THE IMPACT OF THE 150 PER CENT TAX CONCESSION FOR INDUSTRIAL RESEARCH AND DEVELOPMENT IN AUSTRALIA — A PRELIMINARY ASSESSMENT*

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The paper has two main objectives. First, it provides the background and rationale for Australia's introduction of the 150 per cent tax concession for IR&D in order to appreciate some of the problems of its implementation. Secondly, it assesses the effectiveness of the concession in promoting IR&D. The latter requires estimation of the impact of the concession on the user cost of IR&D and the responsiveness of the demand for IR&D to changes in its user cost.

Keywords: industrial research and development, taxation incentives, science and technology policy

INTRODUCTION

There is a growing debate regarding the effectiveness of tax concessions as a means of fostering expenditure on industrial research and development (IR&D). Assuming some justification for government intervention,[1] the case for tax incentives to promote IR&D (rather than grants or subsidies, for example), has generally included claims that tax incentives entail less interference in the marketplace, provide substantial incentives for incremental IR&D, lower administrative costs, promote a more stable policy environment, and are politically more feasible. Critics, however, point to such consequences of tax incentives as their tendency to generate unintended windfalls to firms, the adverse industry effects on horizontal equity and individual effects on vertical equity,

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the loss of government revenue, their bluntness in according similar tax treatment to firms of different age, size and in different industries, and uncertainties regarding the role and importance of financial criteria in project selection.[2] Criticisms at the theoretical level have been supported by emerging empirical evidence casting doubt upon the efficacy of R&D tax incentives in the United States, Sweden and Canada.[3] It was in just such a climate of debate of the advantages and disadvantages of tax incentives in promoting IR&D that the Australian government, in July 1985, introduced tax concessions of up to 150 per cent to stimulate business enterprise R&D.

This paper has two main aims. First, it provides the background and rationale for Australia's introduction of the 150 per cent tax concession for IR&D in order to appreciate some of the problems involved in its implementation. Secondly, it assesses the effectiveness of the concession in promoting IR&D in Australia.

IR&D ACTIVITY IN AUSTRALIA PRIOR TO THE TAX CONCESSION

For some decades now, the standard of living of Australians has been falling relative to other OECD countries and, more recently, to the newly developing countries of Asa. In OECD rankings of per capita GDP, Australia dropped from twelfth place in 1970 to sixteenth in 1985.[4] Among the various causes of this situation, two now stand out as having important implications for Australian science and technology policy.

Over the last two decades, world trade in manufactures has grown at a rate consistently higher than that for commodities, accounting for around 51 per cent of world exports in 1984. Australia's exports, however, are still based on primary production, with only 16.8 per cent of exports coming from the manufacturing sector in 1984. While this reflects Australia's natural endowments and the efficiency of its mining and agricultural sectors, growing world capacity has tended to depress commodity prices relative to the prices of traded manufactured goods. This has resulted in the terms of trade moving markedly against Australia.[5]

The profile of world trade reveals the increasing importance of industries which produce goods with a high value added component and which have a strong R&D base.[6] The nations that are improving their export earnings to the greatest extent are those emphasising the development of skill intensive industries capable of producing goods of outstanding design, quality and performance.[7] However, even by 1981 only 55 per cent of Australia's manufactured exports were elaborately transformed and less than 4 per cent were R&D intensive.[8] Not surprisingly, Australia's technological balance of payments (technological receipts divided by technological payments) has typically been lower than that of other OECD countries.[9]

OECD technology indicators have highlighted the low intensity of IR&D activity in Australia relative to other countries. Some pertinent statistics released prior to introduction of the tax concession reveal *inter alia* that during the 1970s, and at least until 1981-82, R&D expenditure by business enterprises in Australia had been falliong in real terms while generally rising in the OECD countries.[10] While private expenditure on R&D did increase in the three years immediately prior to introduction of the tax concession, by 1984-85 business enterprise R&D still constituted only 30 per cent of the nation's gross expenditure on R&D and represented only 0.3 per cent on GDP, the fifth lowest percentage of all OECD countries.[11]

The causes underlying the relatively low intensity of IR&D activity in Australia have been discussed elsewhere.[12] The causes have included inadequate government science and technology policies; the fragmented structure of Australian industry; a domestic rather than an international market orientation, promoted in part by high tariff levels; a high degree of foreign ownership of manufacturing industry facilitating technological transfer as a substitute for indigenous research; unstable management-employee relations fostering resistance to technological change; a low level of technological awareness and entrepreneurial skills among Australian business managers; and difficulties in accessing venture capital.

The change of federal government in 1983 resulted in a much greater concern with science and technology policy aimed at increasing the nation's industrial competitiveness. The incoming government was, and remains, convinced that attitudinal and structural changes must occur in industry if Australia is to become an internationally competitive economy. As part of a range of initiatives to promote technological innovation by the private sector, the government introduced a 150 per cent tax incentive scheme for R&D.[13]

The 150 per cent concession scheme became effective on 1 July, 1985 and was designed to benefit companies investing in R&D activities in Australia. Previously the concession was 100 per cent for current R&D expenditure. The legislation enacting the R&D tax incentives scheme contained a sunset clause stating that the scheme would end after six years on 30 June, 1991, with a technical review after two years and a cost effectiveness review after four years. The concession is now to be extended to 30 June 1993 and will then be available for a further two years at 125 per cent until June 1995, when it will revert to 100 per cent.

