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FISCAL MEASURES TO PROMOTE R&D AND INNOVATION

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

This document contains information on research and development (R&D) tax provisions in the OECD Member countries. Fiscal measures to promote R&D and innovation, particularly the design of R&D tax credits, are under increasing scrutiny in OECD countries, against the background of flagging or negative growth of business R&D expenditures. Industry investments in research and development are crucial to innovation and to long-term economic growth. This document compares and contrasts national R&D tax measures, presents different ways of measuring and assessing their impact and discusses problems in their design. It includes more in-depth analysis of the R&D tax systems of selected OECD countries. This is preceded by a summary of the major points and lessons to be learned in the design of R&D tax provisions.

The analysis of R&D tax provisions is part of the work of the Working Group on Innovation and Technology Policy (TIP) of the OECD Committee for Scientific and Technological Policy (CSTP) to identify "best practices" in innovation and technology policy in the OECD countries. Most of these papers were presented at an Ad Hoc Meeting of Experts on Fiscal Measures to Promote R&D and Innovation held in 1995. These have been supplemented by more recent work on measuring R&D tax provisions carried out in co-operation with the Conference Board of Canada.

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SUMMARY

Fiscal measures to promote R&D and innovation in industry are an important component of OECD science and technology policies. This is particularly true in light of flagging or negative growth of business R&D expenditures (**Figure 1**) and the current debate on the rationale for government involvement in the emerging knowledge-based economy. The stakes are high: business R&D is a key input to innovation, which is an increasingly important factor of firm competitiveness and, at the macroeconomic level, the main driver of long-term productivity growth and higher standards of living.

The argument for government intervention to stimulate business R&D rests on the concept of '**market failure**', which occurs when the parties conducting research cannot capture its full benefit, thus limiting their R&D investments and, as a result, the benefit to third parties. R&D tax schemes have been shown to have certain advantages in many national contexts over direct government subsidies: less interference in the market, reduced administrative and financial cost and greater predictability and stability compared to periodic budget appropriations.

The **tax treatment of R&D** in OECD countries is broadly similar, with some variations in the use of R&D tax credits (**Table 1**). The following are the main features of R&D tax instruments:

> **R&D Depreciation Rate --** The rate at which non-capital research and development expenditures can be depreciated for tax purposes. In most OECD countries, all R&D expenditures (100 per cent) can be deducted from taxable income in the year in which they are incurred.
>
> **R&D Capital Depreciation Rate --** The rate at which research and development expenditures in capital assets (equipment and buildings) can be depreciated for tax purposes. This varies among countries with some treating R&D capital investment like ordinary investment. Countries differ in their provisions for depreciation of investment in research-related buildings or plant, their use of straight-line or declining-balance accounting methods, and whether they allow depreciation at an accelerated rate.
>
> **Carryforward --** The number of years over which R&D expenditures can be amortised and tax deductions carried forward. In most countries, R&D expenditures can be carried forward or deducted for some 3 to 10 years. This ensures that firms with no tax liabilities due to temporary losses or cyclical downturns are not excluded from the benefits of the tax incentive scheme.
>
> **R&D Tax Credit --** A special credit against taxes owed based on a percentage of R&D expenditures. The base is the amount at which the rate applies, and when it is zero, the credit applies to all qualifying R&D expenditures. The United States, France, Spain, and Japan have an incremental R&D tax credit, which is calculated on increases in R&D above a base level. The Netherlands R&D tax scheme is based on the proportion of R&D wage costs to employer's wage or income taxes. Countries also vary in whether or not the R&D tax credit is taxable.

Small Firms -- Some countries have provisions that favour R&D in small and medium-sized enterprises. In France, a ceiling on the allowable tax credit tilts rebates towards smaller firms. In Japan, small firms do not have to show increases in R&D expenditures to qualify for the incremental tax credit. The level of the Canadian R&D tax credit is dependent on the firm's taxable income.

The **measurement** of the effects of R&D tax provisions on industry research spending is complicated by a number of factors. However, one approach (the *B-index methodology*) theoretically compares the generosity of R&D tax systems across countries. This shows that, for a large manufacturing company, Spain, Canada and Australia have fiscal incentives which should generate the highest levels of business research spending. In contrast, Germany, Italy and New Zealand were found to offer the least incentives to business R&D. Although this analysis contains several simplifying assumptions and does not reflect actual levels of business R&D spending, it does have implications for stimulating national R&D outlays, attracting foreign R&D investments and for maintaining longer-term innovative efforts.

Existing **assessments** suggest that general tax deductions for R&D are a relatively efficient tool for increasing the average propensity of firms to spend funds on research. The additional incentive provided by special R&D tax credits over more general deductions is less certain; most assessments to date show only modest increases in research spending and some relabelling of other costs to benefit from the credit. However, there may be a significant time lag before R&D tax credits show a detectable impact. More analysis is needed to assess how tax incentives interact with the other components of government policies in stimulating innovation.

With regard to **best practices** in designing and implementing R&D tax provisions, the following have been identified:

◊ R&D tax policy should be designed as part of an **overall strategy** to stimulate innovation in industry and should complement other science and technology policies. The R&D tax policy may be designed to further specific national goals, such as fostering basic research or the purchase of high-technology equipment.

◊ R&D tax policy should generally include provisions for the **deduction of all qualified R&D expenses** in the year in which they are incurred, which has been shown to increase the additional research undertaken by firms.

◊ R&D tax policy should be **flexible** in order to accommodate firms at different stages of development. For example, the ability to carry deductions forward allows firms without tax liabilities in a given year to take advantage of R&D tax incentives.

◊ The value of **R&D tax credits** must be assessed on a country basis. The design of these schemes differs broadly by country depending on whether they are volume-based or incremental, based on R&D expenditures or wage costs and vary their treatment of firm size, region or technology. Their benefits depend on overall tax systems including the corporate tax rate and the time-lag associated with firm responses.

◊ R&D tax policy should consider including special provisions relating to **small and/or new firms** in order to encourage entrepreneurship and innovative start-ups.

Figure 1 **Business enterprise R&D as a percentage of GDP**

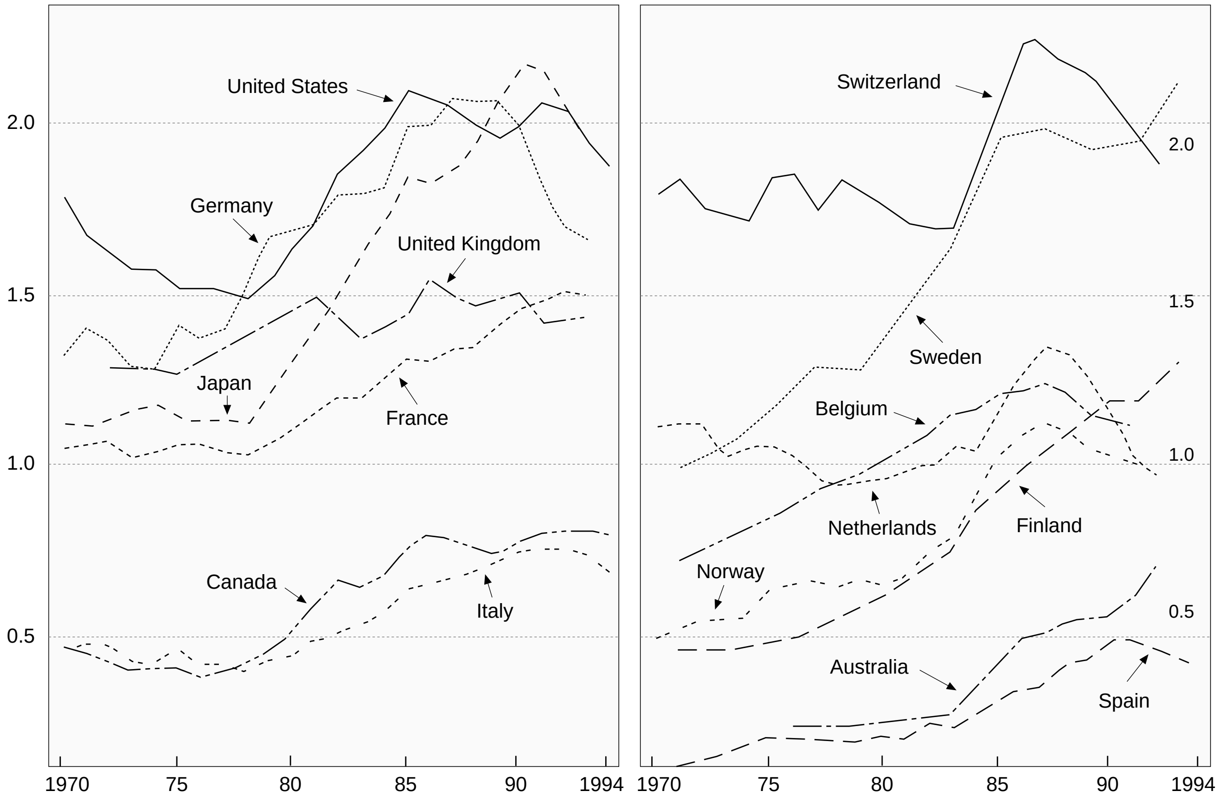

Table 1. TAX TREATMENT OF R&D*

Country	R&D Depreciation Rate	R&D Capital Depreciation Rate	Carryforward Provisions	Tax Credit Rate	Base for Tax Credit	Credit Taxable
Australia	150% (proposed 125%)	3 yr straight-line	none	none	NA	NA
Austria	105%	accelerated	5 yrs	none	NA	NA
Belgium	100%	3 yr straight-line 20 yr - buildings	5 yrs	none	NA	NA
Canada	100%	100% (not buildings)	7 yrs	20%	0	yes
Denmark	125%	100%	5 yrs	none	NA	NA
France	100%	3 yr straight-line (not buildings)	3 yrs	50%	incremental	no
Germany	100%	30% straight-line 4% buildings	1/5 yrs	none	NA	NA
Italy	100%	accelerated	none	none	NA	NA
Japan	100%	straight-line or fixed rate method	none	20%	incremental	no
Netherlands	100%	like investment	8 yrs	12.5/25%	R&D wage costs	no
Norway	100%	like investment	10 yrs	none	NA	NA
Spain	100%	100% or depreciate	5 yrs	15%	incremental	no
Sweden	100%	30% straight-line 4% buildings	tax liability	none	NA	NA
Switzerland	100%	like investment	2 yrs	subcontracted R&D	0	yes
United Kingdom	100%	100%	5 yrs	none	NA	NA
United States	100%	3 yr 15 yr for buildings	3/15 yrs	20%	incremental	yes

* Please note that R&D tax provisions are continually changing and these tax provisions may have been recently modified.

COMPARATIVE ANALYSIS OF R&D TAX PROVISIONS

MEASURING THE VALUE OF R&D TAX PROVISIONS

Jacek WARDA, Principal Research Associate, Conference Board of Canada

Introduction

In many OECD countries, R&D tax incentives to stimulate private sector research spending are a significant element of technology and innovation policy. A "*B-index Methodology*" is used here to compare the relative importance of R&D tax support across countries. The value of the B-index depends on the tax treatment of R&D in a country and is based on the before-tax income required to break-even on a $1 R&D outlay. The more favourable its tax treatment of R&D, the lower is a country's B-index and, other things being equal, the greater the amount of research that will be conducted by its corporate residents. While the B-index is a useful analytical and comparative tool, it is based on a number of methodological assumptions; it also does not consider the full range of taxes in a country or the effects of other types of technology policies on research spending. An important issue for consideration is the appropriate role for R&D tax incentives relative to other types of policy instruments.

The initial comparison of R&D tax provisions according to the B-index methodology (updated in August 1996) indicates that, for a large manufacturing company, Spain, Canada and Australia have the lowest B-index, which should theoretically generate the highest levels of business research spending. At the opposite end of the spectrum, Germany, Italy and New Zealand were found to have the highest B-index, which would offer the least incentives to business research spending. The comparisons for a small manufacturing company show that Italy, Canada and the Netherlands have the lowest B-index and thus the most generous R&D tax provisions for smaller firms.

