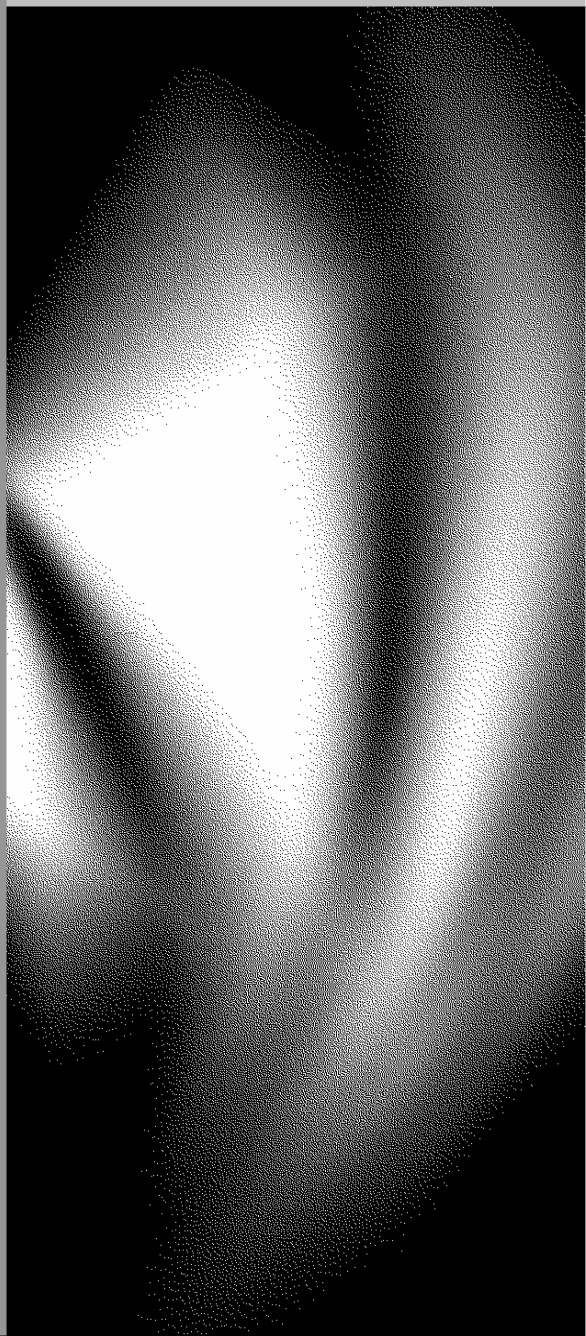
Australian Government
Productivity Commission

Public Support for Science and Innovation

Productivity Commission Research Report
Overview

9 March 2007



Key points

- There are widespread and important economic, social and environmental benefits generated by Australia's $6 billion public funding support of science and innovation.
  – On the basis of multiple strands of evidence, the benefits of public spending are likely to exceed the costs.
  – But, given a host of measurement and methodological issues, it is not possible to provide anything other than broad estimates of the overall return to government contributions.
- Major improvements are needed in some key institutional and program areas.
- The adequacy of existing program evaluation and governance arrangements is mixed, with some notable shortcomings in business programs.
- The net payoff from the R&D Tax Concession could be improved by allowing only small firms access to the 125 per cent concession, changing the thresholds for tax offsets, amending the base for the 175 per cent incremental concession and considering a narrower, more appropriate, definition of R&D. This should increase the amount of new R&D induced per dollar of revenue and achieve more spillovers.
- Strong public support of Rural R&D Corporations with a public good orientation is justified, but the level of government subsidies for *some* narrower, industry-focused arrangements is likely to crowd out private activity and produce weaker external benefits outside the supported rural industry. However, industry will need time to adjust to new arrangements.
- Collaboration can generate significant benefits. The CRC program is, however, only suited to longer-term arrangements. There are complementary options for business collaboration with public sector research agencies and universities that could provide more nimble, less management-intensive, arrangements.
- There are grounds for dealing with problems in the governance and intellectual property frameworks of universities, weaknesses in their commercial arms and shortcomings in proof-of-concept funding.
  – However, the pursuit of commercialisation for financial gain by universities, while important in its own right, should not be to the detriment of maximising the broader returns from the productive use of university research.
- The structure of funding for higher education research has increasingly eroded the share of block grants. Further erosion would risk undermining their important role in enabling meaningful strategic choices at the institutional level.
- The costs of implementing the Research Quality Framework may well exceed the benefits. The benefits from the 2008 RQF round could be improved if its funding scales provide more significant penalties for the poorest research performers than apparently currently envisaged. In the long run, a transition to less costly approaches, such as those that target poor performing areas, should be considered.

