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The Dilemmas of External Earnings in Public Sector Scientific Research

CHRYS GUNASEKARA

ABSTRACT *Governments in a number of developed countries have repositioned their public research agencies to support economic objectives and to alleviate fiscal pressures. This has been accomplished through various strategies, including private–public partnerships and purchaser–provider arrangements. In the 1980s, the Australian Government introduced external earnings targets of up to 30% per annum for its public research agencies, as a means of strengthening their responsiveness to national economic needs. A case study of the Commonwealth Scientific and Industrial Research Organization is presented in this article to discuss the impacts of the external earnings policy. Impacts on the type of research being undertaken by public research agencies, the quality of public research–industry relationships, the nature of scientists' work and the role of stakeholders are considered. A number of dilemmas are raised relating to the role of public scientific research.*

Keywords: external earnings, science and technology policy, CSIRO, public research.

Governments in developed countries have sought to improve the responsiveness of public research agencies (PRAs) to the objectives of economic development. In doing so, a range of strategies have been applied, including: spinning-off companies;[1] collaborative research between PRAs and firms, so called public–private partnerships;[2] targets for expenditure on priority themes that are linked to national objectives;[3] increased contract research;[4] and the use of purchaser–provider arrangements.[5] In most cases, experimentation with these measures has been triggered by pressure on governments to address economic problems or pressure on governments' ability to maintain PRAs.

A number of countries have experimented with broad-based emphases on external earnings as a lever of industry linkage. For example, The Netherlands, Germany, the United Kingdom and, to a lesser degree, the United States. In 1988, the Australian Government imposed external earnings targets of up to 30% per annum on its major national scientific research agencies, in the context of broader economic restructuring, fiscal pressure on government funding of PRAs and perceptions that the performance of PRAs was not achieving its potential in contributing to national objectives.[6]

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The public sector in Australia has been the largest investor in R&D, and, for most of the post-war period, the dominant scientific research performer. Hence, the role of public research has been a key plank of Australian science policy.

External earnings targets have been in place for over a decade. Although there is evidence that these targets have led to the development of an entrepreneurial research culture and greater awareness and engagement with industry needs, their impacts have also raised a number of dilemmas for the role of public investment in R&D. These dilemmas relate to: the type of research being undertaken, the quality of public research–industry relationships, the nature of scientists' work, and the role of stakeholders.

The Australian experience with external earnings targets is discussed through a case study of the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia's major national scientific research agency.

External Earnings Targets

Science policy in Australia has focused consistently on two themes: stimulating business investment in research and development (R&D) and increasing the responsiveness of public sector scientific research agencies to the needs of industry.

External earnings have been a feature of public sector scientific research from its earliest history. Funds for short term, tactical research were secured through research contracts and collaborative research projects. In the primary industries, industry research funds were established from the late 1950s to articulate the research needs of agricultural industry and to coordinate both tactical and strategic research. Funds were contributed by government and from producer levies, and research committees comprising representatives of government, industry and universities made research choices. Other industry sectors, notably, manufacturing, were far less organised and did not have a record of long-term engagement with public research bodies. Hence, beyond contract research for individual companies or groups of organisations, and the granting of patents and licences, public sector research did not penetrate secondary industry.

Debate over the role of external earnings in public sector research began in the 1970s.[7] At that time, the Government was clear that public agencies such as the CSIRO were primarily in the business of strategic research in support of Australian industry, community interests and other perceived national objectives and obligations. They were not to regard external earnings as an important source of income. Rather, external earnings would be a means of understanding industry needs and improving the capability of public sector scientists.

When, in later years, the CSIRO was directed to increase its commitment to short-term, applications oriented research,[8] this was to be in addition to its strategic research focus. Funding for this shift would be drawn from industry on a user pays basis, through contract research, joint ventures, collaborative research, licences and patents. But government funding for strategic research would remain at or near the then current level.

When external earnings targets were introduced in 1988, a similar logic prevailed: public agencies would maintain a long term applications orientation with the support of government funding. However, to ensure that the constitution of public research was relevant to national objectives, part of their funding would have to be drawn from external sources.

