry. This is normally done on a commercial basis and most frequently through licence agreements. For example, DSTO-developed products such as the Barra Sonobuoy and the Laser Airborne Depth Sounder are now manufactured in the private sector under licence. However, there are necessarily some limits on the extent DSTO can collaborate and disseminate its research results to industry.

The Defence Industry Brief (Sep-Oct 1993) reported the results of a recent Defence review, which noted that, in a small number of cases, DSTO licences were directly subject to an open tender process and firms were selected mainly on their ability to exploit the related Intellectual Property. These cases were typically DSTO initiatives to commercialise DSTO inventions. DSTO advertises widely, for the opportunities for firms to license these inventions with interested firms briefed on the nature of the inventions, the terms and conditions of the licence, the support that DSTO is prepared to provide, and the criteria DSTO intends to use in selecting a licensee. In addition, firms willing to bid for these licences are required to describe their capability and intent to exploit the technology as part of the selection process. This, as the review found, is in stark contrast to the dominant Defence approach where details of how a firm intends to exploit a licence is only sought after the licence has been awarded.

Industry Support Office

In 1992, a trial Industry Support Office (ISO) was established by DSTO at the Aeronautical Research Laboratory in Melbourne to market the Laboratory's research facilities and skills as well as the products of research which may have commercial potential. Specific attention was given to composite bonded repair technology, vibration and defect prediction in helicopter gearboxes, corrosion protection and automatic hydraulic test facilities (Cook 1994a).

Initially at least, however, the ISO has not been able to place much emphasis on longer-term strategic alliances with industry. The Department's Inspector-General Division said:

> ... while the ISO is a positive initiative in many aspects, it faces difficulty in being able to give much weight to longer-term strategic alliances under its present guidelines. The ISO has an important role to play in the exploitation of DSTO capabilities. The evaluation recommends that, to assist the ISO in playing a more meaningful role in the promotion of strategic alliances, its guidelines be reviewed (Department of Defence 1993, p. xv).

In this regard, DSTO stated that:

> Drawing on the lessons learned from the ISO experiment, DSTO decided that a DSTO-wide Business Office should be established from 1 January 1995, with branches at the Melbourne and Salisbury laboratories. The role of the Business Office is to promote and facilitate DSTO's interactions with industry and other external bodies (Sub. 405, p. 7).

Defence Industry Development program

The DID program provides local industry with some $10–15 million annually to:

> ... develop local industry capabilities to meet long term Defence requirements that can not be better developed by other areas of Defence (see IC 1994b, Defence Procurement, Report no. 4, p. 59).

At present, the DID program is completely separate from DSTO. However, about one-third of the DID funded projects utilise R&D outputs from DSTO (Defence Industry Brief Sept-Oct 1993). The Commission's recent report on Defence Procurement has made some recommendations on this program.

External earnings requirement?

Although DSTO and the ADF recognise the benefits that flow from industry involvement in R&D, the actual amounts directed specifically to these areas is small in comparison to the overall budget. The CRC program, contracts let to private firms, the Industry Support Office (ISO) program and the separate Defence Industry Development program (DID) scheme account for a very small proportion of expenditure by Defence on R&D.

DSTO stated that when Defence priorities permit, DSTO makes its R&D facilities and expertise available to industry at commercial rates. However, the purpose of this is not to raise external revenue, but to fulfil its objective to support the development of Australian industry. The idea of having some form of external earnings target (such as applies to CSIRO, AIMS and ANSTO) imposed on it would not be appropriate since the primacy of DSTO's obligation is to its main customer — the other components of the Defence Organisation (Sub. 405, p. 8). The Commission agrees with this view.

In its submission on the draft report, DSTO re-emphasised that it would not be appropriate because of special relationship with its main client, the Defence Organisation. It said:

> The purpose of having earnings targets for research organisations is to help focus their activities on R&D that will be most beneficial to the nation. Under some circumstances, an earnings target can provide a rapid means of obtaining client feedback on whether or not the R&D is worthwhile. In DSTO's case, there is an elaborate process of consultation, tasking and transparency which allows DSTO to demonstrate that its work is in accordance with customers' needs and Defence priorities (Sub. 405, p. 6).

The Commission does not consider that an external earnings requirement is appropriate for DSTO.

PART C

UNIVERSITY AND RELATED RESEARCH

PART C UNIVERSITY AND RELATED RESEARCH

C1 HIGHER EDUCATION R&D ACTIVITIES

C2 HIGHER EDUCATION RESEARCH FUNDING MECHANISMS

C3 GENERAL FUNDING ISSUES

C4 COMPETITIVE FUNDING AND THE ARC

PART C UNIVERSITY AND RELATED RESEARCH

This part of the report examines R&D carried out by the higher education sector. The sector includes all universities, colleges of advanced education and other institutions of post-secondary education (excluding TAFEs).

Chapter C1 provides a brief overview of higher education research activities, and considers the types and fields of research activity, the sources of funding, inputs and outputs of higher education institutions. Some international comparisons are also made.

In chapter C2 the various research funding mechanisms for the higher education sector are identified. The emphasis in the chapter is on the Commonwealth Government which is the predominant funder of higher education research. The main mechanisms used by the Commonwealth, namely the operating grant and the Australian Research Council, are considered in some detail.

Chapter C3 looks at the role of research in universities, and funding arrangements. How funds should be delivered is a central concern, especially whether it is more appropriate to employ funding mechanisms which involve competition among researchers and institutions or whether it is best to deliver research funds on the basis of teaching needs.

This is followed in chapter C4 by consideration of funding through the Research Quantum, and the issue of whether the basis for selection of projects and research programs should be excellence or relevance. The role of the Australian Research Council is also examined.

Chapter C5 examines some concerns about the funding of research infrastructure, and also considers funding arrangements for the Institute of Advanced Studies. The chapter ends by examining the question of taxation of postgraduate student scholarships

The final chapter looks at the National Health and Medical Research Council, another major Commonwealth competitive funding scheme. The issue of separately funding medical research is briefly examined. The similarities with research funding under the Australian Research Council are noted and the funding arrangements of the John Curtin School of Medical Research and other research institutes are considered. One focus of the chapter is the current priority setting process, which was recently considered in some detail in the Bienenstock review.

C1 HIGHER EDUCATION R&D ACTIVITIES

C1.1 Introduction

While universities have an important role in contributing to society's cultural and intellectual advancement and act as repositories of knowledge, their main functions are teaching and research, captured in the traditional description, 'centres of learning'. Universities are responsible for a large part of post-secondary education and almost all of the provision of highly-trained researchers. This does not imply just training for the workplace but education in its broadest sense. It is this teaching and training function which separates universities from other research institutions. The Commission has not included the TAFE sector in its consideration of higher education research and development activities (see footnote 2 below).

Universities, as noted in chapter A1, are one of the three major types of innovation-generating institutions. While they are principal research performers, the diffusion of knowledge through education and training and the subsequent progression of people is one of the most important sources of innovation and growth. Chapter C3 considers in more detail the role of the higher education sector in research and development and its contribution to the innovation system.

In addition to the teaching and training role, and to a significant extent complementary to it, universities contribute a major body of research. This research output has many dimensions. For example, research outputs generated for users include patents and papers, research skills and new research methods. These are illustrated in chapter A1, figure A1.4. Universities are also the primary source of pure basic research. Other contributions include the linking of Australia to the world's research community, and the dissemination of research results — of international as well as national origin — to government, industry and the community.

C1.2 An overview of the higher education sector

The most recent year in which comprehensive ABS data are available is 1992.[1] In that year about 27 per cent of Australia's total R&D was undertaken within the higher education sector.[2] This sector spent about $1.7 billion on R&D, compared with spending of about $2.8 billion by the business enterprises sector and $1.1 billion by Commonwealth research agencies. It accounted for some 52 per cent of Commonwealth support for R&D across all sectors in 1990–91. This has declined to 42 per cent in 1994–95. Australia's higher education R&D expenditure as a proportion of gross domestic R&D expenditure is relatively high in international terms (see table C1.1).[3]

Table C1.1: **Some international comparisons of higher education R&D expenditure[a]**

	Million current PPP $[b]	*As % of gross domestic expenditure on R&D*
Australia	960.9[c]	26.2[c]
US	25341.0	16.4
UK	3178.7	17.0
Germany	5613.6	15.8
NZ	74.2[c]	18.6[c]
Canada	2051.3	26.4
OECD median	-	22.0

a 1991 figures unless otherwise specified.

b Conversion to $ using Purchasing Power Parities (PPP). PPPs are the rate of currency conversion which eliminate the differences in price levels between countries. This means that a given sum of money, when converted into different currencies at these rates, will buy the same basket of goods and services in all countries. PPPs are given in national currency units per US dollar.

c 1990.

Source: OECD 1994c, pp. 54–5.

1 For consistency, the Commission has largely relied on ABS data. This is not the only source of data available. However, the Commission has encountered difficulties in obtaining accurate up-to-date data, and where data was available it has been difficult to reconcile figures received from the various sources.

2 Includes all universities and other institutions of post-secondary education whatever their source of finance or legal status. It excludes other institutions such as technical and further education colleges because it is considered that their contribution to total R&D activity would be minimal (ABS, Cat. No. 8111.0).

3 DIST notes that international comparisons should be treated with caution as the type of research conducted in government agencies in one country may be conducted in universities in another and vice versa. For this reason DIST suggests combining international data on Government and academic sectors (DIST 1994a, p. 7).

A number of participants were concerned about the accuracy of ABS estimates for higher education research and development expenditure (see box C1.1). They considered such data overestimated Australia's level of expenditure relative to other countries. Murdoch University said:

> While it is accepted that bench marking is a suitable and appropriate way to compare the level of funding for research, whether within Australia or internationally, it is far from clear that in international comparisons 'like' is always compared with 'like'. International comparisons of the level of funding for research are fraught with difficulty because of the significant differences in the ways in which funding is reported in different countries (Sub. 276, p. 2).

DIST however, argued, that on the general issue of international statistics:

> ... almost all countries acknowledge that R&D statistics in higher education are less satisfactory than in other sectors. Nevertheless, Australian R&D statistics are very well regarded among the NESTI [National Experts on Science and Technology Indicators] group both for their adherence to OECD norms and their overall quality. Within the NESTI Group, those countries generally well regarded for R&D statistics would include Australia, Canada, Ireland, the five Nordic countries, and the USA. Estimates of R&D expenditure in the higher education sector are likely to be comparable in quality between these countries. Outside this group of countries, quality may be more variable – but, with respect to comparisons with Australia, higher education R&D expenditures may be overestimated in as many countries as it is under-estimated (Sub. 412, p. 6).

The Unified National System, introduced in 1987, brought major structural changes to the higher education sector. Colleges of Advanced Education and Institutes of Technology were given university status, and some mergers took place. The number of institutions classified as universities jumped from 19 to 38 (of which 36 are public). University staff describing themselves as engaged in teaching-only fell from 35.5 per cent in 1988 to 13.6 per cent in 1991.[4]

4 This can cause some difficulties in interpreting pre- and post-1987 data, and in differentiating between increases in measured R&D arising from increased activity from those simply reflecting changes in reporting practices.

Box C1.1: **The accuracy of higher education research data**

During the inquiry, there were differences of interpretation in relation to the use of ABS statistics on higher education research funding. At issue was the suggestion that the statistics relied upon an estimate that 30 per cent of academics' time was devoted to research, leading to an overestimate of research funding and making international comparisons suspect. The ARC said:

> ... the impression is given of a relatively high level of funding by OECD standards. The substantial shortfall in funding for research infrastructure and the extreme pressure on ARC program funds are strongly at variance with such a view. The problem lies in the methodology adopted by the [ABS] ... The methodology, which is based on that used by the OECD produces a figure for total R&D expenditure in the sector which is dominated by the fraction of academic salaries imputed to research. Unfortunately, there are substantial differences between countries arriving at that fraction, making international comparisons highly suspect (Sub. 361, pp. 2–3).

It added:

> The magnitude of the problem has increased significantly with the establishment of the Unified National System in 1988. Immediately following the renaming of CAEs and Institutes of Technology as universities, or their absorption into pre-1987 universities, large numbers of staff formerly classified as 'teaching only' were reclassified as 'teaching and research'. This reclassification and its consequent impact on the nominal R&D expenditure reported by the ABS, has occurred in many cases without corresponding increase in actual research activity. The net result, for the Australian data, is a substantial overestimate of total R&D expenditure in the higher education sector (p. 3).

DIST said:

> There is widespread misunderstanding that [the] statistics are derived by a procedure which includes the application of a standard fraction to *all* academic salaries. For that part of university R&D which involves academics involved in both research and teaching, the standard fraction approach uses an estimate of the average fraction of academic time allocated to research. This approach is used to some degree in a number of countries, with the standard fraction being established by a time-budget survey or other survey. For Australian R&D surveys, an element of the standard fraction approach has been used since the early 1980s – but there are no sharp discontinuities with earlier surveys which did not involve this approach (Sub. 412, pp. 6–7).

It cited the *Australian Science and Innovation Resources Brief 1994*, tables A1.2 and A1.5, and said:

> There are no sharp 'blips' in the time series of higher education R&D data ... which might suggest that the modification of survey methodology since the 1970s, and the introduction of the Unified National System after 1988, has grossly changed the pattern of reporting. For example, R&D expenditure in universities as a proportion of GDP was 0.315% in 1978, 0.338% in 1986 and 0.337% in 1990. As the data also show, the Unified National System was not fully in operation by 1990. R&D expenditure in Colleges of Advanced Education was reported as 0.015% of GDP in 1986, and was still being reported separately in 1990 — when it had risen to 0.020%. The absence of sharp discontinuities in these and other data indicate that there is no basis for claiming that the 1990 data were overestimated by 'several hundred million dollars' (p. 7).

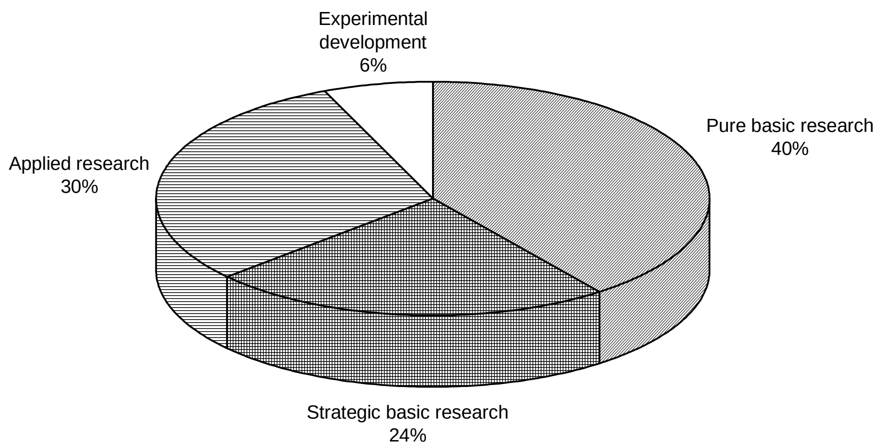
The ABS advised the Commission that, prior to the 1990 collection, university R&D data on human resources were derived through surveys which sought information at the project level. In the few cases where project level reporting was not possible, universities were allowed to report at a more aggregated level. For the 1990 collection, data were provided to DEET, and then ABS, on a more aggregated basis, for different fields of research within departments or schools. Universities were however, encouraged to compile information at a project level before aggregation to the level required by DEET.

Types of research activity

Australia's universities are involved to varying degrees in basic and applied research, and to a much lesser extent in experimental development. Some also seek to commercialise research output in particular fields (see box A1.1 for definitions).

In 1992 about 40 per cent of R&D expenditure by universities was considered by the researchers involved to be *pure basic* research, and a further 24 per cent as *strategic basic* research (see figure C1.1 and table C1.2).

Figure C1.1: **Higher education sector: type of R&D activity, 1992**



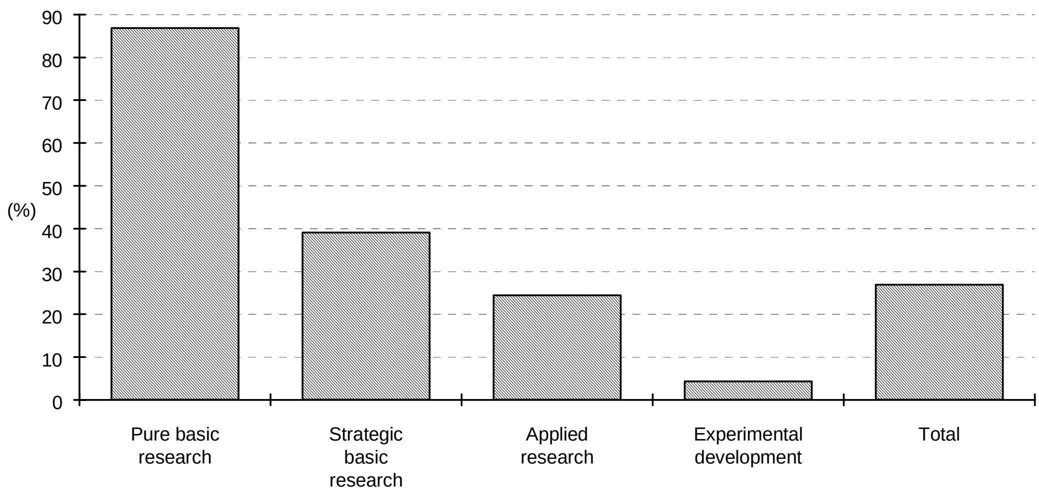
Source: ABS, Cat. No. 8111.0.

These figures are not unlike those for the United States, where academic R&D is also concentrated at the basic end of the R&D spectrum. Of academic R&D expenditures in 1991, about 65 per cent went to basic research, 30 per cent to applied and 5 per cent to development (NSB 1991, p. 116).

However, average measures hide a lot of variation in the detail. For example, about 33 per cent of natural sciences, technologies and engineering was classified as pure basic research and 29 per cent as strategic basic. The corresponding figures for social sciences and humanities are 54 per cent and 13 per cent (see table C1.3).

Universities account for about 87 per cent of all pure basic research undertaken in Australia, but only 39 per cent of all strategic basic research (see figure C1.2).

Figure C1.2: **Higher education R&D as a percentage of total all sectors, 1992**



Source: ABS, Cat. No. 8112.0, table 5.

The changing nature of university research

Universities have become more involved in applied research and in the commercialisation of research results over recent years. The ARC noted that over the last five to ten years, ‘the orientation of academic research towards outcomes of direct benefit to industry and the community at large’ have substantially changed (Sub. 182, p. i).

A 1993 NBEET report indicated that industry linkages with higher education research was probably more in the order of 10 to 15 per cent of total higher education research activity rather than the 2 to 3 per cent which currently reported data would indicate (NBEET 1993b, p. xviii).

ABS data indicate that there has been a decline in higher education funded pure and strategic research since 1978, while over the same period, funding for applied research has increased (see table C1.2). The Senate Committee said:

> It might be expected that, with the greater policy emphasis since 1990 on relevance, university-industry links and commercialisation, such a trend will continue. It is interesting to note that the steepest decline in basic research, with a corresponding increase in applied research, occurred in the years prior to the establishment of the UNS [Unified National System]. Thereafter, the relative proportions of pure and applied research have remained roughly the same (SSCEET 1994, p. 107).

Table C1.2: **Type of research as percentage of total higher education R&D funds**

Type of research	*1978* *%*	*1981* *%*	*1986* *%*	*1988* *%*	*1990* *%*	*1992* *%*
Pure basic research	51	51	38	38	41	40
Strategic basic research	18	15	26	24	22	24
Applied research	25	27	30	31	31	30
Experimental development	6	6	7	7	6	6

Note*:* It is difficult to say anything too definitive about the figures as there are problems with comparing data across years. Respondents self-classify R&D programs by research type and socio-economic objective, and there have also been changes in the collection methodology.
Source: Compiled from ABS, Cat. No. 8111.0, various years.

At the public hearings the ARC said, if the last five years are examined:

> ... it's certainly true that the balance between pure research and strategic and applied research has shifted heavily away from pure basic research as far as government funding is concerned, and the proof of that is in the increased funding that has gone particularly into the various competitive Commonwealth granting schemes which, apart from the ARC, are all concerned with strategic and applied research. The most obvious example is the CRC program, but there are many other examples where the funding has increased substantially (transcript, p. 1970).

At the same time, many institutions, especially those with a more applied focus, stressed that university research in the applied areas should be maintained. Curtin University said that:

> Better official recognition and support of research at the applied end of the R&D spectrum is also important insofar as this research is appropriate to other Government initiatives which encourage research to be transferred into economic outcomes (Sub. 24, p. 3).

Fields of research

In 1992, about 70 per cent of R&D spending by the higher education sector was on the natural sciences, technology and engineering, while the remaining 30 per cent went to the social sciences and the humanities (see table C1.3). Major fields of research in 1992 included medical and health sciences ($314 million), biological sciences ($194 million), humanities ($163 million) and engineering ($116 million).

The ABS *field of research* classification (reported in table C1.3) is based upon recognised academic disciplines and evolving areas of study. It is primarily structured around disciplines or activities, and describes ***what*** research is being performed.

In contrast, the socio-economic objective classification used in table C1.4 is based on the purpose of the R&D as perceived by the researcher. It describes ***why*** the research is being performed.

Table C1.4 shows that 41 per cent or somewhat under half of the research undertaken by higher education institutions is expected to contribute principally to the advancement of knowledge.

Both tables are cross-classified by type of research activity. This illustrates, for example, the importance of pure basic research in the physical sciences and the humanities, and of applied research and experimental development in education, rural science and engineering.

Between 1990 and 1992, medical and health sciences, humanities and social sciences recorded the largest increases in both expenditure and human resources.

Table C1.3: **R&D by higher education organisations, Australia, 1992, by field of research and type of activity**

Field of research	*Total*	*Pure basic research*	*Strategic basic research*	*Applied research*	*Experimental development*
	$m	*%*	*%*	*%*	*%*
Natural sciences, technologies & engineering					
Mathematical sciences	45.1	66	9	22	3
Physical sciences	80.2	72	13	12	3
Chemical sciences	92.4	52	25	18	5
Earth sciences	76.3	44	27	24	4
Information, computers & communications technologies	74.9	24	33	37	6
Applied sciences & technologies	71.0	19	35	36	9
General engineering	115.8	15	28	42	15
Biological sciences	194.4	46	32	18	4
Agricultural sciences	97.2	10	36	45	9
Medical & health sciences	314.3	22	30	39	9
Total natural sciences, technologies & engineering	**1161.5**				
Percentage of total	*100.0*	*33*	*29*	*31*	*7*
Social sciences & humanities					
Accounting & finance	21.7	23	22	49	5
Economics	52.6	39	22	37	2
Political sciences	33.5	58	23	17	2
Sociology	19.1	69	10	19	1
Law	27.0	52	21	23	4
Psychology	36.3	55	17	24	4
Education	73.6	23	15	52	9
Other social sciences	106.7	41	14	41	3
Humanities	163.2	83	3	11	3
Total social sciences & humanities	**533.7**				
Percentage of total	*100.0*	*54*	*13*	*29*	*4*
Total	**1695.2**				
Percentage of total	*100.0*	*40*	*24*	*30*	*6*

a Data within this classification are subjectively allocated by respondents at the time of reporting, using OECD/ABS definitions. Analysis using this classification should bear the original subjectivity in mind.

Note: Totals may not add up due to rounding.

Source: ABS, Cat. No. 8111.0.

Table C1.4: **R&D by higher education organisations, Australia, 1992, by socio-economic objective by type of activity**

Area of expected national benefit	*Total* $m	*Pure basic research* %	*Strategic basic research* %	*Applied research* %	*Experimental development* %
Defence	**2.9**				
Percentage of total	*100.0*	*28*	*40*	*23*	*9*
Economic development					
Plant – production & primary products	58.5	15	44	34	7
Animal – production & primary products	42.2	10	34	43	13
Mineral resources (excl. energy)	21.9	15	39	28	19
Energy resources	9.2	20	38	31	11
Energy supply	30.9	17	26	45	11
Manufacturing	75.0	12	34	43	11
Construction	38.5	11	22	51	16
Transport	4.5	5	15	68	12
Information & communication services	34.6	14	33	46	7
Commercial services	14.2	11	23	60	6
Economic framework	76.3	28	24	45	3
Total economic development	**406.0**				
Percentage of total	*100.0*	*16*	*32*	*43*	*10*
Society					
Health	318.9	21	32	38	9
Education & training	81.3	21	15	55	9
Social development & community services	53.7	31	19	45	4
Total society	**454.0**				
Percentage of total	*100.0*	*22*	*28*	*42*	*8*
Environment					
Environmental knowledge	84.8	36	30	28	6
Environmental aspects of economic development	35.8	35	18	40	8
Environmental management & other aspects	10.0	19	30	48	3
Total environment	**130.5**				
Percentage of total	*100.0*	*34*	*27*	*33*	*6*
Advancement of knowledge					
Natural sciences, technologies & engineering	422.3	60	21	17	3
Social sciences & humanities	279.5	77	8	13	2
Total advancement of knowledge	**701.8**				
Percentage of total	*100.0*	*66*	*16*	*15*	*3*
Total	**1695.2**	**40**	**24**	**30**	**6**

a Data within this classification are subjectively allocated by respondents at the time of reporting, using OECD/ABS definitions. Analysis using this classification should bear the original subjectivity in mind.

Note: Totals may not add up due to rounding.

Source: ABS, Cat. No. 8111.0.

In comparison with other countries, Australia's expenditure on research in universities shows a strong weighting towards the social sciences and psychology, while Australia does relatively much less in physical sciences and engineering. Australia devotes a large proportion of expenditure to life sciences (which includes agricultural research) (see table C1.5).

Table C1.5 **Government expenditure for academic and related research, 1987, percentage of total expenditures**

Country	*Life sciences*	*Physical sciences*	*Engineering*	*Social sciences and psychology*
Australia	36.0	13.7	7.9	12.2
France	34.7	29.7	11.2	4.6
Germany	36.7	25.1	12.5	5.2
Japan	33.7	14.5	21.6	3.9
Netherlands	32.7	21.7	11.7	10.4
United Kingdom	30.9	20.2	15.6	6.7
United States	48.9	15.6	13.2	5.1
Average	36.2	20.1	13.4	6.8

Source: ASTEC 1990a, p. 39.

Sources of funding

Universities are funded for R&D from a diverse range of sources, although the major source of funds is the Commonwealth Government, accounting for 91 per cent or $1545 million in 1992 (see table C1.6). These funds are provided through direct funding to universities and through a range of some 40 or so competitive grants programs. Funds from private non-profit and other Australian sources accounted for 4 per cent in 1992. Both business enterprises and State and local governments provided approximately 2 per cent of funds, while less than 1 per cent came from overseas sources.

As table C1.6 illustrates, funding from private non-profit and other Australian sources increased between 1986 and 1990, but decreased significantly between 1990 and 1992. Funds from State and local governments have remained constant.

Table C1.6: **Sources of funds for R&D carried out by higher education organisations**

	1986		*1988*		*1990*		*1992*	
	$m	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*
Commonwealth Government	821.7	93	983.2	91	1193.8	88	1544.7	91
State & local government	12.0	1	16.6	1	33.8	2	34.8	2
Business enterprises	18.5	2	27.6	3	29.9	2	41.7	2
Private non-profit & other Australian sources	23.3	3	42.1	4	83.9	6	63.5	4
Overseas	6.4	1	7.2	1	9.3	1	10.5	1
Total	**881.9**	**100**	**1076.8**	**100**	**1350.8**	**100**	**1695.2**	**100**

Note: Totals may not add up due to rounding.
Source: ABS, Cat. No. 8111.0.

Australia’s share of government funding is high in comparison with other countries. In the United Kingdom the Government accounted for some 72 per cent of the higher education sector’s R&D funds, in 1991 (United Kingdom 1993a, table 2.2.1). In the United States, the Federal Government accounted for about 56 per cent of universities’ and colleges’ source of research funds (NSB 1991, p. 92).

Human resources

In 1992, over 35 000 person years of human resource effort was performed in universities (see table C1.7). For 1990 the corresponding figure was 27 081. On average, for each member of academic staff there are 1.8 postgraduate research students in 1992.

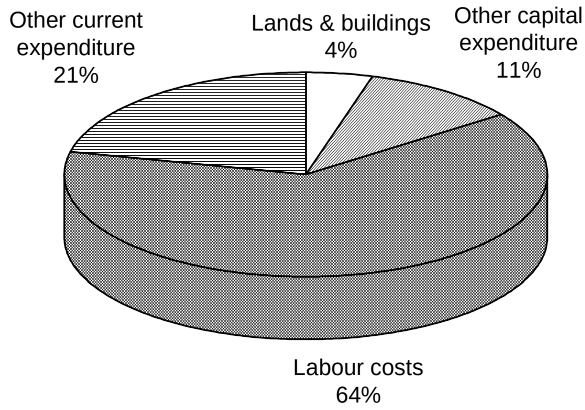
Table C1.7: **Human resource effort by type, 1990 and 1992, person years**

	1990	*1992*
Researchers		
academic staff	7 790	10 059
postgraduate research students	12 876	17 855
Support staff		
technicians	4 166	4 858
other supporting staff	2 249	2 646
Total	**27 081**	**35 418**

Source: DIST 1994a, p. 45 and ABS, Cat. No. 8111.0.

The proportion of postgraduates to academic staff is highest in rural sciences, applied sciences and technologies, engineering and the humanities. The highest proportions of technical staff to academic staff were in immunology, other physical sciences, neurosciences and horticulture. In general, these needs are higher where maintenance of laboratory facilities, or undertaking extensive field work, is involved (DIST 1994a, p. 45).

Figure C1.3: **Higher education research and development, type of expenditure, 1992, percentage of total**



Note*:* Other current expenditure includes materials, fuels, rent and leasing, repairs and maintenance, data processing etc, and the proportion of expenditure on general services and overheads which is attributable to R&D activity. Other capital expenditure includes the acquisition (less disposals) of fixed tangible assets such as vehicles, plant, machinery and equipment attributable to R&D activity.
Source: ABS, Cat. No. 8111.0.

Reflecting the central role of individual researchers, research students and research teams, labour costs are the major component of total higher education R&D expenditure, accounting for some 64 per cent (see figure C1.3 above).

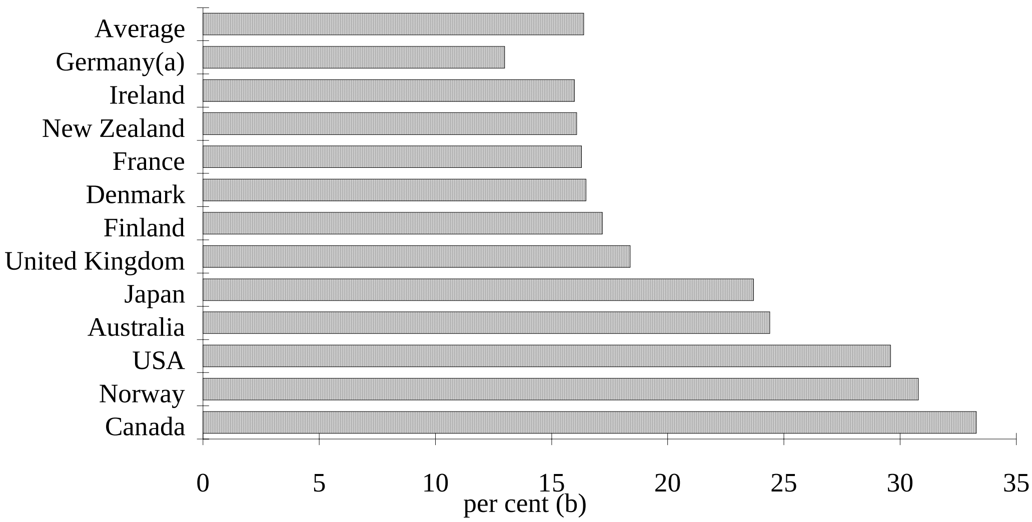
Outputs

The major ‘output’ of higher education institutions is trained and educated people, many of whom are employed by research organisations and businesses. This element of the effort of the higher education institutions is reflected in terms of degrees awarded. Figure C1.4 and table C1.8 illustrate Australia’s graduation ratio in first-degree education and in science and engineering degrees awarded, relative to selected OECD countries.