EFFECTIVENESS OF THE CONCESSION

An obvious first step in determining the effectiveness of the concession is to estimate the additional expenditure on business enterprise R&D which it generates. Some relevant statistics are set out in Table 1.

TABLE 1
BUSINESS ENTERPRISE R&D ACTIVITY

	BERD Expenditure current prices ($M)	**BERD expenditure constant prices ($M)**	**Person years effort on BERD**	**No. of business enterprises performing R&D**
	Average annual % change	**Average annual % change**	**Average annual % change**	**Average annual % change**
1981-82	374	471	8489	1279
	31	18	15	18
1984-85	723	723	12260	1985
	27	19	15	24
1985-86	922	858	14128	—
	29	20	16	24
1986-87	1189	1027	16368	2932
	12	4		
1987-88	1327	1064	16862	—

Source: Australian Bureau of Statistics, *Research and Experimental Development, Business Enerprises, Australia 1986-87*, cat. no. 8104.0 and preliminary estimates, June 1987.

The figures for business enterprise research and development (BERD) taken by themselves, are incapable of revealing a causal nexus between the concession and IR&D expenditure levels. How much of the increase in BERD since 1984-85 is a direct result of the tax concession?

The rate of increase in BERD in Australia, when measured in current dollars, has actually decreased since the introduction of the tax concession for R&D. For example, as Table 1 indicates, between 1981-82 and 1984-85 the average rate of increase per annum of current expenditure on BERD was 31 per cent, while for three years immediately after introduction of the concession the rates of increase per annum were 27 per cent, 29 per cent and 12 per cent respectively. The rate of increase in real BERD grew very slightly during the first two years and fell substantially in 1987-88. The figures for person years of effort in R&D reveal a fairly constant rate of increase since implementation of the concession. While one may not wish to make too much of these figures given the short time range, they do reveal that certain interim assessments of the impact of the tax concession should not be accepted uncritically.[14]

Additional data are needed if we are to provide an informed assessment of the impact of the tax concession for IR&D in Australia. An informed assessment requires at least two additional items of information: first, the impact of the tax concession on the user cost of R&D; secondly the responsiveness of expenditure on IR&D to changes in the user cost.

Impact of the Concession on User Cost of R&D

The usual method of measuring the impact of a tax concession on the R&D performer is to calculate the after tax cost cost of the expenditure. For each dollar which an Australian company spends on eligible R&D, it can deduct \$(1+k) from its taxable income for the year in which the expenditure occurs. This implies a tax saving of \$(1+k)t and an after tax cost of R&D of \$(1−(1+k)t).

The larger the tax concession, the lower will be the after tax cost of R&D.[15] Thus, for Australia in 1984-85, prior to the 150 per cent tax concession, the after tax cost of current R&D was \$(1−.46) or 54c. Following introduction of the concession, the after tax cost fell to \$(1−(1.5).46) or 31c in 1985-86. Following the increase in the corporate tax rate in 1986-87 to 49 per cent, the after tax cost of current R&D fell to 26.5c. As a commentator noted at this time, "the after tax cost of R&D in Australia is now typically less than half of what it is in the US and many European countries".[16] Following the reduction in the corporate tax rate to 39% in the 1988-89 fiscal year, however, the after tax cost of R&D rose to 41.5c.

As these figures make clear, increases in the corporate tax rate lower the after tax rate of R&D. This renders the traditional measure an inappropriate index of the user cost of R&D. McFetridge and Warda have noted the inverse relation between corporate tax rates and the after tax cost of R&D:

> It carries the unfortunate implication that higher tax rates are beneficial to the corporations paying them. Assuming that an R&D expenditure is a deductible expense, the higher the corporate tax rate the lower the apparent after-tax cost of R&D. Since it is unlikely that many would regard higher corporate tax rates as an incentive to engage in R&D or in investment generally, an alternative measure is called for.[17]

An attempt to provide a more appropriate measure of the impact of a tax concession on the user cost of R&D has been made by the same authors. They call this measure the B index and define it as "the ratio of the present value of project-related before tax income to the present value of project-related costs at which an R&D project becomes profitable for the firm that undertakes it".[18] The B index may be regarded as the minimum benefit-cost ratio at which an R&D project is profitable for the business enterprise. An expression for the B index suitable for our purposes is as follows:[19]

$$B = \frac{(1 - aW_1t - bW_2tPVe - cW_3tPVb)}{1-t}$$

where t = corporate tax rate
a = proportion of current R&D expenditure in BERD
b = proportion of capital expenditure on R&D equipment in BERD
c = proportion of capital expenditure on R&D buildings in BERD a + b + c = 1

PVe = present value of capital cost allowance on R&D equipment
PVb = present value of capital cost allowance on R&D buildings W_1, W_2, W_3, = tax concession on eligible R&D current expenditure, expenditure on equipment and expenditure on buildings respectively

The B index is a more sophisticated measure of the impact of a tax concession on the user cost of R&D than the traditional measure of after tax cost of R&D. It recognises that each component of a firm's R&D expenditure can be treated differently for tax purposes.[20]

In order to determine the impact of a tax concession on the user cost of R&D, it is necessary to know the proportion of current expenditures, expenditure on instruments and equipment, and expenditure on buildings in business enterprise R&D and the rates of depreciation on different categories of capital R&D expenditure. The inverse relationship between the B index and the corporate tax rate puts into perspective the impact of the corporate tax rate on the user cost of R&D — higher tax rates increase the relative attractiveness of R&D expenditures which are eligible for the tax concession because they lower the after tax cost of such expenditure.[21] The lower the B index, the lower is the benefit-cost ratio at which R&D becomes profitable for the firm to undertake.