Overview

Innovation is critical to Australia's growth and its preparedness for emerging economic, social and environmental challenges. Governments play a major role in shaping the innovation system through the design and governance of institutions, in supporting the education and training of scientists and engineers, and in funding high-value research that would not otherwise be undertaken by businesses. Governments also play a direct role through their own public sector research agencies and by financing R&D in universities and businesses. Overall funding was around $6 billion in 2004-05.

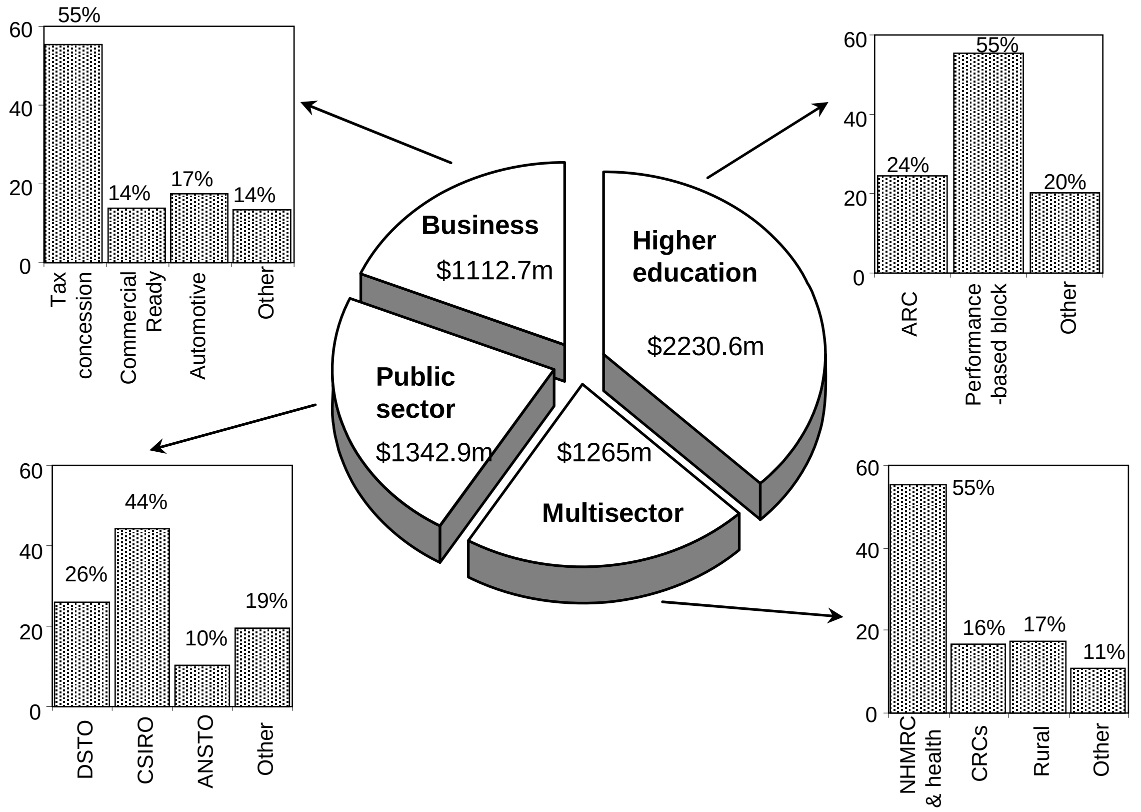
This report examines the impacts of such public support for science and innovation, and considers the prospects for improving outcomes by eliminating impediments to innovation or by changing the way government support is channelled to its various competing uses. The Commission was not requested to systematically review all individual programs. It has therefore adopted a strategic approach, identifying particularly important programs or funding areas and investigating the grounds for their reform.

The overall conclusion is that public support for science and innovation has, by and large, provided widespread and important benefits for Australians. Nevertheless, there is room for considerable improvement in key areas of Australia's innovation system, spanning ineffective business programs, a sometimes excessive focus on the commercialisation stages of innovation, problems in scientific labour markets, inadequate evaluation methods and problematic funding models.

There are strong rationales for public funding support

Public funding support for research and development, an important input into innovation, is substantial. The Australian Government plays the most prominent role (figure 1), but State and Territory Governments are also increasingly active. Accordingly, support should be based on clear and credible rationales, which should then underpin the evaluation criteria used to assess the net benefits of each program.

Figure 1 **Australian Government spending on science and innovation**
2005-06



There are two strong rationales for public funding support of science and innovation. The first is that publicly funded R&D is a significant contributor to innovation in the functions performed by government. Governments need to invest in research to improve the products and services they offer or to better discharge their functions, just as does the private sector. For example, expenditure on research and innovation is pivotal to effective environmental management, the provision of education, defence, and social welfare and health services. It does not follow, of course, that such publicly funded research must be undertaken within the public sector.