A number of trends can be identified in the use of R&D tax provisions in the OECD countries:

◊ All but one country allows current business expenditures on R&D to be fully deducted the year they are incurred.

◊ About half of the countries provide some type of additional R&D tax credit or incentive. There is a trend to the use of incremental tax credits and more targeted approaches such as those favouring basic research.

◊ Six countries have special provisions in their R&D tax credits favouring research by smaller firms.

◊ There are a growing number of R&D tax incentives being offered at the sub-national (provincial and state) levels.

◊ Most countries make incremental rather than radical changes to their R&D tax provisions with the intention of improving their effectiveness over time.

Methodology

In many OECD countries, R&D tax incentives to stimulate private sector research spending are a significant element of technology and innovation policy. Yet it has been difficult to evaluate or assess the effectiveness of different types of R&D tax provisions in order to identify best practices and optimise their design. The purpose of this work is to quantify R&D tax incentives across 25 countries (24 OECD Member countries and Korea) in a way suitable for policy analysis and assessment.

A "*B-index Methodology*" is used to compare the relative importance of R&D tax support across countries. The value of the B-index depends on the tax treatment of R&D in a country and is based on the before-tax income required to break-even on a $1 R&D outlay. The more favourable its tax treatment of R&D, the lower is a country's B-index and, other things being equal, the greater the amount of research that will be conducted by its corporate residents. At the firm level, the B-index yields the present value of before-tax income necessary to cover the cost of an initial R&D investment and to pay the applicable income taxes so that an R&D project becomes profitable for the firm that undertakes it. The B-index is, therefore, the critical (minimum) benefit-cost ratio. Here, projects with benefit-cost ratios higher than B are profitable for the firm as a whole and are undertaken; projects with benefit-cost ratios less than B are not profitable and are not undertaken.

In order that this comparison only measures differences in the tax treatment of R&D, it makes several simplifying assumptions (for example, interest rates are assumed to be equal across countries) and ignores certain other factors that can effect the decision to invest in R&D in a country. In addition, a variety of important concerns, such as differences in the definition of R&D for national tax purposes are ignored by the B-index formula. Finally, many other factors that affect the relative cost of R&D in any single country, like the availability of competent researchers, are beyond the scope of this work. Thus while the comparison can inform policy discussion, it cannot replace the detailed examination of alternatives for any particular private sector decision. While the B-index serves as a benchmarking tool for international comparisons, as a policy indicator, it works best within a set of other relevant indicators.

Corporate income tax rates (CITRs) play an important role in determining the after-tax cost of R&D and are important to the calculation of the B-index. The higher the CITR the lower is the after-tax cost of R&D. The existence of tax incentives will amplify the attractiveness of the country's R&D tax system by lowering its after-tax cost further. It is thus not necessary to have a tax incentive package in order to obtain low after-tax cost of doing research. In some cases, having a high CITR may do it as well. Put another way, the after-tax cost measure carries an unfortunate implication that high CITRs are beneficial to companies while low rates are not. As a before-tax income to cost ratio, the B-index tends to smooth out the impact of CITR and its unfortunate implication that high corporate income tax rates are beneficial to firms because they lower the after-tax cost of doing R&D. Generally, one might expect that countries having low CITRs would have few R&D tax incentives in place. However, exceptions abound: Germany and Italy are the best examples of high tax rate countries that do not have tax incentives. In contrast, Canada-Quebec is a region that has very attractive tax incentives and a relatively low CITR.

Technically speaking, the B-index formula is simple; it represents a ratio of the after-tax cost (ATC) of a $1 expenditure on R&D divided by 1 less the corporate income tax rate. The generic formula for the B-index is as follows:

$$B = ATC/(1-t)$$

where t = corporate income tax rate (CITR)

The after-tax cost is the net cost to the company of investing in R&D, taking account of all available tax incentives for R&D. Using this method, the formulas for each tax jurisdiction can be developed. For example, the B-index formula for Canada (Nova Scotia) is as follows:

$B = (.95(1-c_p)(1-c_f)(1-t)+.05(1-zt))/(1-t)$

where:

t = combined federal and provincial income tax rate

c_p = provincial R&D tax credit rate

c_f = federal R&D tax credit rate

.95 = proportion of expenditures that are written off as current expenses

.05 = proportion of expenditures that are depreciated

z = present value of depreciation allowance

where $z = d(2+i)/2(i+d)$

and d = depreciation rate and i = nominal discount rate

At times the model can be complicated by the fact that the labour, current, capital and building components of R&D expenditures are taxed differently. To ensure comparability in this case, all R&D is assumed to follow these proportions:

Component	% Share
Labour	60
Other current costs	30
Machinery	5
Buildings	5

This study examines the following features of the tax systems of OECD Member countries as they relate to scientific R&D:

◊ the time period over which both current and capital expenditures on scientific research may be written off against taxable income;

◊ the existence of any deductions, including accelerated and bonus deductions, from taxable income that are based on the level or the change in the level of R&D spending;

◊ the availability of any tax credits (reductions in taxes payable) that are based on the level or the change in the level of R&D spending; and

◊ the rate at which corporate income is taxed, including the impact of major provincial or state tax systems.

A number of features of national tax systems that relate to R&D decisions as well as to other investment decisions are outside the scope of the research. A key element not accounted for is the "cost of finance" which is assumed to be the same for all countries. The only element pertaining to the cost of finance which is introduced in the model is a nominal discount rate of 10 per cent, which is used to calculate the present values of project-related income and its cost. In addition, the study does not take into account international differences in:

◊ the extent to which interest rates and other financial charges may be deducted against taxable income at the corporate level;

◊ the tax treatment of dividends and capital gains; and

◊ personal income tax rates.

The study assumes that firms have sufficient taxable income to claim the full amount of R&D tax incentives in the current year. Therefore, certain dynamic aspects of R&D tax incentives, particularly the use of carryforward/carryback provisions, do not alter B-index values because to incorporate them would require restrictive assumptions regarding the distribution of income over time. Similarly, the analysis is focused on the tax treatment of R&D expenditures of large corporations because they commonly perform the bulk of R&D. In the case of graduated income tax rates or graduated tax incentives, the analysis assumes a tax rate or tax incentive available on top eligible income. Because of the assumption that firms are able to claim the full value of tax incentives, this rules out certain limits on income and caps on claimability of tax incentives, often based on size, that may exist in the countries examined. In this respect, the index makes no difference between non-refundability and refundability provisions of tax incentives.

Other important taxation factors involved in corporate decisions to invest in R&D, such as commodity taxes, property taxes, payroll taxes and taxes on capital, grants and subsidies for R&D are also excluded. This is particularly relevant to tax jurisdictions that rely on capital, property and commodity taxes as main sources of their revenues rather than on corporate income tax. In summary, while the B-index is a useful analytical and comparative tool, a thorough assessment of the full impact of R&D tax provisions must consider the full range of taxes in a country.

Tables 2-3 give the current (1995-96) B-indices for 25 countries. These are for a large manufacturing company (**Table 2**) and a small manufacturing company (**Table 3**). The initial comparison of R&D tax provisions according to the B-index methodology indicates that, for a large manufacturing company, Spain, Canada and Australia have the lowest B-index, which should therefore generate the highest levels of research spending. At the opposite end of the spectrum, Germany, Italy and New Zealand were found to have the highest B-index, which would offer the least incentives to business research spending. The comparisons for a small manufacturing company show that Italy, Canada and the Netherlands have the lowest B-index and thus the most generous R&D tax provisions for smaller firms.

Country comparisons of use of R&D tax incentives

This section compares the R&D tax incentives of countries and presents a time-based analysis of major changes in these tax incentive packages (**Table 4**). It compares the B-index for R&D tax incentives for the years 1981, 1989 and 1996. The original study detailing the complete methodology of the B-index was published in 1983 based on tax data available largely as of 1981. The first update of that study was published in 1990, using in most cases the 1989 information. The second update followed in 1994, but because of the small time difference with respect to the current study, the 1994 report is not included in the comparison. Not all the OECD countries were examined in the previous studies, hence the comparisons are limited. What they show, however, is the ability of B-index to depict the evolution of R&D tax policy over time.

Table 2. Comparison of B-indexes and after-tax costs in the OECD Member countries, 1995-96
A large manufacturing company

Country	ATC	B-index	Tax credits	Expense deduction	CIT
Spain	.428	.658	yes	CUR, ME	35.0
Canada	.493	.714	yes	CUR, ME	31.0
Australia	.569	.889	yes	CUR, ME	36.0
Korea	.494	.893	yes	CUR	36.5
United States	.527	.893	yes	CUR	41.0
Netherlands	.589	.906	yes	CUR	35.0
France	.616	.923	yes	CUR	33.3
Austria	.615	.932	yes	CUR	34.0
Denmark	.660	1.000	no	CUR, ME, B	34.0
Ireland	.900	1.000	no	CUR, ME, B	10.0
Turkey	.800	1.000	yes?	CUR, ME, B	20.0
United Kingdom	.670	1.000	no	CUR, ME, B	33.0
Switzerland	.905	1.003	no	CUR	9.8
Finland	.726	1.008	no	CUR	28.0
Greece	.656	1.009	no	CUR, ME	35.0
Belgium	.605	1.011	yes	CUR	40.2
Japan	.501	1.014	yes	CUR	50.6
Mexico	.670	1.015	no	CUR	34.0
Sweden	.731	1.015	no	CUR	28.0
Norway	.733	1.017	no	CUR	28.0
Portugal	.651	1.017	no	CUR	36.0
Iceland	.689	1.028	no	CUR	33.0
Germany	.456	1.051	no	CUR	56.6
Italy	.492	1.051	no	CUR	53.2
New Zealand	.758	1.131	no	NO	33.0

CUR = immediate current expense deduction
ME = immediate machinery and equipment cost deduction
B = immediate buildings cost deduction
NO = no immediate current expense or capital cost deduction
CIT = statutory corporate income tax rate

Note: This comparison assumes for Canada a Quebec-based corporate income tax system; for the US, the California tax system (an 8 per cent tax credit). These are the highest ranking among the regions examined in the study.

The proportion of R&D expenditure is assumed to be 90 per cent (.90) for current expenses (including 60 per cent (.60) for wages and salaries), 5 per cent (.05) for machinery and equipment, and 5 per cent (.05) for buildings and structures.

Source: The Conference Board of Canada.

Table 3. Comparison of B-indexes and after-tax costs in the OECD Member countries, 1995-96
A small manufacturing company

Country	ATC	B-index	Tax credits	Expense deduction	CIT
Italy	**.192**	**.410**	**yes**	**CUR**	**53.2**
Canada	**.407**	**.502**	**yes**	**CUR, ME**	**18.9**
Netherlands	**.368**	**.613**	**yes**	**CUR**	**40.0**
Spain	.428	.658	yes	CUR, ME	35.0
Korea	**.573**	**.814**	**yes**	**CUR**	**36.5**
Australia	.569	.889	yes	CUR, ME	36.0
United States	.527	.893	yes	CUR	41.0
France	.616	.923	yes	CUR	33.3
Austria	.615	.932	yes	CUR	34.0
Japan	**.579**	**.935**	**yes**	**CUR**	**38.1**
Denmark	.660	1.000	no	CUR, ME, B	34.0
Ireland	.900	1.000	no	CUR, ME, B	10.0
United Kingdom	.670	1.000	no	CUR, ME, B	33.0
Switzerland	.905	1.003	no	CUR	9.8
Belgium	**.603**	**1.008**	**yes**	**CUR**	**40.2**
Finland	.726	1.008	no	CUR	28.0
Greece	.656	1.009	no	CUR, ME	35.0
Turkey	.800	1.000	yes?	CUR, ME, B	20.0
Mexico	.670	1.015	no	CUR	34.0
Sweden	.731	1.015	no	CUR	28.0
Norway	.733	1.017	no	CUR	28.0
Portugal	.651	1.017	no	CUR	36.0
Iceland	.689	1.028	no	CUR	33.0
Germany	.456	1.051	no	CUR	56.6
New Zealand	.758	1.131	no	NO	33.0

Countries in bold have special R&D tax treatment for small companies.
CUR = immediate current expense deduction
ME = immediate machinery and equipment cost deduction
B = immediate buildings cost deduction
NO = no immediate current expense or capital cost deduction
CIT = statutory corporate income tax rate

Note: This comparison assumes for Canada a Quebec-based corporate income tax system; for the US, the California tax system (an 8 per cent tax credit). These are the highest ranking among the regions examined in the study.