We can now apply the above formula to determine the B index for Australia for some years prior to and each year subsequent to the introduction of the 150 per cent deduction for eligible R&D. The estimates are set out in Table 2.[22]

TABLE 2
B INDEXES, AUSTRALIAN BUSINESS SECTOR, SELECTED YEARS

	R&D current expend. as % of BERD	R&D capital expend. as % of BERD	Expend. on R&D equipment as % of BERD	Expend. on R&D buildings as % of BERD	Corporate tax rate %	After tax cost of R&D $	B index r = 10%	r=15%
1981-82	86.9	13.1	6.55	6.55	46	0.54	1.01	1.01
1984-85	86.2	13.8	6.9	6.9	46	0.54	1.01	1.01
1985-86	86.2	13.8	6.9	6.9	46	0.31	0.617	0.621
1986-87	86.2	13.8	6.9	6.9	49	0.265	0.568	0.573
1987-88	86.2	13.8	6.9	6.9	49	0.265	0.568	0.573
1988-89	86.2	13.8	6.9	6.9	39	0.415	0.712	0.716

Source: Data for 1981-82 and 1984-85 calculated from Australian Bureau of Statistics, *Research and Experimental Development, Business Enterprises, Australia 1981-1982 and 1984-85, cat. no. 8104.0, table 4.*

The evolution of the tax treatment of R&D in Australia has resulted in reductions both in after tax cost of R&D and in the B index for the nation's business enterprises. In 1976-77, the B index for Australia of 1.01 placed Australia 11th or 12th out of 20 countries studied in terms of the incentives which the taxation system provided for performing R&D.[24] As a result of a reduction in the corporate tax rate and the 150 per cent tax concession, Australia would now rank number two on that list.

Impact of the Concession on IR&D Spending

One might reasonably assume that the decrease in the B index for Australia between 1984-85 and 1986-87 would have resulted in an increased volume of IR&D. While in 1984-85 it was unprofitable for firms to undertake IR&D unless the expected benefit-cost ratio was at least 1.01, in the year following introduction of the 150 per cent tax concession the minimum benefit-cost ratio fell to around .57. This represents a significant reduction in the minimum benefit-cost ratio due to the reduction in the user cost of IR&D.

But how sensitive is expenditure on R&D to changes in its user cost? What is the price elasticity of demand for IR&D by business enterprises? The weight of evidence from overseas studies suggests that tax incentives are generally ineffective in promoting IR&D. A report by Mansfield summarising the evidence regarding the impact of tax incentives on IR&D in the US, Canada and Sweden (which he describes as "remarkably similar"), suggests that tax incentives in each of these countries increased R&D expenditures by only around 1 per cent or 2 per cent. Moreover, the tax incentives led to a considerable redefinition of activities as R&D in the years immediately following their implementation, resulting in a 13 per cent to 14 per cent increase in reported expenditures in both Canada and Sweden.[25]

The issues of whether financial considerations play a major role in R&D decisions, and the extent to which they constitute points of leverage for government action, are unresolved as yet. Regarding the role of financial considerations in determining R&D spending by businesses, it needs to be realised that numerous factors can play a role in determining the overall R&D budget. In order to estimate the impact of tax incentives on R&D expenditures, one needs to access the relative weights of the various inputs to the R&D budget setting process.[26] Regarding the question of whether financial factors provide an effective leverage point in influencing the level of R&D expenditure, the conclusion of a recent survey is only a qualified yes, with tax mechanisms regarded as less effective than either government subsidies or contract R&D.[27] Certainly not enough is known about the role of financial criteria in R&D project selection among Australian business enterprises.[28] As the above discussion indicates, many other factors could have played a role in determining the change in the volume of IR&D between 1984 and 1988.

The little empirical research that does exist on the matter suggests that overseas the price elasticity of demand is fairly low. While highly tentative estimates by Nadiri indicate a value of approximately 0.6, his more recent studies of US manufacturing firms have indicated values of around 0.36 in the intermediate run and 0.28 in the long run.[29] With reference to existing data, Mansfield has recently stated that, "While our knowledge of the price elasticity of demand for R&D is far from adequate, the best available estimates suggest that it is rather low, perhaps about 0.3".[30]

In the absence of empirical studies in Australia, suppose we accept Mansfield's estimates that the price elasticity of demand for R&D is approximately 0.3 for both the intermediate and the long run. The 150 per cent tax concession has resulted in a B index in 1985-86 that is lower by (1.01–.62)/1.01, or 39 per cent, than the B index in 1984-85. On these figures, R&D spending is 30 × 0.3, or 12 per cent higher than it would have been if the tax concession had not been introduced. In 1986-87 and 1987-88, the tax concession for R&D, together with the change in the corporate tax rate, resulted in a B index that is lower by 44 per cent, (1.01–.57)/1.01, than that for 1984-85. On these figures, R&D spending for the year is around 13 per cent higher than it would have been without the concession.