The second significant rationale is the existence of 'spillovers' from innovation. These are benefits that cannot be captured by the innovator — ideas that can be used, mimicked or adapted cheaply by firms or others without payment to the originator. Spillovers may arise through the development of basic knowledge capabilities or diffusion of new ideas among firms and others. Such spillovers arise from research undertaken in universities, businesses and public sector research agencies.

The mere presence of spillovers, does not, in itself, justify public support:

- Many investments that produce spillovers have sufficient private returns for firms to invest without that support.
- Some spillovers accrue to foreigners, and so are generally not relevant to the appraisal of net benefits for Australia.

The challenge for public policy measures is to elicit private investments that would not otherwise have been made (‘additionality’) *and* that generate total private and spillover returns that are still sufficiently positive to exceed the costs associated with the policy measures. These costs include the efficiency distortions of taxation required to finance the measures, the utilisation of resources on administration and compliance, and the consequences of poor choices when selecting projects to be funded. Programs need to be designed to ensure that public funds stimulate genuinely new R&D rather than displacing privately funded R&D.

There are various other rationales for public support. Those found during the study to have some validity include:

- intangible factors — the values that science elicits and entails (for example, national identity and curiosity); and
- the asymmetric tax treatment of highly risky investments — profits are taxed now whereas the tax value of losses fall through discounting as they are carried forward.

Imperfections in capital markets that could affect the availability of finance to risky or uncertain investments in small firms and start-up companies may provide a rationale, though they may merely reflect high, but unavoidable, transaction costs of dealing with some firms.

Other rationales often given for support — the indivisibility of very large research projects; business myopia; and the goal of transforming Australia’s industry structure — have little merit.

Public funding support produces sizeable benefits

Given the significant public funding of R&D, a key question is what gains Australians derive from this spending. No single method for appraising the effects of R&D on productivity or more intangible national outcomes can be definitive. Accordingly, the Commission pursued many approaches to assess impacts.

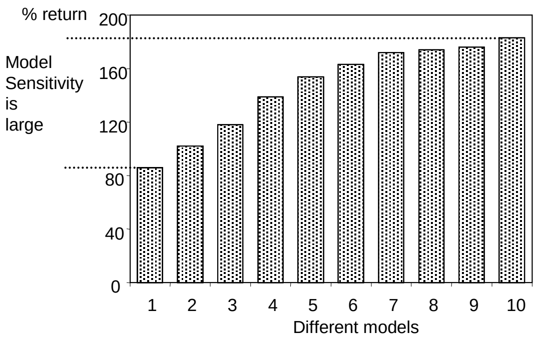
The aggregate time series approaches used by the Commission suggest positive spillover rates of return to business R&D. This is also buttressed by the Commission’s analysis of the sources of economic growth over time among

Australian States and Territories, which suggested high rates of return to total and business R&D. Similar studies undertaken across countries and time also usually find significant returns. But none of these quantitative methods can realistically measure rates of return with precision (box 1).

Box 1 **The problems with numbers**

Aggregate time series studies — often the basis for estimates of the productivity effects of R&D — cannot realistically measure spillover rates of return accurately. This reflects the complex causal pathways through which R&D affects productivity growth, an inadequately short span of data, measurement errors, the potentially long lags from the conduct of R&D to ultimate benefits, and difficulties in controlling for the other factors that also influence productivity. Accordingly, the econometric modelling of the kind used in this report or the companion analysis by Shanks and Zheng (2006) can find it difficult to measure the effects of R&D with any precision.

This variation is illustrated by the multiplicity of estimates of R&D spillover effects obtained for Australian business R&D from time series analysis undertaken by the Commission in recent years. The most statistically adequate models of productivity presented by Shanks and Zheng find a spillover return to domestic R&D of around 50 per cent, while the present report finds considerably higher returns — between around 85 and 180 per cent. These high spillover returns have wide confidence intervals, however, and are highly dependent on model specifications as shown in the chart below. On the basis of other evidence on the sources of economic growth, these point estimates are likely to be implausibly large. Another method, for example, suggested numbers lying in the much lower range from 35 to 100 per cent, but these bounds could readily be exaggerations or underestimates too.



Overall, the results from such modelling cannot realistically aspire to produce accurate estimates of the spillover rates of return from R&D. However, the empirical evidence adds weight to the hypothesis that R&D produces large returns to the market sector through productivity increases that are not captured by the firms undertaking R&D.

In the case of other methods, such as case studies, the evidence relates to average R&D project net benefits, not the benefits of new, marginal, projects, which are relevant to decisions about incremental funding levels. Such case studies are also affected by problems of bias in their selection and the more general problem of data inadequacies.

