Chapter 7

RESEARCH AND DEVELOPMENT FISCAL INCENTIVES IN AUSTRALIA: IMPACTS AND POLICY LESSONS

by

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Introduction

Many countries provide substantial subsidies to innovation, reflecting a whole range of concerns – such as a desire to overcome non-innovative business cultures, secure knowledge spillovers, attract foreign knowledge-intensive multinationals and increase national prestige. At heart, these incentives are premised on the fundamental role that diffusion of knowledge plays in technological progress and economic growth. In 1985-86 Australia introduced one of the most generous tax incentives in the world: the R&D taxation concession, which allowed firms to deduct a range of expenses at up to 150 per cent (but now 125 per cent). In November 1987, following a mid-term review of the 150 per cent incentive, the scheme was elaborated by allowing syndicates of firms to participate in the programme (although often not at 150 per cent).[2] This paper is primarily concerned with the general tax concession, although we also draw on some of the policy lessons from design failures in syndication (which was abolished in 1996).

The principal aims of this paper[3] are to:

◊ develop a cost-benefit framework for evaluating the tax concession;

◊ using this framework, examine the most important facets which determine whether the concession is welfare enhancing – and in particular the issue of inducement – and determine appropriate parameters for use in the cost-benefit framework; and

◊ draw lessons from the (imperfect) design and functioning of the incentive.

We begin briefly with the economic backdrop to the development of innovation policies in Australia, and describe the relationship of the R&D tax concession to Australia's other science and technology policies.

Then, applying the cost-benefit framework, we turn to the impact and functioning of the incentive, and draw lessons for the design of R&D policies.

Background to innovation policies in Australia

The policy environment

The introduction of the R&D tax concession on 1 July 1985 occurred when industry policy was shifting away from protectionism and toward greater integration with the global economy. At the time, the BERD/GDP ratio was very low by international standards – and this was widely perceived as an indicator of business underinvestment in innovation. The concession and other R&D programmes were seen as mechanisms for reorienting Australian firms and in changing the attitudes and priorities of management towards innovation. There was less acknowledgement of other more enduring economic reasons for innovation support – such as spillovers.

From the mid-1980s onwards the basic goals of policy have been to:

- ◊ increase the BERD/GDP ratio;
- ◊ increase the effectiveness of public sector R&D; and
- ◊ improve linkages between different arms of the innovation system, particularly between business and public sector research organisations (as exemplified by the Co-operative Research Centres programme and the Teaching Company Scheme).

While Australian governments have used a plethora of other industrial R&D support mechanisms, such as grants, soft loans and arrangements to encourage linkages, the general and syndicated R&D concessions have almost completely dominated government expenditure on business R&D in the last decade.

The tax concession is also generous by international standards. Notwithstanding reductions in the concessional rate, Australia still provides the third most generous tax treatment of R&D amongst OECD countries.

Trends in business R&D

Over the period of the 1970s and early 1980s, Australian R&D performance differed in three major ways from that of many other OECD countries. First, the ratio of business expenditure on R&D (BERD) to GDP was very low, compared to both the OECD average and other similar-sized R&D performing countries. Second, the ratio had been declining during most of the 1970s, in stark contrast to the generally upward trend in most other OECD countries. The third conspicuous feature of Australian R&D experience is the dominance of government funding and a relatively high profile for R&D actually conducted by the public sector (outside higher education). For example, in 1994, the share of GERD performed by the government sector was nearly 120 per cent higher than the OECD average (OECD, 1996, p. 23).

Since 1984–85, however, the growth rate of Australian business R&D has been one of the most vigorous in the world. Nevertheless, despite above-average growth in BERD during the 1980s Australia's international business R&D to GDP ranking has not changed appreciably, mainly because Australia started from a relatively low base, and other countries with relatively low GERD/GDP ratios also increased their R&D expenditure at an above-average rate. In 1994, Australia still ranked just above the bottom quartile among 23 OECD and other countries in terms of BERD/GDP (OECD, 1996). On the other hand, Australia's BERD/GDP ratio is now around half the average for OECD, appreciably higher than its value in the early 1980s.

Explanations for Australia's relatively low BERD/GDP ratio turn mainly on three factors. First, manufacturing, the sector most intensive in its use of R&D inputs, is a less important part of the Australian economy than in many other OECD countries. Second, Australia has, in turn, a manufacturing industry structure biased towards lower R&D intensity activities. And finally, even corrected for structural differences, Australian manufacturing still has a lower R&D intensity, although the impact of this effect has decreased over time (IC, 1995, pp. 493 *ff*).[4]

Australia's business R&D performance has exhibited a number of distinctive features. First, relatively few enterprises undertake R&D – about 3 500 in 1995–96 (ABS, Cat. 8104.0) or around 1 per cent of non-farm private sector employing enterprises. In 1995–96 around 6 per cent of employing firms in the manufacturing sector undertook R&D – roughly the same as it had been ten years' earlier. Second, BERD has tended to be concentrated in a small number of product fields, with one broad category – information and communication technology[5] – now accounting for nearly 30 per cent of total BERD. Third, among those firms which undertake R&D, BERD has been concentrated in a relatively small number of firms. And fourth, it is mainly small and medium sized firms which have increased their R&D effort since 1984–85.

The Australian R&D tax concession

Description of the general tax concession

The programme was originally intended to be a temporary measure, due to terminate at 30 June 1991. In March of that year it became a "permanent" measure, albeit one subject to many changes over time. The basic objective of the R&D tax concession is to provide an incentive for greater levels of business research and development in Australia. The detailed objectives of the R&D tax concession are broader than that and have evolved over time. But the IR&D Board (1995) captured the essence of *their* aspiration:

"The objective of the 150 per cent tax concession is to encourage Australian companies to be more innovative and internationally competitive by:

◊ increasing companies' 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;

◊ developing a greater capacity for the adoption of foreign technology." (IR&D Board, 1995, p. 43).

From an economic perspective, the preoccupation with benefits to firms sits oddly with the main economic justification for incentives for R&D – the creation of dynamic or static externalities. There is, to some extent, a gulf between the aspirations of economists on the one hand (who would generally be arguing for maximisation of benefits not appropriable by firms) and policy makers and business people on the other, who emphasize the gains to the innovative actors themselves.

The tax concession provides a concessional deduction for all eligible R&D expenditures of 125 per cent (150 per cent up to June 1996). It currently has the following features:

- ◊ Current expenditure may be deducted at a rate of 125 per cent of costs in the year in which it is incurred. Current costs include wages, salaries and other labour costs directly related to R&D activity, and contracted R&D with registered research agencies. Interest on debt and non-consumed feedstock in pilot plants were allowable elements in current expenditure up until June 1996, but have now been barred as deductions at the concessional rate.[6]

- ◊ Equipment used for R&D may be depreciated over three years and deducted at a rate equal to 125 per cent of the deduction that would otherwise apply.

- ◊ Pilot plant will be written off over its useful life to a maximum of 125 per cent of its cost (whereas prior to the 1996 amendments, pilot plant was written off over three years at 150 per cent);

- ◊ Any company wishing to make an R&D claim to the Australian Taxation Office (ATO) must be registered with the IR&D Board. Application for registration with the IR&D Board must be made within six months of the end of the financial year in which the R&D expenditure was incurred.

- ◊ Deductions for core technology expenditure are to be limited to one-third of the expenditure per annum on eligible R&D relating to that core technology. Amounts not deducted in the year of income will be available for deduction in later years if there is further related eligible R&D expenditure (whereas prior to the amendments in 1996, core technology purchases were immediately expensed at 100 per cent).

- ◊ Buildings used for R&D may be depreciated over the standard period of 40 years, but with no other concessional treatment (although prior to 1987 buildings dedicated to R&D could be depreciated over 3 years at 150 per cent).

- ◊ The expenditure threshold for qualification for the full 150 per cent tax deduction is A$ 20 000 (A$ 50 000 prior to May 1994).

- ◊ There must be a high degree of technical risk – that is, there must be some uncertainty over what the results of the R&D will be.

- ◊ It must be innovation – with an appropriate level of novelty.

- ◊ It must, in main, be carried out in Australia, with adequate Australian content. For example, the key personnel and the major items of plant and equipment must be Australian.

- ◊ The results must be exploited on normal commercial terms and for the benefit of the Australian economy. This excludes arrangements such as umbrella technology agreements in which the results of R&D carried out in Australia are provided free to an overseas parent company.

The definition of R&D eligible for the concession is similar to that given in the OECD (1993) *Frascati Manual*. Similarities include the coverage of all types of research (from basic research to experimental development); the key requirement of an appreciable element of novelty; and the manner in which some borderline areas are treated. Differences include the inclusion in the Australian definition of routine testing and data collection, provided that they are directly related to an eligible core activity; and the exclusion of costs incurred in obtaining patents. As in Canada, activities such as market research, quality control, mineral prospecting, and cosmetic changes to products or processes are excluded. These exclusions ensure that there is a scientific or technological basis to the eligible research and development.

Policy direction and administration of the concession are divided between a government department, Department of Industry, Science and Tourism (DIST) and two statutory authorities – the IR&D Board and the Australian Taxation Office (ATO). The Board is responsible for registering firms, and for making determinations on the eligibility of R&D activities, adequate Australian content and exploitation of results. These determinations are binding on the Commissioner of Taxation, who in turn determines whether a company's expenditures, and legal and financial structures, are eligible. The main policy responsibility for the concession lies with DIST.

Trends in the use of the R&D tax concession

The registration data have a number of limitations (which are described in BIE, 1993*a*) so that they provide only a rough indicator of the patterns of use of the concession (Table 1).

Table 1. Trends in the use of the R&D tax concession

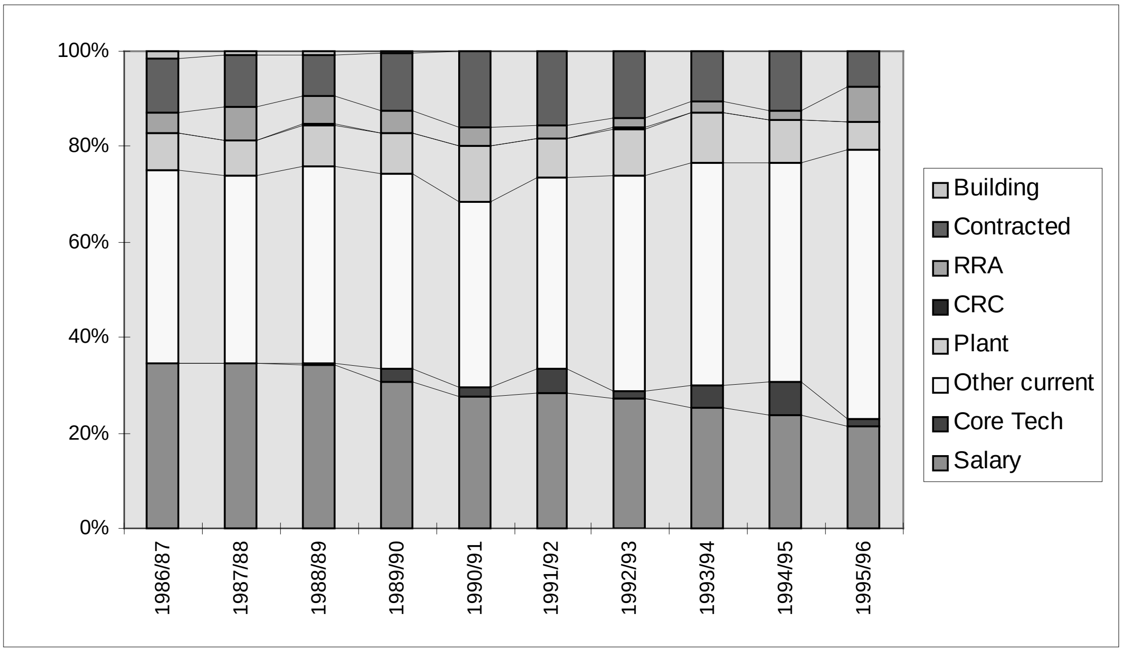
	Registrants	Eligible R&D	BERD	Eligible share	Eligible R&D per firm
	No.	$m	$m	%	$
1985-86	2 561	..	948.0	..	..
1986-87	1 674	734.7	1 288.6	57.0	438 889
1987-88	2 092	1 103.3	1 505.8	73.3	527 390
1988-89	2 158	1 293.1	1 798.3	71.9	599 212
1989-90	2 363	1 595.9	1 989.6	80.2	675 370
1990-91	2 510	2 241.4	2 099.8	106.7	892 988
1991-92	2 818	2 576.0	2 364.6	108.9	914 123
1992-93	2 738	2 723.3	2 862.6	95.1	994 631
1993-94	3 277	3 324.5	3120.0	106.6	1 014 495
1994-95	3 704	4 000.9	3 489.5	114.7	1 080 157
1995-96	3 963	4 489.7	4 242.9	105.8	1 132 904
Trend growth rate 1985-86 to 1990-91	0.028	0.511	0.156	0.355	0.483
Trend growth rate 1990-91 to 1995-96	0.094	0.143	0.136	0.006	0.049

Source: ABS and data from http://www.dist.gov.au and supplied directly by DIST. DIST records eligible R&D as A$103 million in 1985–86, but we consider this number too unreliable to use in the table.