This was seen by the Government, not as an end in itself, but as a plausible strategy to accelerate change in the public sector towards a purposeful industry focus. The purposes of promoting linkages between government research agencies and industry were to:

- increase research awareness and the capacity for technological innovation in industry;
- capitalise on publicly funded research by encouraging its commercialisation;
- align the major public investment in government research agencies more closely with national objectives;
- make the best use of major national research facilities; and
- concentrate the resources and expertise of all research sectors on issues of national and commercial interest.

This policy strategy was not unlike developments that had occurred in PRAs in other Western countries. Germany's FhG had been transformed by a government direction that industry funding be increased substantially.[9] In The Netherlands, the Dutch Government had frozen TNO's direct allocation and reduced indirect support in the 1980s, forcing the TNO to operate on a 'business' basis. Similarly, in Hungary, the amount of central subsidies for public research institutes was frozen at existing levels and new possibilities for external financing were encouraged.[10] Finally, in New Zealand, the DSIR (prior to its abolition), had had its appropriation reduced in the late 1980s, on the basis that they would be offset by growth in external revenue.

Impact of the External Earnings Target on CSIRO

The CSIRO is Australia's national scientific research agency, with an expansive mandate in the physical and biological sciences. Its research primarily takes an applications orientation with an emphasis on longer term, broadly applicable activities. The total revenue of the Organization is approximately $700 million (2000–01) and it employs approximately 6,500 staff throughout Australia and overseas. Research activity is organised into 22 sectors covering research in agribusiness industries; environment and natural resources; manufacturing, information and service industries; and minerals and energy industries.[11]

CSIRO has always drawn its income from both governmental and external sources. Historical trends in these funding sources are shown in Figure 1 below.

Figure 1 shows trends in government funding and external funding in CSIRO between 1949 and 2000. The graph indicates that external income has been substituted for government funding since the 1980s, almost in direct proportion.

In the post-war period, CSIRO saw itself, foremost, as a strategic research agency, addressing the systemic, long-term objectives of Australia's primary industries, and later, secondary industry and broader community needs in areas such as atmospheric research and environmental research. This position was supported by the Government, which insisted that external income should not be seen as a major contributor to CSIRO's revenue.[12] Ironically, in 1981–82, the Organization imposed a limit of 30% on the proportion of external earnings to total salary funds, amidst concern by the Executive that the growing level of external funding may 'distort the Organization's research priorities through the diversion of effort into research areas most likely to be capable of attracting external funding'.[13]

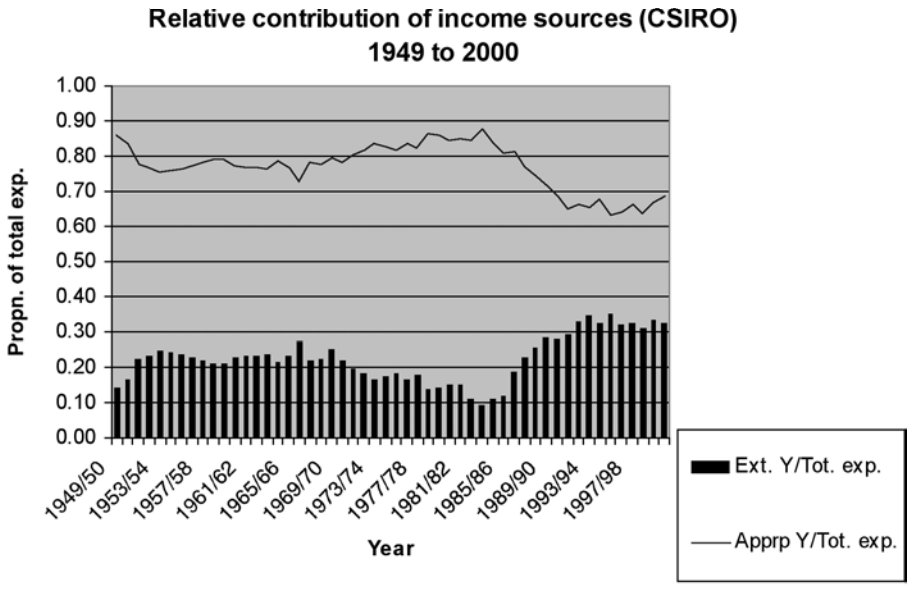

Figure 1. Relative contribution of income sources (CSIRO) 1949–2000

This was a legitimate concern, given that priority setting in CSIRO at that time was largely a bottom-up process, driven by scientists, with input from industry representatives through advisory committees and day-to-day contacts.