The proportion of R&D expenditure is assumed to be 90 per cent (.90) for current expenses (including 60 per cent (.60) for wages and salaries), 5 per cent (.05) for machinery and equipment, and 5 per cent (.05) for buildings and structures.

Source: The Conference Board of Canada.

Leading users

The leaders in the current B-index ranking, Spain, Canada and Australia, have extensively applied tax incentives in their innovation policies for many years. These three countries have maintained their top position over time in terms of the generosity of the R&D tax provisions. In the case of Federal **Canada**, this has been the situation since the 1962-1966 period when a special incremental allowance equal to 50 per cent of the difference between the current and capital R&D cost of any year over that of the previous year was made available. Canada's federal tax system evolved over the 30-year period through a maze of tax incentives from incremental allowances, to level-based tax credits and incremental tax credits, usually reflecting regional disparities, to the package available today. Canada's federal R&D tax treatment now includes an immediate write-off of both current costs and R&D machinery and equipment costs and a 20 per cent, level-based and taxable, tax credit. The rate of R&D tax credit increases to 35 per cent for small companies. Regional preferences have been abolished since the end of 1994.

Similar to Canada, **Spain**'s R&D tax treatment has been in effect for many years. It evolved from the relatively limited 10 per cent non-taxable tax credit in 1981 to a very generous R&D tax incentive package in 1996, comprising an immediate write-off of current and machinery and equipment expenses, accelerated depreciation for R&D buildings and a two-part tax credit: one part based on the level and another on the increment of R&D expenditures. It is then not surprising that under such circumstances, Spain's before-tax cost of doing R&D has tumbled from 0.85 in 1981 to 0.66 in 1996.

Australia has evolved from a country that offered practically no tax incentives 15 years ago to a country that now provides a tax incentive package for R&D, a package based on concessional allowances. The country offers a special 150 per cent allowance for current R&D expenditures and R&D expenditures made on machinery and equipment. The new Australian government has proposed the R&D tax concession be reduced to 125 per cent, and this proposal is taken into account in the calculations.

Medium users

This group consists of Korea, the Netherlands, France and Austria. **Korea**'s position has deteriorated slightly compared with the 1989 study. Korea does not provide now an option to claim double depreciation on capital assets as in 1989. However, it does continue to rank high with two investment tax credits, one on the level and another on the increment in R&D expenditures. In 1981, Korea's B-index was greater than 1 as the country did not provide any specific R&D tax incentive.

The **Netherlands** is a country that 15 years ago did not have any specific R&D tax incentive, except for the basic investment tax credit available for all capital investment. Today, the Netherlands employs a relatively generous refundable tax credit on wages and salaries of R&D personnel, which yields the country a relatively high position in the ranking. The Netherlands has also introduced a special tax rebate for young post-graduates doing research requested by firms.

Table 4. Comparison of B-Indexes of OECD countries across time
The case of large manufacturing companies

Country	1981	1989	1996
Spain	.85	na	.658
Canada	.84	.657	.714
Australia	1.01	.703	.889
Korea	1.01	.805	.893
United States	.95	.972	.893
Netherlands	na	na	.906
France	1.02	.941	.923
Austria	.95	na	.932
Denmark	1.00	na	1.00
Ireland	na	na	1.00
Turkey	na	na	1.00
United Kingdom	1.00	1.00	1.00
Switzerland	na	na	1.003
Finland	na	na	1.008
Greece	na	na	1.009
Belgium	.97	na	1.011
Japan	.98	1.003	1.014
Mexico	.96	na	1.015
Sweden	.95	1.04	1.015
Norway	1.04	na	1.017
Portugal	na	na	1.017
Iceland	na	na	1.028
Germany	1.05	1.027	1.051
Italy	1.03	1.033	1.051
New Zealand	na	na	1.131

Note: Except for 1981, this comparison assumes for Canada a Quebec-based corporate income tax system; for the US, the California tax system. These are the highest ranking among the regions examined in the study. B-indexes calculated for 1981 are based on federal tax systems only.

The proportion of R&D expenditure is assumed to be 90 per cent (.90) for current expenses (including 60 per cent (.60) for wages and salaries), 5 per cent (.05) for machinery and equipment, and 5 per cent (.05) for buildings and structures.

Source: The Conference Board of Canada.

France, due to the existence of relatively generous tax credits, has continued its high position in the ranking. Compared with 15 years ago when it did not offer any specific tax incentive for R&D, in 1996 France is offering an improved tax environment for R&D through an incremental tax credit. Still, in the recent years, the generosity of the French tax package has been slightly diminished by the extension of the average base period in the calculation of the marginal tax credit from one preceding year to two years.

Austria has also improved its B-index compared with 1981 due to an increase in its R&D allowance. The allowance is now 18 per cent of R&D current costs whereas it was only 5 per cent in 1981.

Small users

This group of countries consists of the United States, Japan, Belgium and Denmark. Until 1981, the **United States** offered no special allowances or credits for R&D. The Economic Recovery Act of 1981 introduced a tax credit equal to 25 per cent of incremental R&D expenditures. Incremental expenditures were defined as the excess of qualified R&D expenditures for the year over the average of the three preceding years. The credit is not permanent and has to be renewed periodically by legislation. The following years brought two major modifications to the credit. First was the rate reduction of the credit to 20 per cent. Second was the complete rewriting of the base for calculating the tax credit. The intention was to improve the credit's incentive effect by breaking the link between increases in a firm's current research spending and its future base amounts that had reduced the incentive to undertake additional research. Although the credit expired on June 30, 1995, it was reinstated for an 11 month period beginning on July 1, 1996, and revised to permit taxpayers to elect an alternative credit regime. The B-index for the United States is based on the California tax system, which itself includes an R&D tax credit at the state level.

Japan provides tax credits for R&D at the national level, the value of which is relatively less generous compared with other countries that have tax credits in place. However, Japan is the first country (Denmark is the second country) that has started to promote basic or enabling technology through the specifically designed tax incentive. Because the new credit is levied on only a fraction of R&D costs, its value is small. But, nevertheless, it is a significant step forward for Japan, confirming its aim to provide more focus on basic research and technology.

Denmark, although in this group of countries, is somewhat of an exception as it does not offer incentives for general R&D activity. Denmark grants companies an additional allowance equal to 25 per cent of all R&D costs incurred only on priority basic and applied research. Finally, **Belgium** has an R&D investment allowance. This incentive is of limited scope for it is applicable only on capital assets invested in R&D and new product development.

Non-users

The last group of countries which generally do not use R&D tax incentives, though some countries may have used them before, consists of Sweden, the United Kingdom, Germany, Italy, Norway and Mexico. By and large, changes made in **Sweden** are the most far reaching. Until 1982, companies in Sweden enjoyed a relatively generous R&D tax treatment based on special allowances designed to foster R&D. Those allowances were calculated on the level of R&D wages and salaries, as well as on an increase in R&D wages on a year-to-year basis. The allowances were repealed in favour of the then existing system of tax deductible investment reserves which could be used to finance future R&D expenditures. Currently there is no explicit R&D tax incentive in Sweden which is reflected by Sweden's B-index.

Germany and the **United Kingdom** also do not offer special R&D tax treatment. Until the end of December 1989, Germany granted a tax credit on fixed R&D assets. Since the expiry of the Investment Premium Law, Germany has not had a general tax credit aimed at R&D. The United Kingdom has never offered the R&D tax credit. However, it has always had in place a generous allowance that permits a full write-off of all R&D expenditures incurred in the year. Italy does not grant an R&D tax credit to large firms. However, small firms currently can be eligible for a limited tax credit. The Italian incentive was not available in 1981.

Mexico shows a deterioration in its B-index, largely because of the withdrawal of certain tax incentives for promotion and sale of domestic R&D that were in existence in 1981. Currently, it does not offer any R&D tax incentives. On the other hand, **Norway** does not have R&D tax incentives, but its B-index has improved, nevertheless, on the merit of a significantly reduced corporate income tax rate, from 51 per cent in 1981 to 28 per cent currently.

Overall, in the last two groups, the B-indexes tend to be very close to or greater than 1, indicating the less generous R&D tax treatment, compared to the first and second group of countries that offer specific tax incentives for R&D. Because of the absence of favourable tax incentives and because capital R&D expenditures cannot be deducted immediately in the acquisition year (with the exception of the United Kingdom and Denmark), companies that invest $ 1 on R&D require that the present value of before-tax income earned on this investment be significantly greater than in the countries that offer more generous R&D tax treatment.

Policy trends in R&D tax support

R&D tax deductions

All but one of the 25 countries examined allow current business expenditures on R&D to be fully deducted in the year incurred. The exception is New Zealand whose tax law maintains that any kind of R&D expenditure is an investment expense and needs to be capitalised accordingly. Only a few countries allow an immediate write-off of R&D capital costs. Machinery and equipment can be deducted fully in the year incurred in seven countries, including Australia, Canada, Denmark, Finland, Ireland, Spain and the United Kingdom. A handful of those states, Denmark, Ireland and the United Kingdom, will allow buildings costs to be written off immediately.

Countries that permit a full write off of all the cost within a tax year and do not offer any specific tax incentives for R&D will have their B-indexes equal to one. Based on the available information, the study identified three such countries: Ireland, the United Kingdom and Denmark, the latter applicable only to general companies not involved in priority basic and applied research activity.

Tax depreciation schemes of capital assets may favour R&D investment over other capital investment. The earlier-mentioned full write-offs of capital costs of R&D assets in seven OECD countries are the best examples of a favourable R&D tax treatment. Nevertheless, there are other countries that have designed tax depreciation rates available only to R&D capital assets. Belgium and Portugal, for example, offer a three-year write-off for machinery and equipment used in scientific research. Buildings for research purposes may be depreciated in Finland at 20 per cent per year and in Spain over 10 years.

R&D tax credits

Twelve countries also provide some type of R&D tax credit or other tax incentive. Generally, tax credits can be applied to the increment of R&D expenditure or to the level of R&D spending or represent a mix of both approaches. Countries that use tax credit based on increment include the United States, Japan (for large business), France, Canada (Ontario), Korea and Spain. Countries that offer tax credits based on the level of R&D expenditures are Canada, Spain, Korea, Italy (for small business), Japan (for small business and basic technologies) and the Netherlands. A number of countries give more than one tax credit resulting in a mix of approaches. There are also countries that use a mechanism similar to tax credit but under the name of investment deduction (Belgium) or R&D allowance or concession (Austria, Australia).

These allowances increase directly an R&D cost to be deducted for the purposes of determining taxable income. The eligible R&D cost can be current, capital or both.

There is variation in bases for the tax credit. The base varies from country to country, but it also depends on the purpose of a tax credit. If the credit is to reward investment in basic research, for example in Japan and Denmark, only expenditure on this activity will be targeted. However, in most cases these bases correspond to what is conventionally understood as a current expense of doing R&D. Typically, a current expenditure base would be enhanced by adding an investment cost of R&D capital assets or a depreciation of capital assets. Countries that apply the enhanced base for tax credit include Canada, Spain, Japan, Korea, France and Italy. Tax credit can also be based on some part of a current cost component, typically a human resource component of doing R&D, i.e. wages, salaries and benefits. Countries that calculate tax credits solely on the basis of human resource costs include the Netherlands and the province of Quebec in Canada.