Australia's performance in terms of its graduation ratio in first-degree education (see figure C1.4) is well above the OECD average, and only slightly below that for the United States.

In terms of science and engineering degrees awarded, Australia performs well in the natural sciences (as a proportion of total degrees awarded). However, Australia is well below the OECD average in engineering degrees awarded, as a proportion of total degrees awarded, and as a proportion of total scientific degrees. This may reflect the low demand in Australia for engineering skills.

Figure C1.4: **Graduation rates in first-degree education in selected OECD countries, 1991**



a Average of data for the two parts of Germany.

b Ratio of first-degree graduates to 100 persons in the population at the theoretical age of graduation.

Source: OECD 1993c, table R6.

Table C1.8: **Science and engineering degrees awarded in selected OECD countries, 1991**

Country	*Proportion of total degrees awarded*				*Proportion of engineering degrees in total scientific degrees*
	Natural sciences	*Mathematics and computer science*	*Engineering*	*All scientific degrees*	
Japan	2.9	na	22.8	25.7	88.7
Norway	3.0	0.9	12.6	16.5	76.4
Denmark	5.9	1.5	18.8	26.1	72.0
Finland	5.3	5.8	22.1	33.2	66.6
Germany	9.1	3.7	18.9	26.1	59.6
USA	4.7	3.5	7.1	15.3	46.4
United Kingdom	10.0	5.0	10.7	25.7	41.6
Canada	6.0	3.6	6.5	16.1	40.4
Ireland	13.0	4.3	11.1	28.5	38.9
New Zealand	8.3	3.9	4.9	17.1	28.7
Australia	**14.1**	**na**	**5.3**	**19.4**	**27.3**
Average	7.4	3.4	12.1	22.5	53.8

na Not available.
Source: OECD 1993c, table R7.

Universities also perform research themselves and there are various outputs from this such as papers, publications and patents, see chapter A3.

C1.3 Some key issues

The system of support for R&D in universities currently encompasses a large number of individual schemes with differing impacts on the type of research performed. Most of the schemes are funded by the Commonwealth government which delivers the funds either directly or through the ARC. The way in which these funding mechanisms operate (the topic of chapter C2) is aimed at satisfying a range of objectives which overlap across the schemes.

Determining the appropriate objectives for funding of R&D in universities is therefore a key issue. Clearly the universities' teaching and training role is central to the research that they perform, but there are also other benefits from their research that spread more widely through the community than simply through benefits to students. Decisions are made implicitly about the extent to which each objective should be pursued by the policy instruments that are employed and the levels of funding directed to them. Those arrangements require evaluation.

One issue, for example, is the division of funding between block funds given to universities for research on the basis of their student load and the funds given competitively on the basis of the quality of research. The difference between them has quite different implications for research funding of institutions, with student load implying similar grants for institutions with similar teaching responsibilities, even if research capacity and quality varies significantly.

A related question is the basis on which grants for research should be made — is excellence alone sufficient or should relevance to the needs of the economy play a role? And if research is directly related to national goals, should research funders be attempting to select some areas in which research is likely to be more useful? This involves making choices about disciplines or areas for funding, and if priorities are assigned, implies that there is research which should receive assistance even if projects are less excellent than in other areas.

If university research is an activity which requires the retention of a number of funding institutions, then attention needs also to be given to the manner in which the division of funds among and within programs is to be handled. The current sharing of responsibilities between the government itself and the government's agent, the ARC, is something that requires careful examination to ensure that there is no duplication or working at cross-purposes.

These issues are considered in later chapters.

Finally, there is a related set of issues which arises about the role of the NHMRC in medical research — these are the subject of chapter C6. A threshold question is the rationale for separately funding medical research when other disciplines are funded together through the ARC. Then come issues which are familiar from the earlier discussion: how effectively does the NHMRC allocate funds, how priorities are set, who should set them and in what framework, and what possibilities are there for improving these allocations.

C2 HIGHER EDUCATION RESEARCH FUNDING MECHANISMS

C2.1 Introduction

The majority of university research and development funds are provided by the Commonwealth Government (see table C1.6) through a 'dual funding system'. This system which exists in many other countries provides research funds through institutional operating grants (in the form of block grants), and through separate targeted granting schemes (in Australia, there are some 40 competitive granting schemes which provide project and program grants, the largest being ARC and NHMRC).

The dual funding system in Australia, effectively began with the establishment of the Australian Research Grants Committee (ARGC) in 1965, the predecessor to the ARC. Before that, public funding of higher education research was largely provided through recurrent operating grants to universities.

Unified National System

In 1988 major changes occurred in higher education funding following the release of the Government's *White Paper*. Under the previous binary system, universities were funded for teaching, research and research training, while other higher education institutions — colleges of advanced education and institutes of technology — were only funded for undergraduate teaching and postgraduate course work. The changes announced in the *White Paper* abolished the binary divide and established the Unified National System, with the aim of providing:

> ... the basis for a long term expansion of higher education opportunities and greater equity of access to the system and its benefits (Dawkins 1988, p. 13).

Under the new arrangements, institutions wishing to receive full Commonwealth funding were required to become part of the Unified National System and received funding on a rolling triennial basis. The *White Paper* stated that:

> The new arrangements will promote greater diversity in higher education rather than any artificial equalisation of institutional roles. Institutions that attempt to cover all areas of teaching and research compromise their ability to identify, and build on, areas of particular strength and the achievement of areas of genuine excellence ... Institutions will be able to compete for teaching and research resources on the basis of institutional

> merit and capacity. Teaching will remain the predominant activity of all institutions, whereas research activity will vary according to demonstrated capacity. No institutions will be guaranteed funding for research across all its fields of study, and only those with a demonstrated capacity will be funded for research across the broad range of their programs (Dawkins 1988, p. 28).

One result of giving university status to the previous colleges of advanced education, has been the growth in the numbers of institutions and academics both willing and eligible to be involved in research activities and to compete for research funds. Another effect, which Professor Brennan argues was not foreseen at the time the UNS was conceived, was that:

> ... staff in those professional faculties of the pre-1987 universities in which there had been relatively little research (such as management, law, accounting and architecture) have been swept up in the burgeoning research culture and are also seeking support for basic research (Brennan 1993, p. 92).

'Clawback' of operating grants

A consistent trend in recent history has been the shift of funds from university operating grants to competitive research schemes. The first shift occurred with the establishment of the ARGC, which was initially funded through a 'clawback' of funds from university operating grants (see appendix D). It was established in response to pressure from leading researchers for a source of research funding outside the individual universities which were 'generally perceived to be funding research in an uncritical manner without adequate peer review procedures' (Brennan 1993, p. 91).

Further funds, some $5 million, were shifted in 1988 from universities' general recurrent grants to establish new special research centres and key centres for teaching and research, as well as to assist research in technological institutions in the advanced education sector (Dawkins 1988, p. 83).

This approach of shifting funds from operating grants to more targeted research programs was said to be:

> ... in line with [the Government's] goal of maximising the research potential of the higher education system and achieving a closer alignment with broader national objectives (Dawkins 1988, p. 83).

This process continued with a 'clawback' of operating grant funds from the pre-1987 universities over the 1989–91 triennium. The 'clawback' is a permanent transfer of $65 million per annum (December 1987 prices) phased in over the three years (Sub 361, attachment A). These funds, together with funds from some minor programs, were largely used to fund the ARC, the ARGC's successor, although 10 per cent of these funds went to the NHMRC.

A paper prepared for the Coordination Committee on Science and Technology said that the reason for the clawback of funds from universities to the ARC was that the resources available for research purposes were not being applied efficiently or effectively. It added that:

> The change in balance between general operating grant funding, and funding through direct mechanisms, itself reflects the policies of the Government to bring research closer to national needs (CCST 1992, p. 4).

C2.2 Current mechanisms for funding research

The higher education sector receives Commonwealth support for research through:

- part of the operating grants from DEET, comprising general or non-directed funds (provided jointly for teaching, research and research training);
- funds provided through the operating grants specifically for research (the Research Quantum);
- research funds under the control of the ARC; and.
- other programs which provide funds to the universities (for example, the NHMRC and the CRCs).

These mechanisms and their programs are discussed below (and in appendix D).

In 1993, the AVCC conducted a survey of the tertiary sector which revealed that a total of $524 million (excluding operating grants), was available to universities for research purposes in 1993. Table C2.1 illustrates the diversity of funding sources and shows that the largest proportion of this total, provided through the Commonwealth Government's national competitive grants schemes, amounted to $291 million (AVCC unpublished data).

Table C2.1: **Some sources of funds for R&D for the tertiary sector, 1993**

Source of funds	*1993($m)*	*% of total*
NATIONAL COMPETITIVE RESEARCH GRANTS		
Commonwealth schemes		
Australian Research Council	142.0	27
National Health & Medical Research Council	67.7	13
R&D corporations	35.5	7
DITARD	10.7	2
Other Commonwealth departments	27.0	5
Non-Commonwealth schemes[a]	9.0	2
OTHER PUBLIC SECTOR RESEARCH FUNDING		
State and local governments	39.4	8
Non-competitive Commonwealth sources	40.1	8
INDUSTRY & OTHER FUNDING FOR RESEARCH		
Contract research	39.4	8
Collaborative grants with industry	11.0	2
Donations and bequests	18.1	3
International	8.9	2
Grants for research	25.0	5
Other	23.9	5
COOPERATIVE RESEARCH CENTRES	26.8	5
Total	**524.5**	

a Includes organisations such as medical foundations and industry bodies.
Note: Because it excludes operating grants, this table is not fully comparable with table C1.6.
Source: AVCC unpublished data.

Operating grants

Operating grants for universities are provided to institutions on the basis of an *educational profile*, which defines the role of the institution and the basis on which it receives Commonwealth funding. The bulk of higher education funds are allocated through the educational profiles process.

As part of this process, universities are required to develop Research Management Plans which set out the scale, priorities, objectives and policies for the conduct of research within the university (see appendix D, box D1).

The AVCC said:

> Such plans are institution-specific in the sense that they reflect the diversity of the higher education system. Although each plan is unique, collectively they exhibit certain common features, notably a commitment to the principles of *concentration* and

> *selectivity* based on demonstrable or potential research *excellence* and *planned research priorities*, and a common recognition of the importance of developing links with industry and of fostering the commercialisation of research through these links and other means (Sub. 222, p. 6).

It added:

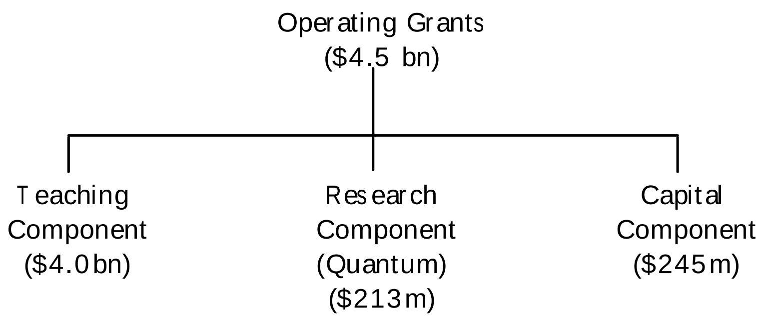
> Recently the Government has signalled that it will be less prescriptive about the contents of such plans and will concentrate more on the outputs of the research (p. 6).

Institutions are also required to produce plans for actual and projected teaching activities, an equity plan, an Aboriginal and Torres Strait Islander education strategy and a capital management plan.

Components of the operating grant

The operating grant is provided as a single allocation of funds, and institutions are broadly free to determine the most efficient allocation of funding among the various categories of expenditure. There are three components to the operating grant, and these are allocated according to different criteria. The components and their amounts are shown in figure C2.1 below.

Figure C2.1: **Operating grant components and level of funding, 1995**



Note: Numbers have been rounded.
Source: Compiled from DEET data, DEET 1994f.

First, the bulk of operating grants, amounting to some $4 billion (or 80 per cent of total DEET higher education funding) in 1995, is provided through the *teaching component*. This is provided to fund academic and general salaries, minor capital works and non-salary items associated with teaching, such as libraries. In this way, the teaching component is also a major funder of university research, which in many cases can be done without further resources. It also facilitates the minimum research which academics need to undertake to keep abreast of developments in their field.

Within the teaching component is a *research training component*, which is allocated to a university on the basis of its postgraduate research student EFTSU. In 1995–96 this will amount to $420 million or 10.7 per cent of the operating grant (Cook 1995a, p. 5.10).

Second, an additional amount is provided through the *Research Quantum* (currently some $213 million)[1]. This is deemed to be for expenditure on research activities and infrastructure not necessarily associated with teaching activities and research training. A report by the ARC said:

> The research component of the operating grant [derived from allocations under the research quantum] is intended to give universities the freedom to carry out research of their own choosing, to pay for the infrastructure required for the project-based research supported by external funding agencies, and to support a portion of academic salaries (ARC 1994, p. 18).

The notional allocation for the quantum was until 1995 determined on the basis of the share which the Research Quantum had at the time the Relative Funding Model was set up in 1990.

From 1995, the Research Quantum will be redistributed annually amongst institutions via a new ‘Composite Research Index’ which gives a dominant weighting to inputs (success in winning competitive grants, including from industry) but also reflects outputs (publications, patents and the like). This represents a change from the method used in earlier years, which had no weighting for research output and relied heavily on success in winning Commonwealth grants.

The index was developed by a working party which included representatives from the AVCC, DEET, ARC and HEC. The formula increases the weight given to output from zero to 30 per cent by 1997, and on the input side will include success in winning nationally competitive research grants, including CRC grants; other public funding, including State and local government funding; and industry and other funding.

1 The 1995–96 Science & Technology Statement refers to an amount of $50m, currently part of the operating grant and not allocated on the basis of the Composite Research Index, which should be thought of as part of the Research Quantum. When added to the amount allocated on the basis of the Composite Index the total Research Quantum would be equal to 6.7 per cent of the operating grant (the proportion applying at the inception of the Research Quantum) (Cook 1995a, p. 5.10).

Third, the *capital component* supports infrastructure for all university activities including research. It was previously separate, but was merged with operating grants in 1994, to give institutions more discretion in their spending.[2] In 1995, $245 million will be allocated for the capital component. In addition $35.3 million is available each year through the Capital Development Pool (CDP) to support new campus developments and institutions that are undergoing extraordinary growth (DEET 1994f, p. 30).

Australian Research Council Funding

The ARC makes recommendations to the Minister on the distribution of resources provided under various research support schemes for which it is responsible. It also provides information and advice to NBEET on research policy issues, including:

- national research priorities;
- coordination of research policy;
- the development and funding requirements of research support programs;
- research training; and
- measures to improve interaction in research between the public and private sectors.

DEET provides funding for the range of research support programs. While the programs are administered within the Department, the ARC makes recommendations to the Minister on the allocation of funding through each of these programs (with some exceptions, such as the Overseas Postgraduate Research Scholarships).

The ARC is supported by four Committees, each of which is assisted by various panels (see appendix D).

The programs

The ARC supports research in all disciplines except clinical medicine and dentistry, which are supported by the NHMRC.

In 1995–96 the ARC and related grants schemes budget will amount to some $350 million (Cook 1995a, Summary Notes). The ARC's programs and their

2 The size of an institutions' capital roll-in was determined in 1992 on the basis of 1994 planned weighted student load, adjusted for over- or under-enrolment (DEET 1993b, p. 30).

funding are shown in table C2.2 below, and are described in more detail in appendix D.

The Commission understands that the ARC provides advice to the Minister on the way in which funds should be divided among those programs for which the ARC has responsibility for recommending grants. Overseas Postgraduate Research Scholarships and the Australian Postgraduate Awards total funding is fixed by the Government on a formula (or quota) basis.

The ARC has set small grants total funding for 1995 at 23 per cent of total funds available for research grants. For the large grants, collaborative grants and fellowships scheme overall funding levels have tended to follow historical precedent, with the aim of maintaining the average size of grants and without at the same time reducing success rates below levels which occurred in the previous year. Funding for fellowships is also based on numbers awarded in previous years. Grant totals are influenced by funds which have already been committed from previous years' allocations. In the case of the research centres program, the ARC determines whether funds will be made available for a new selection round.

Table C2.2: **ARC and related grants schemes**

Mechanism	*Funding, 1995–96*	*Basis for allocation*
Grants awarded on the advice of the ARC		
Large Grants	$85.6m	ARC advisory panels assess applications against selection criteria – peer review
Small Grants	$23.8m	Block grants allocated to universities by ARC on a formula basis (base grant plus amount based on success in large grants) for disbursement by universities
Collaborative Grants	$13.0m	Applications assessed by ARC panel
Research Centres	$18.2m	Assessed by an ARC panel against selection criteria
Australian Postgraduate Awards (Industry)	$7.3m	Applications assessed by ARC panels
Research Fellowships	$24.8m	ARC panels assess applications, then seek independent assessments from experts in applicants' specific field
International Fellowships	$1.4m	
Research Infrastructure Equipment & Facilities Program	$16.4m	To groups of universities, based on ARC selection panel's assessment of applications against selection criteria, excellence being the most important
Total	**$190.5m**	
Grants not awarded on the advice of the ARC		
Research Infrastructure Block Grants Program	$42.3m	Competitive grants index
Australian Postgraduate Awards	$65.6m	Government determines the quota of awards for the universities. University determines on recipients' merit
Overseas Postgraduate Research Scholarships	$14.8m	Quota determined by the Government. Universities determine allocation of awards on merit basis
Grants to learned academies	$1.5m	
Anglo-Australian Telescope	$3.1m	
Targeted Institutional Links	$0.8m	
R&D Internships in Asia	$0.4m	
Advanced Engineering Centres	$1.6m	
Total	**$129.9m**	

Note: From 1996, an additional $35.6 million each year will be provided for Research Infrastructure Programs. Total ARC funding for 1995-96 is around $350 million.

Source: ANAO, 1993a, vol. 5, p. 2; DEET 1993b, pp. 63-8 and Cook 1995a, summary notes.

The excellence of the research is the main criterion against which applications are assessed (although some priority areas are funded through a large grants sub-program — see below). Other criteria, including potential economic or social benefits, training of researchers and contributions to international links, may also be taken into account. This matter is discussed further in the next chapter.

Large grants fund only up to the marginal costs of the project and generally do not provide, as a component of research support, funds for 'relief from teaching'.

The ARC funds both basic and applied research. A report by the Council noted:

> ... the restructuring of research funding within the higher education sector and the static level of research funding within the operating grants since 1991, have resulted in a situation where the Australian Research Council programs are the dominant source of funds for basic research (ARC 1994, p. 6).

It went on to add:

> In 1993, approximately 58 per cent of ARC funds excluding postgraduate awards ($116 million) was allocated to the three programs whose primary objective is to support high quality basic research. The programs in this group are: Research Grants (large and small), Special Research Centres; and Australian Research and Senior Research Fellowships (ARC 1994, p. 19).

The ARC also has programs aimed at promoting links between universities and industry. These programs are the Collaborative Research Grants, the Key Centres of Teaching and Research and the Australian Postgraduate Awards (Industry).

Priority areas

Within the ARC large grants program is a sub-program in which funding is provided for research in designated priority areas (Sub 361, attachment A). Guidelines for large grants for 1996 state that it is Government policy to designate specific priority areas for funding:

> The priority areas are specified each year by the Australian Research Council. An area of research may be given priority because it:
>
> - is associated with favourable social or practical benefits;
> - needs specific encouragement because it can be expected to produce valued benefits.
>
> In 1995 approximately $4 million (out of approximately $34 million) was allocated to assist in the support of initial applications in the priority areas for the year (DEET 1994g, p. 15).

The ARC said:

> The [priority areas] which usually each run for a five year period, are chosen after wide consultation with research and industry and other 'users' (Sub. 182, p. 17).

The purpose of the large grants priority areas is to encourage research activity in fields which hold promise of significant growth in the immediate future and/or have become especially significant areas of inquiry for some aspect of national life.

The ARC said that priority areas for large grants in 1995 reflected the philosophy that there will be occasions when the research community, in conjunction with the wider user community, would see a need for targeting funding into a particular area. It said:

> Sometimes that is clearly identified as what one might see as a national priority, reflecting priorities that are obvious perhaps at the national level without being explicitly stated as criteria. An example of that is Australia's Asian context where it's quite clear that the government is giving a priority to linkages into Asia although they haven't given that as a firm guideline in terms of R and D expenditure ... Nevertheless it clearly is broadly speaking a national priority, and the research community itself saw the importance of responding to that ... A second area, perhaps as a different example, is the area of cognitive science where it was very much the research community which made a case to the research council that this area needed to be lifted up ... (transcript, pp. 1984–5).

About 10 per cent of funds from the large grants program is allocated for priority areas. The discipline panels of the ARC research grants committee are able to bid for this 'pot' of money. Explaining this procedure, the ARC said:

> ... there's an encouragement to a discipline panel in, say, engineering to put money into a particular area because it can get assistance from the pot. So there is a degree of competition between the discipline panels which will encourage them to focus their activity to some degree on the priority areas (transcript, p. 1984).

The ARC also said that it had agreed to provide funding in the future for networking between researchers working in the priority areas. It said:

> ... what we will do with the two new priority areas that we have for 1995, which are citizenship and the biology of sustainability, once we have identified the researchers in those areas who are successful in the grants process we will bring them together ... to look at ways in which they can work collaboratively and particularly on themes that might be identified within broad areas (transcript, p. 1984).

The large grants priority areas for 1996 will be:

- biology of sustainability;
- citizenship;
- food science and technology;

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

The large grants program is not the only program where priorities have been identified. In the last round of bids to establish special research centres, broad areas were indicated where preference would be given or where proposals were specially sought. Similarly, some targeting of fields was undertaken in the key centres program (transcript, p. 1984).

Other funding sources

The issue of diversity of funding sources is one which has been raised as important in both the Commission's inquiry and the Senate Standing Committee on Employment, Education and Training inquiry into *The Organisation and Funding of Research in Higher Education*. Many researchers argue that by providing research funds through a number of sources, academics who are unsuccessful in obtaining ARC grants have the opportunity to seek funding from other sources. The various sources of funds for higher education research were noted in table C1.6 while the diversity of the programs providing funds was illustrated in table C2.1.

Chapter A6 considered in principle the issue of encouraging diversity across the whole R&D support system. It noted the dangers of excessive concentration.

While this chapter has focussed on operating grants and the ARC, universities receive Commonwealth funds for research from a number of other programs. There are several specific granting schemes which are funded by departments other than DEET — such as the NHMRC which is funded by the Department of Human Services and Health (see chapter C6). As noted earlier there are some 40 or so Commonwealth competitive research grants schemes. These schemes fund research on a marginal cost basis.

Some of these programs are aimed at increasing research interaction between industry and higher education. Examples include elements of the Competitive Grants for Research and Development program (previously the Grants for Industrial Research and Development and the National Teaching Company Scheme) which are funded by DIST (see part D), and Cooperative Research Centres. Part F considers in more detail programs aimed at increasing linkages between universities and industry.

The Commonwealth also indirectly provides funds to universities through the various rural R&D corporations. There are 19 such corporations, and these are discussed in part E.

Non Commonwealth competitive research granting schemes, or non-profit and other Australian sources also provide funds to universities for R&D and include the National Heart Foundation, the Australian Kidney Foundation, the Telecom Fund for Social and Policy Research in Telecommunications and the Australian Institute of Nuclear Science and Engineering. About 15 programs are classified as non-Commonwealth competitive schemes in the Composite Grants Index. These also fund research on a marginal costs basis.

Private funding is also channelled to university research through non-government universities such as Bond University, University of Notre Dame and the Australian Catholic University.

Many participants provided evidence of the importance of these other funding sources. The University of Western Australia said:

> ... something like a third of our total money only comes from ARC and NH&MRC in our competitive research grants. So the really big research grants coming in are the CRCs, the GIRD grants and the Rural Industry Research and Development Corporations ... (transcript, p. 122).

James Cook University said that while it ranked well in obtaining ARC grants, its major research programs had in recent years been funded by other agencies, such as ACIAR and some international groups:

> The university has recently undertaken major research programs funded by other agencies in recent years. Revenue obtained from such consultancies and research contracts has increased sharply over the last three years. In 1992, this revenue was more than $6 million. When normalised this represents an average of over $13000 for each teaching-and-research academic (Sub. 99, p. 5).

The University of New South Wales told the Senate inquiry that:

> Together with the National Health and Medical Research Council, ARC is a primary source of funds for university research, but together these funding bodies account for less than 50% of the research funding at UNSW. There is presently too much focus by the higher education sector on ARC and a failure to recognise that other sources of research funding exist (SSCEET submissions, vol. 4, p. 770).

State and local governments also provide research funds to universities. The Victorian Government said:

> The major government contribution to research in the education portfolio is through universities. Most public sector funding originates with the Commonwealth though the State contributes $10 million to $15 million per annum through several different avenues (Sub. 69, p. 8).

Finally, R&D funds are also received by universities from industry sources in the form of, for example, consultancies and contracts and through collaborative schemes, some of which were noted above.

The issue of academics self-financing their research was also raised. Dr Crabb said:

> University research is increasingly supported by academics spending their own financial resources, to fund travel and accommodation, personal libraries, research materials, computing facilities etc (Sub. 14, p. 2).

C2.3 Institute of Advanced Studies — ANU

The Institute of Advanced Studies (IAS) at the Australian National University (ANU), receives the bulk of its block funding from DEET through the ANU operating grant, to undertake full time research and research training. The ANU also receives a block grant for the John Curtin School of Medical Research (JCSMR) from the Department of Human Services and Health. The IAS is the only large university research institute funded in this way. The Stephen report said that:

> Institute funding is about 6% of total Commonwealth Government research funding, and about 12% of the Commonwealth imputed research allocation to higher education institutions (Stephen 1990, p. 13).

The IAS has basic research as its primary mission, although it has increased its level of commercial interaction and strengthened the relevant industrial research base (ANU 1993b, p. 5).

The IAS is estimated to receive about $130 million in 1995, excluding funding for the John Curtin School of Medical Research. It also receives further income, equal to some 30 per cent of its total income, from external sources (Sub. 130, p. 4). By way of a rough comparison, ARC total funding is about $350 million of which it advises on about $190 million (Cook 1995a).

The Institute earns a substantial amount of external income from successful bids for competitive grants from various research funding bodies and from industry. It is ineligible for certain sources of competitive external funds such as ARC research grants, some ARC Fellowships (Senior Research Fellowships and Research Fellowships since 1993), and for most categories of NHMRC funds (although there are exceptions).

This issue of ineligibility by IAS researchers for ARC research fellowships and senior research fellowships was raised in the Senate inquiry. The Senate report recommended that the decision to prevent ARC Fellowships from being tenurable at the IAS be revoked. In response, the Government agreed to examine this situation.

A review of the IAS research schools and centres, and of the Institute as a whole is currently underway and is expected to be completed towards the end of 1995. These reviews have been designed:

> ... first to assist the Government to determine the appropriate level of funding for the Institute as a whole by comparing the productivity of research resources provided to the Institute with those provided to other Australian universities; and second, to advise the University on the best use of the resources at the disposal of the Institute (ANU 1993a, p. 20).

While IAS funding has been guaranteed in real terms for five years from 1992, subsequent funding will be determined in the light of the reviews. In future, the ARC is to advise the Government on the future level of funding for the IAS (ANU 1993a, p. 20).

C3 GENERAL FUNDING ISSUES

C3.1 Introduction

Universities occupy a central position in a national innovation system, alongside public research institutions and privately owned firms.

As an important performer of research, higher education institutions in Australia and overseas have been increasingly pressured to undertake more ‘relevant’ research and to earn more by commercialising the results. This trend has been noted by the ARC which argued:

> In most industrial countries there has been a growing emphasis on the need to conduct more explicit and deliberate policies for science. There are various reasons for this including the escalating costs of many areas of research, growing constraints on government spending and political demands for greater accountability for all areas of public expenditure (NBEET 1993c, p. xi).

The appropriate role of universities and government in supporting university research will be addressed in this chapter. This leads to an examination of the appropriateness of current funding arrangements with particular attention to the defined criteria for allocating funds and priority setting processes. At bottom, is how society should select the most appropriate research for public funding.

Many of the principles for government intervention enunciated in chapter A6 apply equally to higher education institutions as to other sectors of the economy. For example, government support processes should be simple, with well defined criteria; research funds should have an ‘owner’, funding should be contestable; diverse funding sources should be available and the government’s role clearly articulated.

C3.2 What should be the role of research in HEIs?

The gains to society from university research accrue through two broad avenues:

- through the benefits to students that pass through the higher education system; and
- through the dissemination of knowledge generated by the research itself to those in the community who derive (commercial and intrinsic) value from it.

Education through teaching and training is a defining element of universities among all other research performers and brings with it associated research. This research is associated both with formal teaching of courses and with research training. The importance of the latter role was emphasised by many participants. The Higher Education Council, for example, 'considers special recognition should be given to the basic role of universities in providing research training' (Sub. 365, p. 1). Similarly, the University of Tasmania said:

> Universities have a unique responsibility for training the next generation of researchers. Many organisations engage in research, but it is the universities who are responsible for supplying society with researchers. Research training is provided through research higher degree programs, in which the student does research rather than talks about it. Basic or pure research projects are generally the best for research training, so universities have a high proportion of basic research programs in their research activities (Sub. 273, p. 2).

Monash University said

> ... the universities alone are responsible for research training to the doctoral level. The entire stock of Australian-trained researchers acquire their essential skills and experiences from the higher education sector (Sub. 330, p. 3).

The benefits of university research through the knowledge it generates for the wider community are almost universally recognised. These wider benefits arise not just from research directly associated with teaching and training, although that is very important, but also from research independently pursued.

Teaching and research

Universities are distinguished from other research performing institutions by undertaking research in the context of providing education. The importance of this dual role and the complementarity between teaching and research was raised by many participants. Murdoch University said:

> The traditional dual roles of universities, research and training, have not arisen by accident. They are complementary tasks which enhance each other. Research ensures teaching remains 'fresh' and at the 'leading edge' of the discipline while teaching demands researchers retain breadth in their subject area as well as having the input that informed 'naive' inquiry can provide. This dual task distinguishes universities clearly from pure research organisations (Sub. 21, p. 2).

Figure C3.1 depicts the distinct but related roles of teaching and research within universities. It highlights the role of teaching in generating new human capital, and of research in generating new knowledge. It illustrates the role of research in the context of supporting the teaching function and in providing research training. As well there are feedbacks: strategic and commercial R&D can influence the research agenda in universities and this research in turn can influence what is taught. Similarly, while research is needed for teaching, the demands of students for courses of particular types drives what is taught and the research that is needed to support it.

As shown in the figure, undergraduate teaching and graduate coursework teaching involve academic staff in research which has the purpose of maintaining familiarity with advances and changes in the body of knowledge in particular fields. This sort of work is often described not as research in its purest sense but rather as scholarship. Research directed at making new discoveries can also enhance these types of teaching.

Teaching involved in enhancing the research skills of graduate research students, however, usually involves a requirement for involvement with research projects directed at new discoveries.