Although the external earnings target was introduced in 1988, CSIRO had been grappling with the question of an appropriate balance between government funding and external income from somewhat earlier. In 1985, the Australian Science and Technology Council, the Government's chief advisory body on science policy, had recommended that CSIRO refocus its role to the conduct of applications oriented research combined with a commitment to ensuring the effective transfer of its research results to end users.[14] This meant, in effect, that CSIRO would concentrate primarily on research in support of existing and emerging industry sectors and measures to facilitate the adoption of the practical results of its research. External income was a necessity—to validate industry demand—not an option. Simply, if industry was willing to pay, then CSIRO must be doing relevant research.

From here, it was a short step to the introduction of an external earnings target of 30% per annum after 1988. Notwithstanding the changes that had been requested in 1985, the Government insisted that the CSIRO (and other national science agencies) still fell short of their potential in contributing to industry development.

The impact of the external earnings target upon CSIRO may be considered in a number of ways:

- the impact on priority setting;
- the impact on relationships with industry;
- the impact on scientists and their work; and
- the role of stakeholders.

In turn, these impacts raise a number of dilemmas regarding the effectiveness of external earnings targets in public sector scientific research.

Impact on Priority Setting

A formal, two-stage priority setting process was introduced in CSIRO in 1990. Prior to this, research priorities and budgets were shaped by scientists and managers at the local level with the benefit of broad guidelines issued by the Executive, input from research reviews and input from advisory committees at the peak level and at the sectoral level.

The criteria for decision-making canvassed national benefits, scientific prospects, quality of staff, funding requirements, and appropriateness for CSIRO, utilisation of research results and external commitments. A series of questions was posed to aid decision makers in considering each criterion, and a Planning Evaluation and Advisory Unit garnered data on external and internal trends. But there was no rigorous methodology within which to address these issues and analyse the available data, particularly in dealing with competing proposals that satisfied the minimum requirements suggested by the trigger questions.

The priority setting process introduced in 1990 was more robust. It was based on a two-grid model for assessing national priorities that brought together the socioeconomic and scientific environments. The two grids—'attractiveness to Australia' and 'feasibility'—consisted of four key criteria, namely: potential benefits of successful research; capture of the benefits; R&D potential; and R&D capacity.[15] The Executive Committee of the Organization rated each of 17 major research subdivisions using these two grids.

The two grids were then combined to give an overall rating on two axes, attractiveness and feasibility. From its position on the grid, each subdivision was labelled as warranting strong emphasis, selective emphasis or limited support. This exercise was then repeated at the corporate level and the resulting priorities implemented by means of a levy on the Organization's divisions to form a central pool which was then reallocated according to the nominated areas of preference, with dollar-for-dollar divisional back-up.

This process has been refined in more recent years. CSIRO's response to its self-assessment of national priorities considers in more depth issues of mandate, customer base and internal capability.

The external earnings target added a layer of complexity to this process. Alignment of research to industry and community needs was now mediated by the capacity to generate external income, and to do so at a rate that would meet the 30% target each year.

This raised a critical dilemma which was expressed by CSIRO planners thus: 'While external funding should assist in establishing priorities and performance through a market mechanism, the norm of marginal funding by external sources is having a distorting impact. In extreme cases as much as 90% of a division's research resources can be committed to research for specific external users, which then constrains the availability of resources for other purposes'.[16]

In essence, aligning research to industry needs was not, as the Government had assumed, simply a matter of selling tactical research or commercialising products and processes generated from strategic research, at the margins of a strategic research hub.

The distortion in priorities occurs at multiple levels. First, tactical research was displacing strategic research. Second, commercial returns from strategic research were being sought too early, displacing longer-term benefits and potentially higher returns. Third, the integrity of strategic research was itself potentially jeopardised.