TABLE 3
ESTIMATED CHANGES IN BERD RESULTING FROM CHANGES IN TAX TREATMENT OF R&D

	BERD ($M)	Industry financed BERD ($M)	Induced change in BERD resulting from tax treatment of R&D	Estimated increase in BERD resulting from changes in tax treatment of R&D
1984-85	723	635		
1985-86	922	811	12%	87
1986-87	1189	1042	13%	120
1987-88	1327	1167	13%	134

Source: Figures for industry financed BERD in 1984-85 were based on ABS (Australian Bureau of Statistics), *Record of Experimental Development, Business Enterprises, Australia*, cat. 8104.0 table 5. In that year industry financed BERD (own funds plus funding from other businesses) represented 88 per cent of BERD. In the absence of data, the same ratio of industry financed BERD to aggregate BERD was assumed for 1985-86. The figure for 1986-87 and 1987-88 is based on cat. 8104.0 1986-87. Industry financed BERD again represented 88 per cent of BERD.

The estimates set down in Table 3 must be treated with considerable caution. First, the accuracy of the estimates depends crucially on the validity of the assumption that the price elasticity of demand for R&D is approximately 0.3. Secondly, the estimates should be regarded as an upper limit to the amount of R&D induced by changes in the tax treatment of R&D. This is because many firms had no tax liability and thus experienced no reduction in user cost resulting from the concession.[31]

ADDITIONAL CONSIDERATIONS

The results thus far indicate that Australia's tax treatment of R&D is relatively more generous than many other countries and has led to (at best) a 12-13 per cent increase in R&D expenditure. A more detailed assessment of the impact of the 150 per cent tax deduction will need to address other issues however. Is the amount of induced R&D worth the cost in terms of government revenue foregone? What impact has the concession had on invesment in (non R&D) physical capital? In what follows the attempt will be made to provide tentative answers to each of these questions.

Revenue Foregone and the Social Benefits from R&D

The effectiveness of the tax concession for R&D cannot be assessed independently of the estimated amount of revenue foregone by the government as a result of its implementation. The weight of overseas evidence suggests that increased R&D expenditures are generally substantially less than revenue foregone by the government. Mansfield's studies indicate that the ratio of the tax incentive-induced increase in R&D expenditure to the revenue lost by governments in the US, Canada and Sweden was around 0.3 to 0.4.[32] Table 4 compares estimates of revenue foregone with our estimates of induced R&D spending.[33]

TABLE 4
RATIO OF INCENTIVE-INDUCED R&D SPENDING TO GOVERNMENT SPENDING FOREGONE

	1985-86	1986-87	1987-88
Estimated induced R&D spending ($M)	87	120	134
Revenue foregone ($M)	146	170	200
Ratio	0.6	0.7	0.7

While the estimated ratios of incentive-induced R&D spending to government revenue foregone are higher than Mansfield's estimates, it needs to be re-emphasised that any R&D undertaken by firms with no tax liability in these two years must be deducted from our estimates of induced expenditure. Once allowance is made for R&D spending by firms which experience no reduction in user cost from the tax concession, our estimated ratios for Australia will more closely approach those of Mansfield. In any case, the amount of incentive-induced R&D expenditure appears to be substantially less than taxation revenue foregone.

Whether the induced R&D is worth the cost in terms of government revenue foregone depends on at least two factors: first, the returns, both private and social, resulting from the R&D; and second, the extent of future increases in R&D resulting from any 'productive culture' which might be nurtured by the concession during its life. With respect to the first factor, there is very little empirical research to guide us in an attempt to determine the returns to increased R&D activity resulting from the concession. For one thing, not enough is known about the type of R&D activity being undertaken, let alone its private returns.[34] For another, the increased R&D activity is too recent to have had much impact on Australia's industrial competitiveness, even if precise measures were available. The social benefits of R&D activity are even harder to determine with a degree of accuracy. Perhaps the most reliable study of the social benefit of R&D was that of Mansfield *et al.*, which estimated that it ranged between 1.77 and 2.50 for a small sample of major R&D projects.[35] Minor and marginal R&D projects might be expected to yield lower social cost-benefit ratios; unfortunately, the investigation did not cover mainstream projects. The gap between social and private benefits from R&D will vary according to type of project and industry, and this range of values may well be somewhat higher than would be the case for a typical R&D project in Australia.

Regarding possible future increases in R&D expenditure due to an emergent 'productive culture', an explicit rationale for the 150 per cent tax incentive at the time of its introduction was that it might foster awareness on the part of business managers of the value of R&D, an awareness which could lead to increased R&D expenditure in the years after the concession is withdrawn. The Minister for Industry, Technology and Commerce, Senator Button, has described the tax concession as an 'important catalyst' in bringing about the attitudinal changes necessary to support the continuing and sustained commitment to IR&D necessary for Australia to become an internationally competitive economy.[36]

But, we may well ask, does the tax concession really serve to foster awareness of the value of R&D as an activity for promoting a particular firm's competitiveness or industrial competitiveness in general, or does it rather foster an awareness that R&D can be expensed for taxation purposes in the same manner as other business costs? An awareness of the fact that R&D expenses are eligible for a 150 per cent tax concession may not necessarily be accompanied by an understanding of the value of R&D as a crucial component of a firm's corporate strategy and long term survival. Existing government programmes to promote a productive culture in Australia include the National Industry Extension Service, which encourages firms to use the most modern management and production systems, including appropriate marketing, design, engineering and quality control techniques; a nationwide network of Innovation Centres to co-ordinate expertise and facilities required at the research, prototype, business plan, manufacturing and marketing stages of new product innovation; and the Technology Transfer Council, which assists firms in the effective transfer and application of best practice technology. By means of such institutions the government is aiming to foster a more productive and innovative business culture in Australia. At the margin, the role of 150 per cent tax concession as a catalyst for bringing about further attitudinal change remains uncertain.