Nevertheless, they appear to show dramatic increases in the use of the tax concession in the early years of the concession, until the ratio of eligible R&D has approximated BERD. In some years, eligible R&D has actually exceeded BERD – probably reflecting a combination of retrospective claims, an increasing tendency to register for the concession when claiming (BIE, 1993*a*, Appendix 6), and also possibly the inclusion of some expenditures which the ABS does not define as R&D.

The other interesting issue relates to the type of R&D conducted under the concession. While the data is not entirely reliable nor sufficiently disaggregated, information from registrants provides some evidence of the changing nature of deductions (Figure 1). Labour costs have played a smaller role in total eligible R&D, while other current costs such as overheads, interest payments and consumables (such as feedstock) have accounted for a rapidly increasing share. ABS data also seem to show a similar shift in the mix of R&D activities towards "other" current expenditure.

Figure 1. Expenditure shares by type of eligible R&D



Source: Information provided by DIST. Data is subject to revision. Expenditure codes in the legend have the same relative position in the graph, so that the salary share is the bottom portion of the graph, core technology the second from the bottom, and so on.

It was in part concern over the escalating costs associated with "other" current expenditure that fuelled changes in the R&D concession in 1996. There is little doubt that some of the R&D increase over time represents re-classification of other expenses as R&D. However, Bryant *et al.* (1997, p. 102) suggest that the very close correlation between Australian BERD (as a percentage of total OECD BERD) and Australian resident external patent applications (as a share of the OECD total) provides evidence for the legitimacy of most claims for R&D expenses, at least up to 1993.

Relationship of the tax concession to other innovation programmes

We can place R&D funding under the tax concession in context by comparing it with outlays from other government R&D assistance programmes (Table 2). In 1994–95, the 150 per cent general tax concession had just over 3 500 claimants accessing around 550 million in R&D subsidies. The syndication programme in contrast had only 103 users, but accounted for an estimated $255 million of R&D. In 1994–95 the government spent just over A$ 6.8 million in discretionary grants to 99 recipients (or about A$ 70 000 per recipient), A$ 12.2 million in generic technology grant payments to 37 firms and agencies (about A$ 330 000 per recipient), and A$ 16.4 million in competitive grants for 102 participants (A$ 160 000 per recipient). Syndication stood out as unique among this suite of technology programmes – it allocated resources to single firms in excess of what is allocated to whole innovation programmes, which was one of the motivating factors for its demise.

Overall, the R&D tax concession (comprising both the general programme and syndication) accounted for about 95 per cent of government direct funding of business R&D.

Table 2. The magnitude of industry R&D funding to firms via government programmes, 1994–95

Programme	Number of participants	R&D amount	R&D per participant
	No.	A$'000	A$'000
Competitive grants	102	16 371	160
Discretionary grants	99	6 867	69
Generic technology grants	37	12 229	331
National Procurement Development Programme	14	1 710	122
National Teaching Company Scheme	74	1 073	15
Advanced Manufacturing Technology Development Programme	7	1 043	149
Syndicated R&D 1994–95[1]	103	255 000	2 480
150 per cent R&D tax concession 1994–95[2]	3 574	549 146	154

1. See Lattimore (1996, Table 3.7) for the calculation of the number of different firms using syndication for that year and the estimate of the R&D conducted in that year. If a firm is undertaking more than one syndicate in 1994–95 they are counted as one firm only. Note that since the R&D periods of syndicates typically last around two years – the actual level of funding for a syndicate firm is around double that shown here.
2. The R&D amount specified for the general tax concession represents the estimated subsidy element of the concession. It is calculated as D x tax rate x 0.5 x (1– clawback–realisation lag) where D is the total value of claims, the tax rate = 0.36, clawback = 0.05 and rlag = 0.106 (from BIE, 1993*a*).
Source: IR&D Board (1995); BIE (1994); BIE amended DIST Syndicate Database as at mid May 1996 and the IR&D Board Tax Concession registration database.

At the time these statistics were generated, a number of other programmes also stimulated R&D in particular sectors or in particular contexts – and therefore also represent indirect assistance to business R&D (the Factor f programme for pharmaceutical companies, the Partnerships for Development programme for large multinational information technology and CRCs for businesses interacting with public sector and higher education R&D agencies). Nevertheless, even when these additional sources of funding are considered, the tax concession has amounted to by far the most significant source of government funding of business R&D.

To some extent, the situation portrayed by Table 2 has changed somewhat since. There has been some rationalisation and re-orientation, with the different grants being collapsed into a single programme of Competitive Grants for Research and Development with a single set of eligibility and merit criteria. That, together with the reduction in the concessional rate for the general R&D tax concession, the abolition of Syndication, and the inception of a new outlay measure for supporting larger commercially oriented R&D projects in smaller firms (the START programme), has meant that the tax concession now plays a smaller role in the big picture of government support for business R&D.

Evaluation of the tax concession

Methodology

The BIE (1993*a*, 1995), Lattimore (1996) and the IC (1995) undertook detailed, independent evaluations of the general tax concession and its syndicated provisions. This section uses the results and methodology of these evaluations and draws further on the data gathered at that time or later. The approach taken in these evaluations combined qualitative and quantitative indicators of the impact of the concession and of the private and estimated social benefits from the induced R&D.

The basic methodology is one of a social cost-benefit framework (Figure 2 and Box 1), building on the important (but neglected) work of Fölster (1991). Much of the usefulness of the framework stems from the way in which it forces the evaluator to be specific about where and how any benefits or costs are likely to be manifested, as well as enumerating, albeit fairly crudely, the likely magnitudes.

The cost-benefit framework gives an appearance of precision and a scientific basis which is only incompletely founded. Many of the essential parameters for actually enumerating the benefits of innovation subsidies are not available with great accuracy, if at all. This implies that some degree of sensitivity analysis should be part of any evaluation, and, in the section on "Cost/benefit results", we explore how the results vary as we alter the parameters.

We now turn to some of the more significant and interesting elements that make up the cost-benefit approach.

Inducement

Inducement is the responsiveness of R&D to incentives. It has been the subject of numerous international empirical and survey estimates – with varying degrees of finesse. Inducement is critical because the benefits from any subsidy are realised only for the R&D that would not have happened otherwise.

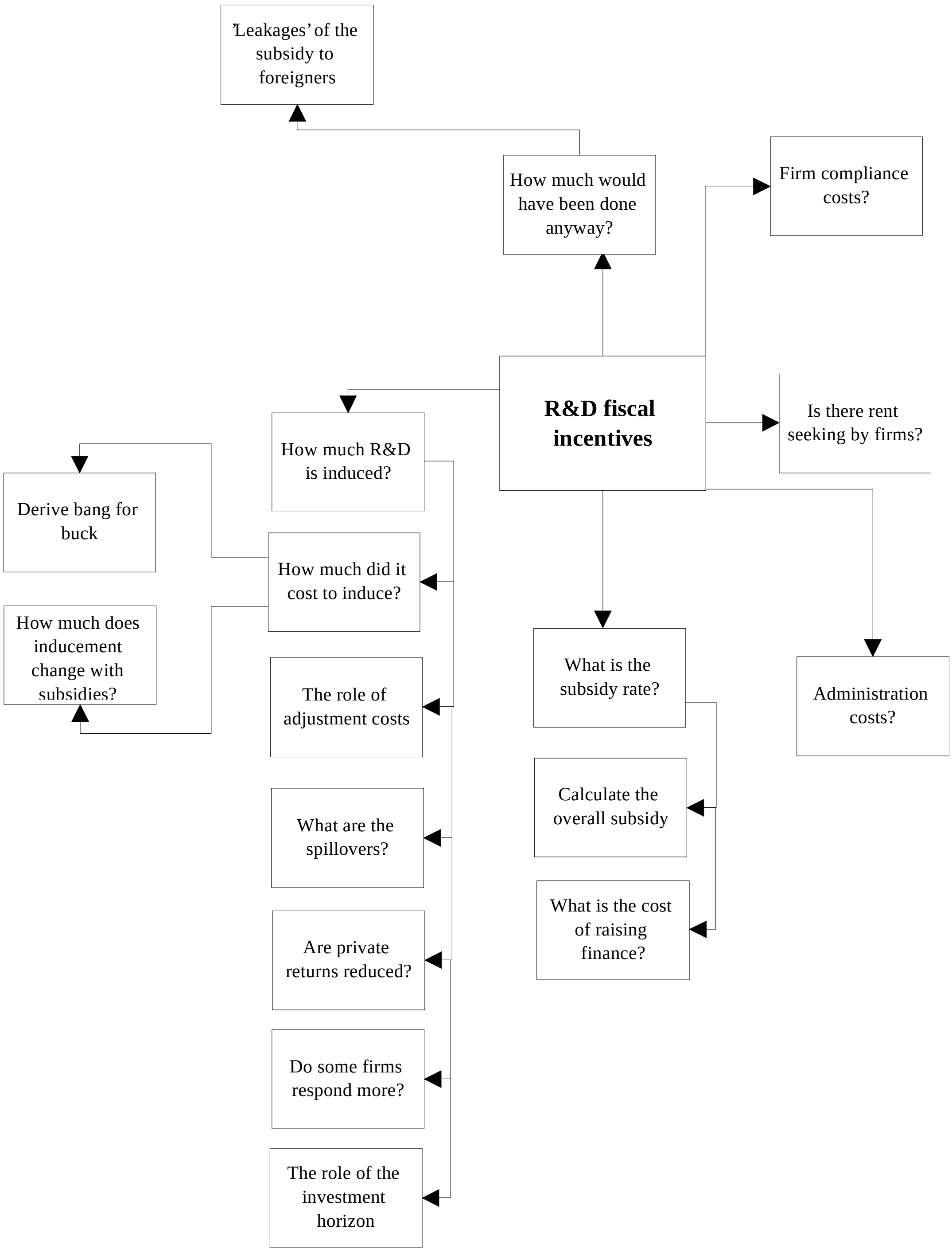
Figure 3 defines the problem. A programme aims to increase R&D. At time T_1 a programme is introduced. In the absence of the programme R&D would have grown to C, while with the programme it grows to B. The amount of induced R&D is the shaded area (area ABC). This is a relatively small component of the total amount of R&D conducted (T_1ABT_2). Sometimes programme administrators use simple rules of thumb for inducement, like the change in the activity (or in this case the vertical difference between B and A). In this example, this rule of thumb is not too inaccurate, but in other cases it could be a very poor estimator of the true level of inducement.

Inducement is usually measured as the proportion of current activity that can be ascribed to the policy:

$$\text{Inducement rate} = \frac{\text{new activity}}{\text{current activity}} \times 100$$

For example, if a firm is conducting A$ 10 million of R&D of which A$ 5 million has been induced by the programme (is new), then the inducement rate is 50 per cent.

Figure 2. The key questions when evaluating the R&D concession



Box 1. The cost-benefit framework

The net social benefits (NSB) of the concession can be broken into many sub-components:

$$NSB = MARGIN + SPILLOVER - LEAK - MEB - ADMIN - COMPLIANCE - RENTSEEK$$

$$MARGIN = (PB^{subsidy} - PB^{market}) = i \times ER(r^{subsidy} - r^{market})$$

$$SPILLOVER = \theta \times i \times ER$$

$$MEB = m \times s \times ER = m.R$$

$$LEAK = fsh \times adj \times RD = fsh \times adj \times (1-i)ER$$

$$R \cong (1-eqsh)(1-claw) \times v \times \tau \times k + eqsh \times (1-claw) \times v \times \tau \times \frac{k}{3} \times (1 + \frac{1}{1.08} + \frac{1}{1.08^2})$$

where MARGIN is the is the difference (if any) between the private post subsidy rate of return ($r^{subsidy}$) on induced R&D ($i \times ER$) compared with alternative uses of those resources (r^{market}). ER is eligible R&D, RD is uninduced R&D, i is the inducement rate (equal to 0 if there is no inducement and to 1 if all of the R&D undertaken by a firm is new).

SPILLOVER are spillover benefits from R&D induced by the programme (at a rate of q per dollar of induced R&D). Spillover returns are benefits derived from R&D spending that are not captured by the private investor.

MEB the marginal excess burden of taxation. These are the social costs associated with raising taxes in order to finance reductions in revenue due to business expenditure on eligible R&D. The marginal excess burden is MEB = m.R where m is the marginal excess burden per dollar of tax revenue forgone and R is the tax revenue forgone.

R is the revenue foregone. (which in turn can be used to derive the effective subsidy rate, *i.e.* s = R/ER). R takes account of the different assets attracting concessionary treatment,[7] clawback of the tax concession through Australia's dividend imputation system and lags in the realisation of the concession (both because of lodgement delays and tax losses for some companies).[8]

LEAK is leakage of tax benefits to overseas shareholders. When tax benefits leak to overseas shareholders, they represent a net loss to the Australian economy. Such leakages only occur on the transfer element of the R&D.

ADMIN are the government administrative costs of the programme including the purely administrative costs of raising the tax revenue (which are not included in the MEB). These are very small (IC, 1995, p. 652) and we do not discuss them further – although they are accounted for in the cost benefit estimates in section 4.8.

COMPLIANCE measures the business compliance costs associated with the programme.

RENTSEEK represents the resources expended by firms and their representatives in lobbying for more generous provisions or in trying to resist the erosion of benefits. In the absence of data we have set such costs to zero, and do not discuss them further.