While teaching and the research that supports it have their principal effects in creating benefits for students themselves, some suggest this can create wider benefits through more subtle influences on the character of the nation. It is argued, for example, that a more inquisitive attitude in society leads to better personal interaction and a culture which is richer and more vibrant. In short, it leads to a better functioning society.

The wider benefits from university research

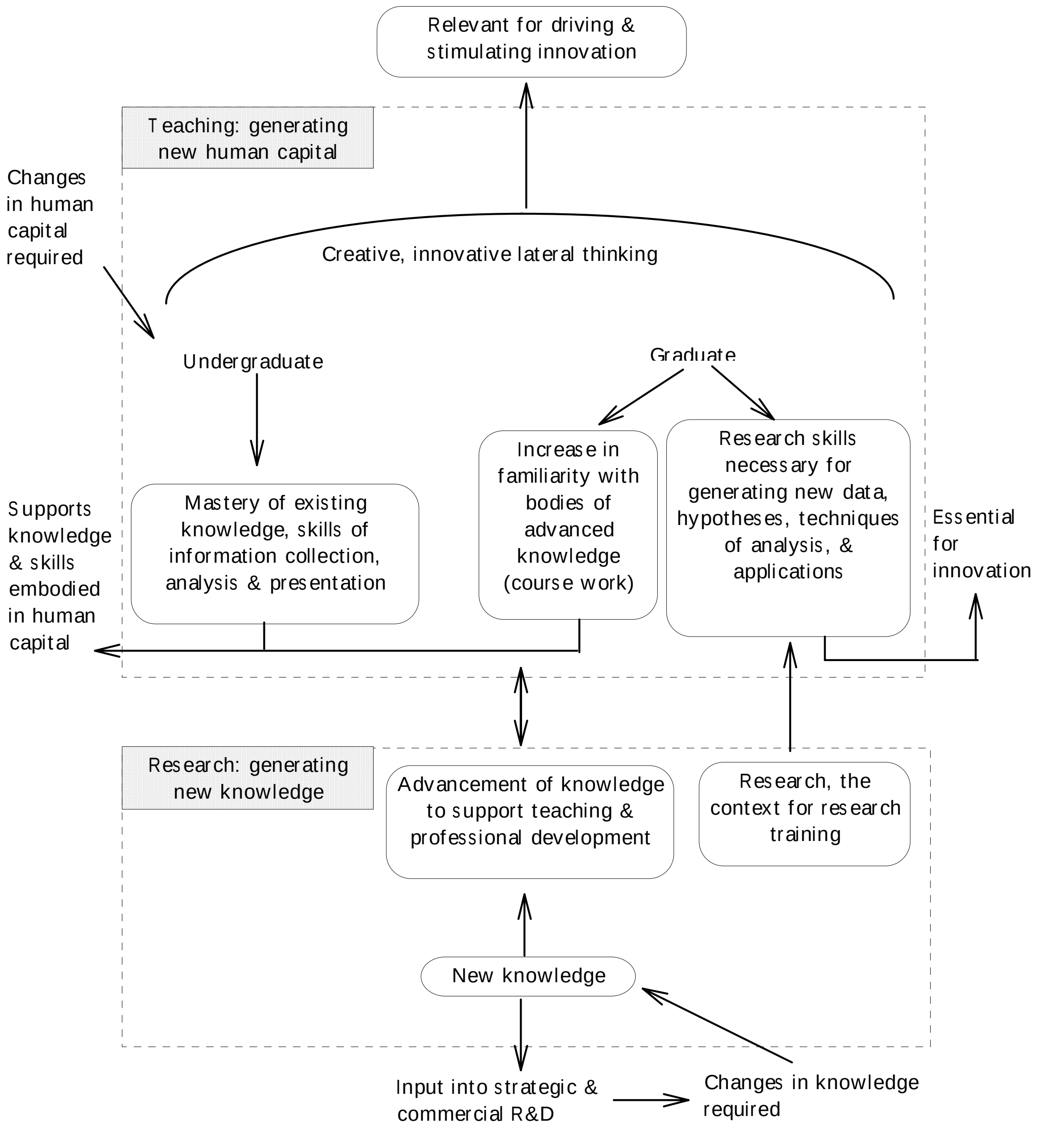
As figure C3.1 illustrates, the research undertaken in universities, whether as part of teaching or for its own sake, produces benefits which extend further than just the gains from having better-educated students.

Some of these benefits are to do with the creation of a body of knowledge (often the result of basic research) which can be drawn on as required by those wishing to apply knowledge to produce improvements in existing products, processes or services or simply to understand the social, cultural and physical environment. It can also be drawn on by basic researchers as a prelude to more applied research. The university is a repository of such knowledge.

Some participants emphasised that universities are the only group which consistently undertakes pure basic research and argued that this must be maintained. Murdoch University said that it sees:

> ... the recent debate and resulting policy shift to encourage greater interaction between universities and business as desirable but believes that the universities have adequate resources to retain a strong basic research function. They are responsible for the vast majority of Australia's basic research. To lose, or further degrade, this capacity would be seriously detrimental to Australia's future well being (Sub. 21, p. 2).

Figure C3.1: **Links between teaching, research and the rest of the innovation system**



The Senate report said:

> The broad consensus emerged that it was perfectly legitimate for universities to be involved in research across the basic-applied continuum, but that universities had a special responsibility to maintain a strong basic research profile in order to — generate new knowledge upon which applied research could build; train new researchers; participate in the international research community as a contributor and not just as a parasite (SSCEET 1994, pp. 100–1).

Universities are also important in establishing durable conduits to the research done outside Australia. This transfer of knowledge from abroad cannot occur without local people working in the area to absorb and disseminate the results. Many of these people are in universities.

Much knowledge transfer takes place in informal ways. To obtain and use research results from abroad, Australians must be making a worthwhile contribution — practising scientists make clear that research input from abroad quickly dries up when there is no reciprocal flow out of Australia. Griffith University emphasised the need for a broad capability to absorb overseas research and to maintain 'a place at the table', when it said that Australia requires:

> ... not just specialised R&D in strategic commercial and industrial enterprises, but also a more generalised capability across a wide range of science and technological areas (Sub. 86, p. 2).

Similarly, the Walter and Eliza Hall Institute of Medical Research noted that Australia only contributes 2 per cent of the world's new knowledge and innovations. In order to benefit from the remaining 98 per cent we need to engage in research to gain access and the ability to understand the new technology. It said:

> Being professionally and successfully engaged in research buys one a seat at the international table and in particular in the power elites or 'invisible colleges' which surround each major discovery area. Reading scientific papers and textbooks, or attending large international conferences as an 'outsider' are relatively ineffective ways of judging competing new ideas and technologies, not only because of significant delays (9–18 months) between discovery and promulgation in these forms; but also because a deep involvement in the research field of interest lends a perspective and a balance that can be obtained no other way (Sub. 233, p. 1).

The distinguishing characteristic of a university among research institutions is its teaching and training role. This defines a central rationale for its research that does not apply in other institutions:

- **to support teaching of courses; and**
- **to train researchers.**

In addition, universities play an important role in:

- **adding to the nation's stock of knowledge;**
- **providing access to international knowledge;**
- **providing a repository of knowledge; and**
- **helping to define a society's culture and contributing to its intellectual vibrancy.**

C3.3 Are funding arrangements appropriate?

For the purpose of analysis of funding arrangements, it is useful to recall that some research is required to enable teaching and research training of the highest quality, while in addition there is 'discretionary' research or that which is considered to be original research leading to the advancement of knowledge and which can be conducted by individuals or groups of researchers. This latter amount is not necessarily related to teaching, although it can greatly enhance teaching. For this reason, it is best not funded on the basis of student numbers.

There is considerable overlap between these types of research and the objectives each serves. In broad terms, however, the distinction between them is that the former is principally directed at teaching and research training, while the latter supports all of the objectives of university research noted in the previous section.

The Commission's distinction between these two types of research was widely misunderstood in reaction to the draft report. The University of Western Australia, for example, was:

> ... concerned that the Commission has a simplistic notion of the nature of university research. UWA contends that the interplay between research and teaching, the so-called teaching and research nexus is, at least at a leading research university such as UWA, richer and more significant than that depicted by the Commission's characterisation of university research in Section C3. Certainly, the University of Western Australia does not see that its research enterprise can be appropriately divided into the two streams identified by the Commission. Indeed, the University would not regard 'absorption of existing knowledge (via journals etc)' as research and definitely not a sufficient basis for staff involved in research student supervision (Sub. 278, p. 4).

The University of Queensland said:

> Any notion of R&D, we believe, should start from the fact that knowledge is a stock (an asset) to those who possess it; research is any activity which adds to that stock. All university teachers are encouraged to increase their knowledge base through research, and therefore universities do not consider 'research for teaching' as a separate category (Sub. 410, p. 2).

The Commission did not mean to imply that the first type of research was the sole type of research necessary for the support of teaching and training. To the contrary, the Commission sees the majority of university research as supporting teaching and training and this as extending far beyond mere scholarship.

Rather what was intended was to point out there was an irreducible minimum of research that was necessary for teaching and providing research training at all levels in any particular discipline. This might be characterised as scholarship and should be funded in a way that gives support to all institutions providing teaching and training. The level of support should vary broadly according to the number of teachers required, which in turn varies with the number of students. (These matters are discussed further in the following section.)

The second type of research, while adding considerable value to the support of teaching and research training, is principally aimed at serving other purposes associated with objectives related to the intrinsic worth of the research as noted earlier.

In broad terms, the funding mechanisms employed to support research in universities fall into three categories:

- grants which are distributed as block funding on a basis related to teaching loads (the teaching and research training components of operating grants);
- grants which fund individual research projects on a selective basis (such as the ARC large grants program);
- grants which are given selectively, but as a block, to particular institutions on the basis of the characteristics of their research in general (such as the ARC small grants program, key centres of teaching and research, special research centres, research quantum and research infrastructure payments).

In addition, universities undertake research on a contract basis for both the government and the private sector.

The role of the operating grant in funding research

It appears logical that requirements for research which supports teaching should, in the first instance, be supported through the operating grant which also funds teaching requirements generally. However, while this is broadly true, it is not necessarily the case that all teaching related research can be supported in this way.

Operating grants are determined after a process by which an agreed educational profile for each institution is negotiated with DEET. As part of this process, a university's research strategy is set out in its research management plan. The outcome is an agreed level of funding which relates to the institution's objectives.

After receipt of the grant, each university has control over how its resources are used, and the sorts of research activities it wishes to foster.

The process by which an amount of grant is agreed on involves negotiation over numerous parameters. An important element, however, needs to be the relative costs of providing the services implicit in its agreed profile. Teaching costs vary with such factors as the discipline mix in an institution (medicine and engineering are more expensive to teach than accounting and history) the number of students in each discipline (the costs of teaching increase with the number of students) and the mix of research, coursework, graduates and undergraduates.

All those factors play a role in determining the relative amounts allocated out of the teaching component of the operating grant. In addition, funding for research skill enhancement under the research training component reflects numbers of postgraduate research students enrolled.

These factors are also relevant in determining the costs of undertaking some research associated with teaching. For example, larger student numbers usually imply a need for an increased number of teachers, each of whom has a requirement for research to keep contact with recent developments and prepare for teaching. Similarly, research that requires laboratories is usually more expensive than desk research and needs more resources.

It makes sense therefore, that research of this type, which supports teaching and broadly reflects student numbers in different disciplines, should be funded as part of the operating grant.

It also makes sense that this funding should be given as a block grant — that it should not be necessarily spent in particular disciplines — so that institutions have some flexibility within their allocations to fine-tune internally the allocation of funds provided to disciplines and academic staff most deserving of support. The universities are in the best position to know the needs of their own students and the capabilities of their own staff.

Universities are themselves well-placed to evaluate their research needs in support of teaching and research training and the Commission considers that as long as universities are block funded to support their teaching function, the same funding arrangements should continue to apply for this research (the status quo).

The operating grant is not suited to supporting all research

A significant proportion of research, however, is required to satisfy more complex requirements. These might be related to the other objectives for research discussed in the previous section, such as maintaining a high-quality national knowledge base and access to international knowledge. Alternatively, the research requirements for meeting the needs of students within a particular discipline can vary from course to course. Courses with a more vocational orientation may require less path-breaking research on the part of teachers and more industry contact, while courses at, and preparatory for, postgraduate level in the same discipline benefit from being taught by those researching at the cutting-edge.

A dynamic and responsive system will allow these variations in research input to teaching to occur. Both students and teachers vary in ability to undertake and absorb the most recent advances in knowledge, and courses rightly vary in the amount of their research underpinning. But this type of research (less directly related to student numbers), being more variable across institutions and courses, is more difficult to fund in a way that relates to numbers of students and types of teaching. It is therefore more difficult to argue that this research should also be funded through the operating grant.

Such variations in research requirements are especially apparent since the introduction of the Unified National System, which incorporated what were previously largely teaching-only institutions into the university system. The ARC said:

> ... if one looks at the Australian university system in the eighties, say, up to the change from a binary to a unified national system ... there were many, many members of academic staff who were not involved in research activity, and yet the quality of the education by international measures ... seem to be quite high. So I think there is already some evidence from the pre-1987 universities that the nexus between teaching and research can't be as strong as some people have claimed ... (transcript, p. 1973).

University staff are currently contractually obliged to undertake research. This is to some extent necessary if universities are to effectively discharge their teaching/research roles. Staff should undertake research necessary to keep abreast of progress in their disciplines. However, it does not follow that all academics should be obliged (nor should they expect) to undertake original research (or that not related to teaching). Professor Aitkin argued:

> The university will have to choose what it wants to be good at ... Some universities will become known as research institutes which also do some teaching; some will become known as teaching institutions where some research is also done. There will be a wide range in the mixture of research and teaching which is seen to be appropriate for an institution which is called a 'university'. And within universities not every staff member will be able to do research, let alone the research that he or she would like to do in the best of all possible worlds (Aitkin 1991, pp. 244–5).

In principle, operating grant negotiations could take account of all these considerations and allocate all research money after discussion between the funder and the universities. However, for grants to address all of the factors discussed above (including the objectives concerned with creating a repository of knowledge and knowledge transfer from abroad) would require significant discretion on the part of the allocator. It would be difficult for the grant recipients to be clear about the basis for the distribution of grants. Given these conditions, funds are better distributed through transparent mechanisms such as those used by the ARC.

In recent years a significant (and increasing) proportion of research grants has shifted from being allocated through block funding to universities to being allocated directly to researchers, centres and so on under competitive granting schemes (for example through the ARC and NHMRC). Most symptomatic of this has been the 'clawback' (see chapter C2) under which funds have been reallocated from operating grants towards competitive mechanisms such as the ARC.

The role of selective grants

The Smith Committee review of *Higher Education Research Policy* considered that there were two principles of paramount importance in any consideration of higher education research policy:

- First, that research funds, which should be allocated competitively, should go to those institutions and individuals best able to make the most effective use of them; and
- Second, the allocation of research funds, whether to individuals or institutions and including the establishment of priorities, should be based on explicit criteria which are publicly announced and applied in an open and consistent manner (DEET 1989, p. 12).

Selective grants enable research funds to be targeted to particular researchers or institutions based on their merits.

Selective grants for individual research projects

Under a competitive grants process, researchers have to compete for funding, and selection procedures attempt to ensure that only the best research proposals are funded. In terms of the objectives of research discussed in the previous section, it permits:

- resources for teaching and research-training related research, not directly related to student loads, to go to the best researchers, rather than being distributed on a more uniform basis; and
- support for basic research which is required for reasons not essential to teaching (for benefits such as links to the rest of the world and the generation of general spillover benefits) to flow to the best basic researchers.

Many participants supported the need for competitive grants processes in relation to this sort of research. The University of Melbourne said:

> Granting bodies such as the ARC and NH&MRC are central to the maintenance of basic research programs in Australia. The opportunity must be preserved for the most

> able academics to be funded for high quality research, irrespective of the higher education institution to which they belong. A competitively-based research grants system is fundamental (Sub. 51, p. 4).

The University of New England said:

> The competitive bidding process with peer review is the best system for the allocation of scarce funds to support R&D and innovation. In particular, the present system of competitively disbursing scarce funds through NHMRC and ARC (and other funding agencies) directly to researchers is superior to any alternative, such as disbursing funds to universities for their subsequent distribution (Sub. 223, p. 16).

The outstanding characteristic of selective project schemes is that competitive success, whether defined in terms of academic excellence or other factors, is the exclusive determinant of funding.

Many participants made the point that selective project schemes can come at a high cost in terms of time, effort and administrative resources involved in the application and peer review process. This is one rationale for the ARC's Small Grants Scheme which provides block grants to universities for allocation in the form of small grants to their own researchers.

However, universities argue that the devolution of administration to universities of some government schemes, such as the Small Grants Scheme, has contributed to increased pressure on resources within institutions (Sub. 118, p. 3). In effect, they suggest the ARC has passed on some administrative costs to the universities.

Selective institutional grants

Some institutions can also receive block funding for their research programs. In some cases this comes from the Government; in others it comes from the ARC. For example, the Institute of Advanced Studies (IAS) at the Australian National University receives a block grant through the university from the government, while special research centres and key centres of teaching and research receive long-term funding through the ARC. Other institutional block grants include the Small Grants Scheme and the Research Quantum.

Like selective project grants, it is the competitive process employed in selective institutional grants which can make this method of funding appropriate both for meeting the demands of teaching, which do not relate directly to student numbers, and for producing the best basic research with limited funds.

Institutions funded in this way rather than through project grants may be able to make better use of their human and other resources, to provide equipment not possible at institutions whose funds are dependent on project grants and to undertake long term planning of research and research training. They thus have the flexibility to develop large scale resources, to move funds quickly into new fields with strong prospects of success, and to take account of the synergy between various fields and researchers in the institution.

Mount Stromlo and Siding Springs Observatories said that block funding was particularly useful for institutions carrying out basic research:

> Basic research projects are frequently of long duration and ... their benefits too can take time to mature. A consequence of this is that the effectiveness of fundamental research suffers greatly from rapid changes of research arrangements. It is virtually impossible to carry out basic research under conditions of stop-go funding ... block funding is much more appropriate for fundamental research than research grant funding. The short-term episodic nature of the latter drives the research effort in the direction of brief projects which are sure to lead to a prompt published result (SSCEET submissions, vol. 2, p. 319).

The Commission considers that university-specific research which is not resourced by funding institutions on the basis of student numbers should be met through competitive funding arrangements for the university sector.

The long-term nature of projects and programs is not in itself, however, necessarily a good reason to prefer block funding to project funding. Stringent time limits need not be placed on project and program grants, even if current practice is not to fund for indefinite periods, in the case of project grants. The ARC currently block funds centres for up to a period of nine years.

Neither does the block funding of institutions lead to any necessary saving in administrative costs compared with project granting processes such as those used by the ARC or NHMRC. Institutions receiving block funding must still employ a mechanism for dispensing the funds. If they employ less demanding methods than the process of external review used by the ARC and NHMRC however, it may be at the expense of effective selection and transparency.

Block grants can produce administrative savings if applied to institutions which have clear and limited research goals. When block-funded, such institutions can allocate funds at low cost because their internal selection procedures are genuinely economical with resources — its research program is integrated and well-understood within the organisation. If the researchers in the organisation had separately to apply for project grants, they would necessarily invoke standard (resource-intensive) selection procedures.

The impact of recent changes in the balance of funding

Recent years have seen a reallocation of funding of universities away from the operating grant towards selective programs. This is consistent with the idea that:

- there is a core of research that is directly associated with teaching that needs to be funded through the operating grant in a way that is related to the relative costs of providing for different student numbers in different disciplines; but that
- research which has as its purpose the creation of some areas of teaching which are at the forefront of the discipline or which are aimed at obtaining other national benefits from basic research, should be selected on merit according to transparent criteria.

In the Commission’s view, this approach has been appropriate. It has allowed funding once given through the operating grant to be employed in a way more consistent with the objectives for university research. In a system with diverse institutions, characterised by courses of different standards in similar disciplines, it has permitted limited funding to be better employed in support of the objectives described in the previous section.

The Commission endorses recent approaches to funding of university research which have seen a shift away from use of the operating grant towards funding institutions and projects on a selective basis.

C4 COMPETITIVE FUNDING AND THE ARC

This chapter looks at some key issues concerned with the competitive funding of university research through the Research Quantum and the Australian Research Council. It considers the extent to which universities should be funded to undertake research on the grounds of 'excellence' and the extent to which it should be guided by national priorities and the considerations of 'relevance'. The final two sections of the chapter look at the role of the ARC

C4.1 The Research Quantum

The Research Quantum, although delivered through the operating grant, is in many ways more like an institutional block grant than other elements of the operating grant. It is allocated to universities on the basis of research performance and may be spent as they choose.

Funding via the Research Quantum is distributed to universities at the institution level, and may or may not be used to underpin the work of, say, successful applicants for ARC grants. Its disbursement within the university is a matter for the university administration.

In recent years the Research Quantum has remained at about $213 million[1] — largely unchanged since the relative funding model exercise of 1990. Moreover, the basis for granting remained unchanged for some years after that, meaning that, for a time, institutions which had performed better in winning competitive grants did not receive increased Research Quantum support. This led to criticism. The University of Adelaide said:

> As one of the smallest (in EFTSU terms) of the major research universities, we are particularly concerned that as much government research funding as possible is awarded on the basis of outcomes achieved and evaluated in a competitive way. In this regard it is disappointing that the so-called research quantum component of our recurrent grant has apparently been calculated once only several years ago and has no significant effect on the portion of recurrent grant which must be used to support our research activity (SSCEET submissions, vol 2, p. 379).

1 This is the amount allocated on a competitive basis. The 1995-96 Science and Technology Statement (p. 5.10) notes that '... while the amount of the RQ that is reallocated is $213 million, for the purposes of estimating the total available for research unrelated to teaching and research training, a more appropriate estimate would be 6.2% of the current operating grant excluding capital funds'. In the remainder of this section, when reference is made to the Research Quantum, it should be taken to be the amount of $213 million allocated on a competitive basis.

More generally, the Senate inquiry was told that funds obtained through the Research Quantum and Mechanism A infrastructure grants were insufficient to support the scale of research many institutions considered appropriate. Many institutions believe that the amount of the Research Quantum has already been greatly eroded since it was established. The University of Western Australia said:

> ... the balance in the funding of the Australian higher education system between research performance and straight student load has swung too far in favour of load. This has occurred as a result of additional funding for student load growth but not growth in the Research Quantum. Thus the university would strongly support the restoration of the Research Quantum to its original figure of 6.2 per cent, if need be at the expense of student load funding and indeed would support an increase in this figure. Given the existence now of a broadly based index — the Composite Index — that is responsive to performance and success in research such a move would ensure that more of the notional operating grant support for research activities was allocated competitively across the system without involving additional administrative costs (Sub. 278, pp. 6–7).

Other criticisms were that:

- Some universities did not direct the appropriate portion of Research Quantum funds to those areas whose competitive grants success had attracted the funds in the first place;
- The Research Quantum reflected past rather than current performance because it has not been updated since it was developed on the basis of 1989 grants data. It should be recalculated; and
- The Research Quantum does not recognise the need for special treatment of emerging disciplines, or those of national importance with low student demand (such as Asian languages) (quoted in SSCEET 1994, p. 37).

The process by which funding under the Quantum has been awarded has recently been reviewed. From 1995 the Quantum will be redistributed annually. In addition the basis for allocation has been changed. The previously-used Competitive Grants Index, based on success in winning Commonwealth research grants, has been replaced. The new measure is known as the Composite Index and takes into account grants received from non-Commonwealth sources (including industry) and research output such as publications.

As a funding mechanism for research, the Research Quantum has a number of desirable features:

- it rewards strongly performing institutions; and
- it does not require the costs of application and evaluation that are associated with the Large Grants scheme or other prospective selective institutional grants such as the Special Research Centres and Key Centres of Teaching and Research programs.

Universities receiving funding from the Research Quantum value highly the fact that they have discretion in the uses to which it is put.

The Commission's view in the draft report

In its draft report, the Commission argued that the purpose of the Research Quantum seemed better aligned with those of the ARC than as part of the operating grant where it is currently located. It is in its nature a program which builds on the basic support for research provided through operating grants (as do ARC programs) because it is selective in its nature and cannot be taken for granted by institutions. The Commission judged that decisions about it should desirably be made in the context of other decisions about mechanisms for support of research provided through the ARC.

The relocation of the Research Quantum in this way would have allowed the ARC, over time, to examine the objectives served by this form of support in the context of its other programs for selective institutional block grants (the Special Research Centres, Key Centres of Teaching and Research programs, Mechanism A and the Small Grants program). In addition, the ARC would have been able to evaluate the broad balance between selective institutional support and selective project grants (the large grants scheme) and, where necessary, transfer funds among programs.

The Commission did not express a view as to whether the amount of the Research Quantum should be increased or reduced relative to the amounts in the various ARC programs. It observed that there is merit in having funding like the Research Quantum which is given on the basis of minimal application and assessment and which funds research institutions of demonstrated excellence. But the Commission considered that since the research being supported through the Research Quantum is in principle aimed at achieving the same objectives as that of other ARC programs, decisions about balance among them and criteria for support should be made in a consistent manner.

Concerns about the Commission's proposals

Many participants were opposed to the Commission's proposal to give control of the Research Quantum to the ARC. One of the main concerns was that the proposal carried with it a significant danger that the amount of the Research Quantum would be reduced by the ARC in order to augment funding in its other programs.

Institutions consider that the ARC is facing large demands on programs such as its large grants program. They judge that it would be under substantial pressure to relieve some of this demand by transferring funds to these programs from the

Research Quantum. For example, the University of New England said:

> While we see the logic behind this [the Commission's] proposal, we are fearful of possible adverse consequences ... the University is fearful that if the proposal was implemented, and given the current pressure on ARC funding, there may be the temptation for either the ARC or the Government, or both, to move some funds from the Quantum to support existing ARC programs (Sub. 350, p. 4).

A further concern related to the ability of the ARC to shift funds is the implication of this for universities' discretionary funding. Universities argued that the Research Quantum is currently provided as discretionary block funding, but were the ARC able to shift funds from the Research Quantum to other programs, universities would instead receive these funds in a 'tied' form.

Institutions fear such an outcome because they believe that the block grant characteristics of the Research Quantum lead to good research outcomes. They say that the Research Quantum provides discretionary funding which the universities need to set their own research agendas and decide their own priorities. This issue of institutions having discretionary funds and autonomy was noted by DEET:

> ... current arrangements for reallocation of the RQ are competitive. At the same time they allow universities discretion over the uses to which the funding is put. Transferring responsibility for the RQ to the ARC would reduce the flexibility afforded by current arrangements and be contrary to the recent policy approach of devolving greater autonomy to the universities (Sub. 57, pp. 1–2).

This point was also highlighted by the University of Technology, Sydney, which argued:

> The suggestion ... compromises the independence of the universities. The flexibility for universities to undertake initiatives and decide their own priorities would be removed. An essential and integral role of a university is research and this would rob the university of the means of controlling and directing its research priorities (Sub. 430, p. 3).

However, the Commission is not suggesting that universities should not have discretionary funding. It considers that such funding is important for universities in setting their own research priorities and agendas and for many of the activities noted by participants (see box C4.1) such as providing infrastructure support, funding new areas of research and assisting new researchers.

The universities also argued that the Research Quantum is currently allocated on a competitive basis among the universities through the Composite Index, and in some instances within universities. Some participants provided evidence on how they allocate the Research Quantum internally (see box C4.2). It is clear that institutions vary in how transparent these procedures are, and in whether objective measures guide the process.

Box C4.1: **Participants' comments on activities funded by the Research Quantum**

The AVCC said that the Research Quantum:

> ... supports the general 'fabric' of university research and research related activities and includes: the use of office and laboratory space; library and information services; office support and secretarial services; technical support; accounting and administration services; building maintenance and running costs; telecommunications workshops equipment and animal house facilities etc.

It added:

> The Research Quantum also contributes to the cost of: staff time to conduct research; staff development, particularly nurturing new and young researchers; internal competitive research grant schemes; internal postgraduate research scholarships; university contributions to large research facilities such as Special Research Centres, Key Centres and Cooperative Research Centres; large items of equipment; contributions to infrastructure support for projects sponsored by the ARC and NHMRC and other Commonwealth granting agencies which aim to cover the direct costs only, not including the time of academic staff allocated to the project; and approval and monitoring of ethical standards etc (these lists are not exhaustive) (Sub. 358, pp. 2–3).

Murdoch University argued that:

> This represents yet another extreme clawback of research funds from the universities to concentrate into a few areas — including full cost infrastructure support for large ARC grants. This would deny the universities flexibility, the capacity to keep together research groups which may not have received ARC support in a particular round, or the ability to prime research which is not a sufficiently developed stage to merit ARC funding (Sub. 276, p. 3).

It added:

> The loss of the Research Quantum funds, which are already allocated on a research performance basis, would be a savage blow to the universities, especially those who do not have access to independent endowments. It would force an extreme selectivity in research fund allocation, consign many academics to non-research, teaching-only activities, and significantly reduce the range of postgraduate research training opportunities especially, but not only in the sciences and technologies (p. 3).

As the Commission emphasised in its draft report, an advantage of the Research Quantum is that it is distributed on the basis of achievements rather than proposals. It involves low administrative costs within the institutions and the grant giving body because once the basis for assessment of past performance is determined, the allocation of funds is relatively straightforward.

In contrast, other competitive grants mechanisms which involve assessment of proposals can involve relatively large administrative costs for both institutions and assessors.

Box C4.2: **Internal university distribution of the Research Quantum**

The University of Adelaide said:

> ... just under half [of the research quantum] was retained for central research distribution (mainly major research infrastructure) and to fund the research support services ... and the remainder was distributed to the faculties in proportion to what each faculty earned in the research quantum, subject to the proviso that no faculty’s total income could drop by more than 3.5 per cent below its previous year’s income (Sub. 386, p. 2).

The University of South Australia said:

> ... we actually run a very centralised research funding activity inside the University ... although we have made the decision from 1995 to provide a relatively small amount of discretionary funds at the faculty level, based on performance in bringing money in through the research quantum ... we have enough schemes ... within the university to make sure that everybody at least has the potential to gain research funding from the research quantum (DR transcript, pp. 2184, 2186).

The University of Western Australia said:

> We don’t consciously say ‘This is the research quantum and we are going to spend it on these things’. We get the research quantum and use a university funding model to distribute the money. So it’s a different model of budget ... (DR transcript, p. 2058).

Murdoch University said:

> ... internal distribution is ... based 50 per cent on inputs and 50 per cent on outputs ... not all the Research Quantum is divided in that way, but ... a proportion [is] allocated to areas of research strength on the basis of a research index ... Some of it will go into an internal special research grant, which is ... based on quality performance and each of the applications would be measured, would be evaluated. Of course we also have a significant input into research scholarships ... The other major use [is] contributions to research centres (DR transcript, pp. 2035–6).

Monash University said:

> At Monash University, the Research Quantum is, and always has been, distributed to the faculties transparently, according to their relative performance in attracting funding and producing publication outcomes. Faculties receive one-line budgets; they know however, what their share of the internal Research Quantum is ... (Sub. 330, p. 3)
>
> ... we allocate it the way it was won at the moment, and that is a mixture ... of winnings in national competitive research grants and publications of various kinds countered in different ways and graduate student load and so on. One of the advantages of that transparency is that heads of department and research centres that attract a lot of research income know how much money went into the faculty budget from their earnings and how much they have received (DR transcript, pp. 2741–2).