In contrast to R&D allowances which are deducted from taxable income, tax credits are always deducted from income tax. Tax credits can be taxable or non-taxable. Those offered by OECD countries are generally non-taxable. However, in a few countries, their benefit to the taxpayer, an income tax saving, can be treated by law as taxable income in itself. Only Canada, Switzerland, and the United States have taxable tax credits in place.

Increasingly, countries design R&D tax credits that are not general in scope, but instead are targeted to stimulate a particular, well-defined segment of an R&D activity. Examples of this trend are Japan and Denmark both promoting investment in basic research. Although these examples are still quite rare, as funds allocated to technology get smaller governments may have to target the areas of research they want to support through the tax system.

Small firm provisions

Selective tax support for R&D performed by small firms is not very common among OECD countries. Only six countries -- Italy, Canada, the Netherlands, Korea, Japan and Belgium -- have programmes that provide selective tax credits for small company R&D. These credits are usually offered in addition to the general R&D tax treatment of companies in those countries. They take the form of an increased rate of a generally available tax credit as in Canada, the Netherlands, Korea and Belgium, or a completely new credit, specifically designed for small innovative firms, as in Italy and Japan. They are usually complemented by reduced rates (except in the Netherlands) of the corporate income tax. Some countries may indirectly favour small companies through the tax system by putting higher ceilings on their claiming of tax benefits. Japan is a good example, as it allows small firms to deduct a larger percentage of their taxes compared with the large firms (15 per cent versus 10 per cent, respectively).

Two-tier tax incentives

In many countries, there is pressure to promote R&D and technology development at a sub-national level. This is marked by a growing number of provinces and states introducing their own R&D tax incentives. This study has noted that, since 1990, the number of Canadian provinces applying tax credit or special allowances has grown from three to six. Both the province of Quebec and the province of Ontario offer generous R&D tax incentives on the top of federal ones. In the United States as well, more states promote R&D through the tax system. The use of the California location for comparisons benefits the US ranking, as the firms located in this state enjoy a number of local tax credits for innovative activity. In some countries, the sharing of R&D tax incentives among the various tiers of government may increase in the future.

Incremental change

The ranking of the leading countries in terms of the generosity of their R&D tax provisions (Spain, Canada, Australia, Korea, United States and the Netherlands) has not changed much since 1981 and certainly not since 1989. Tax policy changes in the respective countries have been largely incremental. As the findings indicate, since 1981, Spain and Canada have had the leading tax treatment of R&D expenditures among the countries examined. These two countries were joined in the late 1980s by Australia. The strength of these countries' R&D tax treatment comes from their consistently attractive and stable base. However, while Spain with each change tended to increase the attractiveness of its R&D tax treatment, Canada and Australia were largely content with the maintenance and improved performance of the system that is currently available.

Countries in the medium user group have also made incremental changes to their R&D tax treatment. In Korea and France, changes zeroed in on the maintenance of the relative attractiveness of the system with a somewhat decreased tax benefit. In Austria, the small change resulted in a relatively more attractive R&D tax treatment. In countries in other groups, the changes to R&D tax treatment across time were also small. The only exception was Sweden where changes made in 1982 were rather drastic.

R&D tax incentives and technology policy

R&D tax incentives remain an important way of stimulating R&D activity among OECD Member countries. About half of the countries employ some sort of an R&D tax incentive in addition to general deductions. However, half of the OECD countries do not have these R&D tax incentives, yet many of them appear to be highly innovative economies. In addition, even among those countries that employ relatively generous tax incentives, the trend over time is to gradually diminish their generosity or focus on improving administrative effectiveness while maintaining the existing system. With fading government resources, countries tend to apply alternative incentives such as a lowering of tax rates, or move away from universal application of R&D tax incentives toward a more focused or targeted areas of promotion such as basic research, small business or other specific activities.

A major issue is the appropriate role for R&D tax incentives relative to other types of policy instruments. Some insight can be given to this question by looking at the B-Index in conjunction with estimates of private and social rates of return to R&D. One study has estimated the rates of return to R&D in the Canadian communications equipment industry and the Canadian manufacturing sector (Bernstein, 1996). The social rates of return were 22.5 per cent and 24 per cent greater than the private rates of return, respectively. These differences suggest that there is an underinvestment in research in both industries. Given the inappropriability of the returns on R&D, resource allocation decisions that are privately efficient may not be not socially efficient. Government can correct this situation by providing tax incentives to conduct R&D.

The relevant question is then whether R&D is, in fact, treated more favourably for tax purposes than other forms of investment and, if so, if the difference in tax treatment is sufficient to offset the relative inappropriability of the returns to R&D. To continue with the Canadian example, say, Quebec's B-index is 0.714. This means that Canada's R&D incentives are sufficiently generous provided the externality generated by R&D activity, or the difference between the social rate of return and the private rate of return, is not more than 40 per cent (1/0.714 - 1). Using the rates of return from the previous study, one could say that to offset the inappropriability of returns and induce the private sector to do more research, Quebec's R&D tax incentive package is not generous enough for high technology intensive industries, such as communications equipment, while for the overall manufacturing sector the incentives may be more than sufficient.

In this example, in industries that exhibit externality greater than 40 per cent, further policy instruments such as subsidies or contracts might be needed to correct the inappropriability problem. In industries that generate externalities of less than 40 per cent, R&D tax treatment is more than sufficient and perhaps its generosity warrants the re-examination of the entire incentive package. This raises a number of issues, one of which is whether government policy instruments should target individual industries. Another deals with the socially desirable mix of policy instruments that reduce the inappropriability of returns on R&D.

A system of R&D tax incentives cannot be analysed independently of its overall tax environment. No matter how generous tax incentives are, they do not work in a vacuum. There are many more factors in the tax system, such as corporate and personal income tax and commodity taxes, that could be more influential than tax incentives. As well, there are other important factors operating external to the tax system that need attention. The most common arrangements include subsidy and procurement systems that together with the tax system create the overall R&D tax-subsidy system of the country. In general, R&D subsidies and R&D tax incentives tend to complement each other, as the former is a direct and target-oriented measure of government support, while the latter is an indirect measure that works through the market mechanism.

The evidence indicates that countries that have generous subsidy-procurement programmes tend to have less generous R&D tax incentive programs. Examples of such countries include the United States, Germany and Italy. Countries that provide attractive R&D tax treatment -- Australia, Canada and the Netherlands -- all tend to complement it with a less generous R&D subsidy-procurement system. Because this study is focused only on R&D tax treatment, it is somewhat one-sided with regard to the overall technology policies of countries.

The B-index methodology used here may have other analytical uses. It can aid in the performance measurement of R&D tax policy: *does the benefit of R&D tax incentives exceed the cost to government? How are R&D tax incentives effective in attracting new investment in R&D by companies? How are firms using R&D tax credits?* The B-index can also be used in studies of locational determinants of R&D investment, both quantitatively as a variable explaining growth of business expenditures on R&D, and qualitatively as an indicator of a pro-innovative policy of the government. It could be used to answer the question whether a low B-index (generous R&D tax treatment) gives a country a significant advantage in attracting R&D or promoting growth and how it compares with other factors that influence the innovative environment of the country or region. The B-index can also be extended to produce a more comprehensive indicator of a country's overall R&D tax-subsidy system and other programmes designed to stimulate technology development and diffusion. Like tax support for R&D, all such programmes have a cost-reducing element coupled with much variation in individual design and delivery and, in principle, might be addressed with a similar methodology to that employed in this report.

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FISCAL MEASURES TO PROMOTE R&D AND INNOVATION -- TRENDS AND ISSUES

Albert LINK, Professor of Economics, University of North Carolina, Greensboro, United States

Introduction

Fiscal measures to promote R&D and innovation have been an important aspect of the macroeconomic policy of most industrialised nations for a number of decades. These measures, which focus on the R&D component of the innovation process, can be divided into two broad categories: R&D tax incentives and other special assistance programmes (referred to herein simply as subsidies). The academic literature (statistical investigations as well as case studies) suggests that these measures have, at best, had a modest impact on innovation and productivity growth, assuming that R&D leads to innovation and innovation leads to productivity growth[1].

As summarised in **Table 5** below, there are a large number of countries that have implemented R&D-related fiscal policies and a larger number that have not. The countries that have implemented policies have relied on a combination of tax incentives and subsidies. Some countries, such as France, Japan, and Sweden, have implemented both, although most countries have emphasised one type of policy measure.

Three questions immediately come to mind after examining the summary information in Table 5.

- Which countries have been most successful with their R&D policies?
- Are tax incentives more or less effective than subsidies?
- Is the rate of innovation different between countries with and without R&D policies?

All of these are valid and important questions, although the quantitative evidence that is available is insufficient to answer any question definitively. As is generally the case when evaluating a stimulative policy, it is easier to pose the question than to answer it! However, while these questions are the ones that immediately come to mind, they are not necessarily the most relevant questions for policy makers to consider.

Before policy makers (much less academics) can begin to answer any of the above questions in a meaningful manner, there must first be a clear understanding about the intended goal(s) of the R&D policies. If the policy goal is simply to increase the *level* of R&D spending, then there is sufficient evidence to suggest that the adopting countries have been somewhat successful, but there is insufficient information to determine which ones have been more successful than the others. If, alternatively, the goal of the R&D policies is to stimulate industrial innovation, then the jury is still out[2].

Table 5. **Inter-country tax policies to stimulate R&D**

Country	R&D tax credit	Special assistance
Australia		150% expensing of R&D R&D grants
Belgium		R&D personnel subsidy
Brazil		Exemptions from profit taxes
Canada*	20% (35% for SMEs)	
France	50% incremental	R&D grants to selected industries
Germany		Investment grants Tax incentive for R&D equipment
Japan	20% incremental	Trade policies beneficial to R&D equipment
Netherlands		Subsidy for R&D labour
Norway		Expense against future R&D
Singapore		200% expensing of R&D
Korea		Expense against future R&D
Spain	15% on R&D 30% on R&D equipment	
Taiwan	20% incremental	
United States*	20% incremental on R&D 20% on basic research	

* Sub-national tax incentive schemes are available in some provinces or states.
Source: Leyden and Link (1993).

The purpose of this paper is to question the effectiveness of fiscal measures used to promote R&D, especially in the OECD countries. This review, which centres around the summary information in Table 5, emphasises that most policy makers have embraced a rather limited view of the innovation process:

R&D leads to innovation and innovation leads to productivity growth

and accordingly, have emphasised the role of R&D in that process to the exclusion of other critical technology elements. A conceptual framework, or model, that illustrates the role of other technology elements is discussed in the paper as motivation for new issues to consider. The paper concludes with several recommendations for OECD countries to consider far more broadly defined fiscal policies to promote innovation. In particular, the paper concludes that:

- R&D tax policies are an effective mechanism for increasing the level of proprietary research;
- proprietary technology research is only one element of the portfolio of technologies that firms rely upon as inputs into the innovation process;
- R&D tax policies should thus be viewed as only one element of a more diversified fiscal strategy for stimulating innovation in the private sector.

Tax incentives as a policy tool

Perhaps the more important or more policy-relevant questions to consider are:

- *Is there a need to stimulate R&D spending?*
- *What are the per se advantages of R&D tax incentives compared to subsidies for stimulating R&D?*

The answer to the first questions appears to be *yes*, based only on the fact that a number of industrialised countries have adopted some form of fiscal measures related to stimulating R&D. However, the presence of an R&D policy should not be interpreted to mean that stimulating R&D is the most effective means to promote innovation, or in fact the most desirable means. Before discussing that issue, the second question posed above needs to be answered.

Tax incentives as a means of stimulating R&D spending offer several advantages compared to subsidies or grants assistance programmes[3].