Impact of the Tax System on the Choice between R&D and Physical Capital

As a result of the 150 per cent tax concession for R&D, firms will find it profitable to invest in R&D even when the present value of the income generated is less than its cost. As Table 2 indicates, the tax concession has resulted in a situation where the minimum benefit-cost ratio at which R&D projects have been profitable for firms is less than one. This is generally not the case for investments in physical capital which do not qualify as R&D. In contrast to current R&D expenditure, investment in plant and equipment cannot be written off immediately, but must be depreciated. This implied that capital expenditure will generally not be profitable for business enterprises unless the present value of their before tax income exceeds the costs. One consequence of the tax concession, therefore, is that it can lead to a shift of resources toward R&D and away from investments in machinery, plant and equipment, even though expenditure on the latter may have a higher benefit-cost ratio.[37] If such is the case, the tax concession leads to an under allocation of resources towards increasing the nation's capital stock.

To appreciate this point better, we can begin by calculating the B index on a representative investment in (no-R&D) physical capital. Assume that this investment is composed of 77 per cent machinery and equipment and 23 per cent buildings and structures, which is approximately the composition of the capital stock of the manufacturing sector as a whole.[38] The resulting index (the B* index) can be calculated from the following formula:[39]

$$B^* = \frac{1 - atPVe - btPVb}{1-t}$$

where a = proportion of (non-R&D) investment in machinery and equipment

b = proportion of (non-R&D) investment in buildings and structures

PVe = present value of capital cost allowance on one dollar expenditure on machinery and equipment

PVb = present value of capital cost allowance on one dollar expenditure on buildings and structures

t = corporate tax rate

TABLE 5
B* INDEXES FOR (NON-R&D) CAPITAL EXPENDITURE, AUSTRALIA, SELECTED YEARS

	B* INDEX
1984-85	1.25
1985-86	1.25
1986-87	1.28
1987-88	1.19

We find that the B* indexes for (non-R&D) capital expenditure are uniformally higher than the B indexes for R&D expenditure following introduction of the 150 per cent concession. In 1984-85, for example, the B index for R&D expenditure (.62) was substantially less than that for non-R&D investment (1.25). A likely consequence of this is that firms undertook R&D projects with benefit-cost ratios between .62 and 1.25 while rejecting capital expenditure with benefit-cost ratios falling within this range. To the extent that firms adopt principles of rational decision-making in their investment behaviour, the greater the difference between the B* index and the B index in any given year, the more will resources be diverted from physical investment toward investment in R&D.

It is possible to speculate on the amount of expenditure diverted from capital investment and to R&D. Following an approach taken by McFetridge & Ward, we can estimate the amount of R&D spending that would have been undertaken by business enterprises if the tax treatment of R&D had been the same as for (non-R&D) capital expenditure.[40] For example, in the year 1985-86, the first year of the 150 per cent tax concession for R&D, the resulting B index was lower by (1.25–.62)/1.25, or 50 per cent, than the B index for an investment in plant and equipment. Using Mansfield's estimate of 0.3 for the price elasticity of demand for R&D, we estimate that R&D spending for that year was .50 × 0.3, or 15 per cent, higher than it would have been had R&D been subjected to the same tax treatment as capital expenditure in general. In this case, BERD financed by industry would have been $705 million instead of the estimated $811 million. So, had R&D expenditure been treated for tax purposes as a typical expansion of the stock of capital, it would have been around $106 million less, and capital expenditure would have been $106 million more than the observed values. By similar reasoning, capital expenditure was reduced by approximately $148 million and $152 million in the years 1986-87 and 1987-1988 respectively.

Given the reduction in the user cost of R&D occasioned by the concession, it is likely that for tax reasons, certain investments in R&D are being preferred to investments in physical capital, even when the latter have a higher benefit-cost ratio. Of course, this substitution existed prior to introduction of the 150 per cent deduction, when the B index was somewhat higher (see Table 2). However, the difference between the B and B* indexes has become much greater since introduction of the concession and so too has the potential misallocation of resources. In view of the importance of capital formation for the nation's industrial competitiveness and historically low rate of gross fixed capital formation,[41] this implication of the R&D tax incentives deserves more detailed study.

CONCLUSIONS

The preceding analysis has attempted to provide the background and rationale for Australia's introduction of the 150 per cent concession to promote IR&D and has also attempted to assess its effectiveness. With respect to the latter aim, it was argued that an informed assessment of the concession's effectiveness required estimating the impact of the concession on the user cost of R&D, and estimating the responsiveness of the demand for R&D to changes in its user cost. It was estimated that the concession induced R&D expenditure has been (at most) 12-13 per cent in each of the years 1985-86 and 1986-87. The paper went on to discuss various implications of the tax concession, such as its effect on government revenue and the rate of capital formation.