The University of Tasmania said

> At present we pass it down one budget level ... The weighting is different, but using the same general factors as is used for the distribution to the universities. ... Also we take account of winnings because we accept that funds gained for research are in a sense a measure of research standing of the people who win it (DR transcript, pp. 2062–3).

In addition there can be flow-on administrative costs from other forms of competitive grants. For example, while universities can plan infrastructure on the basis of expected block grants, it can be much more difficult to do so when they are reliant on sequential project grants. Key buildings and research facilities such as animal houses are more easily financed from a single block grant than by amalgamating components of a number of discrete grants for individual projects.

In its draft report the Commission supported the continuation of the Research Quantum, or more generally block grants as a form of funding. The original proposal to shift the Research Quantum to the ARC contained no implication about a presumed decrease (or increase) in its level. The Commission acknowledges participants concerns regarding possible reductions in the Research Quantum by the ARC were it to have control, but notes that there is no guarantee that such reductions will not necessarily occur if control remains with DEET. In fact as noted earlier, in real terms the Research Quantum has decreased over recent years.

While there are other block grants available to universities, none provides quite the same freedom to institutions as the Research Quantum. For instance the AVCC pointed out that other contestable block grants such as the ARC Research Infrastructure Block Grant and the ARC Small Grants Scheme are not discretionary in the true sense of the word. It said:

> DEET requires funds to be allocated in accordance with guidelines for each program and each program has separate accountability arrangements attached to them (Sub. 358, p. 3).

On what basis should the Research Quantum be allocated?

In the past, one of the strongest criticisms of the way in which the Research Quantum had operated was that the basis for calculation of the criterion for success — the Competitive Grants Index — had been an imperfect measure of research performance.

The basis for allocation has now been revised. The current Composite Research Index constitutes an advance in many respects from the previous Competitive Grants Index. The development of such a measure is, however, inherently complex and will never be capable of specification to the satisfaction of all. There will inevitably be differences in approach to the measurement of research performance. For example, at the draft report hearings, the ARC said that it:

> ... would be more cautious in accepting publications as a measure. In fact we have said quite explicitly to the Australian Vice-Chancellor’s Committee that we are concerned that the publications component of the index should not grow until there is some quality control. There is no quality control on the publications at the moment other than the

> control that is exercised by individual institutions on what is counted as a publication and there are some apparent anomalies in the numbers of publications that some universities are claiming as publications (DR transcript, p. 3127).

Who should determine the allocation mechanism for the Research Quantum?

An ongoing issue is how future revisions are to be managed. A feature of the process by which the index was recently revised was the role of the AVCC.

At an early stage the AVCC formed part of a Working Party set up to review the means by which a more appropriate index could be constructed. That Working Party, which also included the ARC, the HEC and the Department, reported in May 1992 that an alternative index should be devised.

Late in 1993 the AVCC agreed to become involved in the development of a more broadly based composite research index and the Government agreed they should chair the Working Party exercise. The Working Party reached agreement concerning a new Composite Index comprising both input and output measures.

The AVCC then collected data which has been used to form the Composite Index. The Working Party agreed on the weightings of the different component of the index.

At the draft report hearings the Chairman of the ARC discussed the fact that the AVCC had come to lead the revision of the allocation mechanism:

> I think I would say there that the department which had the responsibility for the allocation of the Research Quantum hadn't geared itself up quickly enough, if you like, to address the issues and the Australian Vice-Chancellor [Committee] saw — and I think quite correctly — that there was a need to take hold of the situation and to move it forward and I certainly welcome the initiative that they took ... the research council, the AVCC and the department had all felt that it was necessary to move away from the simple basis of success in winning competitive Commonwealth grants (DR transcript, pp. 3126–7).

He added:

> ... the ARC had no role at that point of time. We had no ministerial reference on the issue and in fact we have in our Act a requirement that says that we shouldn't do things that aren't ministerial references unless we have got the resources and I guess in that sense we had no capacity to consider that issue outside the other business that we had and the responsibility at that point of time rested with the department, not with us (DR transcript, p. 3127).

In considering who should have the ongoing responsibility for determining the allocation mechanism for the Research Quantum it is important to examine the incentives and objectives of the different groups.

The AVCC, quite appropriately, seeks to represent all its members. In doing so it must, on an issue of how funds are to be distributed, come to a resolution which is most satisfactory to most of its members. In the Commission's judgment this is not necessarily the approach that best reflects the objective measurement of research performance.

The ARC on the other hand has been set up to assist the government in making such determinations and to provide information and advice on research policy issues. Also its members do not explicitly represent their institutions.

Given all the possible differences in methodology to the calculation of such an index, the Commission considers that its determination would be better not left in the hands of the representatives of universities themselves through the AVCC. Rather it should become the responsibility of the ARC.

The Commission considers that the ARC should have the responsibility for determining the basis for allocation of the Research Quantum in the future.

This proposal received the support of both the ARC and the AVCC. In particular, the AVCC said it:

> ... would not object to the ARC taking responsibility for determining the distribution methodology for the RQ providing this is determined in consultation with the key interested parties, and that the RQ remains as part of the operating grant of universities (Sub. 358, p. 3).

The Commission agrees that it would be appropriate for the ARC to consult with the AVCC and the ARC has said that it would follow that course (see Sub. 361, p. 7).

Who should distribute the Research Quantum?

Even if the ARC were to determine the basis for allocation of the Research Quantum, it would not necessarily follow that the funds should form part of the ARC's program budget.

The Commission sees the following advantages in allowing the ARC to distribute the Research Quantum:

- it gives clear signals that the funds are delivered for the purpose of research;
- there are some synergies at staff level in having funds associated with the Research Quantum and other ARC programs paid out by the same people. Cross-fertilisation of information from all programs may assist in developing better outcomes across the board.
- the ARC could, if it chooses, top up the Research Quantum with funds from other programs.

However, it is clear that most universities did not support the Commission's draft report proposal that the ARC should distribute the Research Quantum. The universities' main concern, however, was that the ARC would transfer funds out of the Research Quantum to other ARC programs. The Commission now proposes that this not be permitted.

Another concern was that shifting the Research Quantum to the ARC could be seen as significantly boosting the ARC's total budget and may make it a more visible target in budgetary expenditure review. The University of New England said:

> ... if the funds for the Research Quantum were transferred to the ARC, it might be argued that, since the ARC's total budget has been increased substantially, funding for its existing programs could be reduced (Sub. 350, p. 4).

Moreover Adelaide University argued that there were advantages in diversity of funding sources. It argued that by shifting the Quantum to the ARC there was a danger that, if funds were effectively coming from one source (or if funds were all ARC controlled), the universities would become totally dependent on that source.

There was also an issue about the extent to which the Research Quantum logically belonged with the ARC, given the fact that it is used to fund infrastructure supporting all competitive grants, not just those from the ARC. The University of Melbourne said:

> The Research Quantum funds provide essential research infrastructure to underpin general university research and research grant activities funded by external bodies at marginal costs ... The Research Quantum funding is used to provide infrastructure support for all national competitive research grant schemes, not just the ARC schemes (Sub. 313, p. 4).

The AVCC said:

> A further argument against the transfer of the RQ to the ARC is that there are many areas of university research which the ARC does not support. It must be remembered that whilst the ARC is a prime source of funds for university research, it is not the only source. The NHMRC funds a large proportion of research in clinical medicine and dentistry. The R&D Corporations ... also fund [a] significant amount of research related to primary industries and energy. It would be anomalous for one funding body to take responsibility for the disbursement of the RQ funding in line with its own priorities (Sub. 358, p. 3).

This point was also made by the NHMRC which argued that the universities use the Research Quantum to provide infrastructure to underpin research by the NHMRC grant recipients. The NHMRC argues that if the Research Quantum is to be shifted then they should get a share as they did in the last clawback of funds from the universities to the ARC. At the draft report hearings the NHMRC said:

> ... the notion of directing the Research Quantum through the ARC is ... an inappropriate one in the sense that ... it would be effectively diverting NHMRC resources to the ARC. We fund about $120 million worth of research a year [and] something like $70 million of that is in the universities ... so that's drawing on a considerable amount of the research quantum ... (DR transcript, p. 2789).

However, many of the above arguments would lose their force if the ARC were not given full control over the Research Quantum. For if the amount in the Research Quantum could not be reduced by the ARC, those funds do not become discretionary ARC funds, and could not be removed by the ARC from the support of medical research or other activities. The Commission still sees merit in the Research Quantum being treated as an ARC program, but now considers that the level of funding delivered through the Research Quantum should not be permitted to be reduced by the ARC in favour of other ARC programs.

The Commission recommends that the ARC have responsibility for determining the basis for allocation of the Research Quantum. It recommends that the ARC also have responsibility for the disbursement of Research Quantum funds, subject to the requirement that it not reduce funding below its current level.

Should universities account for their expenditure?

There is some concern that as the Research Quantum is given as a discretionary block grant there is the potential in some cases that it can be used to fund activities in areas other than in research. This raises the question of whether universities should have to account for the expenditure of the Research Quantum — whether there should be more transparency in reporting this expenditure.

There is some difficulty with this proposal. Many of the universities have provided the Commission with figures showing that the amount they expend on research is in many cases much greater than that received through the Research Quantum. Given the differences in these amounts it is difficult in some cases to distinguish precisely what research is funded via the Research Quantum from that funded through other research funds. And given that there is a difference between the Research Quantum and a universities' total research funding there is little to prevent a university simply identifying for accounting purposes its most effective research projects as those funded by the Quantum.

The Commission considers that requiring universities to account specifically for their expenditure of the Research Quantum may be unworkable in practice. The

Commission considers that the Composite Index used to allocate the Research Quantum already provides an incentive for universities to use the Research Quantum for funding research. A university's effectiveness in spending the Quantum will be reflected in their research performance which will in turn affect their ability to win further Quantum funds. The Commission considers that the Composite Index provides sufficient discipline or incentive for individual universities to use the Research Quantum to support research.

C4.2 Funding criteria: excellence, 'relevance' and priorities

All around the world there is a vigorous debate about the extent to which universities should be funded to undertake research on the grounds of 'excellence' and the extent to which it should be guided by national priorities and considerations of 'relevance'. In the United Kingdom, for example, the Government has recently expressed its view, in a White Paper, that wealth creation is a central goal of science and should be a guiding criterion for selection of projects by its competitive grants funders, the Research Councils. In Germany on the other hand, excellence is the sole determinant of success in competitive funding of projects which are supported by the principal funder, the Deutsche Forschungsgemeinschaft (DFG).

At one level it is difficult to dispute that national benefit in some sense should be the objective in funding research. What is at issue, however, is whether the explicit introduction of criteria other than excellence would achieve the maximum benefit or whether, after taking account of the difficulties of identifying research which contributes benefits, maximum gain is achieved if research in universities is directed solely to excellence.

Costs and benefits of directing university research

The debate about the desirability of using criteria other than academic merit (or excellence) to select university research for funding is a long-standing one.

Arguments that research should be researcher-driven are derived from many examples in which research motivated by curiosity has led to discoveries that are very important and have had commercial benefits. And it is noted that some of these discoveries have taken decades (even centuries) to reach fruition. Some argue that scientists are better placed to determine what science needs to be pursued. However, while this may be the case for science itself it is not necessarily a good argument in the context of determining national priorities or objectives.

There are however, many cases in which government decisions to concentrate resources in particular areas have failed to produce anything worthwhile and examples of government decisions to stop funding in areas not considered to have potential which have resulted in lost opportunities for Australia. Professor Ninham said:

> Governments are not good at picking winners in science. Research into computers by scientists in the CSIRO who were at the forefront in the 1950s was stopped because the Government believed that there was no future in 'thinking' machines (Sub. 6, p. 5).

He added:

> Progress in science, especially science the value of which to the community can be measured in material terms, is always serendipitous. Discovery is unpredictable, and managed science with defined goals and outcomes invariably fails (p. 5).

The University of New England said:

> The history of research effort reveals that many of the important discoveries and knowledge breakthroughs have occurred as a result of exploratory, as opposed to contractual research, through scientists being curious, innovative, non-accepting of the 'received truth' or otherwise creative and non-conformist in their thinking. For example, Einstein's theory of the special relativity in physics opened the door to the eventual development of nuclear energy (Sub. 223, p. 5).

The alternative view was put by the United Kingdom Government in its White Paper. While mindful of the arguments against directing scientists in their research, it argued that at some point national benefit must guide research priorities. It said:

> The decision for government, when it funds science, as it must, is to judge where to place the balance between the freedom for researchers to follow their own instincts and curiosity, and the guidance of large sums of public money towards achieving wider benefits, above all the generation of national prosperity and the improvement of the quality of life.
>
> Finding this balance is not a simple task, not least because much basic research will ultimately contribute to wealth creation while some applied research will fail to produce exploitable outcomes. There is no guaranteed method for the successful identification of commercial potential. Predicting exploitability is very difficult and forecasts must necessarily be imperfect. At the same time the Government does not believe that it is good enough simply to trust to the automatic emergence of applicable results which industry then uses (United Kingdom White Paper 1993, p. 2).

Some have suggested that significant funds are spent in Australia on research which could never be commercialised. Dario J Toncich said:

> ... Australia spends far too much on fundamental research that can never be commercialised. The contention is that for every one dollar spent on research, ten must be spent on development and a hundred dollars on commercialisation. This means that

> industry in Australia cannot possibly hope to fund the commercialisation of existing pure research programs even if they had the will to do so (Sub. 9, Executive summary).

He added:

> The focus must be shifted towards research that is linked to industry needs and this will not occur until traditional researchers learn to consult with industry before they commence their research (Executive summary).

The Curtin University of Technology said:

> Priority setting for Australian Science and Technology should be closely examined ... Incentive funds need to be provided to encourage research and development in areas of strategic importance to Australia. We should work from our established strengths (eg agriculture, mining) but also diversify into new areas of high market potential (eg aquaculture, telecommunications, new materials) (Sub. 24, p. 8).

Even when the view is taken that excellence should guide research in the main, it may be possible to see virtue in, for instance, projects with a particularly Australian focus. For example, Dr Hume told the Senate inquiry that:

> All over the world there has been a trend towards ‘applied’ research; defining priority areas for study, strategic goals etc. A small research community such as Australia’s is very unwise to follow that trend, except to the extent that the ‘applied’ research is relevant to problems that are **unique** to Australia ... if a broad area of research such as AIDS or breast cancer is universally relevant, much larger scientific communities such as the US will have an obvious tendency to outcompete us (SSCEET submissions, vol. 1, p. 92, emphasis in the original).

He went on to say:

> This is not to say that there should be no research on, for example, AIDS, in Australia. What it means is that the sole criterion for research funding should be excellence and originality by **International standards**. There is no point in Australia funding mediocre research on AIDS in preference to good research in other areas of biomedical science ... or even other areas of science (p. 92, emphasis in the original).

Views on the benefits of excellent versus directed research are deeply felt, and sometimes pursued at a level of generality and assertion that is difficult to unravel. One way of looking more deeply into the matter is to examine individually the criteria that might be used to direct research and to evaluate their merits over the ‘excellence only’ alternative. But in such an examination the ‘excellence only’ alternative also needs to be considered carefully — there are different ways of choosing apparently excellent projects which give different results and may imply a subtle directing of research.

Options for directing research

Although the research profiles agreements made in the context of operating grant negotiations provide some scope for altering the direction of research, the main potential avenue is the operation of the ARC.

There are essentially two mechanisms that could be employed to achieve particular objectives with the research funding allocated by the ARC:

- influencing the criteria by which projects and institutions are selected for funding within programs and within discipline areas; and
- influencing the relative allocation of funds to different programs and to different discipline areas within programs (especially the large grants program, but also block funding of institutions, collaborative grants etc).

How is research directed now?

In its 1988 *White Paper*, the Commonwealth Government announced that it intended that increased emphasis be given to research with direct economic or social benefit, including basic research '... in areas that hold potential for major developments or applications across a range of fields ...' (Dawkins 1988, p. 90).

The *National Report on Australia's Higher Education Sector* (DEET 1993a) documents the evolution of this policy and its implementation through different research funding programs. It notes that Government policies towards university research have evolved towards:

> ... increasing the relevance of higher education research, establishing research priorities, increasing competitive funding, greater selectivity and concentration and improved accountability (DEET 1993a, p. 246).

The establishment of the ARC was, as Professor Brennan noted, a central element of that shift in attitude (Brennan 1993, p. 91). The ARC drew up a mission statement in 1992, identifying the 'five benefits of research' (see box C4.3):

> The five benefits extend the scope of what is usually called 'relevance' by recognising the many ways in which higher education research can lead to benefits to the community (Brennan 1993, p. 94).

Box C4.3: **ARC's five benefits of research**

1. *Contributions to the quality of our culture*

   Universities are not only symbols of our culture and democracy but also a force which shape it. Research plays an important role in this. For the purposes of the large grants scheme the 1996 guidelines require applicants to show what special contribution their proposal will make to the quality of our culture.

2. *Graduates of high quality*

   Research is the vehicle for educating and training advanced undergraduate and postgraduate (research) students. For the purposes of the large grants scheme the 1996 guidelines require applicants to explain 'what particular features of the proposal will lead to graduates of high quality and, where possible, provide evidence of the track record of the investigators in producing high quality graduates'.

3. *Direct applications of research results*

   The most obvious and direct benefit of basic research, the application often stems from several pieces of research, sometimes in apparently unconnected fields, perhaps undertaken over extended periods of time in different locations. It can lead to the commercialisation of a new product or process. Industries can differ in the manner and extent to which they use research results, while science-based industries are closely dependent on continuous inputs of new knowledge largely produced by university researchers. For the purposes of the large grants scheme the 1996 guidelines require applicants to 'summarise the potential applications of the proposed project'.

4. *Increased institutional capacity for consulting, contract research and other service activities*

   This represents a powerful resource for industry and the community in general and is enhanced through the acquisition or construction of sophisticated equipment, improved library and other information systems and through the advancement of both staff and students' skills and knowledge. For the purposes of the large grants scheme the 1996 guidelines require applicants to provide a summary of the proposed strategy and to provide evidence of past performance in this area.

5. *International links*

   It is critical that Australia is represented at the international level in all major fields of research. By participating in research, Australia is able to absorb and benefit from new advances, 98 per cent of which occur overseas, and its influence in international forums is enhanced by its standing in research.

   The guidelines for the large grants scheme for 1996, note that preference will be given to projects of a truly collaborative nature. The ARC has entered into agreements with research agencies overseas in order to facilitate joint funding of research projects. The ARC has signed a Memoranda of Understanding with agencies in Austria, China, France, Germany, Korea and the Netherlands and applicants are required to indicate whether their proposed research involves international collaboration with any of these countries.

Source: Sub. 182, pp. 10–11, DEET 1994g, pp. 19–20.

Later in 1992, the policy was affirmed in the Government's Science and Technology *White Paper* in which the Government said that, in addition to excellence, funding for university research should also take into account:

> ... value to research users, potential for innovation, and ability to contribute to research training and international links (Gallagher 1993, p. 162).

The ARC said that the use of the 'relevance' criteria and its weight will vary among ARC programs, according to the nature of the proposals and of the discipline. It said :

> ... for example, relevance would be given more weight for engineering than humanities, and for Collaborative Grants rather than Large Grants (ANAO 1993a, p. 4).

In identifying the strategic objectives of each of its programs, the ARC has incorporated its 'five benefits of research'. These objectives and their relationship to the various ARC programs are illustrated in table C4.1.

The ARC said that it has:

> ... included consideration of these benefits in the selection and evaluation processes of a number of its programs, and is incorporating consideration of these benefits in all its programs. This is being achieved in two ways:
>
> - by targeting a particular program to one or more of the benefits; and
> - by adding to the criterion of excellence, criteria relevant to the benefits (Sub. 182, p. 11).

In the ARC Large Grants Program, excellence has been the predominant criterion for some time. In 1995, the selection process will be based on two broad criteria — excellence and 'relevance':

> The first of these criteria, excellence, is applied by considering matters that are entirely intrinsic to the research activity: the quality of the researcher(s), the quality of the research in terms of its potential impact and the feasibility of the research ...
>
> The second criterion, relevance (or the potential for realising one or more of the five benefits) requires consideration of matters that are extrinsic to the research endeavour. In the end, the question must be 'What benefits will flow to the taxpayer from the expenditure of public money?' (Brennan 1993, p. 95).

For 1996, large grants applicants are required to provide a summary demonstrating how their research proposals and their expected outcomes relate to one or more of the five benefits of research (DEET 1994g, p. 19).

Table C4.1: **Relationship between ARC programs and the strategic objectives of research**

ARC Programs	*Strategic objectives*[a]			
	Supporting basic research & maintaining the research base	*Graduates of high quality*	*Applied research & services*	*International links*
Research Grants (Large & Small)	1	2	3	2
Centres:				
Special Research Centres	1	2	3	1
Key Centres of Teaching & Research	3	2	1	
Collaborative Research Grants		2	1	
Postgraduate Awards:				
APRAs	2	1		
APRAs (Industry)		1	2	
Fellowships:				
Postdoctoral	2	1		3
QEIIs	2	1		3
ARFs/SRFs	1			3
International				1
Infrastructure	1			

Note*:* 1 - First Level Objectives; 2 - Second Level Objectives; 3 - Third Level Objectives

a These strategic objectives are based on the ARC's five benefits of higher education research which are listed in box C3.5. The benefit 'Contributions to the quality of our culture' is omitted as an objective in the above table as in varying degrees, each of the programs is considered to contribute towards this.

Source: ARC 1994, p. 11.

The guidelines state:

> The strength of the arguments presented with regard to the first four benefits (contribution to the quality of our culture, graduates of high quality, direct application of research results, increased institutional capacity for consulting, contract research and other activities) will be considered by the Research Grants Committee in assessing the ranking of applications near the funding cut-off point (DEET 1994g, p. 6).

In other countries the weight given to excellence and 'relevance' varies greatly (see box C4.4). In the United Kingdom 'relevance' and national priorities are an integral part of the selection criteria used by the research councils who make grants to universities. On the other hand, the DFG in Germany funds entirely on excellence. In the United States the National Science Foundation is concerned primarily with excellence but may move in the direction of greater 'relevance'.

Box C4.4: **Some overseas competitive funding agencies**

- *United Kingdom Research Councils*

The United Kingdom has a funding system for university research in which universities have access to two streams of public funding for research. One stream provides funds for use at the institutions' discretion, and also supports the infrastructure for basic and strategic research sponsored by other funders.

Specific funds are also provided by the Research Councils which have an annual budget of over a billion pounds per year and allocate funds on a United Kingdom-wide basis to support research and research projects in the universities and in the Research Council's own institutes, units and shared facilities. The Councils support basic, strategic and applied research and provide funds through project and program grants and through established research centres aimed at encouraging collaboration with industry and business in key technologies.

There are six Research Councils: the Biotechnology and Biological Sciences Research Council; the Economic and Social Research Council; the Engineering and Physical Services Research Council; the Medical Research Council; the Natural Environment Research Council; and the Particle Physics and Astronomy Research Council.

Research councils take account of multiple criteria when allocating funds. The White Paper stated that while the Research Councils should focus on the value of proposed research in terms of scientific excellence and timeliness, they should take more fully into account the extent to which outcomes could be taken up by potential users. When setting priorities and allocating resources, Councils will take account of the needs of their particular user communities - the relevant industrial or service sectors, private and public, as well as central and local government (United Kingdom White Paper 1993, pp. 26–7).

- *Deutsche Forschungsgemeinschaft (DFG)*

The DFG is Germany's central autonomous academic organisation and is the largest external sponsor of university research. It plays a major role in basic research and is funded on a 50:50 basis by the Federal Government and the Federal States (*Länder).* It also receives an annual grant from the Donor's Association for the Promotion of Sciences and Humanities in Germany (DFG 1990, pp. 2–3).

The DFG promotes basic, investigator-initiated research in all fields of humanities and sciences not only by research grants but by stimulation and enhancement of cooperation among researchers as well (DFG 1990, p. 24).

The Grants Committee takes all individual decisions relating to financial support for research projects. It comprises 29 members, 15 of which are selected by the Senate from its own ranks, and 6 each are sent by the Federal Government and the Federal States. Two members are supplied by the Donor's Association for the Promotion of Sciences and Humanities in Germany.

The DFG also has Review Committees who through their judgment provide the basis for the financial assistance afforded to research projects. Reviewers are elected for four years for each of the current 176 separate fields.

The main criteria applied by the reviews and the Grants Committee when reaching their decisions are the academic quality of the project and the qualifications of the applicants.

- *National Science Foundation (NSF)*

The National Science Foundation is the primary vehicle for funding R&D of non-defence science and technology in the United States. Funding for the NSF in 1995 is expected to be US$3.2 billion. It supports peer-reviewed, university-based science and engineering research.

The Federal Government — primarily the National Institutes of Health and NSF — is expected to provide 61 per cent of the basic research funds used by the academic sector in 1992.

The NSF principally supports basic research. It is an independent agency, responsible for programs in all fields of science and engineering as well as education in those areas. Other functions include serving as the government's statistical studies unit for R&D, undertaking international exchanges to promote scientific progress, and awarding research grants to small businesses (McCullough 1993, p. 83).

Under the director and board are several directorates organised along fields of science. These are: Mathematical and Physical Sciences; Geosciences; Biosciences; Social, Behavioural and Economic Sciences; Computer and Information Science and Engineering; Engineering; and Education and Human Resources. Proposals are reviewed by panels with the help of external assessors.

Grants are determined principally on scientific merit (such as creativity of the proposal, what it might contribute to the advancement of the field, soundness of the proposal) and the capability of the researcher leader and team (such as track record or education record and potential). However, reviewers are also asked to consider the likelihood of a wider use of the potential research results, (that is, to contribute to solution of some applied problem or national goal)

A recent report, *A Foundation for the 21st Century: A progressive Framework for the NSF*, suggested that the NSF should have two goals in its allocation of resources... 'support first-rate research at many points along the frontiers of knowledge ... [and] a balanced allocation of resources in strategic research areas in response to scientific opportunities to meet national goals' (NSB 1992, p. 5).

NSF also has programs aimed at enhancing industry participation. For example, the industry/university Cooperative Research Centres Programs, Engineering Research Centres.

How much weight to 'relevance'?

Moves to consider applications on the basis of excellence and 'relevance' have raised some concerns in the academic research community as to the weighting to be placed on these selection criteria. The AVCC said that it:

> ... sees no conflict with the use of 'relevance' or 'national interest' criteria for the assessment of a proportion of externally funded research providing excellence is the prime criteria that is applied in the research assessment process and that not all research is subject to the national interest/relevance criteria. There are sound reasons for supporting research in Australian universities that is contributing to the body of human knowledge regardless of its immediate relevance in an economic sense (Sub. 222, p. 5).

Some have also argued that selections may be influenced by short-term or politically-motivated considerations. Professor Stoddart said:

> ... if research becomes increasingly linked into the nation's economic output — and I am not arguing that it should not be linked; I am arguing about how much it should be linked — then it will inevitably become some sort of political football; it will result in increased instability, and one thing that any creative process does not need is instability (SSCEET submissions, vol. 1, p. 69).

In the Commission's view the most significant question mark over the use of 'relevance' as a selection criterion is the ability of selection panels associated with programs administered by the ARC to make meaningful assessments of its value. Even on the criteria in box C4.3 it could prove difficult to distinguish, before the results of the research are known, a 'relevant' project which exhibits some of the characteristics from another which exhibits them in different measure or reveals different characteristics altogether.

This problem is compounded when it becomes necessary to then make a comparison of those characteristics with projects that differ in the degree to which they satisfy the excellence criterion. Part of the difficulty is that excellence itself is somewhat subjective and may already, in the minds of panel members, at least in some disciplines, incorporate some of the 'relevance' characteristics.

Another consideration is that panel members are, on the whole, appointed for their academic abilities, not the ability to assess the 'relevance' of research. While those with other expertise could be introduced to panels, there are questions about the ability of such a panel to satisfactorily resolve differences of approach that might be taken.

From the researcher's point of view, problems are created in applying for grants, if it becomes necessary for the researcher to foretell whether and in what way their work will prove relevant, as in many cases this may be difficult if not impossible. Research grants may end up going to those best able to place their research proposals in a light that suggests or implies applicability, rather than to projects which have genuine applicability.

On the other hand excellence is a well-understood concept used for granting purposes around the world. It has proved to be an operational criterion which, when established through peer review, researchers have come to accept.

The Commission therefore questions the systematic use of criteria other than excellence in selecting research for funding through the ARC. However, it acknowledges that judgments about 'relevance' may be more easily made in some areas than in others. For example, while 'relevance' may present difficulties for a discipline panel in the Large Grants Scheme selecting among many individual grant applications, it may be easier for a panel involved in making selections for large block funds under such current programs as the Special Research Centres and Key Centres of Teaching and Research. The purpose of the collaborative grants scheme also implies that ‘relevance’ should receive some weight although, it is also true that projects do to some extent self-select on this criterion because industry contributions are required.

In general terms the Commission considers that research which is valued for its ‘relevance’ to identifiable problems of economic moment is better commissioned through sponsors such as the rural research and development corporations (see part E) or the IR&D Board (see part D).

In the draft report the Commission argued that it did not consider that the ‘relevance’ criteria developed by the ARC provided a meaningful or operational basis for ARC panels to choose among competing projects which involve basic research. The Commission concluded that in most cases the criteria for allocating funds to individual research projects or programs aimed predominantly at the advancement of knowledge (basic research), excellence should be the only criterion.

Some participants strongly supported the Commission’s finding. Many others supported the argument that excellence should be the primary criteria for programs aimed predominantly at funding advancement of knowledge, but considered that there was an argument for the use of ‘relevance’ as a secondary criteria (see box C4.5).

The ARC however, did not accept the Commission’s view:

> Council notes that (i) among the enormous range of research topics that can be considered as appropriate for ARC funding, there is merit in supporting proposals which would otherwise be unsuccessful which, in the judgment of the applicant’s peers, have greater potential than others of essentially equal intrinsic value (excellence) of delivering tangible benefits to the Australian taxpayer; (ii) the Commission provides no evidence to substantiate its assertion; (iii) the Commission acknowledges that ‘relevance’ criteria have been used implicitly by some panels; and (iv) where possible, criteria used by panels and assessors should be explicit rather than implicit. This approach reflects Council’s view that it is appropriate to include consideration of the five benefits for such marginal cases. It is also important to note that criteria of this kind have been implicit in many past assessments, particularly in engineering and applied sciences (Sub. 361, pp. 7–8).

Box C4.5: **Participants’ comments on excellence and ‘relevance’**

The University of Western Australia said that it is:

> ... pleased that the Commission has endorsed the view that excellence should be the criterion for awarding ARC and NHMRC grants ... (Sub. 278, p. 7).

The University of Queensland said that it:

> ... strongly supports the use of excellence (via peer review) as the only criterion for the award of large grants. The focus on relevance through the ARC benefits of research tends to diffuse this criterion, and many researchers in the University would wish to see the primacy of excellence acknowledged and reasserted (Sub. 410, p. 2).

Murdoch University said:

> The recognition of excellence as the prime consideration for funding by ARC is to be applauded. Far too often excellent world-quality basic science sent to ARC is being artificially forced by investigators into trying to meet dubious relevance criteria (Sub. 276, p. 3).

Monash University said:

> Peer review can only make reliable distinctions between proposals to a certain point beyond which hairs are being split. Furthermore, the higher the standard at which the critical judgment is being made, the more unreliable it is. Thus, when the cut-off score is around 80/100 on a linear scale – as it was in the Australian Research Council Large Grants Scheme last year – the criticism which leads to a score of 79 rather than 80 is very minor (and usually highly contestable), whereas at, say, 70/100 there will usually be a pretty clear and significant problem (Sub. 330, pp. 3–4).