Since the external earnings target was introduced, a number of reviews have considered its impact on research priorities. CSIRO itself, and stakeholders, have been vocal about the effects of the 30% target on priority setting. In every case, while acknowledging in general terms the favourable impact that the target has had on research culture, awareness of industry needs and links with industry, criticisms have been made of the deleterious impact that has occurred on strategic research. With some notable exceptions in the primary industries, lack of interest on the part of users in funding long-term research is seen as a critical factor that has contributed to a skew in research choices.

This is consistent with international experience. Balasz,[17] for example, points to the risk of a demand-driven approach to priority setting in an environment where there is a relatively poor climate of private sector interest and investment in new technology. In essence, the contribution of science to national objectives is circumscribed by what firms are prepared to pay for. This may result in a contribution by science to national development that is well below its potential.

The evidence from stakeholders, CSIRO itself and the Government, insists that the external earnings target has distorted research choices towards short-term activity that can yield early returns. The Australian Academy of Technological Sciences and Engineering has claimed that the 30% target has brought about sharp reductions in curiosity-led research and replaced long-term goals with short-term goals, because it is easier to find customers willing to pay for the latter.[18] The Australian Academy of Science has expressed concern that such a narrow but strong focus [on a revenue target] may compromise the independence of CSIRO's tax-payer funded strategic research.[19]

While highlighting the advantages of the external earnings target for industry–science relationships, the Australian Chamber of Commerce and Industry (ACCI) has noted that this has resulted in a greater short-term focus on short-term financial outcomes within the CSIRO, which does not always result in an efficient allocation of public resources.[20] The Federation of Australian Scientific and Technological Societies (FASTS) similarly argued that the target had led to excessive emphasis on the short term rather than the long term, working against the public good.[21] Over time, areas of expertise have been lost because there is no commercial market for them; for example, taxonomy. Finally, the CSIRO Staff Association has been more direct, insisting that: 'The driving force for research projects in CSIRO is getting the money in'.[22]

Coleman[23] has discussed the risks associated with the timing of bringing in commercial partners, relating to the development of an anti-flu drug by CSIRO. Essentially, if, in the absence of government support, external funding from commercial partners is sought too early, the public researcher has limited bargaining power over how and where the final product is taken to market.

Those who acknowledge that the target has improved industry responsiveness, point out that this may be at the expense of drawing down CSIRO's intellectual capital, accumulated over many years, which forms a base on which future applications are built,[24] hence, making external earnings of 30% per annum unsustainable.

Even in respect of tactical research, the impact of the external earnings target has not been convincing. In his review of Australia's science capability conducted in 2000, the Chief Scientist[25] criticised the slowness of CSIRO in shifting resources into areas that underpin growth in the knowledge economy, and the relatively slow rate at which CSIRO spins off new businesses compared to the results achieved by research bodies in the US and the UK. (However, this cannot be attributed wholly to the failure of the external earnings target.)

A broader policy issue raised by this discussion is the extent to which an external earnings target, in effect, amounts to cross-subsidisation of development, at the expense of longer term, public good research. As FASTS observed: 'There is a view that, until Australian industry, learns, or gets forced, to invest more into research, the nation will continue to subsidise purely industry research that benefits particular industries. Industry is reported as being very good at leveraging money out of CSIRO, and getting public funding to do its development research (or pay for it fully)'.[26]

If this is the case, it is arguable that the external earnings target, far from fostering a long term, independent technological capability in industry itself, merely fosters a continued dependence on public research, at the expense of public good research.

Impact on the Quality of Relationships with Industry

While, in general terms, the use of external earnings targets has been regarded as successful in improving awareness of industry needs and in developing links with industry, a second dilemma relates to the impact of earnings targets on the quality and depth of relationships between public research and industry. A recent staff survey conducted by CSIRO showed that only 46% of staff felt that CSIRO as a whole was very customer-oriented; although the majority of staff believed that CSIRO was highly regarded by the general public, its customers, its staff and by the international scientific community.[27]

External earnings targets are a means of improving the quality of public research–industry links by improving communication, understanding and responsiveness. However, there is evidence that, where targets are applied merely as financial performance indicators, they can, in fact, damage long-term relationships.

Some have suggested that the external earnings target has discouraged collaboration. Thus, both the Australian Chamber of Commerce and Industry and the Minerals Council of Australia have argued that the pressure on scientists to bring in revenue has led to this being an end in itself, rather than a means of engaging meaningfully with industry's needs.[28] In some instances, the 30% target was being achieved by the provision of 'fee for service' activities and isolated.