Two sorts of limitations attach to the analysis and must be acknowledged. First, there are significant gaps in our knowledge of such matters as the price elasticity of demand for R&D, the role of financial considerations in R&D decision making, the marginal private and social benefits of different types of R&D, and the impact of R&D on industrial competitiveness. Although quantitative estimates were made wherever possible, is must be emphasised that data limitations require making assumptions which are open to dispute. The numerical estimates made in the above analysis must be regarded as highly tentative and are more indicative of the impact of the tax concession than precise estimates of its effects. The analysis here is most useful in its suggestion of paths for further research using more refined data and more sophisticated econometric testing than has been possible here.

The second limitation of the study is its narrow focus. The study considered only certain facets of the tax treatment of R&D in Australia while ignoring important issues, such as the impact of the income tax structure on entrepreneurship and innovative activity, and the impact of the tax system on the cost of financing R&D and investment in general. It also considered the effectiveness of the 150 per cent concession independently of the macroeconomic climate and other components of the government's science and technology package which provide incentives for IR&D. In its concentration on the effect of the concession on the volume of IR&D, it devoted little attention to the type of R&D that is required if Australian industry is to become internationally competitive. Also missing is a discussion of the importance of factors such as a firm's organisational structure, its innovative climate, corporate strategy, and managerial skills, which help to determine the extent to which any level of R&D effort affects the firm's competitiveness. In reality, the effectiveness of the tax concession in stimulating R&D and, *a fortiori*, in enhancing industrial competitiveness, cannot be considered in isolation from these other factors.

A verdict on the success of the 150 per cent tax concession in fulfilling the government's aims must await further research. Certainly the full implications of the concession cannot be determined until after its cessation in 1995. In the interim, it is to be hoped that this paper has provided some guidance as to the sorts of issues which need to be considered in the final assessment.

NOTES AND REFERENCES

1. The rationale for government intervention is based on correcting or offsetting those defects in the market mechanism which tend to push IR&D expenditures below the social optimum. For a useful summary of the main arguments, see Australian Science and Technology Council (ASTEC), *Improving Australia's Competitiveness Through Industrial Research & Development*, Canberra, AGPS, September 1987, pp. 79-88.
2. For elaboration, see Barry Bozeman and Albert N. Link, 'Tax incentives for R&D: a critical evaluation', *Research Policy*, 13, 1, 1984, pp. 21-31; Richard Slitor, 'The tax treatment of research and innovation investment', *American Economic Review*, 56, 1966, pp. 217-31.
3. D. McFetridge and J. Warda, *Canadian R&D Incentives: Their Adequacy and Impact*, Canadian Tax Foundation, Toronto, February 1983; Edwin Mansfield and Lorne Switzer, 'The effects of R&D tax credits and allowances in Canada', *Research Policy*, 14, 1985, pp. 97-107; Edwin Mansfield, 'The R&D tax credit and other technology policy issues', *American Economic Review, Papers and Proceedings*, 76, 2, 1986, pp. 190-93; Edwin Mansfield, 'Public policy toward industrial innovation: an international study of direct tax incentives for R&D' in R. Hayes *et al.* (eds), *The Uneasy Alliance: Managing the Productivity — Technology Dilemma*, Harvard Business School, Boston, 1985.
4. Australian Manufacturing Council, *Future Directions for Australian Manufacturing Industry*, AGPS, Canberra, 1986.
5. For a discussion of the implications of these statistics, see ASTEC, *op. cit.*, pp. 11-17.
6. There is a strong positive correlation between the share in manufactured exports taken by high R&D intensity industries and the R&D intensity of the industries. This correlation was statistically significant when tested for eleven OECD countries for the period 1970-1980, OECD, *Science and Technology Indicators*, Paris, May 1985, II, Annex, Graph 3.
7. Technology-based industries are of strategic importance to international competitiveness. By generating products which can transform production structures, they can lead to cost savings and productivity improvements in many industries simultaneously. For elaboration, see ASTEC, *op. cit.*, para. 1.12.
8. With respect to the proportion of exports by high intensity industries in total manufactured exports, Australia in 1981 ranked lowest of eleven OECD countries studied. Australia's figure of 3.7 per cent was well below that for other small economies such as Switzerland (23 per cent), Sweden (15 per cent), The Netherlands (13 per cent), Belgium (9 per cent), and also well below the OECD average (15 per cent). Australia was the only OECD country to register a decline in this percentage between 1975 and 1981.
9. In 1981 the coverage ratio for Australia was only 0.10, the lowest for fifteen OECD countries measured and much lower than the median figures for major, medium and small economies of 1.21, 0.47 and 0.64 respectively. The ratio of technological payments

to business enterprise research and development (BERD) for the same year was 36 per cent, which was the third highest of thirteen countries measured and substantially above the OECD median of 19 per cent. Taking technological receipts as a percentage of BERD, Australia's figure of 3.5 per cent was the lowest of all the countries measured and well below the median figure of 9.9 per cent (OECD), *Selected Science of Technology Indicators 1981-1985*, Paris, October 1985, Table 48). Although Australia's technological balance of payments ratio rose to 0.22 in 1984-85 and 0.38 in 1986-87, these figures are still low compared with other countries.