While it is useful to measure the returns to R&D as a whole, the public policy issue is the magnitude of benefits from *publicly supported* science and innovation, not from R&D in total. The bulk of such public funding (about five dollars in every six) is provided to universities or public sector agencies. To have the possibility for positive returns, such funding must not significantly displace private financing of R&D in these institutions or in businesses. There is strong evidence that displacement is small.

A second condition for public support is that the benefits of this research must be sufficient to justify the investment. The Commission examined many strands of evidence — industry analyses, qualitative assessments, international cross-sectional time series studies and case studies relating specifically to R&D undertaken in universities and public sector agencies. Overall, these also suggested good returns. In some instances, such as R&D for many environmental purposes, the net gains are mostly not measurable as short-run changes of GDP, but are nonetheless worthwhile. R&D from these organisations has:

- increased preparedness and reduced risks in some areas;
- been widely adopted in a range of settings (public health, risk abatement in the environment and social and educational policy);
- developed advanced problem-solving skills among Australian graduates; and
- provided spillovers to business, for example in the mining industry.

Other indirect indicators of impacts, such as academic quality, suggest that Australian scientists are performing well by comparison with those in other advanced economies.

Business programs are likely to have generated smaller net returns to Australia than publicly conducted R&D. This reflects several factors:

- a large share of the R&D eligible for tax concessional treatment would have taken place in the absence of public funding support;
- a considerable amount of public support has been directed at incremental, catch-up R&D, where the spillover benefits are likely to be lower; and
- a few relatively declining sectors — such as the auto industry — have benefited disproportionately through special sectorally-specific R&D programs.

Innovation system impediments

Participants in this study identified a range of possible impediments to the operation of the innovation system. Many of these related to perceived deficiencies in the level of funding, structure, multiplicity and administration of the public support programs. These issues are discussed later.

The remaining innovation impediments that were identified related to apparently poor commercialisation; science workforce issues; some unexpected consequences of specific regulations; factors that may weaken the capacity for knowledge diffusion in basic research; and broader institutional settings, such as taxation and general skill levels.

Problems in commercialisation and knowledge diffusion mechanisms

There is evidence of widespread success in commercialisation across all sectors of the Australian economy, which belies a commonly expressed pessimistic view of Australia's capabilities. But the Commission has identified a range of potential impediments to commercialisation and diffusion, particularly in universities, that may merit action:

- There appears to be an excessive variety of arrangements for transferring intellectual property (IP) to firms, often within the same university, which increases the costs for firms seeking to commercialise university research.
- Some universities appear to have poor governance structures and incentives for commercialising IP — such as insufficient sharing of the benefit among the relevant parties.
- Only the largest research universities are likely to be able to develop dedicated commercialisation arms of sufficient scale and expertise to operate effectively. More flexible arrangements — including the use of private sector intermediaries — may allow universities to draw on the commercial expertise they need in a more efficient and cost-effective way.
- Universities can sometimes find it difficult to sell commercialisable IP to business because the concepts have not been adequately demonstrated ('proof-of-concept'). Since the claim is that such IP is inherently profitable to the universities, the Commission suggests that publicly funded support for it should (a) involve a non-contingent loan from the Australian Government; (b) be a last resort after other avenues for private funding have been demonstrably exhausted; and (c) be piloted before any substantial funding is committed.
- There is likely to be some scope for universities to improve their linkages with firms in other ways, but this does not necessitate a dedicated new funding stream, such as 'third stream' funding. Current metrics used to identify problems in such linkages tend to accentuate only specific kinds of mechanisms, such as company spinoffs or IP licensing, and fail to recognise the importance of diffusion arrangements that already work well, such as informal networks, conferences and publications. But new intermediary arrangements aimed at better diffusion are being trialed and will provide a useful experiment.

Claims that public support is required for a whole range of other apparent problems in the commercial exploitation of know-how — such as inadequate venture finance and poor entrepreneurship and management skills — are either ill-founded or overlook programs that already exist.

A balance is needed when considering the role of public support for commercialisation activities in universities, public research agencies and businesses. Placing undue emphasis on commercialisation for financial gains may have unintended effects.