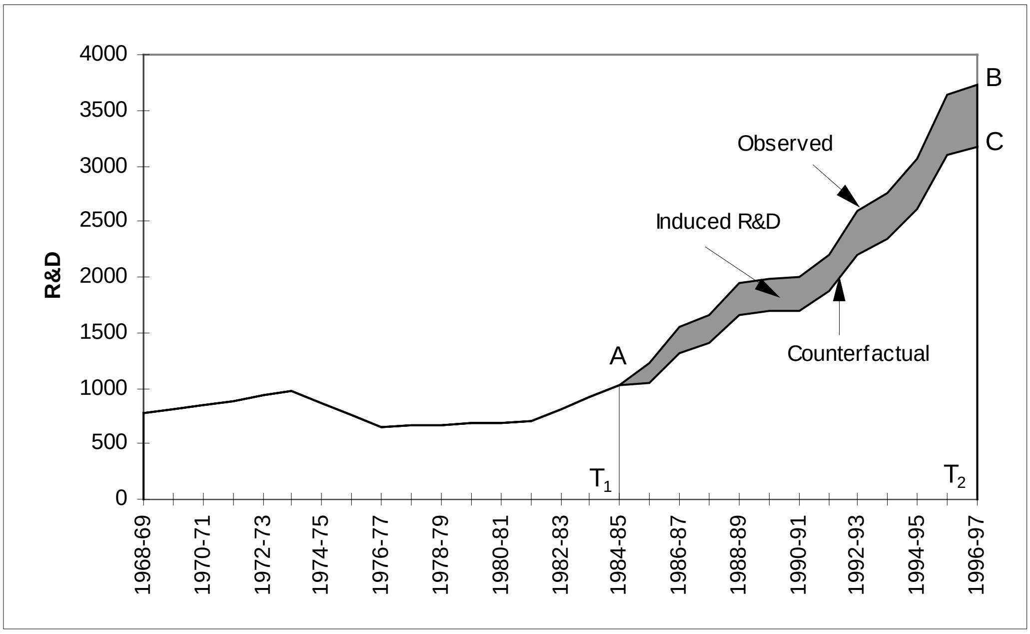
There are a number of methods for examining the impacts of R&D tax concessions on R&D:

◊ econometric methods, based either on individual firms or industries with, ideally, individual observations on the cost of R&D capital, or at worst, dummies to pick up the influence of the introduction of the tax concession;

◊ surveys of users of the concession about their subjective evaluation of the impact of the tax concession.

Unfortunately, little rigorous econometric work has been conducted in Australia. The BIE (1993*a*) undertook two, relatively simple approaches to the econometric estimation of the impact of the tax concession.

Figure 3. Defining inducement



First, they took a group of R&D firms, including both registrants and non-registrants for the concession, and tried to explain the R&D growth rate at the individual firm level (BIE, 1993*a*, pp. 202*ff*). They found that, after controlling for the influence of a number of other variables (such as lagged R&D, employment size and employment growth), a firm registered for the tax concession had an average growth rate of R&D about 24 per cent per annum greater than non-registrants over this period. Some of this, of course, may simply be re-categorisation of non-R&D expenses as R&D, which will tend to bias the estimates. Moreover, this study made only crude corrections for sample selection bias. It could be, for example, that firms with low R&D growth plans tend not to register for the R&D tax concession – leading to an upward bias in the estimate of the impact of the concession.

Second, they calculated the response to the concession using aggregate R&D data. They derived the aggregate R&D of consistent registrants to the tax concession for each year from 1982–83 to 1989–90, and then regressed the log of this value against a time trend, an intercept dummy, a slope dummy and log of real GDP. This model will exaggerate the impact of the concession on aggregate R&D because it ignores R&D performing firms which did not register for the tax concession.[9] The coefficient on the intercept dummy was between 0.177 per cent and 0.255 depending on the specification, suggesting that the initial impact of the concession on firms who registered was to raise R&D by around 20 per cent. The slope dummies were also significant. They may be picking up the delayed response of firms to the tax concession (as appears to have occurred in the United States – Hall, 1995), but they may well also confuse the impact of the concession with other changes in the domestic economy:

◊ Notably, other BIE data show that there is almost no difference in the growth rates of R&D of registrants and non-registrants *after* the introduction of the tax concession (BIE, 1993*a*, p. 204)– which is consistent with the hypothesis that some force in the economy other than the tax concession was responsible for the change in the trend of R&D.

◊ R&D already seemed to be trending up prior to the introduction of the concession.

◊ The attractiveness of the concession has declined since its inception without any apparent impact on the rate of growth of real R&D.

Another, more recent, study by Mitchell (1996) examined changes in the R&D to gross product ratio in 12 divisions of manufacturing (including the total) from 1973–74 to 1990–91. He found a significant impact of the tax concession (measured by the after-tax cost of R&D) for six of the divisions, but the model employed was extremely simple, and could easily incorporate spurious elements.

Other than econometric work, there has been some direct survey evidence on the impact of the concession. The most recent is from a survey by Price Waterhouse and the Australian Industrial Research Group (PW–AIRG, 1996) which examined the impact of the reduction in the deductibility of R&D from 150 to 125 per cent. The survey was based on a survey of "250 strategically selected companies upon which the proposed R&D changes are most likely to impact". While this selection obviously may impart bias to the estimates of the effects of the incentive, the results are nevertheless interesting. About 45 per cent of companies indicated that the reduction in the incentive would have no impact on their R&D, while another 45 per cent indicated an impact of around 20 per cent. Under 5 per cent indicated an impact of around 40 per cent and about 2.5 per cent of firms an impact of 80 per cent or more. The report does not indicate the overall impact of the change to the tax concession, but some simple arithmetic using the unweighted data implies an estimate of around a 13 to 14 per cent reduction in R&D (from around a 7.6 percentage points reduction in the value of the tax concession).[10] This in turn suggests that the "bang for a buck" from increasing the incentive back to 150 per cent would be of the order of 1.7 to 1.8, which is (implausibly) high.

The other major, and probably more reliable, source of survey data is the BIE survey of tax concession registrants in 1992 at a time when the concession was set at 150 per cent. This survey sampled all registrants – with no intention to select companies most affected by the concession. Even so, it suffers from some of the limitations of all such surveys:

◊ Answers are inherently subjective.

◊ Some firms may answer strategically, arguing that the concession has had a bigger effect than is true, in order to try to maintain the concession. The survey design, however, aimed to minimise such strategic responses.

◊ In some firms, accountants or officers unaware of the R&D decision making of the enterprise may fill in the questionnaire, leading to biases in their answers.

◊ Firms observe and react to the behaviour of other firms in their industry. They learn from other firms and, in some industries, try to win strategic battles for competitiveness. For example, if one firm increases R&D because of a government programme, then another, competing, firm may also increase (or decrease) R&D in response, even if they do not use the programme. Inducement can flow beyond the firm accessing the programme. Econometric studies will tend to pick up these effects, while survey-based ones do not.

◊ Resources used in any activity induced by a government programme have to come from somewhere. Thus inducement may have wider implications for the economy. For example, induced activity may alter the demand for specific factors. If the supply of specific factors to an industry is unresponsive to price changes, then a subsidy to the activity employing those factors simply drives up their price, with no inducement, although each individual firm may *think* that there has been inducement (since they may take the higher prices as a given).

However, in most evaluations (and the majority of economic analysis), these general equilibrium issues are eschewed – mainly because of their complexity.

Even so, the BIE survey[11] provides useful information on the responsiveness of firms, and given the rich auxiliary data sets, allows us to also test how responsiveness varies by the type of firm.

In the survey, registrants were asked several questions relevant to inducement:

- ◊ Twenty-three per cent of respondents reported that the tax concession had been critical to their proceeding with at least one R&D project in the last three years.
- ◊ The proportion of firms responding positively to this question differed little by size of firm or taxable income status. However, of the 392 firms whose R&D performance could be tracked continuously over the four years to 1990–91, those with fast growth of R&D were twice as likely to have had a project critically influenced by the existence of the tax concession as those with no growth in R&D.
- ◊ Projects critically influenced by the concession accounted for 10 per cent of expenditure on overall eligible R&D (6 per cent of incremental R&D; 12 per cent of strategic R&D; and around 20 per cent of expenditure on pilot plants). This data implies that at minimum around 10 per cent of eligible R&D might have been induced by the tax concession.
- ◊ Forty to 50 per cent of respondents indicated that the concession had had a significant or very significant effect in allowing projects to be continued; widened in scope; or improved in quality.
- ◊ Firms were asked to indicate the level of R&D they would have undertaken if the deduction rate had been 100 per cent, 125 per cent or 200 per cent instead of 150 per cent. We derived the implicit inducement rates and the corresponding "bangs for a buck" from the survey data (Table 3). The results suggested that the inducement rate was 16.7 per cent for a 150 per cent tax concession rate, around 10.5 per cent for a 125 per cent tax concession rate and about 30 per cent for a 200 per cent tax concession rate. The "bangs for a buck" were 1.27, 1.01 and 0.91 for deduction rates of 125 per cent, 150 per cent and 200 per cent, respectively. The corresponding elasticities were 0.82, 0.62 and 0.51 for deduction rates of 125 per cent, 150 per cent and 200 per cent, respectively.[12] The BIE survey data therefore, point to a much weaker likely response by firms to the reduction in deductibility from 150 per cent to 125 per cent than the PW-AIRG results.
- ◊ The survey data also points to a diminishing marginal responsiveness to R&D tax incentives, as indicated by declining "bangs for a buck" as the incentive value increases.

The "bang for a buck" estimates from the BIE survey are consistent with a range of international studies on inducement summarised by Hall (1995) – see Table 4. They are lower than estimates of the "bang for a buck" generated by more recent studies on the US incremental scheme – but this is not surprising given that incremental schemes are theoretically better able to induce additional R&D.

Table 3. Inducement and "bang for a buck" estimates from the BIE survey for different rates of the tax concession[1]

	Inducement			"Bang for a buck"		
	125%	*150%*	*200%*	*125%*	*150%*	*200%*
All respondents	0.105	0.167	0.301	1.27	1.01	0.91
Type of project						
Incremental	0.106	0.145	0.280	1.28	0.88	0.84
Strategic	0.098	0.166	0.300	1.19	1.00	0.91
Pilot plant	0.162	0.289	0.422	1.95	1.75	1.27
Firm size						
Very small (< 20 persons)	0.200	0.250	0.382	2.41	1.51	1.15
Small (20–99)	0.127	0.210	0.350	1.53	1.27	1.06
Medium (100–499)	0.121	0.219	0.358	1.47	1.32	1.08
Large (500–999)	0.098	0.155	0.289	1.19	0.94	0.87
Very large (1 000+)	0.083	0.128	0.270	1.00	0.77	0.81
Tax status[2]						
Tax profit	0.110	0.173	0.319	1.24	0.98	0.90
Tax loss	0.096	0.157	0.271	1.43	1.17	1.01
Mixed profit/loss	0.093	0.138	0.283	1.12	0.83	0.85
R&D performance[3]						
Better performers	0.120	0.189	0.335	1.45	1.14	1.01
Poorer performers	0.070	0.115	0.240	0.85	0.69	0.72
Ownership[4]						
Australian-owned	0.114	0.193	0.331	1.38	1.17	1.00
Foreign-owned	0.100	0.129	0.285	1.21	0.78	0.86

1. The BIE survey asked firms to nominate the index value of R&D that would prevail under different tax concession rates, relative to the level conducted under the 150 per cent tax concession. We derived the inducement rates from these indexes as:

$$i_{125} = (D_{125} - D_{100}) / D_{125}$$

$$i_{150} = (D_{150} - D_{100}) / D_{150} = (D_{150} - D_{100}) / 100$$

$$i_{200} = (D_{200} - D_{100}) / D_{200}$$

where D_n is the index value of R&D conducted at the tax concession rate of n relative to the amount conducted at the tax deduction rate of 150 per cent. In turn we also derived a measure of the amount induced relative to the revenue forgone (the "bang for a buck'" by first calculating the subsidy rate:

$$s_n = \Omega\,(k_n \times \tau \times v_p \times \{\Psi_{uf} \times (1 - claw_{uf}) + \Psi_{ff} \times (1 - claw_{ff}) + (1 - \Psi_{uf} - \Psi_{ff}) \times (1 - claw_o)\})$$
$$+ (1 - \Omega)(k_n \times \tau \times v_l \times \{\Psi_{uf} \times (1 - claw_{uf}) + \Psi_{ff} \times (1 - claw_{ff}) + (1 - \Psi_{uf} - \Psi_{ff}) \times (1 - claw_o)\})$$

$$bang_n = \frac{i_n}{s_n}$$

W is the share of companies in tax profit (74 per cent) and v_p is the degree to which realisation lags reduce the value of incentives in such companies (95.6 per cent). v_l is the corresponding reduction in value for companies in loss (73 per cent). Y_{ff} is the share of companies which pay out fully franked dividends (50 per cent) and the corresponding clawback, $claw_{ff}$ (0 per cent), while Y_{uf} is the share of companies which pay out unfranked dividends (50 per cent) and the corresponding clawback, $claw_{uf}$ (62 per cent). For the remaining companies, the clawback, $claw_o$, is set at 5 per cent. k_n is the concessional element of the deduction rate for R&D (*i.e.* 0.25, 0.5, or 1). t, the tax rate, was set at the 39 per cent corporate rate applying at the time of the survey. The same formula was used for all firm type categories, with the exception of the estimates for tax loss and tax profit companies where the shares were appropriately altered in the formula.