10. OECD, *op. cit.*, Table 4.
11. ABS statistics quoted in *Scitech*, 'Fillip for Ind. R&D in Revised Figures', January 1987, p. 9. In 1986-87 and 1987-88, BERD represented 0.46 per cent and 0.45 per cent of GDP respectively.
12. See, for example, Larry Dwyer and Terry Alchin, 'R&D activity in Australia', *National Australia Bank Monthly Summary*, January 1987; Donald F. Lewis and John Mangan, 'Research and development in Australia: the role of multinational corporations', *Prometheus*, 5, 2, 1987, pp. 368-85.
13. The definition of R&D covers such activities as industrial design; engineering design; production engineering; operations research (the improvement of the efficiency of organisations by techniques of numerical analysis); mathematical modelling and analysis; psychological research; computer software development (for sale, rent, license, hire or lease to multiple clients) but not routine computer programming or in-house software; and the design, construction and operation of prototypes. Specifically excluded are activities such as market research, market testing or market development; quality control; prospecting, exploring or drilling for minerals; the making of cosmetic modifications or stylistic changes to products, processes or production methods; management studies and efficiency surveys; research in social sciences, arts or humanities; pre-production activities such as planning or demonstration of commercial inability, tooling-up, trial and production runs. See Industry Research and Development Board, *Explanatory Notes. Tax Concession for Research and Development*, Department of Industry, Technology and Commerce, Canberra, Form 86/11.8.87.
14. An ASTEC report has claimed that "there has been a definite net increase in the level of IR&D over the last few years as a result of the 150% tax concession . . . it is expected that further benefits will be realized and expressed through expenditure statistics over the next four years". ASTEC, 1987, *op. cit.* para. 2.19. According to a survey produced by the Centre for Technology and Social Change at the University of Wollongong called *The 150% Tax Incentive for R&D: As Assessment of its Effects*, the scheme has had considerable success. The survey covered 12 large computer and communications firms, 28 small innovative communications companies and 37 large R&D performing firms drawn from membership of the Australian Industry Research Group. The authors conclude that the scheme has not only encouraged an increase in R&D, but has led firms to re-examine their R&D strategies to link them more effectively into their business strategies. See D. Scott-Kemmis, T. Darling and R. Johnston, 'R&D tax concession has positive effect', *Laboratory News*, June 1989. A recent study of the employment effects of the tax incentive, however, concludes that there is no clear evidence that the scheme has increased the number of R&D jobs in Australia. See B. Doube and C.D. Beaton, 'Has the 150% tax incentive scheme created new jobs in R&D', *Search*, 20, 3, 1989.
15. For an overview of the legislation, see G. Lehmann, 'Research and development tax planning', *Australian Accountant*, November 1986, pp. 32-6.
16. A. Gosling, 'The 150% tax concession for research and development', *Australian Technology Magazine*, October 1987, pp. 4-5.
17. *ibid.*, p. 17.
18. *ibid.*, p. 17. An alternative way of interpreting the B index is to regard it as the ratio of the after tax cost per dollar of R&D to the after tax cost per dollar of other expenses.
19. More complex expressions can be constructed taking into account the value of any specific allowances or credits for R&D in addition to tax concessions. See McFetridge and Warda, *op. cit.*, p. 71.

20. In most countries current R&D expenditures can be immediately written off against income while capital expenditures must be depreciated, often at different rates. Consequently, tax savings on current R&D expenditure will be greater than these for eligible capital expenditures. In Australia, current expenditure on plant and equipment incurred on or after 1 July 1985 is deductible at the rate of 150 per cent over three years. This means that 50 per cent of the expenditure is deductible in the first year, 50 per cent in the next year and 50 per cent in the year after. A lesser deduction is allowable if the company's 'aggregate R&D amount' for any of these years is less than $50,000. Capital expenditure incurred on or after 1 July 1985 on buildings, extensions or improvements wholly attributable to R&D does not attract the 150 per cent deduction, but can be written off over three years.
21. "In general the earlier an expenditure may be written off against taxable income the greater the present value of deduction (hence of the tax saving involved) and the lower the net-of-tax cost of R&D". McFetridge and Warda, *op. cit.*, p. 12.
22. Table 2 assumes R&D capital expenditure is apportioned equally between equipment and buildings. In the absence of data on the proportions of current and capital expenditure in R&D spending after 1984-85, it is assumed these proportions remained unchanged. A further assumption involved selection of an interest rate in calculating the discounted present value of R&D capital expenditure. Since the interest rate on long term government securities has fluctuated between 10 per cent and 15 per cent during the decade, B indexes were calculated using both figures as discount rates. The B index appears to be not very sensitive to changes in the discount rate. Estimates of B index values were derived by applying the general formula. For example, in 1984-85 (prior to the tax concession), $W_1 = W_2 = W_3 = 1$; a = .862, b = .069; t = .46. At a discount rate of 10 per cent, PVe = .91. Thus B = (1 − (.862 × .46) − (.069 × .46 × .91) − (0.69 × .46 × .91)/.54 = 1.01. In 1986-87, after introduction of the 150 per cent tax deduction for eligible R&D, $W_1 = W_2 = 1.5$, $W_3 = 1$; a = .862, b = .069, c = .069; t = .49. At a discount rate of 15 per cent, PVe = .88, PVb = .88. Thus B = (1 − .862 × 1.5 × .49) − (.069 × 1.5 × .49 × .88) − (.069 × .49 × .88)/.51 = .573.
23. B indexes for 20 countries in 1981 were estimated by McFetridge and Warda, *op. cit.*, Table 5.4 for discount rates of 10 per cent and 15 per cent. Their calculation of a B index for Australia was based on data for 1976-77. Some other estimates of B indexes for selected countries, assuming a 10 per cent discount rate, are as follows: Japan .97, Hong Kong 1.0, South Korea 1.01, Taiwan 1.02, Singapore .41, UK 1.0, US .95, Canada .84, Belgium .97.
24. Top of the list, with a B index of .41, was Singapore because of a 200 per cent deduction on current R&D expenditures.
25. Mansfield, 1986, *op. cit.* While the Australian government has made considerable effort to define more clearly eligible R&D, the extent to which 'creative accounting' has redefined activities in this country remains uncertain.
26. *cf.* R.E. Seiler, *Improving the Effectiveness of Research and Development*, McGraw-Hill, New York, 1965; A.M. McCosh and R.D. Maluste, 'Simulating the forces impinging upon the research budget and organisations of a major firm — a test of a possible method', *R&D Management*, 2, 1, 1981, pp. 9-18. Seiler, for example, proposes eight determinants of a company's R&D expenditure — the firm's long term financial policy, stockholder pressure for high current profits, length of life cycle of the firm's products, backlog of research ideas needing exploration, competitors' R&D efforts, availability of resources in the shorter term, capacity to produce or market the results of research effort, and stability of research staff. The links between certain of these determinants and objective financial considerations are quite tenuous.
27. Chor Hin Ong, A.W. Pearson and A. Wilkinson, *The Role of Financial Subsidy and Other Government Incentives in Industrial R&D and Innovation: A Survey of the Literature (with Case Studies)*, a report prepared for the Department of Trade and Industry, R&D Research Unit, Manchester Business School, April 1986. As Bozeman and Link have noted, "Given the various determinants of R&D there is reason to believe that response to R&D incentives will vary considerably according to industry,