> *Tax incentives entail less interference in the marketplace, and thus allow private-sector decision makers to retain autonomy.* Of course, it is possible to devise a subsidy or grants assistance programme that entails few controls. For the most part, however, tax incentives do not create artificial markets because firms are free to respond to real demand as opposed to government-created demand.
>
> *Tax incentives require less paperwork and entail fewer layers of bureaucracy.* Tax incentives do require administration and paperwork, but it is generally the case that the administrative burden is significantly less compared to other incentives. As well, a policy that follows from tax incentives is for the most part more predictable and more stable than one that requires periodic appropriations and is subject to legislative change.
>
> *Tax incentives avoid the need to set nebulous and detailed requirements for receiving assistance.* Avoiding detailed requirements has the distinct administrative benefit of efficiency and equity. Regarding R&D, tax incentives are ideally designed to reward past behaviour (which assumes that past behaviour has been successful and is still appropriate to meet future goals).
>
> *Tax incentives have the psychological advantage of achieving a favourable industry reaction.* While this advantage is difficult to document empirically, tax incentives seem to draw nourishment from the taproot of the free enterprise system. The free enterprise ethic has "symbolic" importance to many policy makers.
>
> *Tax incentives have a high degree of political feasibility.* At least in the United States, tax incentives face less political opposition than subsidies or grants assistance programmes. Tax incentives have generally been the favoured child of conservative politicians and their business constituents.

There are, of course, critics of tax incentives in general, and tax incentives directed toward R&D in particular. These critics not only may disagree with the advantages listed above, but also may note the following disadvantages of tax incentives compared to other assistance programmes.

Tax incentives bring about unintended windfalls by rewarding what would have been done without the tax incentive. Verification of this proposition requires knowledge about unobserved phenomenon; however, the speculation has long existed.

Tax incentives led to undesirable inequities. In the case of R&D, the more successful the firm undertaking the R&D the more it will benefit from an incremental R&D tax incentive. Thus, tax incentives toward R&D may influence those firms that "need" the incentive the least, or they may not even be applicable to those firms that "need" the incentive the most[4].

Tax incentives can raid the national treasury. There is an unpredictable element to any tax incentive because the effects are determined by numerous economic and political variables[5].

Tax incentives are an ineffective means to achieve focused results. In the case of R&D, tax incentives are directed toward expanding the entire portfolio of R&D as opposed to specific categories of spending. R&D is not a homogeneous activity, but rather it consists of a variety of activities (obviously ranging from research to development)[6]. Any tax incentive to promote only the level of R&D spending explicitly ignores the fact that not all categories of R&D have the same effect on stimulating innovation, and not all categories have the same measured impact on productivity growth[7].

While there are obvious pros and cons to tax incentives for stimulating private-sector R&D, the question remains as to why to stimulate it at all.

Why stimulate R&D spending?

The answer to the question *Why stimulate R&D spending?* is more complicated than simply saying that countries do adopt R&D policies, therefore these policies must be necessary. It may well be the case that the policies are appropriate, but to understand the significance of adopting a more broad-based approach to an innovation policy it is important to first understand the economic justification for such public-sector intervention.

The economic justification for government intervention into private sector activities rests on a concept that economists call *market failure.* Market failure occurs whenever society's benefits and costs are not in an appropriate balance. Market failure can arise for a number of reasons. In the case of R&D, and especially in the case of basic research, market failure is often the result of features intrinsic to the production of information. A firm will under invest in the production of knowledge because the firm that produces the knowledge is unable to fully capture all of the profits that arise from its creation. In the United States, for example, there is some evidence that policy makers understand this point. The tax incentive on R&D is a 20 per cent incremental rate and the tax incentive for basic research is a 20 per cent flat rate.

As noted above, the implicit assumption that underlies fiscal measures to promote R&D and innovation is that there is a need to stimulate the level of R&D:

> R&D leads to innovation and innovation leads to productivity growth -- so more R&D will lead to more innovation and more innovation will lead to more productivity growth.

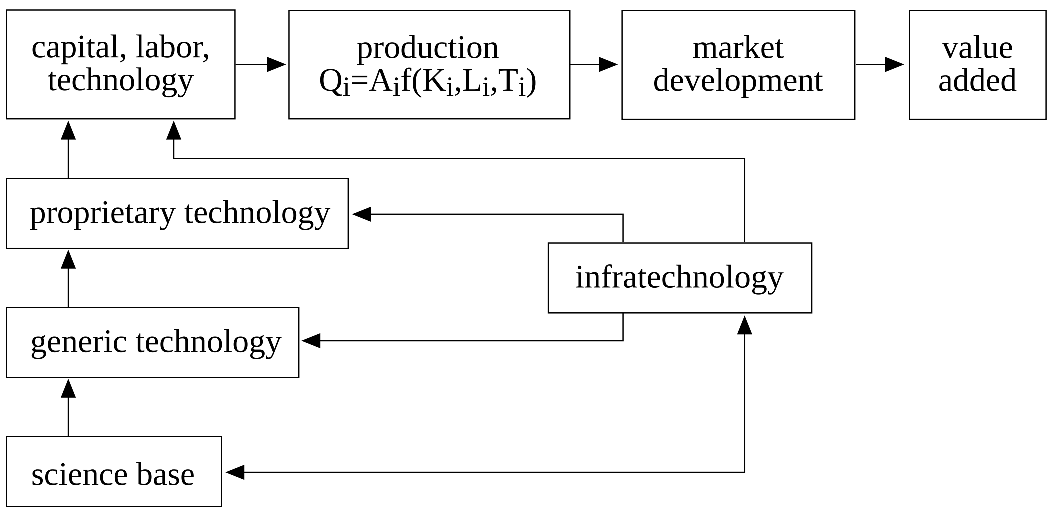
If innovation is the desired policy outcome, it is not necessarily the case that increasing the *level* of R&D is the most desirable solution or even the correct solution. It could very well be the case that what needs to change is the *composition* of firms' R&D portfolios rather than their level of total R&D spending. Or, it could be the case that both the level as well as the composition of R&D needs to change. Or, it could be the case that neither the level nor the composition of R&D need to change, but what needs to change are the levels of other elements related to the innovation process, and which complement R&D.

To understand these issues, policy makers should not only understand the concept of market failure, but also must understand the complexities associated with the overall innovation process.

A model of technological development

Consider the model of technological development illustrated in **Figure 1**. Embedded in this model, which is illustrated for one representative firm within an industry of other similar firms, is a simple linear view of economic activity. Factors of production -- capital, labour, and technology -- interact in a production process and output results. Market conditions then give this output (or product) economic value.

Figure 1 **Model of technological development**



Source: Leyden and Link (1992)

Supporting the technology input has several key technology elements: proprietary technology, generic technology, infrastructure technology, and the science base. Each element in the model is defined below:

> *Proprietary technologies* are in the private domain; they are fully appropriable by firms due to the assignment of intellectual property rights. Such product and process technologies result from the firm's self-financed R&D. R&D-related fiscal measures directly affect the proprietary technology box in the model. An R&D tax incentive or a subsidy reduces the cost of conducting R&D and thus, depending on the portfolio of projects from which the firm can choose, gives the firm an incentive to increase its level of R&D. It is critical to emphasise that the active R&D policies in OECD countries, emphasise the proprietary technology box as the relevant target

variable for stimulating innovation and thus increasing productivity growth. This single-minded emphasis on self-financed R&D is appropriate:

- if the innovation-enhancing potential of self-financed R&D is greater than other innovation enhancing potential of the other technology elements in the model (discussed below), or

- if the extent of market failure is greater regarding self-financed R&D compared to the other technology elements in the model, or

- if self-financed R&D is not complemented by the other technology elements in the model in such a way that the synergy created by all is greater than by any one alone.

Generic technology represents the organisation of knowledge into the conceptual form of an eventual application and the laboratory testing of the concept. An example of such early-on technology research, which is a fundamental building block for proprietary technology research, is basic integrated circuit architecture and design concepts. Generic technology research is usually characterised by both high risk and high potential return. As such, it is not unreasonable to expect that market failure is greater at the generic technology research stage compared to the proprietary research stage. Private sectors firms will under invest in generic technology research because of its high risk and possible mismatch with existing market strategies. Likewise, the government will under invest in generic technology research. R&D policies as we know them today may not provide sufficient incentives for private sector firms to invest in generic research. As such, emphasis on either R&D tax incentives or subsidies to enhance innovation may be incorrectly focused. This is not to say that such fiscal measures are not appropriate, but it is, in my opinion, inappropriate to initiate them in the absence of an overall understanding of all technology elements and how they complement each other. In the United States there have been two policy actions intended to increase generic technology research. The first was the National Co-operative Research Act (NCRA) of 1984[9], and the second was the formation of the Advanced Technology Programme (ATP) within the National Institute of Standards and Technology (a part of the US Department of Commerce)[10]. In practice, the NCRA and the ATP have had the economic effect of stimulating co-operative research on a "variety of pre-competitive and generic technologies by means of grants and co-operative agreements ..."[11]. The available quantitative information, based on studies of the US manufacturing sector, suggests that generic research undertaken collaboratively complements firms' self-financed research[12].

Infratechnology, or infrastructure technology, is a less widely recognised element of an industry's technology base. These are technologies that facilitate the conduct of in-house R&D and of generic research. Infratechnologies include evaluated scientific data used in the conduct of R&D; measurement and test methods used in research, production control, and acceptance testing for market transactions; and various technical procedures such as those used in the calibration of equipment. Infratechnologies facilitate the development of generic technology by providing highly precise measurements and creating organised and evaluated scientific and engineering data necessary for understanding, characterising, and interpreting relevant research findings. Infratechnologies lie in the public domain, and for the most part are invested in by the public sector. In the United States, infratechnology research is conducted at federal laboratories such at NIST. The available quantitative information, based on studies of the US manufacturing sector, suggests clearly that firms that make use of the technical knowledge developed in federal laboratories are not only more efficient in the conduct of their own R&D but also enjoy a significantly higher rate of measured productivity growth[13]. In addition, case studies suggest that the social return from federal laboratory investments in infratechnology is between 100 per cent and 400 per cent[14].

The *science base* provides the foundation for all new technologies. This base comes from basic research, primarily funded by the public sector and conducted at universities. Basic research is the search for fundamental scientific principles without consideration of practical applications. Discovery of these principles does not necessarily lead, nor is it intended to lead, to new products or process applications.

This overview of the model of technological development illustrates two important points:

- self-financed R&D is only one of many elements that affect the innovativeness of firms, and hence the competitiveness of industries;

- the efficiency with which firms can conduct R&D depends on the availability of and their use of complementary technology elements.

Observations and conclusions

Government's role in innovation, at least from an economic perspective, is to overcome market failure[15]. Market failures are implicit in each technology element in the model illustrated in Figure 1. Market failure occurs when firms' under invest in self-financed R&D owing to the commercial risk of the undertaking. Market failure occurs when firms' under invest in generic technology or infratechnology research, or under utilise it, because of the technical risks of the undertakings. Market failure occurs when firms under invest in basic and fundamental science because of technical risks and an inability to appropriate benefits. An appropriate role for the government is to initiate policies to solve the market failure problem.

Overcoming these market failures requires fiscal measures that acknowledge all aspects of the portfolio of technical elements that affect the innovativeness of private-sector firms, and their interactions. Fiscal measures that focus exclusively on self-financed R&D are not inappropriate, but they should be viewed as part of a diversified public sector technology policy. R&D tax incentives, for example, should have an effect of stimulating the level of private-sector R&D spending. But that alone is not enough. The public sector should, being aware of the complementary nature between technological elements, also initiate measures to encourage firms to participate in the conduct of generic technology research. Such measures could take the form of:

- matching grants to firms engaged in collaborative research ventures, much like is done through the ATP awards in the United States, or

- favourable antitrust policies to provide an incentive for firms to form research joint ventures, much like was done through the passage of the NCR in the United States, or

- tax incentives for involvement in a research joint venture[16].