FASTS also noted that the target had encouraged 'excessive competition instead of collaboration'.[29] This resulted from public agencies engaging in 'cut-throat' competition with each other for limited industry funds, where it would have been far better to pool their resources and expertise and make a joint approach. Presumably, this may have contributed to sub-optimal results.

The ACCI has also argued that the target has resulted in CSIRO increasing its focus on conducting research for overseas-based organisations, resulting in an increase in the amount of Australian-conducted research being commercialised overseas with little or no benefit to Australia.

At a deeper level, concern has been expressed by industry that the drive for external earnings by PRAs might well encourage contract relationships, but discourage other valuable forms of collaboration, such as secondment of government research agency staff to industry. Other perennial criticisms have been that the target has discouraged the contracting of work by government research agencies to industry; that they have caused agencies to focus on large companies and on government funded schemes such as the Cooperative Research Centres Program (in which CSIRO has a substantial presence) in order to obtain stable, large volume funding, to the detriment of other industry users, notably, small and medium-sized companies; that they lead to a favouring of one-to-one arrangements with companies, rather than broader industry-based arrangements. In particular, concerns have been expressed regarding the equity of using public funds for projects that generate a competitive advantage for a single sponsor, especially where core knowledge is tied up by non-disclosure arrangements with the company.

These issues are far from unique to the Australian institutional setting. A study by Fritsch and Lukas[30] of 1,800 German manufacturing enterprises engaged in collaboration R&D projects with PRAs raised similar concerns.

Further criticisms suggest that public agencies seek to maximise 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 (the counter argument to this position was noted earlier); retaining cash follow generators that should be spun off; providing services that are in direct competition with private sector research providers and adopting an inflexible approach.

It may be unreasonable to lay all of these concerns at the feet of external earnings targets. For example, the tightening of practices on pricing and intellectual property rights are largely a consequence of broader public sector reforms dealing with the accountability of government research agencies.

Nevertheless, the dilemma raised here stands: that external earnings targets can be a blunt instrument in leveraging public research–industry relationships. This has been highlighted recently by the Chief Scientist.[31]

The Impact on Scientists and their Work

The third dilemma raised by external earnings targets specifically, and the commercialisation of research more generally, relates to the impact on scientists and their work. This is perhaps the most unfortunate area of impact, and one that is related to the changing structure of the science system more broadly. A challenge for public research institutions lies in integrating the competing cultural perspectives of science, industry, markets and the corporation.

Most of the public discussion about R&D, science policy and public research–industry links canvasses institutional and interest group behaviours, but rarely, individuals—the men and women who 'do' science. At a deeper level, and of more concern, is: who speaks for the scientists? This is not easy to answer.

Their employer, perhaps understandably, raises the eminent achievements of scientists to emphasise the contribution that science makes to national development. The peak scientific bodies position the importance of science and scientific research on the national stage. In some respects, the CSIRO Staff Association has been one of the clearest voices speaking for scientists.

As well as being an active contributor to policy debate, the Staff Association has pointed to a number of less desirable impacts of external earnings targets on the work of scientists. For many scientists, working with private industry has been remarkably satisfying. They have thrived in the direct interaction, the focus on results and in seeing the fruits of their efforts being taken up and used. On the other hand, the drive for external income has been claimed to have created a climate of boom and bust at the divisional and lower levels that has resulted in loss of expertise in particular specialities, job insecurity, increased personal stress, more short-term employment, redundancies and reduced capacity for careers in science. The multiple layers of reporting required with external sponsors has impacted on productivity and reduced morale.

This obviously does not apply to all scientists in all locations. Like many change strategies that are introduced into organisations, some will thrive and some will be damaged. Anecdotal evidence points to deep resentment, anger and fear as scientists try to adjust to an entrepreneurial environment that can be just as treacherous as exciting. For some, perhaps many, their work in the current policy environment leads them to question why they became scientists at all.

This is not to suggest that change should not occur. Simply that, when external earnings become reified as a financial performance indicator, the purpose of public research and the motivation of public researchers may suffer. As one scientist said: 'We have become the toolshop of industry . . . I became a scientist to do outstanding science, to make a difference . . . I didn't choose to become an entrepreneur, chasing funds to keep myself employed after the end of this year'.