- Universities' core role remains the provision of teaching and the generation of high quality, openly disseminated, basic research. Even where universities undertake research that has practical applications, it is the transfer, diffusion and utilisation of such knowledge and technology that matters in terms of community wellbeing. Commercialisation is just one way of achieving this. The policy framework for universities should encourage them to select the transfer pathway that maximises the overall community benefits, which will only sometimes favour commercialisation for financial gains.
- Apparent cultural barriers between universities and businesses may reflect, in part, the preferences of researchers, who can be more motivated by curiosity and research excellence than commercial opportunities. Addressing any cultural 'barrier' requires prudence because it poses risks for the research functions of universities and some of the motivations for science career choices.
- While public spending to support business commercialisation is smaller than the support given at the earlier stages of the innovation process, business programs are increasingly oriented at commercialisation objectives. However, there are fewer clear-cut spillovers at this later stage, which weakens the rationale for programs directed to this end. There are also large potential private returns to commercialisation — failure to commercialise gives rivals the time to poach the pre-existing R&D knowledge. So public support risks financing some investments that would occur anyway.
- Calls for governments to assume the risks for highly risky commercial ventures also have a poor basis since such an approach would merely transfer commercial risks from firms to taxpayers.

There are barriers to the future growth of human capital

Some areas of concern about the supply of scientists— such as the 'brain drain' — are not well-founded. Australia gains considerably in net terms in immigration of scientific personnel.

However, while most science occupations are not in short supply, there is a recognised shortage of engineers and of secondary school teachers in science and mathematics. The shortage of engineers is partly self-correcting as it has elicited a rapid growth in salaries for both graduate and experienced engineers, encouraging entry into the profession. In the case of science and mathematics teachers, shortages have instead been accommodated by using teachers without adequate skills in these areas. This may adversely affect student performance and engagement and decrease future university enrolments in the sciences. In teaching, price signals have not been able to respond to shortages due to the inflexible pay levels and structures. This should be subject to reform.

Job satisfaction amongst scientists appears to be falling, with potential consequences for productivity and future recruitment. This morale problem reflects scientists' concerns about poor career pathways, excessive use of short-term contract employment and a burgeoning non-research workload. Many of the issues are best addressed by negotiation and agreement between employers and employees. However, job satisfaction can also be increased through:

- longer-term funding certainty;
- carefully designed performance assessment processes that reward higher performing institutions, research teams and individuals;
- a level of academic freedom consistent with the strategic interests of the employing institution; and
- the minimisation of non-research workloads.

The need for better use of physical research infrastructure

There is a diverse range of pricing and sharing arrangements for infrastructure between public institutions that may sometimes result in inadequate utilisation. The Commission broadly supports the recommended pricing approach of the National Research Infrastructure Taskforce. Fixed and standing operating costs should be met through public funding. Prices of major infrastructure should then be set at marginal costs for research users — with congestion charging for infrastructure that is over-utilised. A stocktake of existing research infrastructure would also help identify areas where assets could be better shared.

There are some signs of inadequate infrastructure in universities. Infrastructure spending has not kept pace with other public funding and there is a growing backlog of deferred maintenance. However, the real extent of problems across the university system is obscured by measurement problems.

Possible impediments to diffusion in the basic research community

There are several possible barriers to knowledge dissemination in basic research.

Legal uncertainty about the use of patents for research has the potential to impede knowledge dissemination. One option proposed by the Australian Law Reform Commission and the Advisory Council on Intellectual Property is to introduce a provision in the Patents Act for exempting researchers from infringement when they make experimental use of patented intellectual property. This model has been applied in the United Kingdom, several European countries and Japan, and recently in New Zealand. The intention is to reduce legal uncertainty about the use of patents for research, without affecting commercial incentives to invest in innovation. However, the extent to which such legal uncertainty acts as a barrier to innovation is unclear, as are the costs and risks of any unintended consequences of implementing the proposed model.

The growth of the internet has made it possible to lower to zero the marginal costs of disseminating much basic scientific knowledge. Current models of scientific publication, while changing, have nevertheless been perceived as limiting the possibilities of diffusion of publicly supported research because they restrict access. Major funding bodies in the United Kingdom and the United States have already instituted reforms. There is further scope for the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC) to progressively play a more active role in achieving open access to the results of their sponsored research.

Privacy and ethics regulation may constrain some research

Complexities associated with privacy regulation across jurisdictions and multi-site ethical review processes can adversely affect the conduct of some types of research, particularly in the medical field. This report recognises the valid aims of both regulatory approaches. However, streamlining the ethical review of multi-site research and introducing national consistency in privacy regulation of health information can achieve the objectives of the regulations, while imposing fewer costs on researchers.

High quality performance evaluation is an imperative

Effective performance evaluation and benchmarking are vital tools in the allocation of funding, both across programs and to projects within programs.

The adequacy of existing performance evaluation and benchmarking is mixed. Programs with significant budgetary implications are not always subject to routine, transparent and independent evaluation, nor always use rigorous methods to determine program effects. The results of evaluations are not always used to change programs that are not working well. There are some notable shortcomings in the arrangements for evaluating business programs, and most recently *R&D Start*, the predecessor to *Commercial Ready*. Reforms are needed.