The University of Melbourne said:

> Excellence should be the primary basis upon which grant project selection is made. Peer review should be retained as a central part of grant assessment and fund allocation mechanisms. While peer review and excellence criteria are essential parts of the selection process they may not always be sufficient. Excellence as a discriminator may need to be augmented by other selection such as the benefits of the research and its relevance to national needs (Sub. 313, p. 4).

The University of South Australia said:

> ... the argument that basic research will automatically lead to commercial spin-offs has been well described by the previous chair of the ARC, Prof Don Aitkin, as the ‘serendipity rules ok’ argument. It neglects the fact that applied research has equally well lead to important breakthroughs in understanding of natural physical processes. Rather than examining this issue as an either/or argument, it is more appropriate to say that both excellence and relevance should be used as criteria for ARC grants (Sub. 286, p. 1).

Dr Colin Hansen said:

> It is much easier to define objective relevance criteria than excellence criteria. One just had to examine the many conflicting peer reviews to discover that excellence is extremely subjective as well as being difficult to compare from one discipline to another. There is a strong argument in favour of dividing research funding from the Federal Government explicitly into two groups — one group which is for projects of no obvious relevance and the other group for projects which are relevant by virtue of satisfying one or more pre-determined relevance criteria (Sub. 449, p. 3).

It is true that when projects are often difficult to separate, judgments on excellence grounds alone can be arbitrary. And ‘relevance’ can be a useful additional criterion to resolve that difficulty when it occurs. But to introduce ‘relevance’ criteria on a systematic basis to distinguish among excellent projects, while expedient in the short-term, will inevitably have an impact on the way future projects are framed. Once this occurs, the problems that the Commission noted in its draft report become magnified: proposals will be framed, and judgments will be made, by those whose expertise is not in ‘relevance’. And as the use of ‘relevance’ criteria becomes more widespread, the decisions become more complex rather than more straightforward.

The Commission agrees with the ARC that selection criteria should be explicit rather than implicit. But this applies equally to excellence as to ‘relevance’. The more that the individual characteristics of an excellent project can be articulated for each discipline, the more credibility the selection process will assume. However if it becomes necessary to decide between two equally excellent projects, a useful criterion that might redress a bias that some see in the ARC selection processes might be to favour the less experienced researcher.

The use of ‘relevance’ in guiding research funding is not, however, being ruled out by the Commission — as the remainder of this section makes clear. It is only the use of excellence as a criterion by those selection panels making judgments about basic research that the Commission feels is untenable.

The Commission does not consider that the ‘relevance’ criteria developed by the ARC provide a meaningful or operational basis for ARC panels to choose among competing projects which involve basic research (particularly the Large Grants Program). The Commission concludes that in most cases the criteria for allocating funds to individual research projects or programs should be limited to excellence by international standards.

In practice, this means that programs aimed predominantly at funding the advancement of knowledge (basic research), particularly the Large Grants Program, should use excellence only as a criterion.

How much weight to different disciplines and programs?

The direction of research in the ARC is also influenced by the weight of funds going to different programs and, within programs, to disciplines. This can be altered according to priorities seen for particular fields of research.

Funding of programs

The allocation of funds among programs can have a significant effect on the type of research which is undertaken. To give more funding for collaborative research for example is likely to imply a favouring of physical science over humanities. Similarly with the large grants scheme, allocations to different disciplines clearly can change the balance of research. As the 1990 ASTEC report on *Setting Directions for Australian Research* recognised:

> The choice is not between setting guidelines for research on the one hand or having completely undirected research on the other. Priorities are set already. Where everything cannot be funded without constraint, choices must be made, and they have been, in Australia, as elsewhere. Those who believe that we should not attempt to develop or implement a formal structure by which national directions for research can be set, forget that choices will continue to be made as to which researchers, which areas will be funded. Those choices will be made on the basis of current information, and current processes. (ASTEC 1990b, pp. 55–6).

The Commission understands that currently, even though grants are made under the auspices of the ARC, the allocation and reallocation of funding amongst its programs is subject to Ministerial approval. To the extent that it reflects a view that the ARC's role should be restricted to awarding grants rather than the broader goal of supporting basic research, it needs reconsideration.

Because the ARC has a range of programs broadly aimed at the same purpose, there is merit in allowing the ARC to pursue those objectives with the range of programs it sees as best suited to meeting them. If the ARC were given greater control over allocation of funds, decisions about priorities among programs could be given closer consideration by the ARC.

The decisions taken by the ARC about the weight to be put on different programs would reflect its assessment of the mix that would best advance its goals, and that would favour those areas likely to have the largest perceived payoff for the nation in the future.

In practice, the Government may wish to place restrictions on the operation of the ARC. It may, for example, require that some funding methods be retained and even set minimum amounts to be allocated. The Commission perceives that, at present, the ARC is broadly limited to making choices within programs which are to some extent 'ring-fenced'. The Commission's position is that if the ARC is to manage government funds to greatest effect it needs more scope to do so.

The ARC supported the Commission's proposal. So did the University of New England which said:

> The University supports the proposal of the Commission that the ARC should be given increased autonomy over the way it distributes funds among programs and disciplines in the light of priorities that it identifies. It considers that this approach allows the ARC

> to give close attention to priority setting, without direct ministerial influence. However, the University believes that the ARC should make public its decisions on the balance it chooses between disciplines and programs and that it should do more to elaborate on the reasons why it either maintains or changes this balance over time (Sub. 350, pp. 5–6).

The Commission proposes that the ARC receive increasing autonomy over the way funds may be distributed among its programs. The Commission would expect, however, in line with the principles expressed in chapter A6, that the ARC would maintain a diversity of funding programs and that government may wish to ensure this by specifying minimum allocations in some programs.

Funding of disciplines

Within the large grants program, grants to particular disciplines are made by expert panels in those fields. Funding of disciplines is currently entirely on merit which currently encompasses both excellence and 'relevance'.

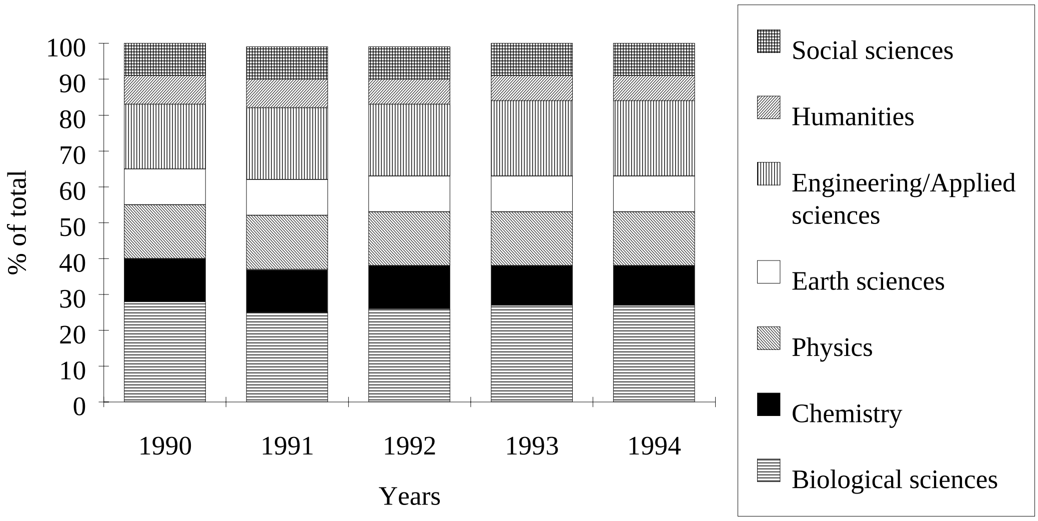
There is also an additional allocation of funds for projects directed at priorities determined by the ARC after consultation with the community. Ten per cent of funds are currently devoted to this end.

In other programs, some areas for targeting are also pursued in the special research centres program and the key centres program.

In the large grants scheme funding allocations among disciplines appear to be made somewhat arbitrarily initially with the aim of maintaining the success rate of previous years and the average size of grants. While there also appears to be scope to reallocate funds according to the quality of applications in each area, as figure C4.2 shows, there is in practice, relatively little variation in allocations from year to year.

The low variation appears consistent with the idea that some limits are currently being placed on funding to particular areas to ensure that imbalances in funding are avoided. Alternatively, it may be consistent with allocation on the basis of excellence across disciplines if the relatively high level of aggregation disguises the variations in funding that might be expected in the number of excellent proposals in particular areas from year to year. Whichever is the case, the Commission considers that more could be done by the ARC formally to prioritise funding allocation among disciplines.

Figure C4.2: **Share of funding to discipline panels in ARC Large Grants Scheme**



Source: Information provided by DEET.

This is not an easy task. The ARC noted the extreme difficulty of such priority setting for basic research, because adequate data was difficult to obtain and because the links between basic research and R&D targeted to specific socio-economic objectives were sometimes tenuous. The ARC said:

> Council is currently collecting further data, and undertaking further analysis of these two aspects, through in-house work and commissioned studies. When this work is completed, Council will tackle the task of adjusting the balance of funding across the disciplines in the Research Grants Program and in the other programs whose primary objective is the support of high quality basic research (Sub. 361, p. 9).

Some work on this topic has recently been published (NBEET 1995). The work is in a number of stages. The first stage considered theory, international practice and the framework and data constraints on mapping such connections in Australia. It concluded that:

> ... a framework linking basic research and socio-economic objectives in Australia cannot be directly extrapolated from international studies nor theoretical models, but requires empirical examination of the socio-economic linkages of different fields of basic research in Australia. A major focus of further work will be on surveying tacit linkages and the knowledge transfer embodied in research personnel since these aspects are of demonstrated importance and least well informed by existing data. Investigation of codified outputs is also valuable in mapping the linkages between basic research and socio-economic benefits (NBEET 1995, p. xvii).

The process by which funding is allocated among disciplines, is not at all clear, and there would be benefits in making this more transparent. For example, there may be scope for the ARC more systematically to draw upon the views of outside bodies by establishing a ‘workshop’ or some other forum to allow government and community input to inform the ARC’s priority-setting decisions. One model by which this might be done was discussed in chapter B4 and recommended for used by CSIRO.

The Commission sees merit in a broadly analogous approach for the ARC also. Workshops with representatives from government, business and the community generally could take part, and the ARC could draw on such advice in its decisions. Funding amongst disciplines might then be take place after advice from both the research community and from broader ‘stakeholder’ interests represented at the workshops. Not only would such an approach provide a basis for more transparent processes for allocating funds among disciplines, but it would provide some benchmarks for ex post monitoring and review of research outcomes by the ARC.

The Commission proposes that the choice among disciplines become one explicitly made by the ARC in the light of priorities it identifies in consultation with major stakeholders. Within disciplines, however, funds should be allocated on the basis of excellence.

C4.3 The role of the ARC

The ARC’s mission

The Commission is proposing that, as a result of its recommendations, the ARC be given a wider role with greater responsibilities for setting priorities.

In broad terms the ARC would be charged with responsibility for making the best use of its resources to stimulate research in universities which is of most use to the nation. Eventually the ARC would be able to shift resources between programs to achieve those goals.

The detailed design of this process is a matter for further consideration. For example, the Government may wish to prescribe which programs should be used and place some limits on the extent of possible transfers of resources. But the broad thrust of what the Commission is seeking is clear — an ARC which is accountable to government for contributing to the achievement of beneficial higher education research and which has the power to effect real change itself.

To achieve these objectives the ARC may need to seek broader representation from research stakeholders on its Council than at present: representatives of the business community, for example. The Council will have the responsibility of allocating funds both between programs and within programs. It will also need to appoint subgroups, such as the discipline panels.

To achieve these goals effectively the ARC needs to be given statutory independence. The University of Adelaide said that:

> The location of ARC within NBEET tends to restrict the range of its research policy advice to a narrower view based around the higher education sector. Naturally we believe that the special needs and obligations of universities should be understood and supported by government; for the universities have a unique role in fostering creative individuals and small groups of international stature even when their research is not in the mainstream of prevailing paradigms. That said, there is a need for independent advice, which takes account of the full interactions of industry, government research organisations and higher education, to be provided to government ... Thus we advocate that ARC should report direct to government and together with NH&MRC should be used as a major source of broad band research policy advice. At the same time measures should be taken to ensure that the particular issues of concern to higher education research are addressed separately within any new ARC/NH&MRC structure (SSCEET submissions, vol. 2, p. 383).

A recent review of NBEET said:

> The ARC submission to this review was the most pungent of all the Council submissions principally because it signalled a desire to break away from the NBEET system and become an independent statutory authority. The ARC argued that the split between a policy advisory role through the board, and advice to the Minister direct on grants distribution were 'cumbersome and unsatisfactory' (Wiltshire 1994, p. 48).

A further argument outlined in the review was that the ARC considered that linking it with other NBEET Councils with different responsibilities, for example employment, labour market programs and literacy:

> ... places undue emphasis on areas of far less importance to the role of the Council than others such as science and technology, the environment, and primary industry, responsibility for which lies in other portfolios (Wiltshire 1994, p. 48).

The review recommended however, that the ARC should remain within the NBEET system.

The ARC supported the Commission's recommendation that it be given statutory independence. It reiterated its position that links with the HEC need to be maintained and would be maintained if it were made independent. But it considered it more difficult to argue as strongly for keeping the Council linked with some of the other NBEET Councils. At the draft report hearings the ARC said:

> ... we find ourself in a somewhat awkward situation in straddling these two roles and each of them is important — that is the role of research in higher education, the system as a system and the role in the R&D system. Our present location I think is not the optimum one for meeting those two roles. We clearly have and must have a strong

> formal link with the Higher Education Council but it's very hard to see how one could argue for the strong link into the Skills Council and the Employment and Skill Formation Council, rather than some positioning which would enable linkages with other portfolios and agencies to be stronger. But I think it is extremely important to emphasise that whatever structure that one would adopt you do need to keep that linkage between the Research Council and the Higher Education Council and nothing that we have ever said would diminish the importance of that particular linkage (DR transcript, pp. 3137–8).

On the other hand, the Higher Education Council stressed the need for research to stay linked to the teaching and training functions of universities. It considered that research should not be taken in isolation from the other purposes of universities as something to be pursued in its own right. The HEC said that it:

> ... accepts that, while the ARC may have experienced some administrative difficulties in the past, there are not likely to be any significant benefits to establishing a separate statutory body for research in isolation from the rest of university funding. Research is only one of the activities undertaken within universities and research funding via the ARC is only one of the sources of university funding. The Council is firmly of the view that the various elements of higher education policy and funding should not be separated. Issues relating to the balance of research funding across discipline areas, research infrastructure and other sources of university funding need to be considered in the broader context of higher education policy and programs (Sub. 365, p. 2).

While the AVCC took a similar view to the HEC, many universities supported the Commission's recommendation (see box C4.6).

In earlier discussion the Commission made clear that it regards the role of teaching, training and research as closely intertwined. However, this does not necessarily imply that each component of the university funding system need be directed to all objectives simultaneously. It is consistent with this view for the ARC to pursue objectives principally connected with excellence in research while other programs are directed to some or all other objectives.

Universities currently have substantial flexibility in tailoring their overall mix of activities (courses offered, research undertaken) to achieve their teaching, training and research objectives. In research activities alone they have considerable freedom to use their untied funds (for example the operating grant and the Research Quantum) to pursue their goals. And there are many sources of competitive grants for research other than the ARC.

In the Commission's view the role of the ARC should be primarily connected with the pursuit of excellence in research. The Commission does not consider that the type of research supported by the ARC should be modified to give effect to shorter-term objectives connected with, for example, those arising out of the labour market.

Box C4.6: **Participants' arguments on ARC statutory independence**

Participants favouring statutory independence of ARC

The University of Technology, Sydney said:

> Statutory independence would be appropriate for an ARC with an enlarged role provided that this does not lead to diversion of funds from programs to administration, nor lead to demands for additional statistical information etc from the universities (Sub. 430, p. 4).

The University of Melbourne said:

> The attainment of a more independent role by the ARC is strongly supported by the University. The minimum position should be that the ARC has its own secretariat which is responsible for program delivery, accountable to the Council through the Chair. A greater independent role for the ARC preferably as a statutory body, should enhance its capability to provide independent research policy advice to Government. Furthermore, it should be possible to improve the quality of grant allocation management and monitoring. At present a low level of administrative support and program delivery expertise is available to the ARC through DEET (Sub. 313, p. 4).

Murdoch University said:

> ARC is poorly serviced by DEET and this appears to affect the efficiency of the operations of ARC. The suggestion to make ARC an independent entity with appropriate resourcing sounds attractive – provided that such resources are, in fact, provided from administrative sources rather than out of funds allocated for research (Sub. 276, p. 3).

Not in favour of statutory independence for ARC

The AVCC said:

> With regard to statutory independence, the AVCC believes there is a demonstrated need for the ARC to continue to reside within the NBEET structure. The Higher Education Council (HEC) which also sits within the NBEET structure provides advice on the general concerns of the higher education sector and the ARC focuses on research in higher education ... The AVCC believes there is a fundamental interdependence between university teaching and research. Whilst teaching is and must continue to be informed by the latest research, the research programs will also continue to depend to a significant extent on the involvement of teaching staff as well as students at both the postgraduate and senior undergraduate levels. A further argument for the ARC remaining in the NBEET structure is the establishment of the Australian International Education Foundation (AIEF) as a council of NBEET. The AIEF aims to promote Australia's education and training services and research opportunities overseas and the links between the ARC and the AIEF will be of increasing importance as Australia strengthens its offshore activities (Sub. 358, p. 6).

It went on to say that it:

> ... would endorse the establishment of a stronger discrete Secretariat to support the ARC. NHMRC has recently strengthened its Secretariat following the Review of the NHMRC conducted by Prof Bienenstock, 1993. By and large, the ARC relies on administrative support for its activities from the Research Branch of DEET. The AVCC sees merit in the secondment of staff from this Branch or from universities to provide dedicated administrative support for ARC activities. This would not obviate the need for continued strong links between the ARC and the Research Branch of DEET (p. 6).

This role of the ARC should not be thought of as working counter to the objectives of excellence in teaching and training. There is a need in the university system for the best research to be strongly supported, in order for the best teaching and training to occur. First class research needs to be strongly defended, and giving the ARC independence is one means to this end.

It is relevant also that the NHMRC was recently given statutory independence. The ARC and the NHMRC are the largest of the Commonwealth’s competitive granting agencies which provide research funds to the universities.

The ARC provides advice to the Minister on the distribution of resources for which it is responsible and provides information and advice on policy issues. The ARC noted that the practice to date has been for the Minister to accept Council's recommendations on the distribution of funds among its programs.

However, statutory independence would draw the boundaries around the role of the Council and the government more clearly. It would allow for the Minister to give general directions to the Council and to refer matters to it, but would prevent the Minister from specifically directing the Council in its allocation of research funding and from directing it on scientific issues. Statutory independence would also allow for greater accountability.

The Commission considers that with the broader role for the ARC that the Commission envisages, the ARC should be given statutory independence and report directly to the government.

The Commission considers that the main effect of its proposal, if implemented, would be a reorganisation of the way funds are delivered, in a more transparent and consistent process. Diversity of funding sources would be maintained not only through the ARC’s various programs but also through the many sources and programs noted in C1.6 and C2.1.

Administration

The administrative functions of the ARC programs are divided between the ARC secretariat and NBEET and DEET. A review of NBEET found that:

> The administration of the grants is an enormous task involving some thirty staff, and this function has been performed for the ARC by DEET in a manner which, even the Department has conceded, has left a lot to be desired. The ARC has recently concluded an agreement with DEET for the more efficient operating of the research grant application and distribution process (Wiltshire 1994, p. 48).

The funding provided for administrative support has been claimed by some to be insufficient when compared with support received by similar agencies overseas. Professor Brennan said, with respect to the administrative support the ARC receives from a combination of NBEET and DEET:

> ... the total cost of administrative support for the ARC amounts to about 1.4% of total program funds. The bottom end of the range for funding agencies in other OECD countries is in the range 4–5% (Brennan 1993, p. 93).

Similarly the Australian Society for Biochemistry and Molecular Biology told the Senate inquiry that:

> The ARC has been very effective in promoting scientific research in Australian universities. It is however, in danger of losing the respect of the scientific community because of administrative difficulties brought about by limited resources available for its administration. The administrative budget, as a proportion of the total ARC funds, is amongst the lowest of any similar granting agency in the world (SSCEET submissions, vol. 4, p. 778).

This issue of ARC’s administrative support and dependence on DEET was also raised by participants in the Senate inquiry. Many argued that because of current arrangements, ARC did not receive adequate support to be able to administer its programs as effectively as it could. Many argued that the ARC was too dependent on DEET for its administrative support and that the responsibilities of the two should be separated out. Griffith University told the Senate inquiry that:

> ... the ARC is presently compromised in its function by a deficiency in administrative support and its reporting mechanism by way of NBEET. ARC should be established as a ‘stand alone’ entity of DEET, with direct reporting and responsibilities to the Minister (SSCEET submissions, vol. 1, p. 109).

The Australian Society for Biochemistry and Molecular Biology told the Senate inquiry that:

> The ARC’s budget for administration (i.e. sitting fees and interview tours) is taken from the ARC allocation for research funding. The administrative implementation of the program is in the hands of the Research Branch of DEET. Members of both the ARC panels and the Research Training and Careers Committees have pointed to the minimal resources in personnel and facilities (computers, databases, faxes, photocopiers etc), that are allocated to these critical activities. International best management practices are not being followed and when the deficiencies are combined with low success rates for project grants and fellowships there is an unease in the academic community and a ready tendency to blame the peer review system rather than its implementation. Our preferred solution ... is to separate the ARC from the DEET bureaucracy and to provide sufficient stand alone funds for its efficient administration (SSCEET submissions, vol. 4, p. 778).

Professor Stone said:

> It appears that only sitting fees and travelling expenses for members of ARC committees is provided [through] the ARC budget. The secretariat is supplied by DEET

> and the Chairman of the ARC has no role in the disbursement of DEET’s budget for this supporting activity. This dichotomy of responsibility needs to be redressed so the ARC has control over the funding of the support staff and the associated office infrastructure. This structural adjustment is needed urgently. I have had first-hand experience with funding agencies of comparable magnitude in the US and elsewhere and in no case was the executive and the administration separated as I have outlined. I believe the ARC and its committees would be better able to discharge their tasks if they were not embedded in the framework of DEET where their activities are clearly not rated as important (SSCEET submissions, vol. 4, p. 945).

The level of support for ARC functions has recently been addressed. The ARC informed the Commission that:

> The earlier, parlously low level of administrative support for the Council was increased in the 1994/95 budget following representations from the Council to the Minister (Sub. 361, p. 9).

A number of participants, including the University of Western Australia and the AVCC, while supporting the provision of increased funds, expressed regret that those funds had come from a transfer from program funds (that is money that might have been used for grants) rather than additional support.

The ARC noted that even though increased funds had been provided, this may not be sufficient if its role were to change:

> Any increase in responsibility (as envisaged by the Commission) would require additional administrative resources (Sub. 361, p. 9).

If the Commission’s recommendation is followed, and the ARC is given independence it will be necessary to separate out the resources necessary to service it from those in DEET. This may imply a need for some additional resources. Moreover, the additional functions suggested in this report (such as discipline reviews across programs) are also likely to imply a need for additional resources.

The Commission recommends that consideration be given to the additional resources that may be required by the ARC when effect is given to the proposed expansion in its role.

C4.4 ARC — other funding issues

A number of issues were raised with the Commission about the operation of the ARC, particularly the large grants program. Concerns focussed on the success rate for ARC grants, the operation of the peer review system in the large grants program and the concentration of research grants in the larger universities.

Success rate of ARC grants

There are many claims that the level of ARC funding is too low and that many top quality researchers are missing out. The success rate for ARC grants is roughly 20 per cent, having declined from 31 per cent in 1991 to 19 per cent in 1993. For 1994, it increased to 22 per cent. The ARC said:

> The low success rate of 22 per cent for Initial grants for 1994 has been repeated for 1995. At the current levels of funding and applications, Council anticipates a success rate of 20 per cent for Initial grants in 1996 and 1997. This is an unacceptably low figure in terms of the many high quality researchers ... in higher education institutions. It also presents serious problems for the expert panels in choosing between proposals of very high quality (Sub. 361, p. 10).

Many researchers argue that the success rate should be around one-third.

The decrease in the success rate is said to be a result of government funding to the ARC not keeping pace with increases in postgraduate numbers and the increasing interest from ‘new’ researchers in the post-1987 universities. Gatton College, University of Queensland said:

> ARC funding is insufficient. A success rate of only 20% precludes 80% of academics from satisfactorily fulfilling not only their job expectations, but also their job requirements (Sub. 33, p. 7).

The 1989 ASTEC report *Profile of Australian Science* found that while Australia is on par with the highly developed countries in expenditure on basic research, individual researchers are not being adequately supported. It added that:

> The Commonwealth Government appears to favour a reduction in the number of active researchers in higher education as a means to concentrate research effort. This is the sector where the current number of researchers is, on average, receiving a low level of funding (ASTEC 1989, p. 86).

Curtin University of Technology said:

> The major source of funding to the universities is via the ARC where the extremely tough climate for obtaining large and small research grants is well known. It will be apparent that the current success rate of approximately 20% is far too low: there are many excellent research proposals that are not able to be funded at this time ... and we urge that funding be increased to allow the success rate to be progressively increased to approximately 33% (Sub. 24, p. 1).

University of Queensland said:

> The level of funding for basic research supported by agencies such as the Australian Research Council is patently inadequate to fund the country’s research needs. Some 646 projects in 1993 for example, were unable to be supported by ARC despite the fact that peers acknowledged the work as high in quality. The gap in funding that exists approximates $25 m (Sub. 23, p. 3).

The Commission was told that in Britain, there were many similar complaints about the non-funding of excellent projects with high assessment ratings — known there as the 'problem of unfunded alphas'. In Germany, however, about two-thirds of projects are approved, amounting to half of the expenditure bid. US success rates for applications to the National Science Foundation were about one third, while applications to the Korea Science and Engineering Foundation were less successful (about 25–33 per cent).

The ARC Research Grants Committee told the Senate inquiry that the cut-off grade for funding has increased over recent years. In 1990 a grade of 5.5 on a 7 point scale guaranteed funding whereas in 1993 this has risen to 6 (SSCEET submissions, vol 1, p. 222).

However, not all participants were concerned with the low success rate of ARC large grants, and highlighted the importance of other sources of funds. At the public hearings, Professor Aitkin said:

> ... we have a good attitude towards research, and I think if we could encourage a culture which said, 'In universities all academics are expected to contribute to the disciplines from which they draw their authority as teachers but you can contribute to your disciplines in a variety of ways and you don't all have to get an ARC grant' ... You must have had people who told you about the appalling success rate in the ARC. It's one in five. Why is any particular success rate important? ... most of the people in my university who do research — we're not in the ARC business at all but we're a very research-active organisation, but we do research for people who want research done. That's what the old advanced education sector did; that's how it got into research (transcript, p. 1364).

The problem in judging whether current success rates are appropriate or not is the difficulty in knowing exactly what success rate would be ideal.

The ARC supported this and added:

> A better measure may be the fraction of academic staff supported by ARC grants (and, indeed, by other funding sources). Such information is not readily available. Council intends to commission a study to generate this and other related data (Sub. 361, p. 10).

The success rate depends as much on the rate of application for grants as the budget for the scheme and a large number of unsuccessful applications could be indicative of many things, including a lack of general familiarity with the selection criteria and a lack of knowledge of the quality of other applications against those criteria. To put it another way, a much larger budget for the scheme need not solve the problem as it could attract an even greater proportion of unsuccessful applications if there was uncertainty about the criteria and the rewards for successful projects were high enough.

The low success rate may, however, be an indication that researchers are generally less able to predict the success of their applications than might be desirable. With better accuracy, less unsuccessful applications would be received as researchers would not willingly go through the process of preparing applications when they had a low chance of success. Recent moves to provide applicants with information about the competitiveness of their projects may help to reduce the understandable frustration that applicants feel when so many projects are unsuccessful.

Peer review

There are mixed views about the peer review process. Many consider that it is the best method of allocating these funds; others argue that this system has too many biases and is not a *'fair'* method of distribution.

Some participants said that peer review is biased towards experienced researchers with a track record, and that less experienced researchers and those from the newer universities are disadvantaged. The Union of Australian College Academics and the Federated Australian University Staff Association told the Senate inquiry that:

> The older and larger pre-1987 universities receive by far the biggest proportion of ARC funding. They are also over-represented in the composition of ARC panels and committees: staff from pre-1987 universities comprise nearly 74% of the members of ARC committees and panels, compared with 11% from post-1987 universities (SSCEET submissions, vol. 3, p. 574).

They added that:

> Increased competition for research funding makes it more difficult for junior researchers without a research 'track record' to gain a foothold within the system (SSCEET submissions, vol. 3, p. 577).

Some participants argued that because Australia has a small scientific community with only a small number of experts in the various disciplines, grants may be judged by people who sometimes have little or no expertise in the matters they review. Although there are international experts on some granting panels, this is still considered by some as a problem. Professor Carnegie said:

> ... ARC and NH&MRC funds for basic research are increasingly difficult to obtain. Because they use mainly Australian assessors, the pool of unbiased expert talent which is available to assess grant applications is limited, so that the scores and ranking of the applications greatly depend upon the chance of the project being sent to someone who knows something about it, has the time to study it and prepare an objective report (Sub. 20, p. 1).

In his view:

> With only 20% of new projects being funded and with slashed budgets, a formal lottery system would be fairer (p. 1).

The University of New England said:

> ... judgments should be made by researchers with strong reputations in the particular field or discipline. Thus it is important for research grant applications in, for example, the humanities to be reviewed by peers in the humanities, because they are familiar with not only the problems and issues and a sense of priority needs, but also with technical or discipline-specific language used (Sub. 223, p. 16).

Others say that outcomes are unduly influenced by the knowledge base and research biases of those on the review panels. The Senate inquiry reported that, because Australia has a small research community:

> ... assessors were themselves often competing for ARC grants with the people whose proposals they were called upon to evaluate. An unbiased assessment was problematic in these circumstances. There was a danger that the perception of bias, even when unwarranted, would bring the ARC peer review system into disrepute (SSCEET 1994, p. 170).

A related criticism is that original research can miss out on ARC funding, because public accountability requirements and demands for quick results can bias funding towards the already-established and more applied research which is more broadly predictable. Professor Steele said:

> ... under the pressure of public accountability, the system demands that it produce results, which means that referees and review panels assess the likelihood of publication in the immediate time horizon of the grant, which too often means that applicants who demonstrate that they have already done the work will be funded — this is the antithesis of what we would define as funding research, the outcome of which (if is truly original) is largely unknown (Sub. 140, p. 4).

The Senate report noted the concern that basic research, where a long time frame was involved, was in danger of ‘losing out’ to short term projects which to some extent could specify outcomes in advance. It found that the increasing use of direct or targeted funding mechanisms exacerbated this problem as they often required applications to state the anticipated outcomes for the project (SSCEET 1994, p. 100). The Committee said it:

> ... has no argument with the fact that universities are undertaking a greater level of applied research. However, the fact remains that in Australia universities have been and will remain the prime sites for the conduct of basic research. It is unlikely that equivalents to the large private sector laboratories and research institutes characteristic of the US, Japan and Europe will develop here. Therefore universities must continue to fulfil this fundamental research role. Notwithstanding the need for applied research, it would be a mistake to secure improvement in this area at the expense of basic research (SSCEET 1994, p. 110).