2. Companies with a mixture of tax losses and profits in the three years 1988 89 to 1990–91.

3. The better R&D performers are those who increased their R&D spending between 1989–90 and 1990–91, while the poorer performers are those who decreased their R&D spending.

4. Defined as companies with less than 50 per cent foreign ownership.

Source: BIE Survey of tax concession registrants, 1992 and value of tax parameters for the subsidy calculation are from BIE (1993*a*, p. 66).

Table 4. Estimated "bangs for a buck" from Hall (1995)

Author(s)	Period of study	Country	Bang for a buck
Collins	1981	US	<1.0
Eisner *et al.*	1981-82	US	insignificant
Mansfield	1981-83	US	0.30-0.60
Berger	1981-88	US	1.74
Baily and Lawrence	1981-89	US	1.30
Hall	1981-91	US	2.00
McCutchen	1982-85	US	0.29-0.35
Hines	1984-89	US	1.3-2.00
McFetridge & Warda	1962-82	Canada	0.6
Bernstein	1981-88	Canada	0.83-1.73
Mansfield & Switzer	1980-83	Canada	0.36-0.67
Mansfield	1981-83	Sweden	0.3-0.4

Source: Hall (1995).

We undertook further exploratory analysis of the BIE registrants survey data using regression techniques to understand the determinants of inducement. This process inverts the usual econometric approach to estimation of response elasticities. In the orthodox approach, the demand for R&D is modelled as some function of the R&D cost of capital (with a selection of other variables to capture other influences) and an elasticity representing inducement derived. Here, we have a subjective assessment of the inducement level and we want to examine how this inducement changes with factors associated with the cost of capital (such as tax losses, dividend policy and expenditure type), adjustment costs, liquidity constraints, compliance costs and technological opportunities.

One outstanding feature of the subjective inducement data (either the BIE or the PW-AIRG set) is the large number of firms reporting no responsiveness to the tax concession whatsoever. In the BIE survey for example, about 50 per cent of respondents reported that they would not reduce their expenditure on R&D if the 150 per cent rate of deduction were reduced to 100 per cent. It appears that some firms would require a large tax concession to induce new R&D.[13]

This might reflect:

◊ inertia;

◊ operating rules;

◊ large adjustment costs of changing R&D (say because there are few available specialist staff in the discipline covered by the firm);

◊ lumpy technological prospects, for example, there may be no significant additional innovative possibilities for the firm – or they may be associated with high-cost lumpy complementary investments which are not assisted;

◊ resource constraints (no access to liquidity); and

◊ the fact that R&D is simply not very important to some firms.

We estimated a probit model to see if there are any statistically and economically significant factors which might explain if a firm was responsive or not to the concession (INERT = 1 if no response, else = 0). The initial specification included a set of industry dummies covering 17 product fields (to pick up possible variations due to systematic technological differences between products); foreign ownership status; subsidiary status; firm size; the proportion of R&D which was incremental, strategic and pilot plant; the payback period of a representative R&D project; whether the firm was a user of other government industry programmes (a variable whose coefficient has some policy interest); tax loss status; dividend payout strategy; collaborative strategy and a variety of other variables. The final specification (Table 5) indicated that firms with longer paybacks or who were subsidiaries were more likely to not respond to the concession at all, while firms which were collaborators, exporters, consistent R&D performers, undertook strategic R&D, or who had an R&D plan were more likely to respond to the incentive. Surprisingly, we were unable to find a role for any tax variables, such as whether the firm was in tax loss or paid out partially unfranked dividends (where the dividend imputation system washes out some of the benefits of the concession). Also, notwithstanding the apparent relationships in Table 3, we were unable to find a role for firm size, although this is partly picked up by the payback variable.

The role of the payback variable is interesting. *Ceteris paribus*, longer payback periods are associated with lower rates of return to R&D. To the extent that a firm had undertaken additional R&D (which was unprofitable without the subsidy), then we would expect the rate of return to be relatively low – that is we would expect induced R&D to have longer paybacks. The model results are not consistent with this. One possible explanation is that short payback periods are associated with companies facing liquidity constraints, so that either they limit the investments to only the highest returning investments (net of unsystematic risk), or cannot diversify the unsystematic risk associated with their investments. Firms facing liquidity constraints would like to do more R&D but need finance. It may be that the concession helps leverage debt from a lender, or that past concessional income can be used to finance this year's induced R&D. Another interpretation is that firms with longer investment horizons for their R&D substantially discount the value of the concession because of uncertainty over its permanence. While the tax concession was announced as a "permanent" measure prior to the BIE survey, no tax measure can really be regarded as permanent given the myriad of changes made to the Australian tax system.

Table 5. Probit model of whether a firm was unresponsive to the tax incentive
INERT = 1 if no response to measure

Variable mnemonic	Coefficient	t-stat	Prob	Mean of variable[1]
Constant	0.781	8.6	0.0%	..
SUBSID	0.081	1.8	7.9%	0.385
COLLAB	–0.183	–3.0	0.2%	0.163
EXPORTER	–0.110	–2.3	2.0%	0.563
CONTIN	–0.181	–2.6	1.0%	0.878
STRAT	–0.133	–2.2	3.1%	0.673
PAYBACK	0.027	2.9	0.4%	3.309
RDPLAN	–0.161	–2.4	1.5%	0.865

1. The means are for the whole sample, not just the sample used in the regression. The regression sample was N=460. $\zeta(7) = 49.7$ where this is the joint test of the significance of the explanatory variables distributed as a chi squared with 7 degrees of freedom. See Appendix for the description of the variables.

The role of planning in the model is also revealing. An R&D plan is most likely to be formulated by firms who see R&D as important in their business strategy, and who are always considering projects at the fringe of profitable opportunity. These firms are less likely to be limited by technological opportunities than firms with limited interest in R&D, a consideration which may also explain why continuing R&D performers are more likely to respond to the incentive than sporadic performers.

Dichotomous variables, such as INERT, conceal most of the information about the responsiveness to the tax concession. The next stage in our empirical work was to look at the determinants of the variable INDUCE. This is a continuous variable (between 0 and 100) describing the subjective assessment by the firm of the amount of inducement. However, OLS is not likely to be an appropriate estimation technique, given that roughly half the observations lie at 0. The situation is somewhat like hours of work regressions, where there is a mass of observations around zero, and negative hours of work are not defined. OLS leads to underestimated absolute values for explanatory variables. As in that literature, we use a censored regression approach (in this case Tobit).

As before, we find a role for subsidiary status, type of R&D, R&D plans and continuing R&D performance in shaping the response to the tax concession (Table 6). As before, no role is found for any cost of capital terms, like tax variables. This time, we also find that size is related to responsiveness (with smaller firms being more responsive than large firms), although the effect is only barely statistically significant at the 10 per cent level. Interestingly, we find that firms which have had difficulty in recruiting suitable staff are more likely to have higher inducement rates. In all likelihood, the causality runs the other way – firms which have had higher inducement have expanded their R&D and are more likely to experience recruitment difficulties.

Table 6. Tobit model of responsiveness to the tax incentive

Dependent variable = INDUCE

Variable mnemonic	Coefficient	t-stat	Prob	Mean of variable[1]
Constant	–30.4	–4.408	0.0%	
RECRUIT	12.8	3.427	0.1%	0.231
STRAT	8.0	1.833	6.7%	0.649
RDPLAN	13.4	2.929	0.3%	0.820
SMALL	6.5	1.688	9.1%	0.650
CONTIN	13.7	2.817	0.5%	0.841
SUBSID	–5.6	–1.51	13.1%	0.419

1. The means are for the whole sample, not just the sample used in the regression. The regression sample was N=742. $F(6, 742)=8.13$, where this is the joint test of the significance of the explanatory variables distributed as an F test with 6 and 742 degrees of freedom. See Appendix for the description of the variables.

So far, we have only looked at a variant of one variable: INDUCE in either its discrete or continuous form. Since, to some extent, the selection of variables has been *ad hoc* and constrained by the limitations of the database, it is useful to have corroboration from other results in the BIE survey. As noted above, the BIE survey also asked firms to indicate whether the R&D tax concession had been a critical influence in deciding whether any R&D projects should go ahead in the last three years (CRITICAL). The survey also asked firms to indicate (on a four-point scale running from no effect, some effect, significant effect to a very significant effect) some other impacts of the concession, such as whether it had:

◊ Encouraged a more favourable attitude to your undertaking R&D (ATTITUDE)?

◊ Encouraged placing R&D more centrally in your business strategy (CENTRAL)?

◊ Allowed projects to continue (CONTINUE)?

◊ Widened the scope of projects (WIDEN)?

We estimated a probit model for CRITICAL and an ordered probit for ATTITUDE to WIDEN (Tables 7 and 8). The probit model tends to confirm the previous findings, with a number of interesting additions to the story. One particular product group (fabricated metal products) appears to respond more significantly to the presence of the incentive, although the result is not very robust. As well, firms which had been users (over the last five years) of two other government technology programmes were more likely to rate the concession as critical. It may be that the selection processes employed in these other programmes tend to pick out firms with richer technological opportunities, and therefore greater inherent responsiveness, than the average firm.

The ordered probit models also provide a similar picture of the determinants of firm responsiveness to the concession, except that operating losses (before tax) appear to exert a negative impact on the likelihood of a heightened response to the concession. Moreover, firms which regard the cash flow of the company as an important influence on R&D (the liquidity constrained?) tend to have greater responsiveness across all four behavioural categories.

Table 7. Probit model of whether the tax incentive has been critical
Dependent variable = CRITICAL

Variable mnemonic	Coefficient	t-stat	Prob	Mean of variable[1]
Constant	–1.14	–8.395	0.0%	
RECRUIT	0.21	1.801	7.2%	0.222
SUBSID	–0.32	–3.001	0.3%	0.412
RDPLAN	0.25	1.812	7.0%	0.807
EXPORTER	0.23	2.249	2.4%	0.493
FMP	0.28	1.548	12.2%	0.074
COLLAB	0.40	3.093	0.2%	0.169
GENERIC	0.62	1.889	5.9%	0.019
AMTDP	1.39	2.042	4.1%	0.005

1. The means are for the whole sample, not just the sample used in the regression. N=833. $\zeta(8)=42.4$. See Appendix for the description of the variables.

Table 8. Ordered probit models of response of firms to the tax concession[1]

	FAVOUR		CENTRAL		CONTINUE		WIDEN	
	b	t	b	t	b	t	b	t
Constant	0.79	5.0	0.30	1.9	0.57	3.6	0.28	1.8
RECRUIT	0.23	2.4	0.10	1.1	0.00	0.0	0.17	1.8
SUBSID	–0.34	–4.1	–0.35	–4.1	–0.38	–4.5	–0.32	–3.6
RDPLAN	0.17	1.6	0.44	4.3	0.17	1.7	0.44	4.3
AMTDP	1.40	1.9	1.23	2.3	1.09	1.6	1.31	2.4
CASH	0.23	2.7	0.29	3.4	0.32	3.8	0.35	4.0
LOSS	–0.24	–2.9	–0.18	–2.0	–0.11	–1.3	–0.15	–1.8
AGE	0.02	2.7	0.01	1.6	0.00	0.2	0.01	2.1
STRAT	0.17	1.7	0.20	1.9	0.21	2.1	0.03	0.3

1. The means are for the whole sample, not just the sample used in the regression. N=768,759,765 and 753 for each of the models from left to right. $\zeta(8)=59.5$, 70.4, 60.8 and 68.1 for each of the models from left to right. See Appendix for the description of the variables.

In summary, one set of BIE data point to inducement rates of 16.7 per cent (with the deduction rate set at 150 per cent) and 10.5 per cent (with the current 125 per cent deduction). Data based on the share of firms critically affected by the concession point to weaker inducement (of around 10 per cent when the deduction rate was 150 per cent and probably around 6.3 per cent under the current arrangement.[14] Modelling of the inducement data finds a few strong relationships between inducement and observable firm characteristics, but much of the variation in inducement rates remains unexplained.

In the cost benefit analysis which follows we use a mean estimate of the inducement rate: 13.35 per cent when the concession rate is 50 per cent, and 8.4 per cent when the concessional rate is 25 per cent. These represent mid-points between the proportion of R&D critically influenced and the alternative, higher, estimates of inducement.

Spillovers

Apart from the (surely) ephemeral benefits that the tax concession may have had on firms who undervalued innovation as a business strategy, the major rationale for government intervention in R&D rests on the dynamic and static spillovers that stem from the generation of new knowledge. It is sometimes misunderstood that it is not the existence of spillovers *per se* that lend justification to potential intervention, but the existence of spillovers for induced R&D only. Firms who proceed with an investment because the private rate of return is sufficiently high may gratuitously generate spillovers, but no agent needs to compensate them for these additional benefits because they have already made the socially optimal decision.

The rigorous cost-benefit analysis of a government R&D programme requires a difficult feat – the evaluator must sample the innovations of the programme users, determine which ones are induced, and then make an assessment of their aggregate current and likely future spillover benefits. Because of the practical impossibility of this task, it is customary to use generic estimates of spillover benefits.