firm size, current level of R&D intensity, profitability, competitiveness of markets, strategic plans and organisation composition". B. Bozeman and A.N. Link, *Investments in Technology. Corporate Strategies and Public Policy Alternatives*, Praeger, New York, 1983, p. 97.

28. Overseas studies show that the use of formal R&D project selection techniques is not as widespread as one might have expected. See J.C. Higgins and K.M. Watts, 'Some perspectives on the use of management science techniques in R&D management', *R&D Management*, 16, 6, 1986. For a perspective on the quality of decision-making by the managers of Australian industry see Larry Dwyer, 'R&D project assessment as an information and communication process', *Prometheus*, 6, 1, 1988, p. 78-93.
29. M. Ishaq Nadiri, 'Contributions and determinants of research and development expenditures in the US Manufacturing Industries' in George M. Van Furstenberd (ed.), *Capital, Efficiency and Growth*, Ballinger, Cambridge, Massachusetts, 1980, pp. 386-8. P. Mohnen, M.I. Nadiri and I. Prucha, 'R&D production structure and productivity growth in the US, Japanese and German manufacturing sectors: a non-separable dynamic factor demand model', *European Economic Review*, 30, 4, 1986, pp. 749-71.
30. Mansfield, 1986, *op. cit.*, p. 191. Commenting on the low elasticity of demand for R&D as revealed by empirical studies, Mansfield and Switzer state "In our interviews many R&D executives said it was low because R&D is named as one component (and often a small one) in a package of inputs that must be considered in relatively fixed proportions to launch an innovation". Mansfield and Switzer, *op. cit.*, p. 102.
31. Mansfield and Switzer also state that in Canada in 1980 around one-third of the IR&D was performed by firms that did not have sufficient taxable income to use any of their R&D tax credits. *ibid.*
32. Mansfield, 1986, *op. cit.*, p. 190.
33. The figures for government revenue foregone from the concession come from *Taxation Expenditure Statement*, AGPS, Canberra, December 1988, p. 23.
34. The required revitallisation of Australian industry depends crucially on its ability to produce quality products which are valued on world markets. For arguments that Australian industry should devote more resources to product innovation rather than process innovation, see Dwyer and Alchin, *op. cit.*
35. Edwin Mansfield, John Rapoport, Anthony Romeo, Edmond Villari, Samuel Wagner and Frank Husic, *The Production and Applications of New Industrial Technology*, Norton, New York, 1977.
36. J. Button, 'R&D incentives were temporary catalysts', *Sydney Morning Herald*, 8 June 1988.
37. *cf.* Barry Bozeman and Albert Link, 'Public support for private R&D: the case of the research tax credit', *Journal of Policy Analysis and Management*, 4, 3, 1985, pp. 370-82. McFetridge and Warda, *op. cit.*, p. 42-4.
38. In 1985-86, non-dwelling construction accounted for 23 per cent of the net capital stock of private enterprises, with other capital expenditure accounting for the remaining 77 per cent. According to the Australian Bureau of Statistics, "These proportions have been fairly constant over the 20 years covered by these statistics". Australian Bureau of Statistics, *Australian National Accounts. Estimates of Capital Stock 1985-1986*, cat. no. 5221.0.
39. It is assumed that the representative firm writes off machinery and equipment over five years at 20 per cent per annum and buildings and structures over forty years at 2½ per cent per annum. Using a discount rate of 10 per cent, the present value of the capital cost allowance on a one dollar expenditure on machinery and equipment is .834, while that on buildings and structures is .270.
40. McFetridge and Warda, *op. cit.*, pp. 84-7.
41. Australian Manufacturing Council, *op. cit.*, p. 11.