Finally, the costs associated with a competitive granting scheme may be high. Some participants raised this issue arguing that funds and resources which could be used to undertake research are wasted on administration and application processes. Professor Luther-Davies said:

> Since much attention has been paid to efficient use of research funds, the ARC and DEET should be asked to properly cost the issue of grants through the ARC (Sub. 112, p. 14).

The cost to peer reviewers can also be high.

Peer review has support

Many participants, while acknowledging problems, argued that a peer review process was still preferable to any alternatives. The Faculty of Science, University of Technology, Sydney said:

> Peer review is essential but current practices are badly flawed, largely due to administrative problems and the limited expertise in many areas within Australia (Sub. 39, p. 2).

The University of New England said:

> In research grant allocations it is of utmost importance that peer review be maintained (Sub. 223, p. 16).

More generally, Macquarie University told the Senate inquiry that the ARC:

> ... is both a cost effective and efficient organisation in the deliberative academic process involved in the assessment and allocation of research funding through an international peer review system. Whatever its weaknesses, there is no demonstrably better system available and the research community feels reasonable confidence ... because it is undertaken by a group of competent practising researchers themselves (SSCEET submissions, vol. 4, p. 983).

Again, these matters are difficult to settle. In any system where there are ‘winners’ and ‘losers’, there will inevitably be claims that the system is not the ‘best’. On the one hand, there may well be some biases in peer review — towards existing paradigms or better known researchers, for example. Equally it is likely that with rejection rates of 80 per cent there will be some disaffected researchers about. It is not surprising that experienced researchers do well under competitive processes — they may well be putting forward the better proposals.

The ARC has in recent years attempted to address these concerns on biases in their selection process. The Senate inquiry reported that the ARC had in 1992:

> ... implemented an appeals process which enables unsuccessful applicants to appeal if they believe ARC selection procedures were not adhered to. Also in 1992, unsuccessful applicants were for the first time given reasons for their rejection, together with a copy of each evaluation report submitted on their proposal. In 1993 the ARC released assessors’ reports on a trial basis to applicants before they were interviewed. Each of these measures has been introduced in an attempt to allay concerns about possible prejudice in the assessment process (SSCEET 1994, p. 171).

Peer review will always have its critics, but so does every system of allocating funds. **The Commission considers that peer review has an essential place in a pluralist funding system for universities.**

C5 OTHER FUNDING ISSUES

This chapter discusses three sets of questions. It begins with a discussion of some issues concerning research infrastructure. This is followed by an examination of funding arrangements for the Institute of Advanced Studies at the Australian National University. The chapter concludes by considering the question of the taxation of postgraduate scholarships.

C5.1 Infrastructure

Concerns about infrastructure

The issue of funding of research infrastructure was raised by many participants who were concerned that there was inadequate support provided to maintain infrastructure and that university infrastructure was in danger of becoming run-down. Many were concerned that there appeared to be a growing imbalance between direct project funding through the ARC and the provision of research infrastructure. The Australian Vice-Chancellors’ Committee said:

> There is a danger that the funding of specific projects will be favoured over general infrastructure funding. Adequate infrastructure is needed, however, not only to support current research capacity but to anticipate the needs of future researchers (Sub. 222, p. 3).

Some submissions attributed the problems with infrastructure to the establishment of the Unified National System. La Trobe University said:

> Reclassification of the former Institutes of Technology and Colleges of Advanced Education to university status brought with it the expectation of support for research and postgraduate research training that the Commonwealth has been unable or unwilling to provide (Sub. 54, p. 4).

The University of Sydney said:

> The ‘clawback’ of operating grant funds to expand ARC resources undeniably removed discretionary funds from the university. These funds were formerly available to enhance infrastructure, but were mostly ‘returned’ to universities as project grants (Sub. 87, pp. 6–7).

Others argue that the growth in funding for research infrastructure has not kept pace in recent years with the growth in funding for Commonwealth competitive grants and the increases in the numbers of approved postgraduate research students.

The reliance of selective grants on infrastructure provided through other means is, in the view of many participants, placing undue pressure on the institutions. The University of Melbourne said that:

> Government agencies (ARC, NHMRC etc) fund research projects on the 'marginal funding' principle. That is, only direct costs are funded on the erroneous assumption that the universities can absorb the associated infrastructure costs from their operating grants (Sub. 51, p. 3).

The Senate report found that:

> One aspect of the design of the Large Grants program repeatedly criticised by witnesses was its failure to include in each grant a sufficient component to cover the associated infrastructure costs ... These costs were thus borne by the institutions. Grant projects were a heavy drain on infrastructure which as a consequence of the cumulative effects of under funding over a number of years, is at crisis point in many institutions. In some cases these indirect costs are now so high as to discourage institutions from applying for large grants (SSCEET 1994, p. 140).

The Committee recommended that:

> ... each Large Grant specify a proportion of its funds to be allocated specifically to meet infrastructure costs (p. 141).

This Government rejected this recommendation stating:

> In supporting applications for Large Grants, institutions undertake to provide adequate and appropriate infrastructure to accommodate and sustain research; that is, to provide a suitable 'research environment'. The Government's position is that institutions should take such undertakings seriously. The allocation of infrastructure funds, from any source, is entirely a matter for institutional administrators (Government response, p. 10).

An NBEET report on *Higher Education Research Infrastructure* noted that the Boston Consulting Group's survey of higher education institutions indicated that, due to the expanding research activity of the higher education system, institutions are finding the provision of research infrastructure increasingly difficult to fund and as a result research infrastructure is coming under increasing pressure (NBEET 1993a, p. 4). NBEET recommended that:

> Commonwealth funding for research infrastructure be increased by $125 million per annum (37 per cent) (NBEET 1993a, p. 3).

This recommendation was supported by the Senate Committee report. However, the Government rejected this recommendation arguing:

> ... it was based on the arbitrary benchmark of 1987 funding levels, and on universities' own reporting of their infrastructure needs. There is no current, objective inventory of institutions' infrastructure that indicates its condition and use. However, DEET agrees that the widespread concern about deficiencies in research infrastructure needs to be addressed and is exploring options in this regard (Government response, p. 5).

These concerns have a number of dimensions

There is a number of possible areas of concern about the provision of infrastructure in universities, but not all of them fall within the scope of this inquiry.

One concern is that the university system receives insufficient resources in total and is unable to fund infrastructure along with other requirements. Another form of this concern is that due to the reduction in block grants relative to competitive funding, universities which have been less successful in winning selective grants have insufficient resources. Those questions relate to the overall level of funding of the university system and are beyond the scope of this inquiry.

A different concern is that the growth in funding given by way of selective grants, especially the large grants program, has produced a situation in which too much pressure is being put by recipients of grants on infrastructure obtained from other sources (for example, that funded through the operating grant). This is a structural question to do with the way in which competitive research funds are provided and the balance between funds for infrastructure and those for other purposes and is directly related to the issues in this inquiry.

How is infrastructure provided to support competitive grants?

ARC programs which fund projects and institutions usually do so on the assumption that infrastructure will be provided from sources other than the immediate grant:

> In each of these programs ... salaries for the principal research workers (academic staff involved in teaching and research), the primary laboratory facilities and support facilities of the institution are assumed to be funded through the operating grant from the Commonwealth to the higher education system (DEET 1989, p. 87).

Until 1995, funding for research infrastructure was provided through ARC infrastructure mechanisms A, B and C. Costs funded through this program include: non-capital aspects of facilities, such as libraries, computing centres and animal houses; equipment purchases, installation and maintenance; and salaries of research support staff (including research assistants and technicians).

Elements not regarded as research infrastructure under these mechanisms include: capital works; salaries of teaching and research staff (including the cost of ‘buying time’ to free such staff to do more research); postgraduate research student stipends; and travel costs directly associated with individual projects (DEET 1994a, pp. 5–6).

From 1996, research infrastructure costs will be met under the Research Infrastructure (Block Grants) Program. The ARC will also provide some funding for infrastructure for collaborative proposals under its Research Infrastructure (Equipment and Facilities) Program.

Options for infrastructure support

Currently the ARC obtains substantial leverage on the research program in universities by funding only the additional costs of projects proposed by researchers who often already have access to research resources (including funding for their own time). This is apparently consistent with its role in creating a university system in which the best researchers obtain additional resources in order better to fulfil their researching role, and through good research, possibly better fulfilling their teaching role as well.

There are alternative ways in which the ARC could proceed, however, and it is helpful to consider what the consequences of adopting them would be for the overall objectives for the university system.

If the ARC were to increase its support for infrastructure associated with grants, it could do so in a number of different ways. An important distinction in considering this is between:

- project-specific infrastructure which is defined as relating to the needs of a particular project, such as equipment required for that project; and
- deep infrastructure which is not specific to individual projects but which is required if any research is to be undertaken, for example, research libraries, adequate computing facilities, ‘well found’ laboratories and so on (NBEET 1993a, p. 3).

One option would be for the ARC to increase its grants to include an allowance for all costs attributable to the project, including deep infrastructure. Assuming total funding for the university system is unchanged, this might imply that funding through the ARC’s programs for infrastructure support (excluding the Research Quantum) would be reduced, or the operating grant reduced.

A second option which provides a middle way between the status quo and the provision of all infrastructure is to fund just part of the infrastructure. That is, to fund costs directly attributable to projects but not the deep infrastructure costs. In this context this may mean, for example, that the ARC would meet the costs of all equipment required, implicit rental charges of laboratories and other accommodation, and where practicable the costs of the chief investigator’s salary.

Both options would allow researchers rather than university administrations to get direct access to a larger amount of funding for research (although in different amounts under each option). As NBEET noted, such arrangements would ensure that funds get down to the 'grass roots' researcher and it would cut out some administration costs associated with allocating the funds (NBEET 1993a, p. 53).

However, if university administrations were slow to claw-back funds that they would otherwise supply from their block grants to those researchers, there is a danger of recipients of those grants being overfunded. As NBEET noted:

> Allocating directly to the researcher removes the ability and the incentive for the department, centre or institution to establish centralised facilities and resources to be shared efficiently by several researchers and teams. Funding direct to the researcher would be likely to result in the uncoordinated duplication of resources and spiralling costs. The institution survey showed that the need for increased pooling and sharing of resources caused by the scarcity of funds had in many cases resulted in efficiency and productivity gains (NBEET 1993a, p. 53).

There is a clear funding dilemma here. If money goes first to the researchers who win fully costed ARC grants there is danger that some resources will be used less than effectively in their labs because universities in effect also fund them in distributing their block funding. But if money goes first to university administrations in the form of larger operating grants and ARC infrastructure grants, the best researchers may be allocated insufficient amounts to make viable bids for ARC funds.

The issue is not clear cut and there are good arguments on both sides. ASTEC concluded in 1991 that:

> ... the current arrangements for financing research in the higher education sector through a mix of operating funds and competitive grants are generally appropriate, but research councils should adopt greater responsibility for maintaining infrastructure (ASTEC 1991a, p. 3).

However, the Government, in responding to SSCEET (1994), indicated that it considers:

> ... allocating infrastructure separately enhances institutional capacity to manage resources flexibly and effectively (Government Response, p. 10).

In the draft report the Commission concluded that, on balance, it favoured the second option (that is, to fund all the direct costs but not deep infrastructure) as a first step. It considered that this would allow resources to flow to the best researchers while limiting potential double funding of those researchers who were already benefiting from university funding. The Commission observed that if this partial move proved to be successful in better accommodating the best researchers, and wastage were avoided, further increases in the scope of competitive grants could be examined in the future.

The Commission proposed that these costs should be met, in the first instance, from the ARC's other programs.

The Commission then sought comment on how practicable it would be to include the costs of the chief investigator's salary in direct costs and secondly, what scope there is eventually to move to including deep infrastructure costs in competitive funding.

Participants' responses

In broad terms, universities were opposed to suggestions that funding in grants be extended to include infrastructure and principal investigator's salary. They observed that in a situation in which total funding for research was not increased, the reallocation of funds to provide infrastructure support would mean cuts in (usually discretionary) funding elsewhere. Such cuts would imply a diminution in institutional autonomy. The University of South Australia said that it:

> ... does not support the recommendation that the ARC fund the direct costs of projects it funds by reduction in ARC infrastructure programs or the Research Quantum. Two previous government reports have found a shortfall of $125 million pa (1993 dollars) in university research infrastructure. To take funding from existing infrastructure programs or the Research Quantum will continue to erode the capacity of the UNS to undertake broad spectrum high quality research (Sub. 286, p. 2).

However, responses on the possible inclusion of individual elements of expenditure on research projects varied to some extent with the type of infrastructure under discussion.

Physical infrastructure

If a payment for physical infrastructure was included in grants, large facilities that are shared among a number of researchers or shared between teaching and research could in principle be treated like assets hired from the university. An implicit rental charge for their services could be included in grant amounts.

Most institutions were opposed to including a component for physical infrastructure in grants. Many said that in planning for investments in infrastructure, it was too uncertain to have to rely on a series of grants. Moreover, this type of investment was difficult to attribute to specific research projects because of its joint use characteristics. As a result, the inclusion of infrastructure in grants would be administratively expensive. Melbourne

University said:

> ... you have to be able to engage in long-term planning — for example, for libraries ... the University of Melbourne is one of the major library-holding resources in the country and it's not confined to use by the University of Melbourne ... There would also be the tension with researchers who would really wish to spend the money by and large directly on their own projects rather than upgrading fume cupboards, basically putting in communication networks — the information technology, electronic mail-type Internet — servicing those things. They all underpin research, and some of them underpin teaching as well. It's very hard to differentiate in those areas (DR transcript, pp. 2769–70).

The AVCC was even stronger:

> ... there is a 'social overhead' capital associated with the conduct of research that project or program funding <u>can never provide</u>. That is the 'deep' infrastructure and covers non-project specific support for equipment and laboratories, libraries, administrative and technical support. Therefore the AVCC argues that it is not possible to tag research project grants with funding for 'deep' infrastructure. Such a move would increase considerably the costs of administrating the research grants for both ARC and NHMRC and the universities. Each grant would need to have a proportion shaved off the top to contribute towards the libraries, power, gas workshops, animal houses, other central facilities and other items which are provided though the RQ (Sub. 358, p. 4, emphasis in original).

A major objection was to increased administration costs. If universities have to finance large infrastructure installations from a large number of future grants rather than from large discretionary grants as at present there would be more uncertainty and paperwork. This would apply not only in the universities, but also in the grant giving organisations. The University of WA said it:

> ... is concerned that the Commission's suggestions that more infrastructure costs should be directly associated with project grants will increase considerable the costs of administering research schemes for both ARC and NHMRC and the universities (Sub. 278, p. 8).

Similarly, the University of Melbourne argued:

> We in the University would have, say, a thousand research grants or so operational, recognising the size of the University of Melbourne. It would mean my office of the office of the dean would have to in effect engage in negotiations on every single grant potentially. In that sense we mean it would be inefficient (DR transcript, p. 2771).

Another consideration was that much infrastructure is also used jointly for teaching and research. Some participants pointed out that it is not obvious that it should be provided through research funding rather than funding which is provided for teaching as well. Universities considered themselves to be in the best position to allocate resources between teaching and research and make the decisions necessary to achieve optimal utilisation. At the draft report hearings the AVCC said:

> ... there are a number of infrastructure costs across the universities — the library, the laboratories, the researchers themselves — where there is a flow backwards and forwards between teaching and research. It's awfully important to keep that going. So the extent to which direct costs are funded I think has to be a definition left to a large degree to the universities (DR transcript, p. 3095).

Principal investigator's salary

The question of the salary of the principal investigator involves somewhat different considerations to physical infrastructure.

First, unlike infrastructure, it buys a service (a researcher's time) which does not usually serve two purposes at once. Notwithstanding that research is useful in teaching, particularly postgraduate teaching, there is a core of time which must be spent by the principal researcher in research to the exclusion of other activities. It is this that could be financed as part of grants.

Second, there would be fewer new administrative expenses created by the inclusion of these costs in grants than in the case of physical infrastructure. With infrastructure, installations would have had to be planned on the basis of anticipated grants and individual grants docked to finance them. In the case of salaries, there may be scope for university salaries to researchers to be reduced for the duration of grants and the salary budget allocated elsewhere.

University planning processes may be complicated if an unexpected lack of success in winning grants meant that universities could find themselves temporarily overstaffed. That would imply that they had employed more people on the basis of expectations of grants than was justified by the outcome in grants applications. But with reasonable planning, this could be overcome through natural wastage or temporary diversion of funds devoted to non-salary expenditures.

If the principal investigator's salary was included in grants, funding for it would have to come from elsewhere, possibly the operating grant. Monash University said:

> Estimates of the proportion of all academic salary which should be imputed to research are very unreliable, but range from around one quarter to one third. Grant supported academics indicate they devote between one and three fifths of their time to externally funded projects. If the Industry Commission's suggestion were implemented, even restricted to projects whose non-salary costs lie in the currently supported ranges, it would still very greatly decrease the amount of research which could be supported with the resources currently available to the Australian Research Council and National Health and Medical Research Council, etc. It could only be generally implemented if there were a major shift in from operating grant to central competitive allocation. Neither of these options is attractive (Sub. 330, p. 7).

Over the whole system, this would have the desirable effect of concentrating available research resources in the competitive grants, thus channelling the limited research funds to the best researchers.

Other advantages are that it would permit researchers who were good enough to consistently win grants to devote more of their time to research. Such specialisation could be to the university's advantage in enhancing its research reputation, although the process would have to be managed properly.

But a reduction in the operating grant would have the effect of reducing that amount of funding which is available to be spread over all institutions, and which is currently divided among them largely on the basis of teaching load. The net effect on university research would be unclear. In effect, this would put pressure on staff in those institutions which were less successful in winning ARC grants to do more teaching and less research. However, the AVCC pointed out a potential danger in:

> ... the possible impact on the overall teaching capability of universities if the granting bodies were to fund the salaries of chief investigators. Implicit in this proposal is that these researchers would be 'freed' from their teaching duties. The involvement of such people in teaching and research training is a crucial feature of universities and the way they operate (Sub. 358, p. 4).

The ARC said:

> Provision for a chief investigator's salary in the project grant (as is done by the US National Science Foundation, for example) has the advantage, recognised by Council in its advice on The Strategic Role of Academic Research, of enabling Government through its agencies to more directly influence universities' research activities by breaking the nexus with staff numbers determined by student enrolments. It would however, require a major change in the industrial relations context (Sub. 361, pp. 9–10).

Another consideration here is how cuts in operating grants would be shared out within universities. Large grants tend to go mainly to researchers in the natural sciences and similar disciplines with large equipment and infrastructure demands. It is possible that if teaching loads on staff not receiving research grants had to increase that they would increase across the board in institutions and squeeze research time by high quality researchers in other disciplines such as the humanities. For example Monash University said the change:

> ... would involve a very radical change in the way university research is supported. Present arrangements mean that availability of competitive grants drives much of the research which has relatively high non-salary direct costs (chiefly the natural sciences, medicine and engineering), and has comparatively little influence upon research which has relatively low non-salary direct cost (chiefly the humanities and social sciences). Salary, however, is by far the largest cost component all research, regardless of field (Sub. 330, p. 7).

This could be compensated for by the ARC also funding these other disciplines. However, this could itself involve higher administrative costs relative to the current institution-based funding system.

Assessment

The comments made by participants were particularly useful in drawing attention to the costs that would be involved in including physical infrastructure components in large grants. The Commission finds these persuasive in many respects.

It is relevant also that the Commission has in this report recommended that the Research Quantum not be made available for purposes such as augmenting grants in the Large Grants Scheme. This reduces the possible sources of funds for infrastructure financing from within the ARC, relative to the situation envisaged in the draft report.

The Commission therefore does not consider, on balance, that shared infrastructure should be financed by a component of grants within the Large Grant Scheme. Perhaps the most telling argument is the administrative costs associated with financing major assets with many small payments from grants received by a large number of researchers.

Although the Commission is attracted to the idea of including the principal investigator's salary in grants, it is not convinced that the consequences in practice would justify the substantial changes involved. It is particularly concerned about the implications of any reductions in operating grants, which may place unreasonable constraints on research undertaken by researchers in disciplines which do not usually benefit from the Large Grants Program.

Consulting

Similar issues arise when considering research which is sponsored by those outside the university system. The University of Sydney summarised the issue as follows:

> Universities have been under considerable pressure from academic staff and from government and industry to participate more in applied R&D projects. The desire to offer consulting and contract research services has led to strong pressure from staff to accept opportunities without covering the full cost of providing the service; frequently tension on the level of overheads develops between the office, or university company, responsible for administering commercial agreements and staff (Sub. 87, p. 7).

It added:

> Government and industry also seek to eliminate or minimise overheads charged by universities; Commonwealth government agencies in particular often refuse to permit any overheads. Industry may argue for small or no overheads on the grounds that they pay high taxes! Estimates using information supplied by the AVCC suggest overheads should be 60 to 70% over direct costs and not 30 to 40% as is commonly charged to industry ... Universities are therefore not recovering full costs on much of their applied research (p. 7).

A number of recent reports (CCST 1992, ASTEC 1991a) have considered the issue of consulting within the context of higher education infrastructure funding. These reports have recommended that, for research undertaken through contracts or where there is an expectation of a product of commercial importance to the funder, then the funder should meet the total (direct and indirect) costs.

The ASTEC report found that research commissioned by industry or Government which was not priced to recover at least full-costs is in effect being subsidised by higher education institutions and as such adds to the pressure on research infrastructure (ASTEC 1991a, p. 18).

The CCST report concluded that higher education institutions had a responsibility as both performers and funders of research to distinguish between grants and contracted research as this affected the provision of infrastructure. It said:

> The higher education institutions should adjust their internal priorities as necessary through processes of research management planning, proper identification of the costs of research, and accurate financial reporting. Funders need to recognise their responsibilities towards providing for the infrastructure costs, according to the type of support they provide and the sharing of the benefits of the research (CCST 1992, p. 5).

Unless outside funders meet the full costs of research which is done for private benefit, a number of distortions in funding can occur:

- universities may attract research business which would be more efficiently performed by the contractor itself, the CSIRO or by other full cost research contractors such as private research firms; and
- researchers in universities may forego research with higher public benefits to undertake subsidised private research.

However, there are two practical considerations. First, it is also possible that some research for outside customers is genuinely able to be performed in universities without putting any additional demands on some infrastructure, especially deep infrastructure. Second, similar questions arise here (as for ARC project funding) about how funds paid to researchers for university faculties might practically be transferred to the university itself to prevent double funding of researchers. These imply that a sensible course may often involve a middle course between full charging and substantial cross-subsidisation from resources provided publicly for research in general.

In comment on the draft report, the University of Technology Sydney argued that full charging was easier for some infrastructure than others:

> There would seem to be little impediment to contract/consultancy research to be funded on the basis of full cost recovery. Deep infrastructure costs can (and commonly are) charged in a time or per sample basis where major equipment is involved, with the charges reflecting capital outlay, machine life, maintenance costs, consumables, data processing and operator time. Charges for the use of infrastructure such as libraries during consultancies is more difficult to address (Sub. 430, p. 4).

On another level, not all research is only of benefit to the customer. Sometimes it is also of value to the institution. The ARC said:

> Council suggests that the Commission's view [in the draft report] that full project-specific costs should be recovered by institutions when contract research is undertaken, should be modified to allow for the fact that much of this type of research has beneficial effects on the academic work of the institution (for example, by enabling students to undertake industry-related projects); in these circumstances, some discounting of the total cost may be appropriate (Sub. 361, p. 10).

The Commission considers that where research is undertaken on a contract or consultancy basis, or where the funder of the research has a commercial interest in the results, then higher education institutions should charge, at least, for the full direct cost of research. Direct cost in this context would include project-specific infrastructure costs but not the deep infrastructure costs.

The Commission does, however, accept that at times a university might wish to discount the cost, where there are demonstrable benefits for the institution's teaching or research program.

C5.2 Funding for the Institute of Advanced Studies

A brief history of the IAS

When the ANU was established in 1946, it was to be a completely research-oriented university without undergraduate facilities. Its charter was to undertake:

> ... postgraduate research and study, both generally and in relation to subjects of national importance to Australia (ANU 1993a, p. 19).

The ANU summarised the philosophy behind its establishment as follows:

> It was established in 1946 by government in the post-reconstruction period after World War II, in recognition I believe that Australia was very much in danger of being isolated from the rest of the world. We realised that we knew very little indeed about our neighbours in the Asia and Pacific area but we were also aware that we were no longer major participants in science. Not only that, we still had not the capability only 50 years ago to provide research training. No university in Australia was actually able to award the PhD degree. So there was a specific mission for the Institute of Advanced Studies and that was to engage in fundamental research at the highest international levels ... it really was deliberate government policy (DR transcript, p. 3279).

In 1960, teaching facilities were added through amalgamation with the Canberra University College. This resulted in a university with two distinct parts: the Institute of Advanced Studies (IAS), comprising the research schools with research and graduate training responsibilities; and the School of General Studies (now known as the Faculties), comprising faculties with undergraduate and graduate teaching and research responsibilities.

A review of the IAS in 1990 noted that the Institute’s main original role was to provide training of students for the Doctor of Philosophy degree, to attract back Australian researchers who had achieved distinction overseas, to give Australia a high reputation in the international research world and to raise research standards in the State universities (Stephen 1990, p. 12).

The report noted that the state of Australian higher education has changed significantly since the establishment of the ANU. By 1987, prior to the establishment of the Unified National System, the original six State universities had grown to 20, part of a total of 65 tertiary institutions. In a number of these, research and study of very high quality was (and still is) being undertaken, much of it fundamental research, of a long-term and high risk nature similar to that for which the IAS was originally founded and is still funded (Stephen 1990, p. 1).

The Stephen Committee also noted that while the Institute was a major producer of PhDs in its early decades, it was no longer dominant in Australia in PhD education. It noted for example that in 1989 the ANU had only 6 per cent of the nation’s PhD students. The Committee found that: ‘In postgraduate education the Institute is an under-utilised resource’. It concluded that ‘Doctoral training must be re-established as a key part of the IAS mission’ (Stephen 1990, pp. 39–40).

At the draft report hearings, the ANU noted that the role of the IAS was recently reaffirmed by the Minister for Employment, Education and Training, who said that:

> The Government recognises that the Institute, as a major performer of research, should be a resource for the higher education system and for the Australian research sector as a whole and that this national role also has an international dimension (cited in DR transcript, p. 3279–80).

Although the role of the IAS has changed somewhat due to changes in the higher education system, the Commission has no difficulties with the idea of having one or more research-only institutions in Australia. In some other countries, the advantages of separately-funded basic research organisations are taken for granted — the Max Planck Institute in Germany is an obvious example (see box C5.1). Nevertheless, this still leaves unanswered questions about how such institutions are best organised and funded.

Funding arrangements and contestability

Funding for the IAS is currently provided as part of the ANU's operating grant. It is not provided through a contestable mechanism whereby funding would be subject to possible reallocation to other Institutes or researchers outside of the ANU if they demonstrated a capability for using the funds more effectively.

The value of contestability is explained in greater detail in part A of this report. There the Commission argues that where practicable, funding should potentially be open to all researchers who could do the job, rather than being reserved for particular groups.

This is not to deny that in some cases researchers need certainty of funding to pursue long-term research with slow payoffs. However, funding can be provided in a way that supports institutions or long-term programs but leaves open the possibility of such funding being allocated elsewhere after a fixed term.

When the IAS was reviewed by the Stephen Committee (1990), the question of contestability was an important issue. The review considered the possibility of setting the Institute's block grant at, say, 90 per cent of its present level, and adding a sum equal to the remaining 10 per cent to the resources allocated by the ARC. This, the review noted, would free Institute researchers to compete for ARC funds (currently they are excluded from ARC funding), with competition determining whether the amount won in open competition was more or less than the 10 per cent forgone from the block grant.

This proposal was said to hold some attraction as it would provide an incentive for the Institute to maximise its performance level and would also help satisfy researchers elsewhere that the Institute does not enjoy an unfair advantage in funding.

Despite these arguments in favour of the proposal, the review dismissed it on four grounds (see box C5.2).

Box: C5.1: **Max Planck Gesellschaft**

The predecessor to the Max Planck Gesellschaft (MPG) was established in 1911 because there was an obvious gap in research in natural science in Germany compared with other European countries and the US caused by the lack of non-university research institutions. Adolf Von Harnack the originator of the Gesellschaft said that such institutes are, in addition to existing academies and universities, a prerequisite for comprehensive and reliable scientific activity.

He argued that requirements for instruction and training were always in the foreground at universities. There were, however, tasks which could only be completed if researchers were in a position to devote themselves solely to them over the years. And there was experimental research which, for universities would not yet yield fruitful results. Scientists with a special talent for research should be relieved of teaching obligations and be supplied with sufficient means for carrying out their research.

Founded in 1948, the MPG is an autonomous scientific organisation in the legal form of a registered society. Its research activities are closely linked to the universities and its leading scientists are generally recruited from universities. It spends about 80 per cent of its funds on the natural sciences. There are about 63 facilities including 57 institutes and a number of research groups, throughout Federal Republic of Germany. Another five are in the process of being established.

The MPG tries to take up promising new fields of research which cannot adequately be pursued at universities due either to their interdisciplinary character which does not fit into the organisational framework of universities, or to the fact that they require equipment which is so expensive that it can be neither provided nor maintained by universities. Funding comes largely from Federal and State governments.

Almost all Max Planck Institutes are divided into several departments or subinstitutes each headed by a scientific member (or director). Scientists who are appointed to leading positions at Max Planck Institutes are, as a matter of principle, totally unrestricted with respect to the choice, order of sequence and execution of their scientific work.

The MPG has a staff of almost 11 000 employees, including 3000 scientists (almost 40 per cent of them from abroad) who work at Max Planck Institutes each year for six and a half months on average.

Advisory boards assist the MPG’s Institutes in defining the objectives of their research and in carrying out their work. These boards are comprised of renowned German and foreign scientists. In addition, the boards assess the importance and success of the respective institute in regular reports submitted to the president of the MPG.

Source: MPG 1993.

Box C5.2: **Stephen Review arguments against 10 per cent proposal**

First, it argued that for the proposal to achieve its objectives, the least meritorious of the Institute's projects would have to be subjected to the competitive process. This meant that those projects would have to be identified. The Committee considered that it was difficult to see how this requirement could be satisfied if only a fraction of the Institute's activities were externally appraised.

Second, the review did not consider that the ARC's criteria for assessing projects should necessarily apply to Institute projects. There may, it argued, be differences in the levels of priority accorded to long-term and shorter-term objectives and it may be appropriate to take into account the interrelations between the various activities encompassed by the Institute.

Third, a plurality of sources of research funding was considered to be of value so that different perspectives could be brought to bear on the merits of different areas of inquiry .

Finally, the review considered that, as its stated view was that there should be contestability within the Institute, and that this was expected to be facilitated by the recently adopted approach to strategic planning, there was merit in allowing time for the effectiveness of the strategic planning to be tested before adopting an alternative allocation structure.

Source: Stephen 1990, p. 44.

However, some of these arguments are not compelling. For example, under a clawback proposal it may well be that the best researchers, not the 'least meritorious', seek out external funding, and that the remainder would be funded from within the IAS. And while the Commission agrees that plurality of sources of funding is important (and discusses the diversity principle at length in part A), it does not see greater contestability for IAS funding as compromising this. Indeed, it should increase the funding options available to researchers both inside and outside the IAS.

Although the Stephen Committee rejected this particular form of contestability, the Government endorsed the need for contestability of some kind. In his Statement responding to the Stephen Review, the Minister for Higher Education and Employment Services, Mr Baldwin, said:

> ... given the increased competition for research funding in Australia's higher education system, the Government believes that it is unacceptable to continue to fund the Institute on the present basis, with essentially no linkage of funding to assessments of performance (27 March, 1991b, p. 3).