To elaborate on this last recommendation, we know that research joint ventures are an effective mechanism for sharing uncertainty and pooling risks. As a result, it is reasonable to expect that firms, left to themselves, will collectively engage in more fundamental or generic research as opposed to proprietary technology research because the results from the former are less appropriable.

Infratechnology research is also a key element, and the public sector should both foster continued investments in this critical technology element and establish mechanisms for the effective transfer of the technology to the private sector. As a precursor, it is recommended that governments fully understand the nature and significance of the activities that take place within their national laboratories. In the United States, detailed economic impact case studies of federal laboratory programmes are being conducted and are providing important insights into how to allocate/re-allocate resources.

Lastly, the science base is the corner stone of the model of technology development presented in Figure 1. It is generally accepted that an appropriate role for the government is to support basic and fundamental research at universities so as to enrich this science base. A complementary strategy would be to establish mechanisms where research consortia support both fundamental and focused university-based research. The incentive to do this could take the form of matching government funding. The advantage of this mechanism is that it establishes the private sector as a joint stakeholder in the conduct and use of the knowledge that results. One case where this has been successful in the United States is the research consortium SEMATECH and its university-based affiliate, the Semiconductor Research Corporation[17].

To conclude, R&D tax policies, as practised by OECD countries, are an effective mechanism for increasing the level of proprietary technology research. However, proprietary technology research is only one element of the portfolio of technologies that firms rely upon as inputs into the innovation process. R&D tax policies should thus be viewed as only one element of a more diversified fiscal strategy for stimulating innovation in the private sector.

NOTES

1. A more detailed overview of the history and experience of industrial countries with R&D tax policies is in Leyden and Link (1993).

2. On a related matter, we still have little information about private-sector firms' investments in the overall process of innovation. We do know that these investments are much broader in scope than self-financed R&D, however the OECD has taken an important step toward the collection of such data. See OECD (1992).

3. These points are discussed in more detail in Leyden and Link (1992).

4. The word "need" is obviously used here in a normative sense.

5. While the data are speculative about the social benefits associated with the R&D tax credit, it has been estimated that the 1995 revenue loss from the R&D tax credit in the United States will be $1.27 billion. See Ernst and Young (1994).

6. At least for US firms, the National Science Foundation data reporting categories of basic research, applied research, and development accurately describe the spectrum of investment activities related to innovation. See Link (1994).

7. The early studies documenting this are summarised in Link (1987).

8. This model is based on Link and Tassey (1987), Leyden and Link (1992), and Tassey (1992).

9. This legislation initially grew out of the 1978 White House Domestic Policy Review of Industrial Innovation. The objective of the Act was to create a favourable antitrust climate so as to encourage private-sector firms to collaborate at the basic research phase. See Link and Bauer (1989) for the legislative history of this Act.

10. The Advanced Technology Programme (ATP) was established as part of the Omnibus Trade and Competitiveness Act of 1988 (the relevant portion of that Act is also known as the Technology Competitiveness Act). The stated goals of the ATP are to assist US businesses in creating and applying the generic technology and research results necessary to commercialise significant new scientific discoveries and technologies rapidly, and refine manufacturing technologies. For a discussion of the early activities of the ATP and how it is evaluating itself, see Link (1993).

11. Quoted from the stated purpose of the ATP as reported in the *Federal Register*, July 24, 1990.

12. Link and Bauer (1989) report that the rate of return to self-financed R&D in firms engaged in collaborative research ventures is 150 per cent greater than in firms that are not part of collaborate research organisations -- "Co-operation represents an investment in technical knowledge that manifests itself in a more efficient overall R&D programme." See also Link and Tassey (1989). It is premature to draw conclusions about the effect of the ATP on the technological competitiveness of firms receiving matching funds to form and participate in a research joint venture.

13. See Link and Tassey (1993).

14. See Leyden and Link (1992) and, for example, Link (1995).

15. This point is emphasised in Leyden and Link (1992), Tassey (1992), and Tassey (1994).

16. This proposal was first set forth in Bozeman and Link (1983) and later modified in Link and Bauer (1989).

17. The Semiconductor Research Corporation (SRC) receives government funding through SEMATECH (SEmiconductor MAnufacturing TECHnology) to conduct basic and fundamental research in universities. See Finan and Link (1994) for an overview and preliminary assessment of the benefits of the SRC to the US semiconductor industry.

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METHODOLOGIES FOR EVALUATING THE IMPACT OF R&D TAX CREDITS

John Van REENEN, Project Manager, The Institute for Fiscal Studies, United Kingdom

Introduction

This paper gives an overview of the ways in which researchers have tried to evaluate the "success" of R&D tax incentives. It is not exhaustive, but is meant to convey in a relatively non-technical way the differences between the main methodologies. It is well known that the existence of spillovers from R&D causes a divergence between the private rate of return and the social rate of return to R&D. In theory, an optimal R&D tax incentive would bring the private rate of return up to the social rate of return. The existing tax structures of different countries could be evaluated by calculating how close they came to bridging this gap. Unfortunately, the social rate of return is generally unknown and policy-makers have been forced to fall back on seeking answers to simpler questions.

There are two essential questions to be addressed. First, how is the price of R&D affected by different tax incentive regimes. Second, given the changes in the cost of R&D, how do firms respond? Once one knows the answer to these questions the policy cost can begin to be calculated. This will include the associated administrative costs of the scheme. Whether one thinks this cost is worthwhile will depend on the benefits deemed to have come from the additional R&D. For lack of space, we do not try to survey the evidence on the social benefits here.

In almost all OECD countries most R&D expenditures can be expensed, *i.e.* written off immediately against profits. Given that other types of investment are capitalised over several years, this means that R&D is treated more favourably than other types of capital. This immediately gives a tax advantage to R&D. Some types of R&D are also depreciated, but in most cases there is accelerated depreciation compared to other forms of capital (like land, buildings or machinery). Many countries have gone even further than this and offered a tax credit for R&D over and above what is allowed for by expensing and accelerated depreciation. It is these tax credits that are the focus of this section.

Normative approaches

The simplest way of evaluating the R&D tax incentive is to calculate what the marginal effective tax credit (METC) is for different firms. A tax credit of 20 per cent will not generally translate through to a METC of 20 per cent. This arises for several reasons. First, many firms may not have sufficient taxable income to offset against the tax credit. Although there are usually provisions to carry forward the credit, carry forwards are less valuable because of inflation and discounting. Few countries follow the French example and allow firms to claim back any excess credits from the government in cash.

Second, and most importantly, most countries only count R&D above a "base" level as qualified for a credit. This is because governments do not wish to subsidise R&D that would be performed anyway. Despite this natural desire to keep down costs, the existence of the base causes many problems. In the US, for example, the 1981 Research and Experimentation tax credit defined the base to be an average of the company's R&D expenditures in the previous three years. A company which was considering increasing it's R&D would have to take into account that the higher this year's R&D expenditure was the higher would be the next year's base. The higher the base was, the lower would also be the next year's tax credit. Although the definition of the base changed in 1991 to try and avoid these problems (it became the 1984-88 average R&D sales), it is intrinsic in any incremental tax credit. Defining the base to be the industry average R&D intensity is an attractive alternative but one is then faced with the problem of placing every firm in an industry. Most larger firms operate across several different industries.

These factors meant that METCs in the US were much lower than the tax credit rate and varied considerably across firms and industries. It also meant that some companies actually faced negative METCs -- giving them a disincentive to invest in R&D. Eisner *et al* (1984) considered the US tax credit to be relatively ineffective because of these problems. It was both distortionary and on average, too low to have had a significant effect on aggregate R&D. The problem with the normative approach is that it can only tell us what the changes in prices were and not how responsive agents are to such changes. For such evidence one must turn to surveys or statistics.

Survey evidence

Mansfield and his co-workers have spent considerable effort in questioning senior R&D managers concerning their response to changes in the R&D tax credit system. Surveys were conducted in the United States (Mansfield, 1986), Canada (Mansfield and Switzer, 1985) and Sweden (Mansfield, 1985). In all cases the tax credits only induced a modest increase in R&D spending -- on the order of 1-2 per cent a year. A particularly worrying feature of these surveys is that Mansfield pointed to a lot of redefinition of expenditures as qualified R&D in order to get the benefits of the credit. Mansfield and Switzer (1985) argue that reported Canadian R&D increased by about 14 per cent between 1977 and 1987 for this reason.

Although highly suggestive, one must be wary about survey data for several reasons. There is always the danger that managers themselves may not be fully aware of all the reasons why R&D has increased during any particular time. There is the issue of whether all respondents are interpreting the question in the same way. Furthermore, the sample response may not be random across all firms. Finally, it is difficult to get solid quantitative estimates of the effect of changes in the tax price and behavioural responses from subjective evidence. For this we turn to econometric evidence.

Econometric evidence

There are a number of studies of R&D behaviour which attempt to calculate the price elasticity of R&D. By a price elasticity we mean the percentage increase in R&D induced by a percentage fall in the price. If this is known then a calculation of the effect of the credit on the price will enable us to deduce the overall impact of a tax credit on R&D.

The major problem with estimating the tax price elasticity is that the price of R&D does not vary very much across firms or over time. Without any "experiments" it is very difficult to identify any behavioural response. This could be one reason why early studies of the price elasticity found relatively low estimates -- on the order of -- 0.4 (e.g. Bernstein and Nadari, 1989). The useful thing about the introduction of a tax credit from a purely econometric point of view is that it is a very good experiment to test the responsiveness of companies to changes in price.

Researchers who have used the ‘natural experiment’ of the introduction of the US tax credit have found much greater responsiveness of firms than was previously imagined. Hall (1993), Hines (1993) and Bailey and Lawrence (1992) all find elasticities of around unity. This suggests that a 10 per cent reduction of the price of R&D causes a 10 per cent increase in the quantity of R&D. A large and significant policy response.

Conclusions

Of the three methodologies, micro-econometric evidence is the most informative for policy makers. The best practice modern studies of the US tax credit strongly suggest that R&D is far more responsive to changes in the price than was previously thought. This has the implication that tax credits can elicit strong private sector responses and that R&D does not depend purely on technological or demand-driven factors.

One must be wary of several problems in generalising from these econometric studies, however. First and foremost these studies are confined to the US. There is far less statistical evidence on the other OECD countries which are characterised by having a far greater reliance on exports than the US. Secondly, Manfield’s surveys highlight the dangers of relabeling their costs as “R&D” in order to enjoy the benefits of the credit. Effective auditing of the credit is a priority if abuse is to be avoided. Thirdly, the ‘normative’ approach emphasises the fact that credits give a variety of different incentives to different firms. It may be that tax credits do not sufficiently help the firms who may need them most (SMEs) or at the times they need them most (in recessions). Despite these qualms, it is clear that a political space has been opened up by these intellectual inquiries. Given an intelligent and innovative policy response, improved tax credits could improve the performance of the OECD countries.

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PROBLEMS INVOLVED IN DESIGNING AND IMPLEMENTING R&D TAX INCENTIVE SCHEMES

Stéphane LHUILLERY, Researcher, Direction des Synthèses et de la Prospective, Ministry for Higher Education and Research, France

Introduction

Tax incentives for R&D are the most innovative tools of science and technology policies. Except in Canada and Japan, they have been introduced only in the past fifteen years. Most of the articles on the subject relate the market's failure to co-ordinate R&D and proceed to gauge the impact of tax incentives on R&D outlays (for a summary of the results, see: Cordes, 1989; Hall, 1992; Leyden and Link, 1993). In comparing the outcomes, the difficulty involved and the variety of assessment methods mask an essential piece of the puzzle. As Mowery (1994) put it, "Evaluation of the effectiveness of technology policies should be linked to the goals of program designers...". R&D tax incentives (RDTIs) -- here defined as R&D tax credits and other special incentives -- must therefore be viewed as the fiscal translation of conflicting goals among all players in the public and private sectors. We shall identify five types of constraints that RDTIs have to satisfy; understanding how countries meet these constraints is a necessary prelude to any assessment. Here, this will entail a comparative analysis of the various national mechanisms.