There are two major problems when assessing such spillover rates. First, estimates of spillover benefits may be mismeasured significantly. Knowledge stocks, the raw material of econometric studies, are at best measured crudely. Moreover, many other inputs to this knowledge stock (such as improved human capital, changing modes of transmission of knowledge, and non-R&D contributions to knowledge through simple learning-by-doing) are typically absent so that the measured spillovers to the economy as a whole from R&D may wrongly include the influence of omitted factors.

Second, what holds for the average project may not hold for a particular suite of R&D projects. In particular, spillovers may be low if:

◊ A programme selects projects where benefits are largely appropriable by the innovator.

◊ A programme selects projects where there is little domestic capacity to absorb any spillovers (for example, because of insufficient industry depth in a certain technological field).

◊ There are many similar projects in the world so that the incremental knowledge produced by the innovation is small.

◊ The projects selected involve little novel research.

◊ Too many projects fail *and* the lessons from the failures are small.

◊ "Poor" quality firms are selected to undertake the research. This may have several adverse impacts on spillover returns. First, the quality of researchers in a poorly run and/or financially desperate firm are likely to be lower (because career paths, remuneration and tenure in a financially distressed or poorly run company are less good so that it will be harder to attract or retain excellent staff). Second, the process of decision making may be far from optimal so that management exercise poor judgement about what constitute promising innovations. Third, these firms are less capable of commercial exploitation and fast and efficient management of projects, and may indeed fail altogether. This would tend to decrease spillovers because some products will not get to market when they should and because financial constraints or inefficient management will lead to a slower pace of innovation and therefore deferred benefits. It was on the basis of the peculiarly strong problems of adverse selection operating in Syndicated R&D that generic spillover returns were adjusted down for that programme (Lattimore, 1996).[15]

There is now a huge literature on the general magnitude of spillover returns – summarised in IC (1995, Appendix QA, QB and QC) – but none relate to the marginal investments generated by government fiscal incentives. We really do not know whether there are quality differences between the spillover effects of these marginal investments and intramarginal ones, and how these quality differences depend on the nature of the firm undertaking the innovation. Scherer (1983) maintains that the social returns from R&D vary from the private returns by a constant fraction. In its evaluations of the 150 per cent R&D tax concession and the syndication programme (BIE, 1993*a* and 1994) the BIE used a spillover rate of return of 90 per cent.[16]

We have very little rigorous basis for selecting a *particular* spillover rate for cost-benefit analysis. In this paper, we assume a slightly more modest level of spillovers – a 70 per cent rate of return – which lies centrally within a range of international estimates of spillovers. But we also examine how the outcomes vary as the spillover returns are altered.

We also considered how spillovers might be related to the nature of the firms using the tax concession. The BIE survey questionnaire asked firms to nominate whether a representative innovation had provided other firms with new opportunities for innovation – which is one of the principal mechanisms for the dynamic diffusion of innovation benefits. A probit model (Table 9) found that the likelihood that a firm would nominate such benefits were greatest for firms in the software and the photographic and scientific equipment industries, for firms who participated in the Partnerships for Development Plan (one of whose goals was diffusion) and who had R&D plans. Of more interest, we found that firms with higher inducement rates also had also a higher likelihood of nominating such a benefit. This provides weak evidence that spillover benefits (of this sort) are *not* negatively correlated with inducement as supposed by Scherer.

On the other hand, the extent of innovation dynamism of a firm[17] was slightly negatively related to inducement (Table 10), although the effect was not even significant at the 10 per cent level.

In summary, we do not have a strong basis for the notion that spillover returns associated with the marginal projects induced by the incentive are lower (or higher) than the average estimates generated by econometric and case studies.

Table 9. Probit model of whether R&D provides new opportunities for innovation in other firms (SPILL)[1]

Variable mnemonic	Coefficient	t-stat	Prob	Mean of variable
Constant	–1.41	–9.817	0.0%	
SOFTW	0.370	2.956	0.3%	0.19
PHOTO	0.43	1.809	7.0%	0.04
INDUCE	0.0050	2.464	1.4%	17.78
PDP	0.74	1.992	4.6%	0.01
RDPLAN	0.41	2.726	0.6%	0.81

1. The means are for the whole sample, not just the sample used in the regression. N=809. ζ(5)=35.3. See Appendix for the description of the variables.

Table 10. OLS model of future sales dependent on innovation (INNOV)[1]

Variable mnemonic	Coefficient	t-stat	Prob	Mean of variable
Constant	42.26	12.5	0.0%	
INDUCE	–0.06	–1.5	13.5%	17.89
CASH	6.49	3.3	0.1%	0.35
MINING	–18.92	–4.2	0.0%	0.05
FBT	–12.19	–2.9	0.4%	0.05
CHEM	–7.70	–2.7	0.7%	0.12
EMDG	5.40	2.7	0.7%	0.34
CRC	12.98	2.4	1.6%	0.02
SIZE	–3.56	–6.3	0.0%	4.00
INTENSE	1.50	3.0	0.2%	0.26
RDPLAN	8.17	3.4	0.1%	0.83
AGE	–0.49	–2.9	0.4%	14.22

1. The means are for the whole sample, not just the sample used in the regression. N=618. $F(11,606)=20.5$. $R^2=0.271$. See Appendix for the description of the variables.

The marginal excess burden of taxation

It is not always understood that revenue costs are not net social costs. If the government transfers a dollar of revenue to an Australian firm, then the firm's shareholders gain a dollar and taxpayers lose a dollar, but no value is extinguished. However, such transfers do not occur without frictions – the costs of administration that lie behind such transfers, the compliance costs that firms face as they meet eligibility criteria, and, most importantly, the costs of distortions imposed when government raises revenue – the marginal excess burden (meb) of taxation. When income taxes fall on labour income, the meb reflects the costs from disincentives to work.

The magnitude of this burden depends critically on the economic framework, and the manner in which the tax revenue is raised. However, with the exception of the case where downwardly sticky wages are unresponsive to changes in taxation (Freebairn, 1995), this cost is non-zero. There are a range of estimates of the meb (Table 11). The BIE used a mid-point estimate of the marginal excess burden of 32.5 cents in its examination of the tax concession. However, given the lower estimates recently produced by Campbell and Bond (1997) for Australia, we use a range from 15 cents to 40 cents with a mid-point of 27.5 cents in this analysis.

Table 11. Estimates of the marginal excess burden

Study	Country	Range of estimates	Preferred
Findlay and Jones (1982)	Australia	0.10 – 1.60	0.40
Stuart (1984)	US	0.09 – 1.33	..
Ballard, Shoven and Whalley 1985)	US	0.17 – 0.56	0.33
Browning (1987)	US	0.09 – 3.03	0.32 – 0.47
Jorgenson and Yun (1990)	US	..	0.38
Fortin and Lacroix (1994)	Canada	0.39 – 0.53	..
Diewert and Lawrence (1995)	New Zealand	..	0.18
Campbell and Bond 1997	Australia	0.19 – 0.24	..

Leakages to foreigners

The proportion of total revenue forgone on transfers attributable to foreigners depends on the share of R&D transfers which could theoretically be transferred to foreign shareholders, adjusted for withholding taxes and other aspects of the treatment of repatriated dividends. We use ABS statistics to impute the share of R&D that can be attributed to foreigners (22 per cent), and then make a somewhat *ad hoc* adjustment to reflect clawback (adj = 0.8 or clawback of 20 per cent). Overall, this provides a somewhat smaller estimate of the transfers to foreigners than in BIE (1993*a*).

Compliance costs

Compliance costs may include changing reporting structures within firms, introducing new accounting systems and filling in forms.[18] Analysis of the BIE survey of registrants to the concession suggests relatively high compliance costs (of between 1.6 to 3 per cent of eligible R&D)[19] – but the numbers do not gel with common sense.[20] Much of the concession is claimed by large companies with multimillion dollar claims. It seems highly improbable that an R&D project of A$ 100 million would require tax concession compliance costs of A$ 1.6 to A$ 3 million over and above the compliance costs which would be associated with normal tax treatment of R&D expenses. It seems probable that the marginal compliance costs are much more modest. We have used 0.5 per cent as the measure here. We note, however, that there is some concern by industry that the cost of complying with the provisions introduced in 1996 will increase, with one survey indicating an average increase in compliance costs of 114 per cent (PW-AIRG, 1996).

But while compliance costs can play a role in whether the tax concession is welfare enhancing or not, they may have some beneficial impacts on firm selection. We found that compliance costs tended to be higher in firms with higher inducement (although the effect was not statistically significant at the 10 per cent level) and lower in firms which professed a virtual indifference to the role of R&D in their companies (Table 12). One explanation for this is that a selection mechanism may be at work. Those firms that are indifferent to R&D and face high compliance costs (because of their accounting structures, or the size of their R&D budget) simply do not register.

Table 12. Grouped data regression model of the determinants of compliance costs (COMPLY)[1]

Variable mnemonic	Coefficient	t-stat	Prob (%)	Mean of variable
Constant	2.37	4.8	0.0%	..
INDIF	–1.19	–2.3	2.1%	0.16
INCREM	1.60	3.0	0.2%	0.28
SIZE	–0.20	–2.0	4.5%	4.05
SOFTW	–1.29	–2.7	0.8%	0.20
FOREIGN	0.013	1.5	13.8%	11.94
INDUCE	0.009	1.2	24.4%	18.43

1. The compliance costs were grouped into five intervals (<2, 2-4, 5-9,10-24,25 or more). A special type of censored regression model is appropriate in this case (Greene, 1995, p. 629). N=669. See Appendix for the description of the variables.

The private rate of return on R&D

In many ways the original basis for the tax concession was premised on the notion that firms underestimate the rate of return on R&D and thereby fail to make the appropriate investments. If this hypothesis were true then one of the gains from the tax concession would be that firms which undertook additional R&D because of the concession would be earning higher rates of return on those resources than on alternative resources in the economy. There is some evidence in favour of this hypothesis. For example, using a small survey of firms, SIRF (1996) found that the average private rates of return on R&D are much higher than rates of return on other assets. But this need not suggest underinvestment, if for no other reason than the relevant measure for the underinvestment hypothesis is the marginal return not the average return. Without extensive knowledge about the marginal efficiency of capital at different levels of investment, the average provides little guide to the value of the marginal investment.

Nevertheless, a more rigorous set of econometric studies (reviewed in IC, 1995, Appendix QA) found *private* marginal rates of return (in other countries) ranging from 10 to 50 per cent – which at least for the upper bounds, exceeds returns on physical capital. For example, Bernstein (1989) found that the average rate of return to R&D lies between 24 and 47 per cent (for different industries) while the average rate of return for physical capital lies in the range of 9 to 12 per cent. In another study, Bernstein and Nadiri (1991) found that the average rate of return on R&D lies between 18 and 36 per cent while that on physical capital lies between 15 and 28 per cent.

The existence of these hypothetical excess returns poses a challenge: why would a firm's shareholders relinquish profitable investment opportunities in R&D in favour of lower returns elsewhere? There are a number of possible answers, each with different implications for the valuation of extramarginal R&D projects:

1. A liquidity constrained firm may have high returning investments which are simply not financed. It seems likely that firms are more likely to be liquidity constrained when making R&D investments than physical capital. Markets for core technology (the implicit collateral) from R&D are incomplete, and in any case a core technology is only defined if certain technical parts of the R&D process succeed. Moreover, the typically secretive nature of R&D may prejudice some forms of finance. The problem of information asymmetries can be deliberately heightened because of appropriation concerns over such intellectual property. A lender or equity investor wishes to know something about what

they are investing in, but the borrower or target firm may be reluctant to provide that information if it dilutes their intellectual property. However, most R&D in Australia is performed by large firms – and here the proposition that liquidity constraints are endemic seems highly suspect. Nevertheless, the likely existence of liquidity constraints for some smaller firms would probably lead to higher rates of return for marginal projects for those firms.

2. These figures do not correct for risk. There are two forms of risk that need to be contrasted: systematic risk (the risks that cannot be eliminated by pooling many projects); and unsystematic risk (the risks that can be eliminated by pooling a large number of projects). In a perfect capital market, an investor makes no gain from bearing diversifiable risk, but does make a gain from bearing non-diversifiable risk. An investing firm continues to invest until the marginal investment earns a rate of return equal to the risk-free rate plus the systematic risk for that asset. The divergence of average returns on R&D from returns to physical capital may therefore represent the residual undiversifiable (or systematic) risk associated with this asset class.

3. Businesses can have "cultures" that are hostile to innovation, even if R&D should be an important ingredient to their competitiveness. For example, it is claimed that the long heritage of border protection blunted incentives for innovation by Australian firms and built up a culture that did not value innovation.

4. Other firms may not always make optimal investment decisions for R&D because R&D is not a central part of their overall investment strategy. Businesses may have enduring sub-optimal practices for parts of their business that are not key to their core competencies, and still survive.[21] Or businesses may use simple rules of thumb for some investments (to save complex calculations), such as requiring stipulated payback periods, which have the effect of limiting some higher rate of return investments. The IC (1996) found some evidence of this for small firms with energy-saving investment opportunities.