There are also deficiencies in the assessment of the quality and impacts of higher education block funding for the purposes of funding allocation. The proposed Research Quality Framework (RQF) is intended to remedy this but, as noted below, has its own limitations.

Institutions such as the CSIRO, the ARC and the NHMRC are constantly developing their research management and evaluation approaches. CSIRO's process involves:

- identifying new-to-the-world R&D with strong potential impacts;
- staged financing of R&D that depends on re-assessments of future impacts; and
- a peer reviewed ex post assessment of impacts and quality.

This approach should be assessed alongside their own approaches by other mission-focused research institutions, but is less relevant to university research because of the more basic nature of the research and the high transaction costs of assessing many thousands of small projects.

Business programs need adaptation

Australia's current suite of business support programs could be improved to target more effectively the twin objectives of encouraging research activity with high social benefits beyond the firm (spillovers), which would not take place without public support (additionality).

Reforms of general business R&D funding arrangements

The R&D tax concession — including its incremental component — is the largest single mechanism for public funding support of business R&D. It has an advantage over grant programs in that it leaves businesses with the flexibility to undertake the kinds of R&D suited to their own strategies and needs. Its total budget costs were over $600 million in 2005, which was around 60 per cent of total direct business R&D support by the Australian Government.

One of its major limitations is that the criteria for the basic 125 per cent tax concession do not screen out R&D that would have happened anyway — the bulk of business R&D. This increases the costs to revenue from stimulating any additional R&D and reduces the magnitude of net benefits from the program. At present program settings, the net benefits of the program are not large and could be negative.

The net payoff from the concession could be substantially improved by maintaining access to the concession for small firms only. Smaller firms' R&D is more responsive to the flat rate subsidy, is less affected by 'washout' of the subsidy through the dividend imputation system and could less readily benefit compared with large firms from an incremental R&D scheme of the kind preferred by the Commission.

The activity thresholds determining access to the arrangements for concessional deductions for R&D companies in tax loss (the *Tax Offset*) should also be amended to address the perverse incentives associated with the current expenditure and turnover limits.

The Commission considers that there are also grounds for enhancing the existing 175 per cent incremental tax concession scheme by:

- adopting a fixed base of an R&D to sales ratio as the basis for payment, rather than the current rolling base;
- giving start-up firms access to the premium component from which they are currently largely excluded, but taking account of the fact that such firms usually commence with high R&D to sales ratios;
- assessing the merits of relaxing the beneficial ownership requirement by allowing foreign subsidiaries that hold their IP abroad to have access to the incremental concession only; and
- potentially even increasing the concession rate for the premium component, or introducing a tiered system with progressively higher subsidy rates that depend on the extent of the increase in a firm's R&D activity.

Such an incremental system will not function well for companies whose ratio of R&D to sales is very volatile. But it is expected that it could play an important role in stimulating additional R&D for large firms, which account for a large share of total R&D and whose R&D intensities are more stable. The administrative data to check the exact effects of this and alternative incremental designs are not yet available, and the precise design should be contingent on the Department of Industry, Tourism and Resources undertaking simulations of their likely effects and risks.

More generally, a narrower definition of R&D in line with international conventions should be considered, which requires eligible R&D to be innovative *and* highly risky (rather than the present condition for R&D to be highly innovative *or* highly risky). If administratively feasible, this change has a higher chance of generating spillovers.

As noted previously, the increasing focus of some business programs on later-stage commercialisation, rather than research, runs the risk of supporting R&D that might have occurred anyway and of shifting support away from the stage of R&D where spillovers are most likely. The evaluation evidence available to the Commission points to this as being a substantive risk for the Commercial Ready program. Analysis by the Commission of international evaluations of other R&D grant programs has shown that some countries appear to get better outcomes from their grant programs. Why this is the case will depend on specific features of the programs and the evaluations, and should be investigated further. Introducing loan repayment mechanisms, rather than straight grants, may be part of the answer.

The various manufacturing industry-specific programs, while generously funded, should be evaluated in part against a broader objective of facilitating structural adjustment — the automotive industry program being a case in point.

Subsidy rates for some types of RRDCs should be re-calibrated — with a lead time

The governance design of the Rural R&D Corporation model is inherently sound. Levies that are decided by, and apply to, all beneficiaries of the R&D overcome free-riding and the resultant under-provision of rural research. There are strong grounds for significant public co-funding of those RRDCs where there are spillover benefits beyond industry members and where that research would not proceed in the absence of support (for example, research into improving salinity-damaged areas).