In seeking to categorise RDTI mechanisms, we have drawn upon various sources of information. Foremost among them are delegations to the OECD Workshop on Fiscal Measures to Promote R&D and Innovation. Rounding out their information have been various assessment reports, some of which describe systems, and input from the science and technology attachés of various French embassies[1].

Notwithstanding, we are still limited by the amount of information available. Our summary is incomplete for four reasons. First, it was impossible to find a description of each country's control system. Second, because of their fiscal, rather than statistical nature, RDTI-related data are rarely available. Even where detailed descriptions of national systems to promote innovation exist, the sums involved are rarely disclosed (e.g. Taiwan in the article by Chi-Ming Hou and San Gee, 1993). Third, because we have information about the Italian mechanism, which was never implemented, we have kept it in this article. Unfortunately, this is not the case for Mexico, nor for mechanisms that no longer exist (Germany, Sweden and Finland). Fourth, while one might expect to derive enough information from RDTI mechanisms that have been in place for several years to analyse how systems and user practices have evolved, there has been too little documentation (except in the United States) to support interesting analysis and balanced, international comparisons of how systems have changed. This overall lack of information being aggravated by the dubious quality of some of the data, this summary cannot claim to be a precise representation of the mechanisms in place in the various OECD countries.

The two types of R&D tax incentives (RDTIs) and the problems involved

More than fifteen countries around the world use RDTI mechanisms proper. Such schemes are generally divided into two main categories: volume mechanisms and incremental mechanisms. Both types pose many problems when the leap is taken from theory to actual implementation.

The two types of RDTIs

The first, so-called "volume" mechanisms give an incentive proportional to investment. A firm operating in a country that allows volume RDTIs at a rate of, say, 25 per cent would therefore get a $ 25 tax credit for every $ 100 of R&D expenditure. Australia, Canada, Italy, Japan, Korea, Malaysia, the Netherlands, Singapore and Spain have each set up a system based on this principle.

The second type of mechanism is a bit more complicated in that it aids only a firm's marginal expenditure. Incremental RDTIs therefore lower the marginal cost of R&D, but only for outlays in excess of base-period expenditure. Under this system, and assuming an RDTI rate of 50 per cent, a firm that spends $ 300 in base year *t* and $ 400 in year *t + 1* will get a tax credit of $ 50 [0.50 x ($ 400-$ 300)]. Belgium, Denmark, France, Italy, Japan, Korea, Taiwan and the United States have opted for such mechanisms.

The problems involved

Problems can be detected from both an examination of the mechanisms themselves and of their evolution over time. While the latter are symptomatic of administrative difficulties[2] they do not suggest that one type of mechanism is prevailing over the other. Five problems have been identified, and they affect volume and incremental mechanisms alike.

First is the problem of *equity*. If all R&D spending can yield knowledge that cannot be entirely appropriated, then any firm carrying out R&D ought to be compensated in proportion to its total outlays and not its marginal expenditure. Under an incremental system, a firm whose R&D effort is constant over time (e.g. $ 100 each year) gets no tax credit, even though it too disseminates knowledge that is of use to the entire economy. Similarly, under such a system, aid is not proportional to a firm's true effort: if, for example, two firms each increase their outlays by $ 10 between *t* and *t + 1* but in *t* had spent $ 100 and $ 1 000 respectively, the tax credit will be the same for each, even though their efforts, as measured by the growth rate of their expenditure, were respectively 10 per cent and only 1 per cent.

Second is the issue of *neutrality*, *i.e.* whether RDTIs distort the structure of R&D expenditure. Such neutrality is not necessarily an objective, however, since some mechanisms deliberately seek to orient corporate R&D or to promote the R&D of selected companies, e.g. SMEs.

Third is the difficulty of *budgeting* for RDTIs. Business cycles generate R&D investment patterns that make RDTIs hard to predict or control.

Fourth, RDTI administrators run up against *corporate opportunism*. For example, under a system of 25 per cent volume credits, a firm having to invest $ 100 in an R&D project need invest only $ 80 to attain its initial objective [100 = (1 + 0.25) 80]. This "crowding out" effect is thus primarily relevant to volume mechanisms, because with an incremental mechanism, while the effect can occur, it affects only some firms and concern only marginal R&D expenditure. Opportunistic behaviour also shows up in corporate reporting strategies. Incremental systems in particular offer benefits that vary with the way in which expenses are incurred, and they are therefore conducive to strategic manipulation on the part of firms. If a firm decides to implement an R&D project over more than one year, it can delay the outlays or bring them forward, or it can juggle the books so that the expenditure is charged to only one year or spread over several. The higher the discount rate companies apply to future cash flows, the more attention they will pay to this strategic consideration (Summers, 1987).

Fifth is the problem of *how RDTIs fit into their environment*, which includes other types of R&D incentives but also the tax system as a whole. This problem is often brushed aside because of its complexity.

R&D tax incentive mechanisms

Three types of provisions will be discussed: those intended to limit the revenue shortfalls and administrative costs primarily associated with new measures; those to ensure that firms with no tax liability can also benefit from tax incentive schemes; and those designed for giving some selectivity -- in terms of firm, technology and region -- to tax incentive schemes.

Limiting the risks attached to RDTIs

Three types of provision lessen the risks of budgetary overshoots and manipulation that arise with tax incentives. While the first type is applied to incremental and volume mechanisms alike, the other two are used primarily with incremental systems.

Crowding-out effects and budgetary overshoots can be limited by putting a *ceiling* on tax benefits. Half the systems studied have such ceilings. Two methods are used: either the ceiling is a fixed deductible amount (Australia, France, Italy, the Netherlands), or it is a percentage. Korea, Spain and Taiwan have rates of 10, 35 and 50 per cent respectively. Japan is an interesting case in that the ceiling, which is a percentage, is also a way to favour SMEs, which may deduct up to 15 per cent of their taxes, whereas for large firms, the ceiling is lower -- 10 per cent. The United States uses an original double ceiling mechanism: not only must a firm spend no more than twice the previous year’s base amount[3], but the average intensity of R&D expenditure (i.e. its ratio to turnover) must not exceed 16 per cent.

By calculating the rate of increase over a base period of several years (the United States, France, Korea, Taiwan), the amount of tax benefits can be *smoothed*. In France, Korea and Taiwan base amounts are calculated over the previous 2-4 years. In the United States, the base is the average ratio of R&D spending to turnover, which fairer in that RDTIs are indexed to the actual efforts a firm makes during the year.

The smoothing method nonetheless has two drawbacks. First, the price adjustment of past R&D expenditures raises problems (see OECD, 1993). The CPIs or (in France’s case) investment indices used by tax authorities do not always accurately reflect cost trends in R&D (see Mansfield *et al.*, 1986). Second, as Hines (1994) emphasises, the fact that the base on which a firm is to get a credit is calculated over several years will prompt it to postpone its investment. Consequently, the base will be lower and will yield a bigger credit in the subsequent period. It would therefore appear that budgetary planning considerations outweigh concerns over the cost of firms’ opportunism, which may be underestimated.

The smoothing of tax credits, along with the fact that penalties are imposed if R&D spending is subsequently reduced, limits the scope for strategic behaviour on the part of firms. There are two types of *negative credits:* a strict system whereby credits have to be paid back every year (as in France between

1983 and 1987, and in Belgium); and a system that allows negative credits to be carried forward (as in the United States and France today). While the first system is dissuasive, the second allows a firm to reap benefits on a one-off basis without incurring any real penalties; it thus facilitates a firm's initial efforts but does not ensure that R&D will be continued (Asmussen and Berriot, 1993). In the latter case, the inequity of incremental RDTIs also affects small innovative firms and firms in low-tech sectors. Often, such firms invest in R&D on a one-off basis and can therefore benefit from the RDTI only *temporarily*, even if they maintain their effort afterwards. In order to benefit from the mechanism, firms will tend to inflate their reported R&D spending. From the companies' standpoint, tax credits/debits also run the risk of exerting a countercyclical effect, since firms that wish to invest during an upswing are held back by the negative credits accumulated over the years (France, United States).

For the State, incremental mechanisms are advantageous because they tend to be offset by other items in the national budget. In other words, the loss of tax revenue caused by RDTIs is high when other tax inflows are high. This is not an economic argument, however, but a budgetary consideration; economically, the ongoing nature of such a mechanism poses a problem. Alternatively, a rule could be instituted to depreciate negative credits over time.

The case of new firms or firms with no tax liability

A firm has to *have a tax liability* in order to benefit from R&D tax incentives. As a result, SMEs and start-ups in particular can be penalised. To solve this problem, most systems incorporate special arrangements.

A system of tax credit *refunds* for those firms that have no tax liability. In Spain and France the full amount of a credit can be refunded. Canada refunds the 35 per cent credit for SMEs (large firms have carry forward and backward privileges). This system also limits the impact of the budget cycle for the State, which during a recession has to make refunds to a number of firms that owe no tax. From the company's point of view, the refund is also a means of limiting the impact of business cycles, since when a firm is not liable for tax it still gets the refund.

Australia and the United States prefer to allow tax benefits to be *carried forward*, so that a firm has to improve its overall profitability before it can benefit. Here the tax credit has a wider goal than that of promoting technology. The United States, given the method adopted for computing the base, offers start-ups a flat-rate base derived from turnover. Such firms get a tax credit if they spend more than 3 per cent of their turnover on R&D. This rule puts fledgling SMEs wishing to engage in a limited amount of R&D at a disadvantage; similarly, low-tech sectors also seem to miss out, since they rarely need to invest much more than 3 per cent in R&D.

The Netherlands have adopted another approach, a tax incentive scheme in which tax credits are based on R&D labour costs instead of profits. Firms need not have incurred these R&D labour costs, but they may apply for a tax credit in advance. Under such a scheme, new firms and firms with no profit tax liability are therefore not penalised.

Several incremental tax credits include a volume component. The *two systems* can be used alongside one another: firms can be given both options (France from 1987 to 1989, Korea), or the two systems can complement one another (Japan and Taiwan).

-- Given a choice between two *competing* mechanisms, a firm can choose the system it finds the more advantageous; also, SMEs whose level of R&D expenditure is constant will qualify for a credit. In France, the option existed between 1988 and 1990, but only for firms that had not done any R&D previously and whose base was consequently zero.

-- The *juxtaposition* of the two systems allows firms with no tax liability to benefit from a credit. Taiwan gives a flat-rate tax credit of 0.5 per cent of annual turnover for first-time investment in R&D.

The search for equity therefore entails a risk that systems will not be neutral and become more complex.

Different approaches

Disparities between firms are taken into account to varying degrees by the RDTI systems of each country, with some firms being treated better than others. RDTI mechanisms frequently feature three types of segmentation -- by size, by technology and by region. Here, RDTIs are far more than a remedy for market failures; they constitute an instrument of industrial policy.

Segmentation by *size* is to the benefit of smaller firms: either they receive credits at preferential rates (Canada, Italy, the Netherlands, Korea) or credits are reserved to SMEs. In Japan, SMEs with equity capital of less than 100 million and fewer than 1 000 employees get tax credits equal to 6 per cent of their R&D expenditure. The size criterion varies widely from one country to the next. Italy, for example, uses a twofold criterion: a firm is considered small if its capital is less than L 20 billion and it has no more than 200 employees.

A more advanced mechanism is used in the Netherlands, where the rate of tax credit varies by “tranche” of R&D spending. The first “tranche”, under Gld 100 000, qualifies for a credit of 25 per cent, and the upper “tranche” for a credit of 12.5 per cent. There is an additional credit for the self-employed -- up to Gld 7 800 if they spend more than 1 225 hours per year on R&D (Netherlands Foreign Investment Agency, 1994).

The Canadian system bases credits on firm size. SMEs earn refundable credits at a rate of 35 per cent on the first C$ 200 000 of R&D. All other firms earn 20 per cent credits that are not refundable.