Under 1), extramarginal returns from R&D are likely to be higher than returns on alternative assets (and MARGIN>0). On the other hand, if there is a set of eligibility criteria that selects certain firms, then the expected extramarginal returns could, under certain circumstances, be very low, or even close to zero. While this paper is not a review of the now abolished syndication programme (the sister programme to the tax concession), that programme demonstrates the risks posed by certain eligibility criteria. Syndication was most attractive to deep-loss firms with tax losses which were of low value to the firm.[22] These are firms that would not be able to readily access finance elsewhere, and in this sense they appear likely to be liquidity constrained. In turn this *appears* to offer the prospect of extramarginal projects with high private rates of return.[23] However, deep-loss firms with low valued tax losses do not represent a random selection from the population of R&D-performing firms (especially during a time of buoyant economic growth). While some may be good firms, the probability of finding a badly managed firm with few genuine long-run prospects is greater amongst this population of firms than among the general population. The eligibility criteria have effectively adversely selected these firms, and extramarginal returns could be low and MARGIN<0.

Under 2), the ostensible difference in rates of return reflects systematic risk. In this case, as firms select extramarginal projects, the existence of the subsidy will drive down the pre-subsidy rate of return on R&D below the (risk-adjusted) market equilibrium. MARGIN is then <0.

Under 3), the existence of subsidies to encourage additional investments has an unknown impact. If the firm is inefficient and internal incentives are distorted, nothing guarantees that the firm will choose the profit-maximising investment. It may choose a technically inviting pet project of the R&D manager, or a project which provides prestige to the firm but few competitive advantages. The value of MARGIN is unknown in this case. Moreover, if the subsidy has the effect of "educating" management about the real returns to R&D then, over time, the firm should converge on the optimal investment strategy and any further incentives after that time will drive returns on extramarginal projects to levels below the opportunity cost of the resources. In this case, MARGIN might be >0 for some time, but slowly reduce until it becomes negative. Notably, Australia has now had a tax concession for R&D for over ten years.

Under 4), the value of MARGIN will probably be >0 for sufficiently modest subsidies, but probably only for small firms or for firms where R&D is not a core decision variable.

Overall, the recipients to the tax concession probably represent a mix of all the possibilities above. We have no secure basis for determining whether MARGIN is positive or negative overall. In the absence of information about the proportions of firms in each camp, or the degree to which marginal projects supported by the subsidy earn super returns, we have assumed that the overall value for MARGIN is conveniently zero. More micro-based research on Australian data sets needs to be conducted.

The cost/benefit results

In this section we bring together the ingredients described above with the framework described in the "Methodology" section. Using the preferred estimates, the social rate of return to the 125 per cent tax concession is strongly positive and exceeds the rate of return to the 150 per cent tax concession by around 60 per cent (Table 13). This stems from the fact that the "bang for a buck" is higher under the 125 per cent tax concession, which in turn can be traced to decreasing marginal inducement from an increase in the subsidy rate. The net benefits from the 150 per cent tax concession are, in absolute terms, larger than those obtained from the 125 per cent tax concession. However, relatively modest changes in parameters can make the 150 per cent concession inferior in terms of both social rates of return as well as absolute net benefits.

There was concern that compliance costs of the 125 per cent tax concession were high (PW-AIRG). Even if the compliance cost share of eligible R&D doubles (to 1 per cent) under the 125 per cent compared to the 150 per cent, the superiority in the rate of social return is maintained (although it falls to 23.8 per cent).

The results in Table 13 are indicative at best about the impacts of the tax concession on welfare. Almost every critical parameter used above is uncertain, so that we should examine how the results are affected by changes in our assumptions.

One way of doing this is to simply calculate the net social return to the programme as we shift critical parameters (Table 14). It is clear that if the spillover rate or the inducement rate are in fact somewhat lower than our estimates then the programme generates net losses for the Australian economy. At higher values, the net benefits become very large. The question is: To what extent is it *likely* that the programme generates net benefits?

Table 13. Cost benefit analysis of the 125 per cent compared to the 150 per cent tax concession

Formula	Category	125%	150%
	Social benefits		
ER = RD/(1-i)	Eligible R&D (A$m)	2401.7	2538.9
100 x i	Inducement rate (%)	8.40%	13.35%
INDUCE = i x ER	Induced R&D (A$m)	201.7	338.9
100 x SPILL	Spillover return (%)	70%	70%
SPILLOVER = q x i x RD	Spillover benefits (A$m)	141.2	237.3
	Social costs		
DISP = $PB^{subsidy} - {}^{PBmarket}$	Reduction in private returns (A$m)	0	0
claw x 100	Imputation clawback rate (%)	12.5%	12.5%
r	Discount rate	8%	8%
lagr x 100	Realisation lag factor (%)	90.2%	90.2%
k x 100	Concession rate (%)	25%	50%
t x 100	Tax rate (%)	36%	36%
eqsh x 100	Equipment share (%)	10%	10%
R	Revenue forgone (A$m)	169.4	358.1
s = R/ER	Subsidy rate (%)	7.1%	14.1%
m x 100	meb rate (%)	27.5%	27.5%
MEB = m x R	MEB costs (A$m)	46.6	98.5
COMPLIANCE	Compliance costs (A$m)	12.0	12.7
ADMIN	Administration costs (A$m)	3.0	3.2
forsh	Foreign ownership share (%)	22.0%	22.0%
RD	Uninduced R&D (A$m)	2200.0	2200
AFT = fsh x RD x s	Apparent foreign transfer (A$m)	34.1	68.3
LEAK = 0.6 x AFT	Actual foreign transfer (A$m)	27.3	54.6
TSC = MEB+ COMPLIANCE + ADMIN+ FT	Total social cost (A$m)	88.9	169.0
NSB = DISP + SPILLOVER–TSC	Net benefit (A$m)	52.3	68.3
INDUCE/R	Bang for a buck (%)	1.19	0.95
NSB/R x 100	Net benefit to revenue (%)	30.9	19.1

A method for gauging such a likelihood is to assign reasonable distributions for the key variables and to simulate the net benefits. Results from a 10 000 repetition simulation (conditional on the assumptions concerning the underlying distributions and their means) suggest that there is a 74.8 per cent probability that the tax concession is welfare-enhancing when the concessional rate is 25 per cent, with mean and median social rates of return of 31.8 and 26.5 per cent respectively. The probability is somewhat lower (67.5 per cent) when the concessional rate is 50 per cent, while the mean and median rates of return are 19.1 and 15.0 per cent respectively.

Table 14. Impact of changes in spillover and inducement rates on the net social rate of return of the 125 per cent tax concession[1]

Spillover rate	Net social return	Inducement rate	Net social return
10%	–40.6	2.1%	–32.7
20%	–28.7	4.2%	–11.5
30%	–16.8	6.3%	9.7
40%	–4.8	8.4%	30.9
50%	7.1	10.5%	52.1
60%	19.0	12.5%	–40.6
70%	30.9	14.7%	94.5
80%	42.8	16.8%	115.7
90%	54.7	18.9%	136.9
100%	66.6	21.0%	158.2

1. The results show how the net social rate of return to the concession alters as either spillover rates or inducement rates are changed, with all other variables held at their values in Table 13.

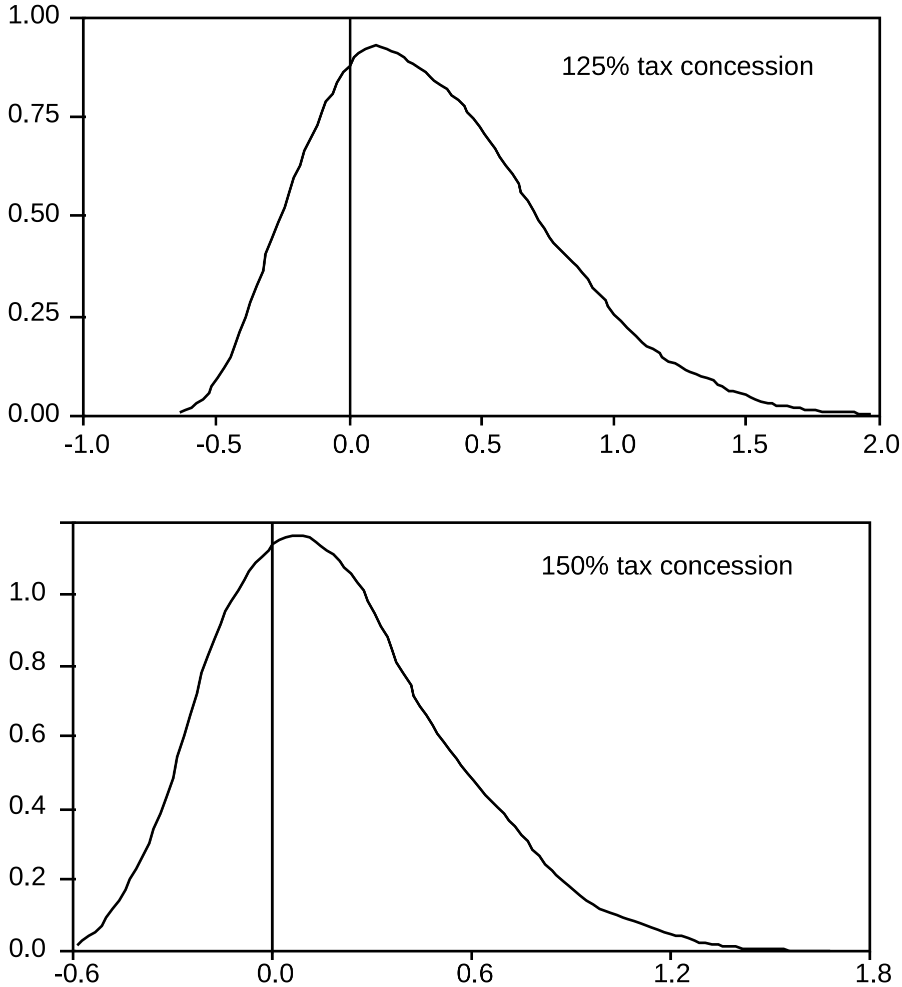
The estimated densities of the net social returns (for k=25 and 50 per cent) are shown in Figure 4, centred around their normalised means. They reveal a strongly positively skewed distribution of the returns – although none of the underlying distributions of the parameters were skewed.

Some sub–categories of firms provide much higher (or lower) estimates of net social benefit:

◊ Small firms, those conducting strategic R&D, and continuous rather than sporadic R&D performers had a higher inducement rate than others, and would therefore (at fixed values of the other parameters) generate bigger net social returns. On the other hand, the modelling in the section on "Spillovers" revealed that inducement was poorly explained by firm characteristics. Many small firms had low inducement and many large firms had high inducement. A rule which restricted access by large firms would not deliver very significant net benefits – because it excludes too many large firms which are encouraged to undertake more R&D. Moreover, the absolute benefits from such a programme would be small, because most R&D is performed in larger enterprises. The other difficulty posed by access restrictions is that firms may mimic eligibility conditions in order to access the programme. For example, we show that firms with R&D plans tend to have more induced R&D than those without. However, if an R&D plan was made a condition for eligibility, many firms would simply develop such plans, without necessarily increasing inducement.

◊ The inclusion of transfer payments to foreign residents as a social cost means that there is a major difference in net social benefit of the scheme from foreign- and Australian-owned companies. This is accentuated by the lower apparent inducement present in foreign companies. For almost all combinations of parameter values, the net social benefit arising from Australian companies is positive, whereas for foreign-owned companies, the impact is frequently negative. At the values of the key parameters in Table 13, the net social return to the R&D subsidy among Australian companies averages 47 per cent, compared to –26 per cent among foreign companies even ignoring any gap between the inducement rates between the two sorts of firms.[24]

Figure 4. Estimated density functions for the net social return to the R&D tax concession[1]



1. The densities are estimated using a kernel smoothing programme (Silverman, 1986). The data have been normalised, so that 0 represents the mean.

Possible modifications to the tax concession scheme

A plethora of mechanisms are employed around the world to support business R&D, from indirect measures such as subsidies to inputs (such as subsidised university training for scientists and engineers and the provision of knowledge from public research entities) to direct measures such as grants and tax measures. Broadly, the economic rationale for support is strong (*i.e.* the tax concession passes the test of *appropriateness*). However, very little explicit recognition is given in policy circles to the formal design of innovation policies, or even to articulation of the rationale of policies, their goals and the criteria for success. While policy evaluation is required, it is not seen as a wholly positive process, and so has less influence on optimal policy design than it might. In a sense, we know we want a bridge over the river but we don’t know how to build it very well.

We turn next to a set of design criteria[25] which should be addressed by almost any industry programme and make a brief assessment of the tax concession against them – suggesting some possible modifications associated with some of the criteria.

Design principles

Once appropriateness has been established, there are other important, more specific, issues which guide industry policies (Box 2). It may not be possible to meet all these design criteria, as there can be trade-offs. These should be explicitly acknowledged as part of any design or evaluation.