But *some* industry-focused RRDCs should be less reliant on public co-funding. They receive significant subsidies without a demonstration of commensurate induced spillovers. There are grounds for adjustments of subsidies for these RRDCs, though the precise corrections should be determined through independent review processes on a case-by-case basis. RRDCs should be given a lead time for any changes, so that they can adapt to the new policy.

There may be grounds for a complementary program to CRCs

The Cooperative Research Centre (CRC) program received mixed responses from participants, some arguing there are high returns while others pointing out low ultimate impacts, high start-up costs and ongoing compliance burdens. Current cost-sharing arrangements seem to direct high levels of subsidies to the business collaborators, as they are primary beneficiaries of the Centres.

Several options may improve collaborative arrangements of this kind.

The original objectives of the program should be reinstated — namely, the translation of research outputs into economic, social and environmental benefits, rather than focusing public support on the commercialisation of industrial research alone.

The CRC program is geared toward large-scale, longer-term research programs, which are more suited to big research users. There are relatively cumbersome avenues for CRC partners to enter and exit the venture and a heavy compliance burden. There is scope for complementary options for business collaboration with public sector research agencies and universities that could provide more nimble, less management-intensive arrangements than the present CRC program. Some eligibility criteria for a new program are mooted by the Commission. Any new arrangement should be piloted. The merits of other forms of intermediation between business and research organisations are discussed in the report.

Funding arrangements for higher education

Funding of higher education research accounts for over 40 per cent of total Australian Government financial support for science and innovation. Universities receive block funding direct from the Australian Government (about $1100 million in 2004). They are also the primary recipient (about $700 million in 2004) of the competitive funding programs administered by the ARC and the NHMRC.

The conceptual arguments for dual streams of funding of higher education research are sound. They encourage researchers to compete on quality and impact (competitive grants), while providing institutions with a base research funding level intended to allow them to make their own strategic choices (block grants) with reduced transaction cost burdens compared with external grant applications. But changes to funding for higher education research have increasingly eroded the share of block grants. The Commission assesses that further shifts away from block grants would risk undermining their important role.

Block grants are currently allocated on a formula-basis that does not include direct peer review or direct assessment of economic, social and environmental benefits. This is set to change with the implementation by the Australian Government of the Research Quality Framework (RQF). This will use peer review and other indicators to review quality and impact as a basis for the distribution of some university block funding. The Commission agrees that the RQF may well allow the development of better measures of quality and impact.

However, while the RQF may bring some benefits, the UK and NZ experiences suggest that these would have to be substantial to offset the significant administrative and compliance costs. But since a decision on its implementation has now been made by government, the relevant policy goal is to achieve the benefits intended at the minimum possible administrative and compliance costs.

The maximum benefit from the 2008 RQF round could be obtained only if its provisions allow scope for significant change in funding outcomes compared with the existing block funding formulae. Accordingly:

- safety nets should be minimal; and
- scales should be set so that there are significant penalties for achieving low quality and impact grades — a linear funding scale, as apparently envisaged, could be counterproductive.

The first round RQF 2009 evaluation should consider the merits of other, less costly, ways of promoting quality and impact in higher education research. These would include auditing approaches that uncover those areas with the highest risk of poor performance, in conjunction with modified formula-based approaches to funding.

If the RQF is to continue beyond 2008, then consideration should be given to bringing forward the 2014 round and/or conducting a partial round in the intervening period — this would provide an earlier basis for assessing the effects of the RQF in promoting quality and impact improvement.

In regard to competitive funding, little, if anything, would be gained through amalgamating the ARC and the NHMRC.

National Research Priorities give some guidance

The Australian Government has articulated the broad direction of its priorities for publicly-funded science through its National Research Priorities (NRPs), though these are neither binding nor quantitatively expressed.

The Commission supports the retention of the priorities in the present level of detail as these usually provide sufficiently meaningful signals of areas for research. Any marked loosening or tightening of the priorities would be problematic. Central government control would lack the flexibility and information to prescribe more precise research agendas. Any broader level of prioritisation would no longer usefully guide research at all.

How big should the pie be? — funding issues for science

Although the study's terms of reference seek guidance about where and how public funding should be allocated, several participants also addressed concerns about the level of funding — unsurprisingly the majority of these submitting that it should be increased.