His apparent intentions were reported by the Senate Standing Committee on Employment, Education and Training in its report on *The John Curtin School of*

Medical Research, which said that:

> What is clear is that it was the Minister's intention, at the time of 27 March statement, to subject *all* the Schools of the Institute of Advanced Studies (not only the John Curtin School) to outside review of their work and funding levels. Schools remaining in the Institute would be assessed separately for funding every five years by ARC-appointed review teams. While these Schools would stay together, total funding for the Institute would be determined as an aggregation of the separate funding amounts allocated to the Schools. Schools that were judged to be not performing would have their funding withdrawn and the monies allocated competitively through the ARC (SSCEET 1992, pp. 72–3).

In the event, the decision was taken to have a more restricted series of reviews of the schools of the IAS. In the case of schools other than the John Curtin School of Medical Research:

> ... reviews would be conducted as a joint ARC-ANU exercise and would only include members jointly agreed upon, and the ARC would not involve itself in any way in the internal allocation of funds to individual Schools within the Institute (SSCEET 1992, p. 81).

Reviews arising out of this process are currently underway.

Currently, the IAS is unable to compete for funding from ARC programs. This has raised concern among some IAS researchers. For example, the decision by the ARC to exclude IAS researchers from some of its Senior Research Fellowship Awards is reported to have prompted the Director of the Research School of Biological Science to state (in a speech) that:

> The ARC recognises that this decision flies in the face of Mr Dawkins' 1989 statement on research in Australia, that 'funds should go to those institutions, research groups and individuals best able to make the most effective use of them'. The best researchers naturally gravitate to what they perceive to be the most golden opportunities; opportunities usually measured in terms of intellectual and physical resources. Thus the ARC has denied individual justice to some of the most promising researchers seeking to consolidate their careers in Australia through research in the Institute (ANU 1993a, pp. 22–3).

He added:

> The ARC seems to have a clear agenda to hamstring the Institute of Advanced Studies. It knows that the attrition of budgets in the Institute, like those of all other universities, forces us to compete for external support. The Institute simply cannot fulfil its mission if it is systematically excluded from competition which sustain its sole activity, excellence in research, and which in the process serve to demonstrate that excellence (p. 23).

However, the IAS is not excluded from all national competitive grants. At the draft report hearing, the ANU said:

> ... 20 per cent of our money comes from other than the block grant ... we have access to other national competitive grants such as the Heart Foundation and Juvenile Diabetes ... We still have people out there competing because as I mentioned their support is minimal as that drawn from the block grant. But that enables them to have a long-term view of what they're going to do with that component and still give them the platform for competing for national competitive grants and international competitive grants (DR transcript, pp. 3293–4).

The Commission's proposal in the draft report

In its draft report, the Commission discussed how some contestability of IAS funding might be introduced.

In its view, the principle of contestability could be applied not only to funds going to the IAS but also to the scope for IAS researchers to compete for other research grants. The Commission argued specifically that consideration should be given to allowing some proportion of the Institute's funding to be competed for by the broader university sector and by allowing researchers in the IAS to compete for ARC funding.

The ANU challenged this proposal vigorously. It argued that internal competition was already fierce for researchers at the IAS:

> Research, including basic research, is underpinned by competition: competition for appointment to prestigious institutions, for tenured positions (quota of 30% in the Institute of Advance Studies), for promotion to professorship (annual quota of 5% of the professoriate in the Institute) ... (Sub. 351, p. 9).

It also argued that some of the Institute's funds are reallocated through an internal competitive bidding process through the Strategic Development Fund. This is funded by a 2 per cent levy on the Schools and Centres of the Institute (Sub 351, attachment C).

Evidence of strong competition within an institution says nothing, however, about whether the institution thereby produces better research than that conducted elsewhere. In that sense therefore there can be a continuing role for external contestability even where internal mechanisms for competition are strong.

In looking at performance, the ANU also argued that the onus was on the Commission to find convincing evidence of poor performance before recommending changes to funding arrangements:

> The Commission professes to be unable to judge the relative quality of research produced in the Institute (and JCSMR in particular) relative to that produced by other research groups funded by the ARC and NHMRC. Yet its recommendations imply an

> assumption that the ARC/NHMRC process is superior. In practice, this question can only be determined by a comparison of research output. The Commission correctly judges itself to be unqualified to perform this comparison (Sub. 351, p. 17).

This criticism would indeed have been valid had the Commission recommended, without analysis of performance, that funding for the IAS be reduced. But the Commission did not do this. Rather it recommended that consideration be given to having a process set up by which the performance of the IAS might be regularly compared with research undertaken elsewhere. In the course of this process, the funding allocated would depend on actual performance, not the judgments of the Commission.

Third, the ANU argued that IAS researchers already face strong external, as well as internal, competition:

> ... for publication in the best international journals or by leading publishing houses, for recruitment of the best research students, for invitations to speak at major international conferences and for membership of learned academies (Sub. 351, p. 9).

It added that objective measures indicated that its research performance relative to other institutions was, in fact, very strong. It argued that the ANU contributes about 10 per cent of Australia’s scientific papers on less than 5 per cent of the Commonwealth’s direct R&D funding (Sub. 351, p. 6). Attachment B of the ANU’s submission shows indicators of per capita publication rates at different institutions. The IAS has a rate considerably higher than the other institutions. What such data cannot provide, however, are indications of the relative value for money across institutions, given that the research funding input per staff member varies among them. This is particularly important in considering the IAS where, unlike other higher education institutions, research is a full-time activity.

Fourth, the ANU raised a number of concerns over the Commission’s proposal to introduce contestability in IAS funding. It argued that research supported through contestable funding mechanisms differed from that supported through longer-term block funding. That is, committees allocating contestable funds tend to focus on a particular sort of research which is not fundamental to the basic research fabric. It noted that block funding leads to decisions about what research is to be done being made close to the researchers and that contestability involves five or six experts making judgments rather than the university. It considered that diversity in funding mechanisms was important. It said:

> ... if we maintain diversity of funding mechanisms and of management practices then we have a diversity of the type of research that is done. There’s absolutely no doubt in my mind that the sort of research that one does with 3-year funded project grants ... is quite different from the fundamental, long-term research that one does with block funding. So I believe that the type of research that is done is critically dependent on the

> funding mechanism. That's why I believe we should have diversity in that area (DR transcript, pp. 3290–1).

It added:

> ... when you look at what you call contestable or competitive funding, it very, very well supports work which is built around the paradigm. It does this for two reasons. Firstly, the peers that are doing the reviewing are selected because they support the paradigm. That is how I have been on review committees in the United States. You get on because you're in with the paradigm. That is the problem with a peer reviewed system — it's not the problem, it's the deficiency. That's where you need another form of funding. The block funding in this country is a way of getting around that; having the long-term funding where individuals are not given an enormous amount of resources but they are given some resources to go out and test the paradigm (DR transcript, p. 3294).

The Commission sees important benefits in maintaining a diversity of funding mechanisms, and is not suggesting that all funding be provided through short-term project grants. It has noted in earlier sections of this report its support for longer-term block funding mechanisms as one of a number of funding options. While the allocation process for block grants may indeed involve a panel of experts, once the university obtains a block grant it has control over how the funds are then allocated to researchers or research programs. Long-term fundamental research need not be precluded by providing block funding in a contestable manner.

Opinions vary on the extent to which research at the IAS differs in character from that performed elsewhere. In his statement following the Stephen Review, the Minister said that:

> ... the extent and management of research had changed dramatically since the inception of the IAS. Nowadays, strength in research was to be found not only in the IAS but in universities throughout the country ... much of the research in the IAS was no longer very different in nature from other research that was project funded (quoted in SSCEET 1992, p. 72).

Finally, the ANU argued that in a small country such as Australia, there was a need to establish an institution of sufficient size to reap economies of scale:

> The assumption (p. A.129) that similar research can be done by a range of researchers in a range of organisational settings is manifestly incorrect. It ignores the reality of the Australian situation where the small population means that resources are inevitably spread thinly unless there is a commitment to centres of excellence ... There are undoubtably excellent research groups and individuals throughout Australia, but the [IC] evinces no understanding of the organisational 'critical mass' required in order to achieve an excellent community of diverse researchers with major benefits from synergy (Sub. 351, pp. 15–6).

It added:

> ... Spreading resources thinly will expand the range of active research groups, but restrict the 'depth' of their activities. It is the 'depth' of research which creates the standards of scientific excellence necessary to participate in the international research community and provides the necessary inputs into world-leading industrial, environmental and medical organisations (p. 16).

On this point it is relevant that many overseas block funded institutions (including the Max Planck Institutes) actually comprise many geographically separate centres. More generally, the issue of 'critical mass' has been much-debated, and its importance varies among areas of research (see NBEET 1993c).

A number of participants supported the general notion of introducing some element of contestability or review into IAS funding, arguing that there were disadvantages with the current IAS funding arrangements. Monash University said:

> Block funding through institutional grants can be defended on a number of grounds, some of which are articulated in [the draft report]. All the same, there are disadvantages — prime amongst which is the danger that researchers in block funded entities, because they do not have to compete for funds with those working outside, are not aware of how competitive or otherwise their work is. In open competition, it seems reasonable to suppose that the [IAS] would gain additional funds in some fields whilst in others funds would move to other institutions. It would be helpful to the higher education system as a whole for these institutions to be tested regularly (Sub. 330, p. 3).

It added:

> The remainder of the system is well aware of its relative performance, either as an institution or by field, compared with the other institutions in the system. We have a pretty exact feel for who does better than us and if we are more effective at raising money or producing publications. The IAS is not in that competition. It's insulated from it by the funding method, so it may well be that they're substantially superior to every other institution but it's not a tested claim really, in a straightforward competitive way (DR transcript, p. 2739).

Obtaining contestability

There are a number of approaches which could be used to increase contestability of funding for the IAS. The Commission has considered two broad options and within these a number of approaches which could be taken.

Transfer of IAS funding?

One option is to attempt to achieve some contestability through transferring some of the block funding of the IAS to competitive schemes, as mooted (and then rejected) by the Stephen Committee. By so increasing the total funds available for direct competition through the large grants scheme (and perhaps other mechanisms), contestability within the research system would be increased.

If block funding were reduced, the IAS could make use of internal review mechanisms to determine those areas which would continue to be block funded. One of the grounds for selection for continued block funding might be whether the research is of a longer-term nature — said to be one of the reasons for instituting the block funding mechanism. By allowing IAS researchers access to competitive grants from elsewhere in the ARC's program, plurality of funding and contestability would be increased within the IAS.

The Commission has considered three possible approaches by which this contestability could be introduced.

The first approach is that proposed by the Stephen Committee, to shift 10 per cent of IAS funds to the ARC and then allow IAS researchers to compete for ARC funds. However, in practical terms such a transfer could, however, lead to a somewhat unsatisfactory contest.

If all of the IAS's researchers could compete for an ARC pool augmented by only 10 per cent of IAS funds, the situation could arise in which 90 per cent of IAS funding was not contestable while fierce competition for ARC funds reduced the funding to high quality research in other universities. Put another way, the best IAS researchers might compete for that proportion that was contestable, while other IAS research was insulated from competition. This conclusion differs somewhat from the Stephen Committee conclusion which was that the best researchers would be funded by the block grant component and the least excellent would have to be identified and would then have to compete.

An alternative but similar approach could be to devise some arrangement in which IAS researchers only competed for some proportion of the (augmented) ARC pool. However, there is a danger that this arrangement could significantly erode the principle of contestability. The ANU commented on the possibility of such limited contests as follows:

> The Commission does not consider the consequences of unleashing the competitive might of 700 full-time researchers on an ARC system which funds teaching and research staff. The proposal that 'researchers at the Institute should be able to compete for ARC funding' is qualified in the text of the draft report to suggest that the Institute could compete only for funds clawed-back from the Institute. This would be an administrative and expensive nightmare (Sub. 351, p. 22).

The University of Melbourne suggested that such transfers of funding had been achieved in the past.

> Australia's other universities have experienced clawback of research funding at several periods during their history. The experience has been that the most able researchers have demonstrated their excellence by gaining research funding within a competitive environment (Sub. 313, p. 6).

But it felt that the proportion of funds contributed by the IAS to the contestable pool should be larger than 10 per cent:

> It would be unreasonable for IAS staff to be eligible to contest more ARC funds than at present, if significant grant funds were not provided to the ARC. The provision of funds for research activities in the future to the IAS partly on a contestable basis has a number of benefits. It will enable the IAS to directly benchmark the quality of its research activities against those of other researchers in Australian universities. It will help to ensure that scarce research funds are targeted to the most able researchers in Australia. It will also encourage researchers when selecting areas for investigation to have regard to the benefits of their research and how the outcomes of their research may interface with national priorities. The proportion of the block grant transferred for competitive bidding should be phased in to at least 30 per cent of present funding (Sub. 313, pp. 6–7).

The difficulty with these proposals is that the IAS appropriation is large relative to the amounts available under competitive grants. Even a transfer of 30 per cent may be subject to problems of dominance by the IAS in competitive grants, with little gain in contestability for the remaining funds of the IAS.

As a third approach, the Commission considered the possibility of shifting the whole of IAS funding to the ARC. Under such an approach, the IAS could be given a minimum block grant to cover certain costs and to fund some discretionary research, with the remainder of its appropriation being added to the various programs administered (and competitively allocated) by the ARC.

In this way, IAS researchers could then compete for funding from all ARC programs (such as project grants, fellowships and centres funding), and researchers from other universities would be able to compete for funding from a larger ARC pool.

This would have a number of desirable features. It would result in greater contestability for IAS funds and help ensure funds were indeed going to the best researchers. Researchers in other universities would be able to compete against each other and against IAS researchers for funding for particular research. (It would also reassure researchers in other institutions that the IAS did not enjoy a privileged position, especially in competing for grants against other researchers.) Equally, IAS researchers would have the opportunity to bid for funding from the various ARC programs, providing some diversity of funding sources for them. And unlike the partial clawback proposals, the scope for IAS researchers to dominate outcomes would be reduced.

Instead of a single institution with autonomy over a large block grant, this proposal would in effect create many smaller centres, albeit themselves largely block funded and with autonomy. This change would be a major one in the eyes of many researchers. It would also constitute a very large change for the ARC — the funds involved would be a large proportion of its budget. There is a question about whether such a significant reorganisation is appropriate at this stage.

Discipline reviews

The question is whether benefits can be generated from introducing some elements of contestability on a smaller scale. The IAS is currently under review. That review will, among other things, give the IAS an opportunity to articulate its broad role in the national and international research context, and to evaluate its research performance. The ARC will use the outcomes of the review to help it formulate advice on research funding for the IAS, to be provided to the Minister for Employment, Education and Training in the development of the 1996-97 Commonwealth budget. The ARC is to provide advice on the total level of funding which should be made available to the Institute as a whole.

One of the functions of the current review being undertaken of the IAS is to consider the performance of the IAS against similar institutions:

> Each school review team will be provided with performance indicator data that compares a particular research school of the IAS with appropriate academic organisational units of the other Australian universities with high productivity in closely related fields and which are comparable in size to that school. For each research school/centre, four university comparators have agreed to participate ... Comparator universities were identified following recommendations of a research project on performance indicators undertaken by Professor Russell Linke; and consultation between the Australian National University and the ARC (ANU & ARC 1994, p. 20).

The issue of reducing the funds of schools which are out-performed by others was raised by Murdoch University which said:

> A substantial case must be made in terms of productivity and international impact to justify the current level of funding. Where Institutes are performing well they should be retained; by contrast those that perform less well than comparable research groupings elsewhere should be integrated into the rest of the ANU with a level of funding comparable with the Faculties. The question has to be asked whether the current system of funding IAS at ANU is the most appropriate use of Australian research funds, or whether over time a devolution of such centres might be more appropriate (Sub. 276, p. 4).

One of the drawbacks to this review process is that the ARC is not able to consider shifting funds from the IAS to areas that may be found to be performing better. Nor is it able to comment on the funding of individual schools.

In the Commission's view, all funding programs supporting research in particular disciplines should be reviewed. At the end of the reviews, panels would be required to make recommendations to government on the balance of funding among different funding mechanisms for the discipline under review. Government could then choose to reallocate funds among ARC programs and institutional funding. Similar reviews were originally proposed by the Minister in his response to the recommendations of the Stephen Review (noted earlier).

Review panels should be selected by the government from nominations suggested by the ARC. (To avoid conflicts of interest, no current member of the ARC would serve on panels.) Different disciplines could be reviewed sequentially, on perhaps a five year cycle. Schools at the IAS would be included in the reviews.

A key element would be to compare the benefits of block funding for different institutions, especially the IAS, but also including the block funds distributed by the ARC. The possibility of widening the scope for block funding of research generally could also be considered. At the draft report hearings, the ARC noted that the IAS's funding represented a significant concentration of research resources in one institution, and suggested that the issue of the concentration of resources should be considered more broadly:

> ... if you were to go down the track of really focusing heavily on the advantages to be gained from block funding — and there are I believe a number of advantages — then it would be sensible, we believe, to do that as a complete package, rather than merely focusing on the [IAS] (DR transcript, p. 3123).

Currently the IAS is funded through the ANU operating grant, and it determines the distribution to individual schools. To bring about successful reviews by discipline it may be necessary for the Government to separately identify and directly fund the Schools within the IAS. Such an innovation would be an extension of the proposal of the Stephen Committee which said that it:

> ... considers it desirable for the Institute to have an identifiable Commonwealth-funded budget to reinforce the need for strategic management of the Institute. This will be particularly so as the budget for The Faculties is likely to be separately derived by the Government following the application of the relative funding formula. The Committee has considered whether the division of the ANU budget between the Institute and the Faculties might cause problems, particularly in the case of common costs. However, after consultation with officers of the University it is confident that there are not likely to be problems such as would cause difficulties for the University or prevent the two lines of the University's grant from corresponding appropriately with the respective responsibilities of the Institute and The Faculties (Stephen 1990, p. 43).

Alternatively, funding recommendations by review panels could be put into effect by simply adding or subtracting the appropriate amounts from the ANU's total budget. The ANU could then itself choose whether to implement the funding changes in the disciplines which had been reviewed or share the changes more widely. This alternative would provide the university with greater autonomy.

Concluding comments

The Commission notes that the structure and terms of reference of the current review is not ideally suited to making recommendations about funding levels. The advantage of the discipline review process suggested by the Commission is that explicit judgments must be made about relative performance which carry with them implications for types of funding and relative funding levels. That is if funding is to be increased or maintained in one area, funding in other areas will be consequentially decreased or not increased. The Commission believes that this constitutes a useful discipline on review panels.

While such an approach does not involve as much contestability as the other options discussed above, it does provide a limited form of contestability through the periodic reviews of discipline research funding in universities, including research undertaken in the IAS.

The Commission recommends that all funding programs supporting research in particular disciplines should be periodically reviewed. Review panels should be required to make recommendations to government on the balance of funding among different funding mechanisms (including the Schools of the IAS) for the discipline under review. Recommendations should refer to the performance of block funding, competitive grants and other schemes relative to each other and the success of each scheme individually in fostering appropriate research. The reviews should also consider the possibility for new arrangements. Members of the review panels should be appointed by the Minister from a list proposed by the ARC, and the ARC should provide the secretariat.

C5.3 Taxing postgraduate students

Recently the Australian Taxation Office has proposed that postgraduate research scholarships and stipends be taxed if the student has 'rendered a service' to the provider of the scholarship.

Section 23 of the *Income Tax Assessment Act* exempts a variety of organisations and funds from ordinary income tax on all their income. Section 23(z) of the

Act provides for specific exemption for all other scholarships, bursaries or other educational allowances (for example, non-Commonwealth technical or secondary scholarships, Commonwealth or other tertiary and postgraduate scholarships).

The student recipient of the grant etc, must be receiving full-time education at a school, college or university. Payments received by a student from an employer or prospective employer 'upon the condition' that the student will, or will if required, render or continue to render services to that person are excluded from the exemption.

The proposed tax ruling defines a scholarship as payment of an amount given primarily for the education of a student. The ruling emphasises that it is the purpose of the provider of the payment which is important, not the use to which the amount is put by the student. The ruling argues that it is not sufficient that there is some educational purpose in the grant where, for example:

> ... the scholarship provider makes the payment to have research on a specific topic carried out but incidentally requires the recipient to be enrolled in a full-time course of education, the payment is not a scholarship.

The tax ruling defines a service to have been rendered if under the terms of the scholarship 'the student is required to undertake activities which may be considered to be of use, help or benefit to the provider'. It is not restricted to employment or employment-related activities. The tax ruling defines 'rendering a service' as including:

- working during or after the term of the scholarship for the provider; or performing work which contributes to the completion of a contract between the scholarship provider and an external body;
- furnishing the scholarship provider with reports or other information beyond the scope of a 'progress report'; or forwarding a final report (other than a progress report) to which the scholarship provider has exclusive access whether absolutely or for a specified period;
- assigning or agreeing to assign to the scholarship provider rights in respect of the intellectual property or exploitable procedures, inventions or products.

At the first round of public hearings, Nucleus said:

> There is now looming a significant conflict in the area of section 23z of the Tax Act, which relates to students who are PhD students and their stipends where if they are involved with co-operative research centres theoretically their stipends are taxable ... (transcript, p. 1036).

The University of Technology, Sydney said:

> ... there is a need for the taxation status of graduate students on scholarships to be clarified; the uncertainty of the past year or two must not continue. We advocate that

> graduate research scholarships up to a pre-determined figure (perhaps $20 000) paid to a student through a university should be tax-free, and that scholarships in excess of the pre-determined figure should be taxed at the marginal rate (Sub. 221, p. 4).

The Council of Australian Postgraduate Associations is reported to have suggested that potential postgraduate students will be reluctant to take up research awards if the ruling comes into force.

At the first round of public hearings the University of Melbourne said:

> ... one of the reasons that the stipend is substantially lower than average weekly earnings is an acknowledgment that in fact that it's not taxable, and so many of these scholarships are 12, 13, 14 000 dollars a year ... the government had conceded as an outcome of the Wilson report back in 1989 that in fact these people were making a very important contribution and the best way of in fact — well, not having to provide more money for scholarships was to ensure that the tax free status was preserved (transcript, p. 522).

Some participants argued that in an attempt to encourage and strengthen collaboration and joint projects between universities and industry, scholarships were to have a tax-free status. Participants argued that attempts by the ATO to tax scholarships is in conflict with other government aims. For example, the University of Melbourne also said:

> It's a little ... ironic because the government through the ARC has established these APRA industry scholarships ... [and] ... the government has declared — when that scheme was launched 4 years ago — that this was an initiative to bring higher education closer to industry and that it would be offering these scholarships, 125 per year at the moment, and they would be tax-free (transcript, pp. 523–4).

In its draft report the Commission argued that the central issue is that when students are working on commercial problems they frequently produce commercially valuable results. This makes them attractive employees for the firm. The Commission said that it is difficult to argue that a research student, working on an applied problem for a firm in a university, is not at least as valuable to that firm as an equivalently qualified researcher who is not a student but in the firm's employ.

The Commission concluded that if firms were remunerating researchers in both cases it is arguable that both should be taxed equally, in order that companies were not encouraged to favour student employees, simply to reduce taxation.

However, the Commission questioned the extent of the distortion produced by current practice, and recommended that if taxation were applied, that student stipends be correspondingly augmented.

In comment on the draft report, many participants reiterated the argument that such scholarships should not be taxed. Some of their comments are in box C5.3.

Box C5.3: **Comments on the taxing of postgraduate scholarships**

The University of New England said:

> ... one of the reasons that stipends for scholarships are substantially lower than the average wage is that it is an acknowledgment that the scholarship is not taxable ... Australian Postgraduate Awards ... constitute the main form of research support and they are intended to support students undertaking research higher degrees especially in areas of pure basic research (Sub. 350, p. 9).

Dr Colin Hansen said that the draft report proposals raised some problems:

> — any income received from part time teaching would exceed the tax threshold and be taxed, making it even more difficult to coerce students to undertake this important training opportunity, but even more importantly reducing the effective income of the students below current levels.
>
> — any income from consulting work that the students undertake in their area of expertise will also be taxed, thus effectively reducing their potential income.
>
> — departments will find it even more difficult to raise funds for additional scholarships, thus resulting in a reduction in postgraduate research students.
>
> The idea of taxing postgraduate students should be resisted in the strongest possible way — it undoubtedly will have the effect of making postgraduate research less attractive and will have a huge negative impact on research undertaken in Universities (Sub. 449, pp. 3–4).

The AVCC said that its preferred option is for a change in the legislation:

> With ... the Government’s policy of more effectively linking public sector research with the private sector ... [taxation] ... presents a disincentive, both to companies to invest in students, and to students to undertake postgraduate studies, thus undermining the broader Government objectives ... the legislation should be changed to align it with the Government’s policies in the areas of education, training, research and development (Sub. 287, p. 8).

The University of Adelaide said:

> Taxing postgraduate students is contrary to the government policies directed to improving links between industry and university research (Sub. 386, p. 3).

Monash University said:

> A significant difficulty arises, however, in relation to scholarships provided by institutions from their own resources ... At present, the Australian Postgraduate Award stipend is just under $15,000 pa, income tax exempt. The Monash Graduate Scholarship is $13,500 pa, also income tax exempt. If the Australian Postgraduate Awards were taxable, and the stipend increased to produce a net zero effect, the Monash Graduate Scholarship stipend would also presumably, become taxable. Unless the University were then to substantially increase its funding for Monash Graduate Scholarships, the differential between the two schemes in terms of the real income they provided would be greatly increased.
>
> ... A further problem arises from the fact that many research students with scholarships supplement their stipend with income from casual teaching and demonstrating in subjects offered by their home departments. This income currently only attracts tax when it exceeds the taxable minimum threshold. Accordingly, even if the net value of taxable stipends were maintained, many students income would still be reduced significantly (Sub. 330, p. 9).

Professor Munch took issue with the idea that students' research work could be compared with that of an employee rendering a service:

> The argument for rendering a service is weak, since a student must publish his or her thesis, making the work available to all. The work cannot be company property and will therefore not be of great specific value to the company. Furthermore, in my experience, a company would never ask a student to solve a problem that was of any great importance, because the company cannot control the schedule, progress or confidentiality of the results.
>
> ... The work performed is primarily for training the student to become a good researcher, but is a very inefficient way for a company to get the job done. A student cannot be compared with an employee and should not be taxed by that argument (Sub. 444, pp. 1–2)

If the company is not buying a service, it would be difficult to maintain the argument that taxation of the scholarship should be different to other scholarships. But if that were so, what would be the motivation for the companies' largesse? Professor Munch said:

> The scholarships enable students to be educated, and by having industrial companies involved, the program ensures that the course of study is relevant, and that the company has an influence on the type of graduates produced. The company does not own the results of the work the student does on the scholarship (Sub. 444, p. 1).

Except in cases in which a company is fostering specific graduates for very specialised work, this would suggest that companies are acting in way which is more for longer-term strategic benefit than immediate profitability. Such behaviour is not uncommon and is seen in such activities as more general sponsorship arrangements. If that is so, it is possible to argue that the services purchased should be taxed in the standard way applicable to those services. In the case of postgraduate awards, this could imply the same tax-free arrangements that apply in other cases.

Thus it is not clear how significant a distortion in employment might be induced were the current tax-free status of students maintained. One test of the extent of private benefit for companies from provision of scholarships might be if competition among companies for good students forced stipends to a level significantly above normal scholarship levels. In that case taxation would be appropriate. However, there is little evidence of this at present.

Certainly, if taxation were introduced, firms offering scholarships would be likely to find it necessary to increase the pre-tax remuneration to attract the same quality of students, although the number offered may be affected. Increased pre-tax remuneration should also hold for scholarships offered by the government which are taxed. Indeed since the scholarships were designed with the idea of offering a given net income, this should be maintained. In the case of government scholarships the change would in effect be revenue neutral — increases in the amount of the scholarship should be designed to completely offset the tax payable.

The presumption that students do render a research service that is in itself valuable to companies, however, may be a mistaken view of current arrangements. If so, such scholarships could remain taxed in the same way as other scholarships (that is, tax free). The Tax Office would, however, need to continue to monitor the conditions under which such scholarships were awarded and the outputs that were produced to ensure that they were not being used as a backdoor method of employment to produce directly profitable research.

But in view of the likely high administrative costs in determining on an individual case basis which students are indeed providing a service to industry (or which component of individual scholarships represented a fee for service), the Commission considers that there are unlikely to be net benefits to the community from taxing postgraduate scholarships.

On balance, the Commission's assessment is that postgraduate scholarships should remain non-taxable. If the ATO nevertheless proceeds to tax the scholarships of postgraduate students deemed to be providing a service to industry, Government scholarship funding should be increased to leave students no worse off.

C6 NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL

C6.1 Introduction

The NHMRC is Australia's peak advisory body on public health, health care, health and medical research and health ethics. It is also a major provider of funding for health research.

The role and operation of the Council was reviewed by Dr Bienenstock in a report presented to the Minister of Health in December 1993.

The Commission has not re-investigated in detail the matters raised by Bienenstock. Instead it has attempted to examine the place of the NHMRC in the overall innovation system and review its role against the principles it has applied to similar bodies in this inquiry.

A key comparison is with the other principal competitive funder of research, the ARC. There are major issues in common and discussion in the previous chapter will form the basis for much of the consideration here.

Although the NHMRC provides a significant proportion of funds for medical research in Australia, there are a number of other funding sources. These include the Commonwealth which provides funds through higher education institution operating grants, through CSIRO and through a number of other programs. Private sources of medical research funds are relatively low in Australia compared to many other countries where charities, voluntary organisations and privately endowed foundations provide substantial funds for research (Bienenstock 1993, p. 28). The Commission has not reviewed these other sources of funds for medical research.

C6.2 How NHMRC operates

The NHMRC is an independent statutory authority with principal functions:

- to inquire into, advise and issue guidelines and to make recommendations on the improvement of health; the prevention, diagnosis and treatment of disease; the provision of health care; public health research and medical research; and ethical issues relating to health; and

- to make recommendations to the Commonwealth on expenditure on public health research and medical research.

The advisory functions are undertaken by three principal Committees:

- the Health Care Committee (HCC);
- the Public Health Committee (PHC); and
- the Australian Health Ethics Committee (AHECS).

The research funding functions are the responsibility of two additional committees:

- the Medical Research Committee (MRC); and
- the Public Health Research and Development Committee (PHRDC).

The broad functions of these committees are discussed in appendix D.

Approximately one quarter of Australia's total expenditure on health and medical research is allocated through the NHMRC. For 1995–96, medical and public health funding through the NHMRC is estimated to be around $129.7 million (Cook 1995a, p. 5.57).

The NHMRC funds investigator-initiated strategic basic and applied research in clinical medicine and dentistry, primarily in universities, hospitals and specialised centres.

Bienenstock found that the NHMRC funded a predominance of basic scientific or biomedical research over clinical research, with 65 per cent of NHMRC's research resources in 1993 (excluding block grants and training awards), being allocated to basic research, as classified by researchers themselves (Bienenstock 1993, pp. 30, 73). The NHMRC block-funded research institutes undertake both basic research and research which has commercial potential.

NHMRC research funding is allocated to five broad streams: block grant funding to institutes and centres, program grants, project grants, directed funds, and training awards. Project funding in 1993 accounted for more than half of the research funds allocated (Bienenstock 1993, p. 29). Scientific excellence or merit is the main criterion for allocating project grants. These five streams are discussed in more detail in appendix D.