Box 2. Design principles

1. Target the source of the problem
2. Selection issues (adverse selection and take-up)
3. Inducement
4. Right scale of resources
5. Timeliness
6. The right duration
7. Avoiding strategic behaviour/distortions
8. Avoiding unforeseen government liabilities
9. Encouraging administrative efficiency and ease
10. Accountability and transparency
11. Policy learning
12. Robustness
13. Avoiding bad interactions/encouraging good ones
14. Cost effectiveness and net benefit
15. Superiority
16. Evaluation, monitoring and reporting

Targeting the source of the problem

Sometimes programmes are designed which target particular sectors or activities, but whose rationale is based on correcting some wider market imperfection. From an economic perspective, the rationale for the R&D incentive are spillovers associated with induced activity (although this rationale is not generally acknowledged in policy documents). The Australian tax concession does not target induced R&D nor spillovers. It is possible that transaction costs (such as the difficulty in determining whether a project is induced or not, or whether it is likely to generate spillovers) make such explicit targeting of the source of the problem difficult, but if so this should be articulated. Moreover, the R&D tax concession provides uneven assistance to different sorts of firms and at different times, depending on their tax loss status and their franking account balance – with no obvious relationship between such disparities in assistance and disparities in spillover rates.

The other advantage of specifying carefully the underlying objective of a programme is that it is then easier to think of alternative policies. For example, some economists advocate strengthened intellectual property as a way of increasing the private appropriation of benefits, and thereby increasing incentives for innovation. Alternatively, taking an opposite tack, mechanisms to encourage diffusion of knowledge to maximise spillover returns might be contemplated. For example, governments may require that the knowledge generated by subsidised projects be made public. As well as encouraging spillovers, this would also decrease the transfer element of any R&D subsidy because it would provide disincentives for firms to put forward R&D projects which would have gone ahead anyway (as they would not want to weaken their claims over the intellectual property). There are practical problems with both of these approaches, but have they have not been genuinely considered as part of the policy design process.

Selection issues

There are two major selection issues: adverse selection and take-up:

◊ *Adverse selection*. The government is somewhat like a financier when dealing with firms. Governments face just the same sort of problems in monitoring the quality, reliability and completeness of information provided by firms and the credibility of their good intentions. Just as high interest rates can result in the wrong applicants for finance, certain designs of programmes may adversely select the worst performing representatives of a group of firms. The fundamental question is: Does the programme use eligibility criteria and incentives in a way to select the "right" firms and projects? The syndicated R&D programme generated very much higher inducement rates than the general tax concession, but at the cost of selecting some firms with very poor prospects for conducting high-quality R&D. The general tax concession seems to suffer few major problems here, because of its broad availability.

◊ *Take-up*. How many firms in the targeted group will take-up the policy? If only a few firms do so, the overall absolute costs of the programme may be low, but it is unlikely to achieve its desired objectives. Also, if take-up is low, then the administrative set-up costs of the programme will be high compared to any outcomes produced. The general tax concession has very high take-up relative to most government programmes (Table 15).

Inducement

Other than equity objectives, a programme which does not sufficiently and appropriately change the behaviour of its recipients is a failure. All other things being equal, programmes should aim to have the highest possible inducement rate. The R&D tax concession has relatively modest inducement. It was estimated that the 125 per cent tax concession had increased the eligible R&D of recipient firms by 8-10 per cent. A corollary is that around 90 per cent of the R&D subsidised by the scheme would have occurred anyway. This involves large annual transfers, which generate economic losses as distortionary taxes are levied. Clearly the net benefit of the scheme would be increased, and its cost to revenue substantially reduced, if transfer payments could be reduced – witness the results in Table 14.

Table 15. Type of government programmes used by firm size, 1993–94 and 1994-95

Programme	Number of firms participating by size grouping:				
	Size of firm (employment)				
	1 – 4	5 – 19	20 – 99	100+	All sizes
National Industry Extension Service (NIES)	896	821	568	225	2 510
150 per cent R&D tax concession	783	643	763	782	2 971
Grants for research and development	30	253	326	110	719
Best Practice Demonstration Program	20	6	26	42	94
New Enterprise Incentive Scheme	544	355	41	45	986
Export Access	30	77	140	45	292
Export Finance and Insurance Corporation	20	140	136	149	444
Export market development grants	66	545	702	325	1 638
International Trade Enhancement Scheme	20	12	44	49	125
Austrade services	245	956	493	238	1 933
Other	4 434	5 067	1 303	405	11 208
Total programmes	7 090	8 874	4 542	2 414	22 920

Source: IC and DIST (1997).

The importance of inducement has not been adequately recognised in the scheme's ten year history. For example, it was only in 1996 that firms were no longer able to have unrestricted retrospective claims for R&D – R&D which clearly could not have been induced by the concession.

What methods might be used to increase inducement? Inducement is typically increased if a programme:

◊ Makes payments for an activity which firms are resistant to doing or which is difficult to carry out. For example, a subsidy to very risky frontier technology is more likely to induce new activity than a general subsidy to innovation. However, careful assessments of risk by agents outside the firm are likely to be costly and difficult.

◊ Sets up as an eligibility requirement some sort of test of whether or not the activity is additional. For example, the UK Loan Guarantee Scheme requires applicants to have been rejected by a bank for finance before considering the application. There is no obvious test like this that could be imposed for industrial R&D.

◊ Only applies the subsidy or programme to the activity that is estimated to be additional. For example, a subsidy might be provided for the change in the level of an activity, rather than to all of the activity. The US applies a subsidy to incremental R&D, as do a number of other countries. The BIE was unable to recommend this as an option in Australia because in the absence of compulsory tax consolidation there would be a possibility of abuse – firms could simply establish special-purpose R&D subsidiaries and switch activity between the two. On the other hand, it may be that firms could, as a condition of eligibility, sign statutory declarations which either certified that the returns were in respect of a non-subsidiary entity, or that grouped returns were being provided for the concession. Any error in a statutory declaration could be subject to severe penalties. Arguably, the possibility of introducing an incremental programme should be further pursued in Australia.

◊ Establishes eligibility criteria that selects firms that are constrained from undertaking the activity. For example, if one could readily identify liquidity-constrained firms, and then provide R&D finance to them, it is likely that the R&D would be mostly additional for those firms. On the other hand, the danger in targeting liquidity-constrained firms is that there are likely to be two types of such firms – “bad” firms with high inducement of bad quality R&D, and “good” firms which undertake high-quality projects but cannot convince others of the value of their projects. Syndicated R&D suffered from this problem.

◊ Provides incentives for firms to disclose projects that are truly additional. Managers in firms *know* the sorts of R&D projects that are just extramarginal. If the return on these projects were to rise, say because of a government subsidy, the firm will undertake them. However, such managers will also gladly put forward inframarginal projects in the guise of extramarginal projects. The design problem is how to make managers disclose which projects are just extramarginal and which ones they would do without a subsidy. Incentive compatible mechanisms aim to achieve this end by penalising firms which incorrectly disclose inframarginal projects as extramarginal ones. A requirement for some disclosure of intellectual property on a subsidised project is one such mechanism. A stock option grant is another – the government buys a share, say 50 per cent, of the value of a company set up to undertake and commercialise a technology. After a pre-set time, the government has the option of selling its share back to the firm (or to others) at the going market rate. If the R&D has failed the government gets nothing. If the venture has succeeded, the government may well make a profit. The point of the grant, however, is not to make a profit, but to provide the incentive for the innovator to choose something that is truly additional. If a firm has a commercially attractive R&D proposition, it will be reluctant to dilute its interest in that project by agreeing to a stock option grant. On the other hand, the firm may be willing to allow the participation of an outsider in a project which would not otherwise have proceeded. Royalties and repayable grants impose similar disciplines on innovators to choose truly additional projects. These mechanisms, however, are relatively costly to administer and are not suitable for small projects. Genuine incentive compatible mechanisms along the lines described by Fölster (1991) have not been applied anywhere to our knowledge. There are arguments for experimenting with some of these mechanisms.

◊ Has an appropriate time horizon. As noted by the Warren Centre for Advanced Engineering (1996), perceptions by business people about the likely impermanence of the concession or its properties are likely to lead to lower inducement rates. As noted previously, the fact that firms with longer paybacks (longer R&D horizons) tend to have lower inducements is consistent with this argument. Bronwyn Hall (1992) has made similar points in respect of the US concession. Operationalising this argument, is, however, quite difficult. Over time there have been many changes to the Australian tax concession, many of them reflecting learning by policy makers and government about defects in the scheme (such as the abuse of “feedstock” provisions).[26] We would not want to avoid such learning. Moreover, “permanence” is an elusive concept when applied to any fiscal instrument. Governments can state an intention to preserve a particular measure, but cannot credibly signal that permanence in the face of future unknown exigencies (such as ballooning deficits).

Applying the right scale of resources

Is the level of assistance appropriate for the coverage of the programme? For example, in some cases a minimum threshold of funding is required to make a difference. Moreover, there are disadvantages of spreading scarce resources among many programmes given the fixed costs of designing and administering programmes – a point we return to below.

There are a number of other more subtle questions which also need to be asked:

◊ should programmes in which the net benefits exceed the net costs be expanded?

◊ should programmes which have net positive benefits always be selected?

The answer, in both cases, is not necessarily. First, even if a programme generates net social benefits, it is possible that *marginal* projects supported by the programme might earn negative social benefits even if the *average* project earns positive ones. In this case, there would be grounds for winding back resources in the programme (although not grounds for abolition unless fixed costs were not too high).

Second, even if a programme generates positive returns, there may be a limited budget to support such programmes. In this case, the government observes a hierarchy of opportunities, starting from very high returning policy options to ones just earning a positive return. The government should undertake projects from the top of the hierarchy, progressing down the list, until the budget is exhausted.

Third, as we argued in the section on "Cost/benefit results", few of the parameters underlying cost-benefit assessments are known with certainty. In this case, a point estimate of a net benefit is only an average assessment. If governments are concerned about risk, then they should also take account of moments in the distribution of net benefits other than the mean. For example, we found that the likelihood of a net benefit is lower when the concessionary rate is 50 per cent, and notwithstanding the positive net benefits found at mean parameter values, this uncertainty may be enough to *optimally* reduce the concessionary rate.

Timeliness

How long is needed to implement the programme? Complex arrangements which require the involvement of many stakeholders or the establishment of new markets can involve long lead times. The R&D tax concession is relatively easily administered – although there is apparent dissatisfaction with AusIndustry by firms (PW-AIRG, 1996).

The right duration

Interventions should have the right duration. Where a programme is intended to change corporate cultures or provide a demonstration of a better way of doing business, the programme should have a fixed life with the objective that the better practices will be self-perpetuated in the market without long-run government support. The R&D incentive was intended at its inception to change corporate cultures to innovation – and was only a temporary measure at that time.

On the other hand, it is likely that R&D spillovers are permanent expressions of the problem of non-appropriability and that there are, therefore, grounds for permanent public support of R&D.

Avoiding strategic behaviour/distortions

Does a programme have undesirable effects on incentives, such as increasing the risk of moral hazard? One-hundred per cent funding for R&D reduces the adverse outcomes of failure for the researcher – leading to potentially poor project management and choices. Moral hazard is weakened by having the involvement of a commercial stakeholder with significant stakes. Because the tax concession provides only very partial support, there are likely to be weak moral hazard problems. The reduction in the subsidy rate as a result of reducing the concessional rate would presumably have reduced any moral hazards further.

Avoiding unforeseen government liabilities

Large adverse risks should be minimised (*i.e.* governments need to be interested in more-than-average outcomes, but also in avoiding unlikely bad outcomes, including government legal or tax liabilities). Programmes should have a risk-management strategy that efficiently limits sizeable risks. For example, this concern suggests that the liabilities to government should be capped. It also suggests questions such as: What is the impact on cost to revenue and outcomes of failures in the assumptions underpinning the programme? And how certain are programme administrators about the assumptions they have used? For example, some economists believe that dividend imputation washes out most of the value of tax concessions. If they are right, then the cost to revenue of features of the tax system like accelerated depreciation and R&D tax concessions, are modest. If they are wrong, the cost to revenue are more extreme.

The R&D tax concession, as a fiscal measure, is uncapped. It was concern over the substantial increases in claims (as firms found a number of loopholes in the legislation) that led to a number of major changes in 1996 – but not to capping. Capping of fiscal measures is theoretically possible – firms would have to put in R&D plans and they would be able to claim the concession on a first come, first served basis. While there are likely to be some administrative hurdles in designing an efficient capping scheme (such as dealing with the uncertainty of the final R&D claims), there may be gains in examining this issue further.

Encouraging administrative efficiency and ease

How administratively easy is the programme to establish and run? How easy is it to restrict the programme to the target group? How efficient is the programme? Is the scale of the programme sufficient to justify the administrative procedures used? Are compliance costs for participating firms excessive?

While the administrative costs of running a programme should be minimised, subject to some target level of programme effectiveness, this does not imply administrative parsimony for its *own sake*. Some programmes would have better outcomes if more on-going monitoring (requiring more administrative resources) were routine. Similarly, while compliance costs faced by firms should, *ceteris paribus*, be minimised, compliance costs and inducement may be related. This may mean that in some cases, higher compliance costs may be preferred (as they may deter claims by firms which plan little real additional R&D). This is relevant to criticisms made by business of the higher compliance costs of the new 125 per cent arrangements.

The level of firm take-up of the programme should be enough to justify the fixed costs of programme development and administration. If only a very few firms take up a programme because its eligibility conditions are tight or the programme is unattractive to most firms, then even if it benefits those firms, the administrative overhead may make it inefficient overall. The administration costs of the tax concession are very low, principally because the prime decision making is delegated to the firms making the investments.