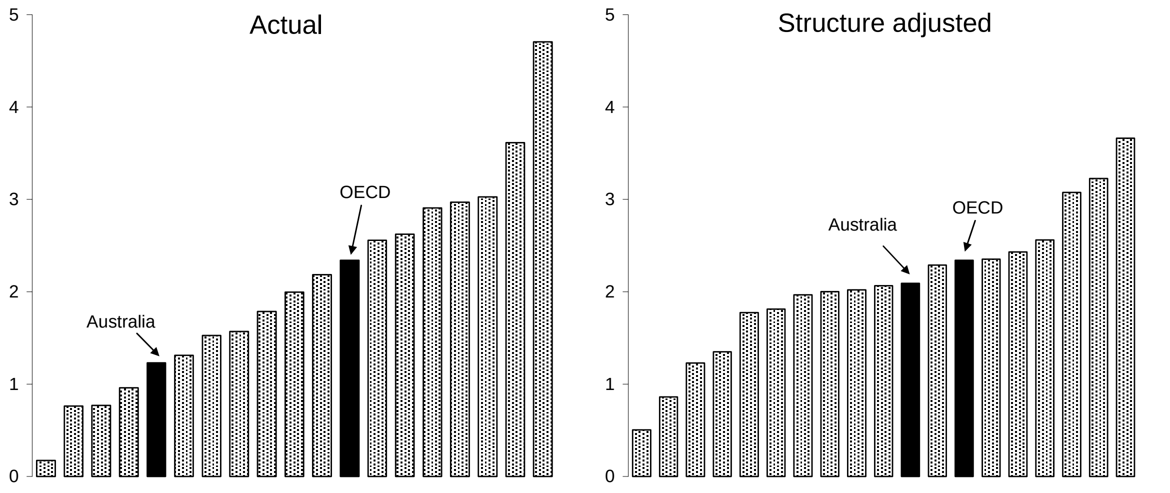
There are several indicators and processes that help guide whether funding levels are appropriate. International comparison is a useful broad indicator of adequacy, but must be undertaken and interpreted carefully. Some participants in this study claimed the apparently low Australian R&D to GDP ratio is an indicator of significant under-investment, requiring redress through increased government funding. However, the apparent disparity in business R&D intensity mainly reflects differences in industry structure, rather than an inherently low R&D orientation (figure 2). And the area where the most concern about inadequate funding was raised — higher education — is not towards the low end of the distribution of R&D spending to GDP among OECD countries.

Other macro indicators — economic growth, innovation rates and multifactor productivity growth — suggest that Australian businesses are generally making sound decisions about their current R&D and other innovation costs.

The Commission also considered a range of indicators of the degree of stress in the innovation system — such as human capital adequacy, scientific outputs and quality, and the capacity for solving local problems. Some study participants pointed to the high impacts from public spending as evidence that more should be spent. But, as noted above, the Commission's analysis of the impacts of publicly funded science and innovation demonstrates a favourable outcome, but is insufficiently precise to calibrate funding levels. In any case, the benefits of past research is not the only relevant criterion for funding. New spending measures also have transaction costs associated with compliance and unexpected incentive effects, as well as the costs of raising finance through distortionary taxes (or those associated with displacement of other public spending). A decision to spend more has to balance the marginal benefits against the marginal costs.

Figure 2 **The R&D ‘gap’ narrows considerably once industry structure is taken into account**

BERD/value-added ratio (per cent), 2002[a]



[a] The structure-adjusted estimates use the (OECD average) industry structure.

At an aggregate level, the available evidence suggests that Australia’s public support of science and innovation is not in the ‘danger zone’ of demonstrable over- or under-funding. But as the Commission has highlighted, there are some stresses on the system, including:

- emerging pressures in the academic and teaching scientific workforces, stemming from aging and ongoing workplace inflexibilities;
- *possible* infrastructure inadequacies in universities;
- expanding needs for public good research, given new environmental, energy and climate challenges; and
- the need for more effective collaborative arrangements between businesses and universities.

But equally, there are areas where potential savings might be realised:

- the base R&D tax concession and some other business programs; and
- diminishing requirements for public funding for some traditional areas of research, including research undertaken by public agencies for industry on non-commercial terms.

The net balance of these contrary pressures is not clear. Nor is the balance between emerging needs in science and innovation compared with competing priorities of government spending, such as health or education, or lower taxation burdens for Australians. Given that public spending on science and innovation is not in the ‘danger zone’, aggregate funding is best determined by a bottoms-up approach. This would involve judgment on a case-by-case basis in a budgetary context, supported by Australia's existing institutional processes and structures. While this process usually works adequately, it needs to be informed by high quality evaluations as well as other detailed evidence. Current practices are poor in some evaluation areas.

Several participants considered that the balance of public support had shifted inappropriately towards applied R&D and commercialisation at the expense of basic and strategic R&D. While there is no absolute standard against which to judge the appropriateness of this shifting balance, when assessed against the rationales for public support for R&D, there are dangers if the trend goes too far.

Australia's State and Territory Governments are increasingly active in the provision of public support for R&D. At the intergovernmental level, federalism risks program proliferation, poor coordination and overlaps, but also creates some unique experiments in new program design.