The Role of Stakeholders

A fourth dilemma surrounding external earnings targets relates to the role of stakeholders in priority setting. In a pluralist system, distortions in priorities may be 'corrected' by countervailing pressure brought to bear by interests representing alternative preferences. There is little evidence that this has occurred in Australia.

The Australian science system is decentralised and fragmented. Priorities are set at government, agency and sectoral levels.[32] There are well developed mechanisms at the sectoral and agency levels, but as the Chief Scientist has noted recently, there is a need for an integrated priority setting mechanism across the span of Commonwealth Government R&D investment, to assist in both providing solutions to national problems and to maximise returns to the community.[33] Thus, broad-based agreement on a framework of national priorities would provide context and control over the direction of agency and sectoral research priorities.

There is a further dimension, however, that relates to the range of stakeholders participating in priority setting mechanisms and the design of such mechanisms. International evidence of foresight processes points to the benefits of open, inclusive planning that draws in multiple stakeholders.[34]. There have been a number of studies in recent years that pose alternative models for participation to improve the validity of priority setting.[35] Processes such as community-based planning, joint planning and strategic conferencing have led to improvements in the quality of priority setting criteria, as well as providing greater balance in the decision-making process. This is translated to improvements in social capital.

The focus in Australia on industry needs, essentially articulated by industry for industry, tends to ignore or isolate broader community interests that may offer

alternative positions or may contribute to a more robust articulation of user priorities. There is much greater scope, therefore, for institutionalising inclusive planning processes. This would provide a richer context within which lower levels of planning are conducted. And, in turn, lower levels of planning would benefit from a more open orientation.

Planning processes undertaken within CSIRO have been hierarchical in their design, with input by stakeholders essentially confined to peak science bodies, industry and other research users. Prior to the introduction of a formal planning system, external input was drawn largely from industry, universities, peak science bodies and other government agencies, through advisory committees at the peak level and at sector level. This was not a representative cross section of societal interests.

The priority setting system introduced in 1990, to some degree, corrected this imbalance, by drawing on a wider range of informed stakeholder opinion and, increasingly in recent years, emphasising dialogue with stakeholders and scientists, rather than technique. External representation on CSIRO's Sector Advisory Committees comprises 70% industry and community members and 30% government officials.[36] It remains to be seen whether national priority setting can support this work by taking an inclusive approach that extends to beneficiaries, defined in the broadest sense.

Conclusion

The drivers of external earnings in science are not unique to Australia. The impacts of external funding targets in public research raise dilemmas that are relevant to a number of developed countries. These dilemmas relate to the nature of research choices, the impact on public research–industry links, the work of scientists and the role of stakeholders in research planning. These dilemmas pose serious questions for the role of public research in national development. In many ways, the cure of external earnings targets has become worse than the complaint.

Postscript

In 2002, a review conducted by the chief scientist recommended that the external earnings target of 30% be discontinued. However, at the same time, the CSIRO has itself adopted a target of 50%, which is likely to accentuate the dilemmas raised in this paper.

Notes and References

1. J. P. Hsu and K. T. Yeo, 'A systemic approach to re-engineer a Public Research Institute (PRI) for commercialization', *International Journal of Project Management*, 14, 6, 1996, pp. 387–93.
2. T. Gonard, 'Public research/industry relationships: efficiency conditions in current innovation', *International Journal of Technology Management*, 17, 3, 1999, pp. 334–50.
3. M. Balter, 'New research strategy drawn criticism', *Science*, 11 October 1996.
4. P. Mustar and P. Laredo, 'Innovation and research policy in France (1980–2000) or the disappearance of the Colbertist state', *Research Policy*, 31, 2002, pp. 55–72.
5. M. Cartner and T. Bollinger, 'Science policy reforms: the New Zealand experience', *Social Studies of Science*, 27, 1997, pp. 775–803.
6. Australian Science and Technology Council (ASTEC), *On Target? Review of the Operation of External Earnings Targets for CSIRO, ANSTO and AIMS*, AGPS, Canberra, 1994.