Accountability

How transparent is the arrangement? Can taxpayers and the government be sure that the right decisions are made with probity and full responsibility? Simpler programmes are more transparent than complex ones – and all things being equal – are superior. On the other hand, some complexity may be needed to either target firms who will respond most to the programme or to create the right incentives for maximum inducement. The R&D tax concession is, by the standards of most programmes, very simple and relatively transparent. However, it was very difficult to isolate the various sub-components of deductions made under the programme (such as feedstock and interest deductions), when changes were being contemplated in 1995 and 1996.

Policy learning

Policy makers can (but do not always) learn from problems and deficiencies in programmes. This requires continuous feedback about how the programme is working and an acceptance of error – which sometimes runs counter to the political economy of policy making. Arguably there should be an explicit framework for encouraging learning – and encouragement of hard-nosed scrutiny of programmes. This domestic learning should be supplemented by looking more carefully and systematically at the experience of policy makers in other countries.

The history of the R&D tax concession has demonstrated sporadic acceptance of these principles. Some evaluations have taken place, and at times, criteria have been tightened. However, more could be learned from overseas experiences about the appropriate design of the R&D tax measures.

Robustness

The policy and economic environment is always in flux. A good programme provides roughly constant net benefits per dollar of subsidy in different environments – it is robust. The R&D tax concession has a number of deficiencies in this area:

- ◊ Corporate tax changes affect the subsidy rate, even when using the more appropriate Warda index (1994, 1996).
- ◊ As the proportion of firms in tax loss changes over time (reflecting the cycle), the rate of assistance changes.
- ◊ The introduction of dividend imputation in 1987 washed out some of the benefits of the concession. For firms who for some reason must pay out unfranked dividends, the concession offers no effective subsidy (BIE, 1993*b*).

All of these features of the tax concession probably warrant further consideration.

Discouraging bad interactions/encouraging good ones

How does the programme affect other interventions? Programmes may overlap, compensate for, complement or adversely affect each other. Programme design should take account of these interactions. In the context of innovation programmes, it should be noted that Australia employs multiple avenues for subsidising R&D. These programmes are rarely analysed collectively (the IC 1995 inquiry being an exception). The existence of these multiple mechanisms for support are relevant to the evaluation of any sub-component. For example, at some point the gains from marginal investments by government in R&D are exhausted. So, even if the amount of support provided by a programme is modest, it may still be sub-optimal even in the presence of externalities, if other programmes have pushed investment sufficiently down the relevant marginal efficiency of capital schedules.

In the case of the 125 per cent R&D tax concession, it could be argued that the type of extramarginal research (from a private perspective) funded by the tax concession differs in type from that encouraged more directly by the public purse, so that concern that we may have oversubscribed to IR&D is probably unwarranted. Indeed the IC (1995) cite evidence of higher overall returns to industry R&D than directly funded public R&D.

Cost effectiveness and a net benefit

The acid test of a programme is that it should generate a net economic benefit – taking into account not just the benefits to recipients but the intended and unintended costs and benefits to others, and the inefficiencies in raising the finance to fund the programme. In all likelihood the 125 per cent R&D tax concession passes this test.

Superiority

A programme must not only produce a net benefit, but it must, for the given amount of resources, have the greatest net benefit among competing uses for those resources. To some extent this is an academic criteria – we rarely know with the required precision the alternative rates of return on project resources. On the other hand, superiority is a claim that no scope for improvement exists. The concession's inducement deficiencies, problems of robustness, and unevenness in rates of assistance suggest that superiority would be a premature accolade.

Evaluation, monitoring and reporting

Whilst there are mandatory requirements for evaluation and reporting of government programmes, these are often regarded as a nuisance rather than as an opportunity for learning. Both accountability and learning depend in systematic information gathering about the performance of a programme and unbiased appraisal of its worth. The general R&D tax concession has been formally evaluated three times (a BIE interim evaluation, a full BIE evaluation and an IC inquiry), and has been the subject of other reviews (Warren Centre, 1996; and SIRF, 1996). In this sense, the record for close scrutiny has been better than most industry programmes. On the other hand, little data on the performance of the concession is publicly available, and there have been some problems in obtaining data of high quality on the cost components of the R&D.

The approach to policy evaluation in government is quite different to that of commercial enterprises when they appraise the performance of their products and services in the market. The former tends to be rigid, sporadic and defensive, with little feedback between the policy makers and evaluators. The latter is far more flexible, continuous and positive, with actions taken as a result of market intelligence. Ideally, there should be far more real-time evaluating akin to commercial processes – this would include examination of how a programme is performing, and small incremental changes made as evaluators, administrators and policy makers detect opportunities for design improvements.

Conclusions and lessons for R&D policy in Australia

The objective of R&D fiscal measures is to induce substantial and worthwhile R&D at low cost to taxpayers. The R&D tax concession applies the concession to all R&D, rather than to only the additional R&D. As a consequence there is substantial dissipation of the concession as transfer payments to firms. These generate real economic costs as some of these transfers flow to foreigners, and the revenues lost from such concessions must be financed through additional distortionary taxation. This means that there must be high spillovers from the modest amount of induced R&D to generate net benefits. Fortunately, we can feel relatively confident that the Australian tax concession does generate net social benefits – especially at its lower current rate of 125 per cent.

However, a number of possible modifications and elaborations of innovation policy could be further explored, particularly aimed at increasing inducement:

- ◊ the development of a programme which could support incremental R&D, with administrative antidotes to the risk of abuse;
- ◊ other mechanisms for encouraging inducement (for example, some evidence for very large projects put forward by companies that they would not otherwise have proceeded with);
- ◊ restrictions on access to the concession by foreigners;
- ◊ trialing of incentive compatible mechanisms;
- ◊ instruments which are invariant to the tax status of the firm (including its dividend policies and status); and
- ◊ capping of revenue forgone.

None of these modifications may be feasible, but they should be considered further.

Appendix

DATA IN MODELLING

Table A1. Description of variables used in modelling

Mnemonic	Variable description
IND#	A set of dummy variables picking up 17 product fields
FOREIGN	1 if firm is foreign-owned
USER	1 if the firm had been a user of any of 9 industry programmes
SIZE	Log (turnover)
SMALL	1 if the business employed less than 100 persons
MEDIUM	1 if the business employed between 100 and 250 persons
EXPORTER	1 if the firm was an exporter
INTENSE	Eligible R&D/turnover
LOSS	1 if operating profit before tax <0
TAXLOSS	1 if carrying forward tax losses from the past
CONTIN	If a consistent R&D performer over the three years 1988–89, 1989–90 and 1990–91
INCREM	Share of eligible R&D which is incremental
PILOT	Share of eligible R&D which is pilot
STRAT	Share of eligible R&D which is strategic[27]
CASH	1 if the firm regarded cash flow in the company as a “very important” influence on R&D
RDPLAN	1 if has a business plan with a defined role for R&D
PAYBACK	Number of years in payback period for a representative innovation
COLLAB	1 if undertakes R&D collaboratively
PFRANKED	1 if partially franks dividends
GENERIC	1 if a user of the Generic Technology Grants Programme in the past 5 years
AMTDP	1 if a user of the Advanced Manufacturing Technology Development Programme in the past 5 years
FMP	1 if product type is fabricated metal products
CRC	1 if firm has been in the CRC programme in the last five years
EMDG	1 if the firm has been in the Export Market Development Programme in the last five years
COMPLY	a range of values from 1 to 5 depending on the compliance cost share of eligible R&D
INERT	=1 if firm does not have any induced R&D in response to the tax incentive.
INNOV	The estimated share of sales in three years time accounted for by totally new products/services
PDP	=1 if the firms has used the Partnerships for Development Programme in the last five years

NOTES

1. This paper does not necessarily represent the views of the Industry Commission. The author is grateful for comments from Dr. Rob Phillips of the Industry Commission. Any errors are the responsibility of the author alone.

2. Syndication was introduced to encourage R&D collaboration by companies with insufficient resources to undertake an R&D project alone. As well, tax-exempt bodies were also permitted (until 19 August 1992) to participate in syndicates. The provisions allow for two or more eligible companies to form a syndicate and contract out or undertake R&D project(s), and claim their proportion of such expenditure at a concessionary rate under s73B of the Income Tax Assessment Act. A syndicate usually involves a research company and two or more investors (one of which can be the research company itself). While the original intention of syndication was to encourage pooling of resources for undertaking R&D, the programme has mainly been used by entities exempt from tax or research companies in tax loss. A syndicate effectively allows such firms to trade their tax losses (however gained) for R&D. The programme ceased in August 1996 and has been replaced by the START programme which is an outlay rather than a fiscal measure.

3. I draw on a number of other research pieces for this paper: Hawkins and Lattimore (1994), BIE (1993*a* and 1994) and Lattimore (1996). Extensive further analysis is made of the unit records collected as part of BIE (1993*a*).

4. The most comprehensive assessment of possible explanations for Australia's relatively low BERD is Hall (1992). See also Castles (1989); Gregory (1993); and DITAC (1992).

5. Comprising information systems and technologies, computer software, communications technologies and other IT technologies.

6. With the exception of the *net* costs of feedstock used in experimental plants Under the previous concession arrangements, feedstock could be sold at commercial prices and still deducted at the concessional rate.

7. We ignore buildings and structures because they are no longer eligible for concessionary treatment. It should be noted that the comparison in Table 13 of the concession's impact at 125 per cent with that when it was 150 per cent is not entirely fair because a number of other provisions have changed as well as the concessionary rate (such as treatment of core technology, feedstock and interest). Nevertheless, the treatment will capture the essential impact of the change in tax concession rate.

8. Notwithstanding the difficulties in measuring m, there are additional problems enumerating R. In particular, as well as the direct subsidy cost of the programme, we would need to measure: *i)* taxable revenue generated by spillovers; and *ii)* taxable revenue streams associated with concession projects relative to those generated by alternative uses of the resources. In the assessment of the revenue costs of the concession it has been assumed, as an approximation, that the ultimate tax receipts from the projects are roughly the same as those generated by alternative uses of resources and that there are no taxation revenue benefits from spillovers.

9. This exclusion, or some re-parameterisation of the equation, is appropriate if the objective is to measure the "bang for a buck". After all, no revenue is forgone for firms who do not register for the concession.

10. Estimated as τ x (1-claw) x (0.5-0.25) where claw = 0.15. We ignored other discounting to the value of the tax concession introduced by tax losses or other lags.

11. An earlier survey by the BIE (1989) also has some evidence on inducement. The Bureau, in an earlier interim evaluation of the tax concession, had asked registrants to identify the factors that had contributed to the observed increase in their R&D expenditure over the two-year period 1984-85 to 1986-87. This suggested that around one-third of the increase had been due to the introduction of the concession, and somewhat less to reclassification of expenditure following the introduction of the concession.

12. The elasticities were calculated as the Δlog (R&D) generated by the concession (equal to 1/[1-I]*100) divided by Δlog (after-tax cost of R&D).

13. If this is a genuine feature of the process of inducement in firms, it points to possible mis-specification in the orthodox approach to estimation of the responsiveness of firms to R&D incentives. The orthodox approach suggests that firm's responses are continuous functions of the cost of R&D capital, when in fact, for many firms, adjustment costs and other inertia may require a threshold to be exceeded before there is any response.

14. We use the relationship between the two estimates when k=0.5 to estimate this (*i.e.* 10/16.7*10.5 = 6.3).

15. In the 150 per cent study by BIE (1993*a*, p. 235) this was then discounted the basis that the existence of the subsidy would have lowered the private rates of return (so that 78 per cent was used instead of the off-the-shelf estimate of 90 per cent), although curiously that study did not subtract the difference between private rates of return on induced R&D and their opportunity rate of return from the net benefit.

16. However, this approach abstracts from one of the likely reason for spillovers – problems of appropriability. If a research project produces easily replicable information then it will be hard for the innovator to appropriate its benefits. The private returns will be low. However, the social returns may be quite high.

17. Measured as the percentage of sales which would be accounted for by totally new products and services in three years' time. Given that many spillovers stem form simply the evolution of new products and services, we might expect a link between such innovation dynamism and spillovers.

18. Compliance costs were measured by the BIE (1993*a*) but not included in the cost-benefit analysis.

19. The estimates were produced by translating the ranges provided in the BIE survey to discrete estimates. The higher number is based on using the mid-points of any interval, while the lower estimate is based on the lowest value in any interval.

20. Perhaps one indicator of this is that in econometric estimates of the compliance costs, there were no predictions which matched the higher values of the apparently observed compliance costs. While this simply could signal model mis-specification, it may also be a symptom of upwardly biased answers.

21. Because they are not in their core, they matter little to their overall competitiveness, and the market is not likely to eliminate them very rapidly.

22. Because the probability that the firm would have been in business in the future was low, or because it would take many years of trading profits to realise the gains from the losses (so that there discounted present value is low).

23. There is little doubt that some syndicates fell into this category (BIE, 1994*;* and Lattimore, 1996).

24. Of course, one interesting question not adequately assessed by the BIE survey is the extent to which an R&D incentive can act as an attractant to foreign investment in the first place – in which case, for some firms the inducement rate can be 100 per cent.

25. Drawing strongly from Lattimore (1996) and also from IC (1997).

26. Feedstock is material input used in a pilot plant (for example, carcases in an pilot abattoir or ores in a pilot crushing plant). Some firms were claiming feedstock at the full concessional rate, even though they sold the finished product at standard market prices.

27. Noting that we only use two out of the three R&D type variables in any regression to avoid perfect collinearity.

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