Of the total allocation of MRC funds in 1993, close to 60 per cent of funds went to the university sector. This was followed by NHMRC block funded institutes[1] which accounted for just under 20 per cent of funds. Hospitals received less

[1] These institutes are the Walter and Eliza Hall Institute, the Howard Florey Institute, Baker Medical Research Institute, Garvan Medical Research Institute and Murdoch Institute.

than 10 per cent of funds while ‘other’ institutes received just over 10 per cent (Bienenstock 1993, p. 75).

In 1993 the Government announced that it would raise health and medical research funding to 2 per cent of total health expenditure by the year 2000.

Many countries overseas have a separate medical research funding agency, many of which are very similar to Australia’s NHMRC. For instance Canada’s Medical Research Council has a responsibility to:

> ... promote, assist and undertake basic, applied and clinical research in Canada, in the health sciences, and advise the Minister in respect of such matters relating to such research as the Minister may refer to Council for its consideration (MRC of Canada 1992, p. 7).

It allocates funds on the basis of rigorous peer review through a broad range of programs for funding training and research.

C6.3 Issues in evaluating NHMRC

The similarities between the NHMRC and the ARC are quite marked. Both competitively fund researchers, with a large proportion of their total grants allocated as project grants. Projects are primarily funded on the basis of excellence using a peer review allocation process. Each funds only the marginal costs of a project (and in some cases less than the marginal costs), relying on researchers’ access to infrastructure funded through other sources, especially the university operating grants. Together they fund a substantial amount of research in universities.

As a result of this similarity, many issues raised in connection with the NHMRC have counterparts in the earlier discussion of the ARC. These issues include the peer review process, provision of research infrastructure and administrative costs.

The points of departure are to do with the nature of medical research itself — in particular, is it sufficiently different to justify a separate funding mechanism to the ARC and, given its apparently more concrete objectives, should a different approach be taken to priority setting?

Why separately fund medical research?

Medical research is perceived by society as one of the most important areas of research, because of its promise of better health care and services. A 1989 report by the NHMRC said that:

> The single most important reason for national support of medical research is its intimate association with health care. Australians are accustomed to a standard of health care services equal to the best in the world, and in the long term the health care system is a reflection of the quality of the research base underpinning it (NHMRC 1989, p. 7).

Given the widely accepted need for medical research, however, what institutional arrangements produce the best outcomes? In particular, does medical research necessarily need to be supported through an independent council such as the NHMRC, operating separately from other research funding agencies, or could it be brought within the ambit of the ARC?

The question is important, especially in light of the Commission's broad thrust, in the previous chapter, to allow the ARC greater freedom in the allocation of funds in order to obtain maximum performance from university research.

Despite the similarities between the NHMRC and the ARC, however, there are some good arguments to suggest that the present separation between them should be maintained.

One reason for this relates to a difference in orientation between the bodies. For while the ARC is essentially a funder of research in universities and is aimed at getting the most out of university research capacity, the NHMRC is aimed at producing benefits in a particular field, namely health. Fundamentally, these are quite different approaches, one seeking to maximise benefits of all types from all research in all fields within universities, the other predominantly following a single objective across all relevant fields. If a piece of research does not appear likely to advance health, the NHMRC's objectives are not served even though it might produce benefits in other ways for society.

A practical difference between the bodies is that the NHMRC funds many institutions outside the university system, whereas the ARC is almost exclusively a university funder.

There are some similarities between choosing to devote a certain amount of funding to health research and choosing other priority areas for funding such as those within the ARC Large Grants Program. An in principle argument can therefore be made to incorporate medical research within the priorities of the ARC. But this would produce a substantial imbalance given the scale of funding involved and the degree of complexity in priority setting for medical research. NHMRC funding amounts to more than a third of ARC funding and the Medical Research Endowment Fund is itself larger than the Large Grants Program. In fact, NHMRC is not just a priority area within government-funded research, it is significant enough to have its own priority areas which, quite rightly, change periodically.

Moreover, the NHMRC has a broader role than simply commissioning research. There are strong links between medical research and public health matters such as health education, the improvement and setting of health standards and the prevention of disease. Bienenstock concluded that the NHMRC takes an active part in fulfilling these roles:

> Australia is fortunate to have the NHMRC. It is unique to this country that one organisation can have a remit that extends over the full field of health, and which includes responsibility for supporting and developing health research. This organisation can harness the knowledge and good will of Australia’s foremost experts, at minimum cost, to provide governments and the community with comprehensive and authoritative advice on a host of complex and important issues which affect the nation’s health (Bienenstock 1993, p. 1).

The reasons for separately funding medical research include the fact that such research is conducted in a number of institutions other than universities, that it has an independent importance and that the objectives of funding programs differ significantly from those of the ARC. The Commission considers that competitive funding arrangements for medical research through the NHMRC should continue.

Some funding issues

There are a number of key principles (see chapter A6) which are relevant to the NHMRC as a research funder. These include the need to adopt a diversity of instruments to achieve objectives, and to ensure contestability wherever practicable.

In broad terms, the NHMRC satisfies many of these objectives. It employs a number of different types of funding schemes including block and project funding and has peer review processes to assess investigator-initiated applications.

A number of specific issues nevertheless arise.

Peer review

The NHMRC allocates funds for research projects using a peer-review process. Block funded research institutes and centres, research units and research programs are peer-reviewed every five years to ensure research is of a suitable standard of scientific excellence.

Many of the problems and biases of a peer-review process were raised in connection with the NHMRC, just as they were with the ARC. For instance, Professor Steel said:

> ... peer review as currently practised by the ARC and NHMRC will often fail to fund truly original research (Sub. 140, p. 6).

Such criticisms have a force which cannot be denied. Following the discussion in chapter C4, however, it seems broadly agreed that whatever its problems, peer-review is still preferable to any alternatives. This was also the view of the Bienenstock review which said:

> The limitations of peer review are well known, particularly in its inherent potential for conservatism, but despite widespread debate and analysis no better basis for assessing applications for research has been developed (Bienenstock 1993, p. 35).

Research infrastructure

The NHMRC funds research on a marginal cost basis. Some participants thought, as did critics of the ARC, that the NHMRC should make a larger contribution to project costs to include full funding of infrastructure. Others argued that project grants were not covering the full marginal costs.

There is an additional dimension to this debate in medical research. It arises from the fact that while large medical schools located at universities obtain infrastructure support through operating grants and the ARC infrastructure programs, teaching hospitals and research institutes do not generally receive infrastructure support, except for what they can obtain from State and Territory governments and from other sources. The Association of Australian Medical Research Institutes said:

> Medical research institutes have been overlooked by the Federal Government for the provision of support of research infrastructure ... Whilst universities receive up to 70 cents on each Federal grant dollar for infrastructure costs, most research institutes have received very little or nothing, and that support provided is often given on an ad hoc basis (Sub. 231, pp. 2–3).

It added:

> Up to the present, medical research institutes have made up for the deficit in federal infrastructure support by a variety of means, including direct funding of infrastructure by the affiliated hospital, endowment income (from past donations), current donations, State government support and infrastructure costs added to private contracts. However, economic and political changes over the past few years have conspired to reduce funding from many of these sources (p. 3).

Bienenstock found that for universities:

> ... infrastructure money is allocated as a block to the institution for allocation as it considers appropriate. These funds are not necessarily transferred by the universities in

> whole or in part to the groups generating the research funds upon which the allocations are based.
>
> Teaching hospitals and institutes have a related problem in that they accept research funded at marginal rates while not having access to infrastructure funds that are linked to additional money earned (Bienenstock 1993, p. 42).

Bienenstock concluded that:

> The disparity between competitive research grant funding and infrastructure support cannot be allowed to continue, particularly if significantly increased resources are expected to be provided for health research. One solution might be to provide that part of infrastructure funding which can be attributed to competitively awarded grants directly as an add-on to grant awards. The National Board of Education, Employment and Training estimated that a 35% loading would be appropriate for this purpose (p. 42).

Most medical researchers have access to some infrastructure which is obtained through their institutional affiliation. As with grants provided by the ARC, the key issue is how to make the most of the necessarily limited budget available to the funder, in a way that avoids any double-funding of researchers, but still ensures that those best able to pursue medical research are not excluded from funding.

In the draft report the Commission proposed that the NHMRC meet the full marginal costs associated with research that it funds, which would include project-specific infrastructure but not deep infrastructure costs. This could have meant, for example that the NHMRC would meet the costs of all equipment required, the costs of the chief investigator’s salary, and implicit rental charges of laboratories and other accommodation.

Similar proposals were considered in respect of ARC grants for universities in chapter C5. A number of problems with including infrastructure in grants were noted including:

- administrative costs arising associated with putting together funding for assets from many individual project grants;
- repercussions elsewhere in the funding system if resources are transferred to enable the systematic support of the salaries of chief investigators.

The problems discussed in chapter C5 with funding infrastructure are, if anything, multiplied in the case of medical research. Some of these are interjurisdictional questions that arise because many medical research institutions receive significant support from the States. It would not be within the Commonwealth’s power to redistribute infrastructure funding from broader support to individual components in grants, if some infrastructure support is currently provided by the States.

The Commission proposed in its draft report that the costs of including an infrastructure component in grants be met from within the budget of the NHMRC.

However, this was considered unacceptable by the NHMRC. At the draft report hearings it said:

> ... the notion that we would be able to provide infrastructure from our existing resources is completely unworkable and, in practice, to meet an infrastructure component of around 40 per cent we would have to reduce our existing grants by about 30 per cent and in effect that would mean no NH&MRC grants for one year and I think you will appreciate that that would be totally unacceptable to the medical research community ... So although we don’t have any particular rooted objection to the notion of infrastructure funding being linked to direct granting we are extremely concerned with what is being proposed (DR transcript, pp. 2787–8).

Given the difficulties discussed in chapter C4 and the additional Federal-State dimension in the case of medical research, the Commission proposes no change to the way in which infrastructure is funded.

Administrative issues

The problems with the current administration of both the NHMRC and its funding mechanisms were raised in the Commission’s inquiry and considered in the Bienenstock review. Again this mirrors concerns raised about the ARC. Walter and Eliza Hall Institute of Medical Research said:

> Although it is proper that expenditure of public moneys be accounted for, there appears a growing bureaucracy of endless forms, reports, statistics and other busy work which do not capture the quality of the scientific endeavour. The burgeoning number of government agencies which may fund R&D may exacerbate this problem (Sub. 15, p. 3).

Secretariat support for the NHMRC and its committees is provided by staff of the Department of Human Services and Health, as are administrative funds. The Bienenstock review raised as a concern the inadequacy of resources and the lack of identification and dedication of such resources to the NHMRC. It noted:

> Staffing and administrative resources for the research funding arms of NHMRC amount to less than 2% of the total program budget, a figure that is less than half of that of comparable overseas organisations (Bienenstock 1993, p. 43).

It went on to say:

> The lack of clear identification of resources for the NHMRC within the Department has raised tensions between the Department and the NHMRC. Identifiable budgets for the administrative support of Council and each of the Principal Committees of the NHMRC should be established, at reasonable levels, and the NHMRC should organise its processes according to the level of resources available (Bienenstock 1993, pp. 43–4).

The Commission also considers that the NHMRC should receive a separately identifiable administrative budget.

John Curtin School of Medical Research (JCSMR) and other research institutes

Current funding arrangements

Major medical research institutions in Australia include the John Curtin School of Medical Research (JCSMR), the Walter and Eliza Hall Institute, the Howard Florey Institute, the Baker Institute, the Murdoch Institute for Research into Birth Defects and the Garvan Institute.

The NHMRC through its MRC provides block funding to all of the above major medical institutes and centres except for the JCSMR. In 1993, total funding from the NHMRC for these institutes amounted to $18.1 million.

The current block funding arrangements for the NHMRC-supported institutions have undergone a period of evolution. The Walter and Eliza Hall said:

> During the Directorship of Sir Macfarlane Burnet (1944–1965) funding for the NH&MRC was negotiated annually at a meeting in about October of each year. This left the scientists within the Institutes in the ridiculous situation that, come about October of each year, they literally did not know whether a salary would be forthcoming for them as of the 1st of January. Between 1965 and 1967, the present Director of the Hall Institute negotiated the block funding arrangements which not only set the pattern for other Institutes, but ushered in a new era for the NH&MRC as a whole, as the Fellowship Scheme was based on essentially similar principles.
>
> What was negotiated was a two-tiered system. On the one hand, the institution as an institution was given a certain degree of stability to its funding base, a privilege which the John Curtin School of Medical Research at the ANU (the most analogous organisation) had enjoyed since its inception. From this base of guaranteed funding, the Director of the Hall Institute was then in a position to go to other national and international funding sources, mainly from the private sector, in order to build up a total budget (Sub. 385, p. 2).

A large amount of funding for these Institutes is obtained from sources other than the NHMRC (see appendix D). The ANU said:

> ... the five NHMRC funded institutes obtain a large proportion of their research funds from other sources such as state governments. Capital works provide additional funding from Commonwealth sources ($13m in 1994). Financial data from Annual Reports, from other medical research centres, show for example WEHI expenditure of about $18m for research, $7.2m of which is from the NHMRC. The Faculty of Medicine, University of Sydney (which is not block-funded), expends about $18m (in addition to the University operating grant) including $11.4m from Commonwealth sources (Sub. 351, p. 26).

The John Curtin School of Medical Research (JCSMR) is part of the Institute of Advanced Studies at the ANU. It conducts research in the life sciences which underpin medicine. Funding for the JCSMR is not allocated by the NHMRC but comes directly through the Department of Human Services and Health. In 1993–94, funding for the JCSMR amounted to some $17.2 million.

Researchers at the JCSMR are not eligible to apply for NHMRC grants, just as researchers at other IAS Research Schools are not eligible to apply for ARC grants.

Funding for the JCSMR has been provided as a block grant through the Department of Human Services and Health or its predecessors since 1992. Funding was shifted to this Department from the Department of Employment Education and Training after the Review of the IAS by the Stephen Committee in 1990. While the Stephen Committee recommended that the NHMRC assume responsibility for funding the JCSMR, this was modified by the Government and funding was provided through the then Department of Health, Housing and Community Services.

The Commission's draft report proposal for the JCSMR

In its draft report the Commission raised the possibility of shifting the responsibility for funding the JCSMR from the Department of Health, Housing and Community Services to the NHMRC.

The Commission argued that the advantage of funding the JCSMR through the NHMRC would be that the quality of medical research for all institutions which are block funded, and indeed for a large proportion of medical research, could be compared as a coherent whole.

Changing the funding source would have no direct implications for the level of funding, unless the NHMRC were to judge that better research outcomes could be achieved by moving resources into or out of the JCSMR.

The Commission noted that the 1990 Stephen review of the IAS had observed a number of problems with the JCSMR and recommended (among other things), discontinuing weak scientific areas of activity and shifting some research activities to other IAS schools. These recommendations were accepted by the ANU. The review had also recommended that the remainder of the school be brought within the ambit of the NHMRC.

In support of the Commission's proposal, the University of Melbourne said:

> The provision of block funding to the John Curtin School of Medical Research through the NHMRC on a basis determined in a similar manner to that for NHMRC funding for other medical research institutes is supported (Sub. 313, p. 7).

Issues associated with funding the JCSMR

The ANU argues that secure block funding is essential to maintain the long-term research undertaken at the school. It said:

> The Commission also proposes that researchers at the JCSMR could have access to project funding from the NHMRC with a reduction in the block grant to the JCSMR occurring as a result of this measure. Ignoring the fact that such a proposal would be an administrative nightmare for scientists (acknowledged by the Industry Commission), this funding model would seriously erode the major advantages of block funded Institutes, namely the ability to perform long term research and to assemble and maintain high class research teams. Project grants are of short-duration (usually 3 years) and provide support for only one or two supporting research staff. Thus, piecemeal support for JCSMR research would be impossible (Sub. 351, p. 26).

This raises two related issues — whether the nature of research undertaken at JCSMR differs markedly from other medical research institutions and whether its long term research would be jeopardised by introducing greater contestability. In regard to the first broad issue Dr Clarke of the ANU questioned whether the JCSMR was the only institution which performed ‘high-risk, long-term basic research that rewrites paradigms and comes to fruition a decade or so down the track’. He argued that the NHMRC:

> ... provides block funding to a number of government-funded medical research institutes (e.g. the Walter and Eliza Hall Institute, the Florey Institute, the Baker Institute and the Garvan Institute). Like the JCSMR, the goal of these institutes is to perform research and postgraduate training at the highest possible international level, and I suspect they would be unhappy with the claim that they rewrite paradigms and undertake high-risk research less frequently than does the JCSMR. So too would many NH&MRC Research Fellows operating on individual grants (Sub. 420, p. 2).

Dr Clarke also argued that the claim that staff at the JCSMR required long-term funding because of the special nature of their work, did not hold up when the extensive list of JCSMR collaborators was taken into consideration. He said that these medical researchers were mostly funded through short-term competitive sources such as the NHMRC. Yet as they are collaborating with staff at the JCSMR their research must also be long-term, risky and share the same goals as their JCSMR collaborative partners. Therefore Dr Clarke argued that any argument for special treatment for the JCSMR on the ground of the nature of their work must be extended to their NHMRC-funded collaborators throughout Australia (Sub. 420, p. 2).

The second issue is whether the uncertainty associated with the fact that block funding would be more contestable could be detrimental to the type of work undertaken at the JCSMR. As has been noted, the NHMRC currently provides block funding to a number of medical research institutes.

The Stephen Committee had considered the argument that the work at JCSMR was distinctive in nature, being long-term and high risk. It had been suggested to the Stephen Committee that therefore the JCSMR could not be accommodated under the NHMRC which was perceived to fund short-term, goal oriented projects with a three to five year cycle (Stephen 1990, p. 50).

However, the Stephen review argued that the scope of NHMRC funding had broadened over the past 10–15 years and did not discriminate against this type of work. The NHMRC now supported programs in State universities and research institutes that were not unlike the JCSMR (Stephen 1990, p. 50).

It also noted that the NHMRC's peer review process and international participation had developed NHMRC's ability to handle a wide range of basic biochemical and biological topics, such that the work at JCSMR would not be out of place funded under the NHMRC. The review said:

> Since the 1960's there has been enormous growth in the extent and quality of medical research in Australia. There now exists a network of medical research institutes set in different organisational ways and with different research themes, but all funded to a major extent by NHMRC. Some of these — the Walter and Eliza Hall Institute is the most obvious example — have long standing pre-eminence in the international medical research scene. The School should belong in this company (Stephen 1990, p. 50).

Would synergies in the IAS be damaged?

ANU argued that there were important synergies between the JCSMR and other IAS research schools:

> The John Curtin School of Medical Research is an integral part of the Australian National University, undertaking biomedical research complementary to the work in other research schools in the Institute of Advanced Studies and collaborating with other schools in joint projects. It should be funded as an integral part of the Institute (Sub. 351, p. 11).

However, there is no evidence that synergies among schools at the Institute or with the University have been damaged under the current departmental funding arrangements or any obvious reason why shifting the responsibility for funding the JCSMR to NHMRC should adversely affect such synergies. Many of the medical research institutes funded by the NHMRC are able to maintain close affiliations with other universities.

Would university autonomy be reduced?

Another concern about shifting the responsibility of JCSMR funding to the NHMRC would appear to be that the University's autonomy would be diminished.

In the ANU Annual Report the acting director of the JCSMR said:

> To date, there have been no major problems with the new funding arrangements but considerable concern remains that such arrangements are a significant infringement on the autonomy of the University (ANU 1993a, p. 27).

However, in the Senate Standing Committee on Employment, Education and Training report on *The John Curtin School of Medical Research* the majority view was that:

> ... the source of funding is of no practical import to the School (SSCEET 1992, p. vii).

The Senate Committee concluded with regard to the funding arrangements whereby the JCSMR is funded out of the Department's budget that:

> ... given the need for stability there, the current funding arrangements should remain in place. In its view the new arrangements do not impinge upon the University's capacity to discharge its responsibilities under its act so that its autonomy is not at risk (SSCEET 1992, p. vii).

There is no reason why a shift in funding responsibility from the Department to the NHMRC would change this conclusion.

Who should fund the JCSMR?

The JCSMR has recently been reviewed (in February 1995) as part of the current review of the IAS. The ANU reported on the conclusions as follows:

> The School was reviewed by an eminent review team ... who visited the school in February ... 1995. The Committee of Review recommended: 'The School's mission in long-term strategic medical research has convinced the Committee that Federal Government block-funding is required. This is best achieved by ensuring that such funding is provided by the Department of Employment, Education and Training (DEET) to the Institute of Advanced Studies of the Australian National University' (Sub. 351, p. 11).

The Commission notes that while the review team recommended on this issue it provides no analysis in its report as to why funding of the JCSMR is better provided through DEET than its existing source. However, the Commission considers that there are benefits with the current arrangements. Funding the JCSMR through the health portfolio places the medical research undertaken at JCSMR into a broader health and medical research context.

The Commission considers an even better arrangement would be to place responsibility for the School's funding with the NHMRC. This would have added benefits over current arrangements, as the NHMRC is better placed to make judgments on the research at the JCSMR compared to other research undertaken elsewhere in the system as it is involved in continually reviewing medical research from a number of different organisations and perspectives.

Also under the NHMRC there is scope to improve overall medical research funding by reallocating funding, in either direction, according to performance. This is best done if all the key medical research institutes fall within its ambit.

The Commission recommends that funding for the JCSMR be transferred to the NHMRC.

It should be noted however, that this proposal does not preclude the continued block funding of the JCSMR. As chapter C3 makes clear there are many advantages associated with block funding which should be retained.

Under the Commission's proposal the JCSMR would still receive a block funding base from the NHMRC. But the NHMRC could compare the JCSMR's performance with that of other institutions which might also be block funded and shift resources if it felt that was appropriate.

Contestability within the NHMRC

In the draft report the Commission said that it saw benefits in block funding provided through the NHMRC for medical research institutes generally becoming more contestable. The Commission suggested that one model for this is the ARC research centres. Block funds could be made available up to a maximum specified time, given favourable reviews at certain points, but once this maximum time is reached, automatic funding ceases and the institute must then compete for continued funding against other institutes and centres. An institute's share of funds may subsequently be altered or withdrawn. At the time of review the MRC would need to consider the tradeoffs between further funding to an institute or directing the available funds to other areas.

In response to this proposal the Walter and Eliza Hall Institute said:

> We totally support a high and constant level of accountability with respect to public funding, and we agree with the principle that medical research funds should be awarded on a competitive basis depending on the merits of research as judged both by track record and the excellence of proposals. However, we disagree that block funding should automatically cease after a maximum specified time (Sub. 385, p. 2).

It added:

> ... the capacity to review funds downwards gives the NHMRC enough flexibility to punish failing performance without the need for some arbitrary deadline for the termination of the arrangement ... (p. 2).

The NHMRC said:

> The Commission stated that it would like to see block funding for medical research institutes through the NHMRC become more contestable. This is a view that is shared by the NHMRC, and the research committees have been reviewing their assessment

> processes to ensure that this is achieved. This review extends beyond the block funding of institutes and is part of a review to ensure that all funding allocated by the NHMRC is appropriately contestable (Sub. 343, p. 4).

Monash University suggested that:

> ... the National Health and Medical Research Council consider conducting all of its quinquennial reviews of block funded institutes simultaneously. A decision could be made at the same time about the relative level of block versus project funding (Sub. 330, p. 10).

However, at the draft report hearings the NHMRC said:

> The logistic arguments against [simultaneous reviews] are extraordinary. Because of the nature of our peer review system and our regional grants interviewing system we put very heavy demands on the local and international research communities to undertake the reviewing process. The logistics of adding in what would be in effect another 25-odd programs are absolutely enormous, so although that's something that we're currently discussing, I would just be very concerned about whether or not it's actually do-able, and of course the more institutes and programs one has got the more difficult it becomes. My own view is that there are other ways of introducing competition within the system, rather than just having it all up for grabs every 5 years (DR transcript, pp. 2795–6).

It added that some thought is being given to introducing more competition into its review processes for medical research institutes, and:

> ... rather than have a group of people, half of whom are from overseas, fly in, look at the place and say 'Yes it's very good' and go away again, that we should try and introduce an element of competition within the system, and to do that we have proposed a review system analogous to that for the programs ... (DR transcript, p. 2794).

The Commission sees particular benefits in arrangements which include review processes directly linked to decisions about resource funding. It notes that there can be significant benefits in the NHMRC having maximum scope to shift funds between programs and institutions on the basis of the outcomes of continuing processes of review. However it sees benefits in putting some limits on possible gains and losses at each review in the interests of providing some longer-term certainty.

C6.4 Priority setting

The NHMRC is bound, under the *National Health and Medical Research Council Act (225 of 1993)*, to consult in its development of research recommendations and guidelines, and the development of its Strategic Plan. The NHMRC states that in preparing its Research Strategy 'input is received from the health and medical research community on aspects and disciplines of health and medical research that warranted particular attention. A Committee was established to prepare a Research Strategy which contained representation from MRC, PHRDC, and a consumer organisation' (CCST 1994, NHMRC p. 2).

The NHMRC states that in determining priorities it takes into account reports from peak science, higher education, industry and community bodies. The criteria it uses to determine priorities include:

- prevalence of disease;
- strength of research being undertaken;
- the needs of the community;
- Government equity objectives;
- commercialisation potential;
- and consideration or issues that arise from the consultation processes.

The NHMRC states that its strategies take into account the national health goals and targets, other national health indicators, and national science and technology goals. The national health goals and targets come under the Department of Human Services and Health's, National Health Advancement Program and focus on the areas of cardio-vascular disease, cancer, injury and mental health.

The majority of NHMRC project grants are awarded on the basis of scientific excellence. However, priorities play a role through two main channels.

First, a small proportion of project grant funds, (around 5 per cent) are allocated to priority areas (Bienenstock 1993, p. 35). These priority areas are also known as special units and special initiative areas. For 1994 the special initiative areas were: Aboriginal health; alcohol and substance abuse; dental health; breast and prostate cancer; and dementia.

The criteria for awarding grants to these areas are slightly less stringent than those for project grants (such as lower cut-off scores) and applications in these areas are given additional weighting in the assessment process. An additional 39 research projects in 1994 were supported as a result of this process (DHS&H 1994, p. 94).

Second, the Council makes block funding awards to groups working in priority areas. In 1994 the Medical Research Council has allocated some $3.1 million to support six research units in priority areas. These are: the Road accident Research Unit; a Mental Health Research Network; the Environmental Toxicology Research Unit; the Social Psychiatry Research Unit; the Schizophrenia Research Unit; and the Clinical Trials Unit.

The NHMRC argues that a substantial proportion of its medical research support is in any case in the key areas of death and disability in the Australian population, including cardiovascular disease, cancer, diabetes, musculo-skeletal disorders, respiratory disease and mental health.

The Bienenstock review said that:

> In the absence of a process for comprehensive review of research needs and available research resources, either at the level of NHMRC as a whole or at the MRC/PHRDC level, these mechanisms [for directing research resources to specific areas], have been introduced in an ad hoc fashion, sometimes in response to pressure from individual, organisations or government, and have not always acknowledged activity in areas outside the NHMRC, for example AIDS was a special initiative area for the Medical Research Council until 1993, by which time more than $35 million had been expended through Commonwealth AIDS Research Grants program. Different mechanisms have not been coordinated or monitored as a whole to analyse the development of research in priority areas (Bienenstock 1993, p. 40).

It added that:

> These shortcomings should not be viewed as inherent faults of the MRC or as evidence of hostility to directing research in principle. Both the Medical Research Council and Public Health Research and Development Council have made genuine efforts to respond to priorities that they have identified or which have been identified by other groups (p. 40).

The Bienenstock review considered that the establishment of a Strategic Health and Research Planning Committee would among other things develop a strategy incorporating identified priority areas and agendas for action by the Principal Committees, and monitor the implementation and evaluation of such a strategy. It recommended that available health information in Australia and overseas should be marshalled together and presented in a way that enables organisations such as NHMRC to develop health plans and policies.

A Strategic Planning and Evaluation Committee is now in operation. Committee membership comprises representatives from government, universities, hospitals and previous NHMRC officials. At the draft report hearings the NHMRC said:

> ... the main role that I perceive for SPEC ... — the strategic planning and evaluation committee — is to develop the strategic plan for the whole organisation and it will feed into the research committees with advice and suggestions and it will make sure that there's coordination between the strategic plans of the health advisory side, the health ethics committee, and the research committees. But basically I would envisage the research committees and their research strategy committee as advising council on research strategies, but SPEC is there to see that there's coordination and to provide advice and information to the research committees and to the health advisory committees. It's also there to evaluate (DR transcript, p. 2807).

Recently the Government has received criticism for its decision to provide additional funds for research and development into breast cancer through the establishment of a national breast cancer centre, rather than through the NHMRC.

This move by the Government could be construed as a signal that the priority setting process within the NHMRC was not addressing Government and community concerns. To the extent that this was the case, such concerns are better dealt with through strengthening the priority setting process (along the lines of the Bienenstock review recommendations).

At the draft report hearings, the NHMRC said:

> ... public pressures for funding in specific directions often fail to take account first of all of what is being done, and, as you will be aware, breast cancer was already a research priority for government. We had made it one in 1992.
>
> But there is often a misunderstanding of how research works, and a failure to understand that the real advances that are going to make a difference in breast cancer may come from breast cancer projects, but they might also come from a project on another sort of cancer, or indeed just on the fundamental way cells behave, or help for patients with breast cancer might come through projects on surgery or anaesthesia or drugs or chemotherapy ... a whole range of things which may or may not have ‘breast cancer’ in the title. So research tends to be part of a spectrum rather than divisible into little boxes ... priority setting is important, but it needs to be looked at in the context of what is best for the national effort (DR transcript, pp. 2799–2800).

A further issue is the extent to which priorities should be set within the project grant schemes of the NHMRC. Currently grants not made within priority areas are awarded on the basis of excellence.

In its discussion of the ARC the Commission came to the conclusion that excellence should be the sole criterion for selection of basic research projects.

Medical research appears different, however, in the sense that it is clearly aimed at an ultimate purpose in one area — improving health. Its more concentrated focus could make possible more overt consideration of the national benefits from individual pieces of proposed research.

As has been noted, however, a significant proportion of NHMRC-sponsored research tends to be of a strategic basic nature. Bienenstock said:

> The data also show a dominance of basic scientific or biomedical research over clinical research: this is neither surprising nor in itself a matter for concern. Basic research is essential for the development of new ideas and understanding of health and must be fundamental to any broad research funding organisation (Bienenstock 1993, p. 30).

Bienenstock went on to endorse the use of the criterion of excellence. Similarly, in its report *Case for Funds for Medical Research* in 1989, the NHMRC said:

> In almost every instance of a major advance in medical knowledge, basic science has provided the springboard from which applied problems have been tackled ... Thus, a major planning objective must be to ensure that applied problems have sufficient back-up in terms of basic research. There is still a major need for the proper and full support of pure research which will advance knowledge, and the NHMRC must continue its role in this area. To this end, scientific excellence must remain the single major criterion for supporting medical research (NHMRC 1989, p. 33).

Monash University said that it is:

> ... artificial ... to insist that selection committees use only excellence to distribute a level of funds previously determined in the light of priorities. The [MRC] and its selection committees are well placed to know when potential application to disease is relevant to a project application, taking this into account together with the intrinsic merit of the project (Sub. 330, p. 10).

The Commission concludes that despite the strategic nature of its research, the NHMRC's processes could operate in a similar manner to those of the ARC. Direction of research should be instituted through the selection of broad areas for priority funding. Priority areas could be chosen as they are now, or broad allocations of funds among specialty areas could also be made, if necessary to guide selection committees. **But there is a good case for scientific excellence to be the major criterion for selection by committees.**