7. A. J. Birch, *Independent Inquiry into the Commonwealth Scientific and Industrial Research Organization*, AGPS, Canberra, 1977.
8. Australian Science and Technology Council (ASTEC), *Future Directions for CSIRO*, AGPS, Canberra, 1985.
9. S. Pearce, 'The Federal Republic of Germany: cooperative federal/state roles in science and technology', in *National Purposes, Federal Government Science and Technology in Australia, Canada and the Federal Republic of Germany*, ASTEC, Canberra, 1990.
10. K. Balasz, 'Lessons from an economy with limited market functions: R&D in Hungary in the 1980s', *Research Policy*, 22, 1993, pp. 537–52.
11. CSIRO, *2000/2001 Annual Report*, CSIRO, Canberra, 2001.
12. CSIRO, *1977/1978 Annual Report*, CSIRO, Canberra, 1978.
13. CSIRO, *1981/1982 Annual Report*, CSIRO, Canberra, 1982, p. 133.
14. ASTEC, *op. cit.*, 1985.
15. CSIRO, *CSIRO Priority Determination 1990: Methodology and Results Overview*, CSIRO, Canberra, 1991.
16. CSIRO, *CSIRO Priority Determination 1990: Role Statements*, CSIRO, Canberra, 1991.
17. Balasz, *op. cit.*
18. The Australian Academy of Technological Sciences and Engineering, *Submission to Government: Review of External Earnings Targets Policy*, ATSE, 2001.
19. Australian Academy of Science, *Submission to Review of the External Earnings Targets Policy applying to the Science Authorities (CSIRO, ANSTO and AIMS)*, AAS, 2001.
20. Australian Chamber of Commerce and Industry, *ACCI Submission to the Chief Scientist: Review of External Earnings*, ACCI, 2001.
21. Federation of Australian Scientific and Technological Societies, *Review of External Earnings Targets Policy: A Submission from FASTS*, FASTS, 2001.
22. CSIRO Staff Association, *Submission by the CSIRO Staff Association to Review of The External Earnings Targets Policy*, CSIRO Staff Association, 2001.
23. P. Coleman, 'Bimolecular research: development of an ani-flu drug', in *Beyond Science*, CSIRO, Melbourne, 1998.
24. ASTEC, *op. cit.*, 1994.
25. Chief Scientist, *The Chance to Change*, AGPS, Canberra, 2000.
26. FASTS, *op. cit.*
27. CSIRO, *Co-Research*, 389, Summer 2002.
28. Commonwealth Parliament, *The Effect of Certain Public Policy Changes on Australia's R&D*. Report by the House of Representatives Standing Committee on Industry, Science and Resources, AGPS, Canberra, 1999.
29. FASTS, *op. cit.*
30. M. Fritsch and R. Lukas, 'Who cooperates on R&D?', *Research Policy*, 30, 1999, pp. 97–312.
31. Chief Scientist, *Review of Marine Research in Tropical Australia*, AGPS, Canberra, 2001.
32. Chief Scientist, *Priority Matters*, AGPS, Canberra, 1997.
33. Chief Scientist, *op. cit.*, 2000.
34. A. Webster, 'Technologies in transition, policies in transition: foresight in the risk society', *Technovation*, 19, 1999, pp. 413–21.
35. C. M. Vos and C. L. Balfoort, 'Strategic conferencing: a new approach in science policy', *Research Policy*, 18, 1988, pp. 51–7; W. J. Oortwijn, H. Vondeling and L. Bouter, 'The use of societal criteria in priority setting for health technology assessment in the Netherlands', *International Journal of Technology Assessment in Health Care*, 14, 2, 1998, pp. 226–36; A. P. Johnson-Masotti, S. D. Pinkerton, D. R. Holtgrave, R. O. Valdiserri and M. Willingham, 'Decision-making in HIV prevention community planning: an integrative review', *Journal of Community Health*, 25, 2, 2000, pp. 95–112; A. J. van der Beek, H. W. Frings-Dresen, F. J. H. van Dijk and I. L. D. Houtman, 'Priorities in occupational health research: a Delphi study in The Netherlands', *Occupational and Environmental Medicine*, 54, 1997, pp. 504–10.
36. CSIRO, *op. cit.*, 2000/2001.