Some countries segment their tax credits by *sector* or by type of *technology*. Japan, for example, gives a 7 per cent credit -- which can be combined with other credits -- to firms that carry out R&D on energy-saving measures and certain drugs (AIST, 1994), and to firms that do R&D in basic industrial technologies such as robotics, electronics, advanced engineering, biotechnology and new materials (Warda, 1994). This is an original approach, most other countries using other forms of support for this type of R&D. To our knowledge, only Denmark restricts its volume-based tax-credit to selected technology programmes.

Another fairly common practice is to vary tax credits by *region*. This is done by federal states like Canada, but also by countries such as Italy, Spain and Korea. Canada has a two-tier system of R&D tax credits: some regions (Gaspée, the Atlantic Provinces) receive federal credits at a preferential rate, while various provinces (Quebec, Manitoba, Ontario, Nova Scotia, New Brunswick) have their own credits which can be combined with federal ones. Assistance of the kind the Canadian federal government provides to certain regions is also to be found in Spain (the Basque region) and Italy (the Mezzogiorno). Since the beginning of 1995, France has also been moving towards a regional structure of tax credits.

This third approach, unlike those that promote certain technologies or companies of a certain size, would appear to be based on the decentralisation of other tax practices, such as collection of corporate income tax by lower levels of government (OECD, 1993).

Tax measures are frequently designed for neutrality. Whether that holds true in this case hinges on how much credence is given to empirical studies that point to substantial disparities between firms. A large body of econometric research shows major differences between intra- and inter-sectoral externality rates (see Mohnen, 1990), while other work demonstrates that for certain innovative processes R&D is not a necessity (Pavitt, 1984; Napolitano, 1991). Similarly, given the uncertain conclusions regarding the returns on R&D (Cohen and Levin, 1990), one could always believe that the difficulty of investing in research and development depends on a firm's size. If so, it would be necessary to assist certain technologies, sectors or companies in order to optimise benefits to society.

The search for flexibility

The distinction that has been made so far between volume mechanisms and incremental systems can be a fine one. Some RDTIs combine both aspects (Australia, Japan, Spain) and original systems to enhance flexibility have been set up in Singapore and Korea.

The convergence of two systems

In Australia, the special rate of tax deduction (now 150 per cent) applies only for R&D expenditure above A$ 20 000. In contrast with the Dutch mechanism, the Australian system rewards firms for the volume of R&D they do. The more a firm invests in R&D, the bigger is the tax incentive. Here, then, the two types of mechanisms *converge*. Firms have an incentive to exceed a minimum amount of R&D expenditure; another advantage is that paperwork costs are reduced accordingly.

The Spanish system also has a progressive component. By making a unique distinction between the portion of R&D expenditure that is constant over time and additional expenses, it blends the two types of R&D tax credit mechanisms. Firms receive a larger credit (30 and 45 per cent for current expenditure and fixed assets respectively, instead of 15 and 30 per cent) for the increment of R&D expenditure[4]. Firms whose level of R&D spending is constant thus benefit from the system in the same way as those that are encouraged to increase their expenditure. In many countries RDTIs are growing more complex, despite the widespread conviction that firms are more responsive to stable schemes (AIST, 1995; IR&D, 1994).

Systems of provisions

Three fairly flexible tax mechanisms for supporting R&D have been identified. The first allows firms to constitute provisions on the basis of expenditure already made. The other two allow provisions to be set aside but do not require that the corresponding R&D should already have been carried out. As seen in the case of Australia and the United States, unused tax benefits can be carried forward over a long period. In Canada, small firms may opt for a *refund* of unused credits. While the mechanism seems very flexible a drawback is that it will always be more advantageous for a firm to apply for annual refunds and invest them in the money market.

In some countries, firms do not have to wait until the end of the tax year to benefit from their tax credits. Tax benefits can be provided as research is carried out (as in the Netherlands) or in advance (as in Korea and Singapore), giving firms a very flexible means of financial management. The Dutch system of constituting *provisions concomitantly* with expenditure allows a firm to benefit from its tax credit on a monthly basis. A small firm with cash flow difficulties will thus not have to bear the full cost of its R&D spending for an entire fiscal year. This monthly arrangement makes it necessary for tax credits to be set off not against annual tax liability, but against other payments, such as social insurance contributions (Netherlands Foreign Investment Agency, 1994).

The logic of the Dutch system is taken a step further by Korea and Singapore. In these countries, firms can constitute *advance provisions* on their corporation tax, before any R&D has been carried out. In Singapore, for example, a firm that intends to invest in R&D in one or two years' time is allowed to constitute a provision equal to as much as 20 per cent of its corporation tax. The rate is 23 per cent in Norway and 20 per cent in Korea[5]. Korea also uses provisions as a means of promoting certain industries, since the rate rises to 30 per cent for industries categorised as high-tech. In each case, provisions must be spent within four years (Kim, 1993).

The system of provisions aims not so much to reward R&D effort as to facilitate internal financing. The mechanism is a very interesting one since, as in Singapore, it can be combined with volume and incremental systems; it thus alleviates the problem of credit rationing, especially in countries where access to capital markets is difficult. Lastly, it allows and encourages firms to plan their science and technology activities over the medium-term. However, any system of provisions is difficult to monitor and control.

Defining the base for RDTIs

Two problems arise when defining the base of a tax incentive: the first is to distinguish between what R&D does and does not encompass; the second is to deal with transfers of R&D results that give rise to financial flows.

The problem of the dividing line

How certain R&D outlays are categorised can create substantial distortions, since firms will tend to neglect investments that are not included in the base (Eisner *et al*., 1984). Governments are therefore compelled to draw a strict dividing line between expenditure that can and cannot be regarded as relating to R&D. The criterion used would seem generally inadequate and is usually supplemented by other considerations.

Most countries define R&D on the basis of the *nature of the activities* carried out (France). For purposes of R&D tax incentives, the definition of R&D is often close to that of the "Frascati Manual" (OECD, 1994*b*). However, this restrictive definition does allow for national features. Also, it aims to standardise international statistics and is not necessarily the most operable definition. Canada, for example, has widened the definition of the uncertainty attaching to any research to include not only uncertainty as to results but also the uncertainty of R&D costs, whereas the United States acknowledges the absence of uncertainty in respect of some of the work that is done on technical systems (IFRI, 1992).

Most countries have introduced additional criteria. We have identified three in the documents at our disposal. While Canada and the United States use the restrictive term "research and experimental development" (R&ED), in some countries (e.g. Spain), this distinction is embodied in a *list* of activities considered to constitute R&D. The Netherlands is an interesting case in point, since both R&D activities and activities that are not considered to be R&D are officially listed. The United Kingdom and France do not draw up any specific list, on the grounds that such a list might be incomplete.

Another option is to define the *nature of R&D findings*. In general, R&D expenditures are industry-biased, in the sense that they are a better indicator for innovative activities in manufacturing than in service sectors. Consequently, R&D tax schemes are industry-biased as well.

However, a third criterion is required to calculate the amount of eligible R&D expenditure if staff are not assigned to R&D on a full-time basis. Personnel are considered to be doing research if they spend a given percentage of their time thereon. Likewise, in respect of equipment, it is necessary, as Canada has done, to set a threshold for the amount of investment considered eligible for a RDTI. However, such a threshold is unsuited to (the increasingly frequent) project-based R&D, the horizontal structure of which can make it difficult to allocate equipment to specific tasks. The Canadian system was made less restrictive in 1992: equipment had to be used for R&D 50 per cent of the time, instead of 90 per cent previously, to be eligible for a credit.

Another, more flexible, approach is to count only the use of human resources. This limits allocation to R&D to the most visible and most easily controllable of corporate outlays. In the Netherlands, for example, only R&D-related wages and social security contributions are taken into account. While this method is certainly simpler, it also has two drawbacks: it does not compensate a firm for the entirety of its research and development effort, and it may induce labour/capital substitution with regard to R&D. The French system -- a more elaborate arrangement, but one that retains this simplicity of calculation -- pegs current expenditure at a flat 75 per cent of wages and social security contributions, for research technicians and researchers only. Although it is a more accurate reflection of actual corporate expenditure, this method favours those companies -- of which there are many in, say, the service sector -- whose overheads constitute less than 75 per cent of operating expenditure. The Canadian system is similar but seems fairer and more flexible: the rate is 65 per cent of wages and social security contributions for all R&D personnel, and firms are free to opt for this flat-rate treatment or not.

The same difficulty countries experience in finding a working definition of research and experimental development arises when a finer distinction is drawn between basic research and other R&D expenditure, and when one wishes to broaden the base to encompass outlays that cannot be treated as R&D expenditure. Since 1986, the United States has given a separate tax credit for *basic research* carried out jointly with universities. A second dividing line is therefore needed, but it is as difficult to apply as the first one (IFRI, 1992).

Since research and development is just one facet of innovation, financial support to R&D is an incomplete way of encouraging that entire process. Concretely, R&D costs could never represent more than a fraction of the full cost of *technological innovation* (Brouwer and Kleinknecht, 1994). The question therefore arises as to whether the base of the tax credit should be broadened to include, alongside research and experimental development activities, spending on industrial development, market development and so on.

The sheer variety of tax incentive bases reflects very different perceptions of R&D and innovation. As has been seen, the United States, Canada, the Netherlands and Japan have very restrictive tax credit bases. France also adopts a Frascatian definition of R&D. Nevertheless, the fact that standardisation expenditure has been incorporated into the base signals a broadening of the system. Some of Pacific rim countries (Australia, Korea, Malaysia and Singapore) have already opted for a wider vision of R&D by extending the range of eligible innovative activities (such as market surveys).

Widening the base for RDTIs poses the same problem of how to draw the boundaries of what constitutes innovative activity. The definition of innovation as a "significant" technological breakthrough by a product or a technological process (OECD, 1992) underscores just how difficult this can be. Apart from the problem of identification, that of indivisibilities is becoming increasingly acute, inasmuch as the process of innovation clearly cuts across corporate functions. Once these practical problems are out of the way, the feasibility and relevance of such form of government assistance to innovation remain at issue.

Economic theory legitimates assistance for corporate science and technology activities to the extent that they are pre-competitive[6]. But tax incentives for innovation are classified as competitive measures in that selected firms are aided by governments, thereby distorting domestic and international competition. Moreover, this latter point has been written into EU regulations and GATT agreements. Such an extension of RDTIs, as for R&D outlays proper, represents an essentially quantitative approach. But it is perhaps less important to increase expenditure on innovation than to enhance the quality thereof by altering the very structures of the process of innovation.

Intramural and extramural R&D

Corporate R&D expenditure is not, however, limited to research that is done in-house. Firms subcontract or co-operate in order to achieve research and development objectives, thereby generating R&D-related financial flows. Different countries treat these flows in different ways, reflecting a variety of trade-offs between the double bookkeeping cost incurred by including such expenditures in the tax base and the co-operative R&D savings achieved by internalising externalities, co-ordinating work, eliminating duplication of effort and harnessing synergism (Kamien *et al.*, 1992). More generally, numerous theoretical analyses conclude that "networking" is inherent to any innovating process (Freeman, 1992), even though its impact on corporate performance is not easy to gauge (Hagedoorn and Schakenraad, 1991).

Systems differ considerably from country to country. Canada, France, Japan, the Netherlands, Spain, and Singapore encourage R&D ties to varying degrees, while the other countries try to limit the accumulation of tax benefits by restricting eligibility to in-house expenditure. Countries not imposing such restrictions allow credits for R&D carried out by three possible sources: independent organisations, affiliates, and firms or laboratories located abroad.

Some countries limit double crediting by disqualifying R&D flows *between private firms*, in respect of the sources and/or uses of funds devoted to acquiring or producing R&D. In the United States, for example, a commissioning firm is not permitted to include expenditure on outsourced R&D in its tax credit base, while in Canada a service provider may not include the contractual payments it receives. It will be noted that although this distinction is of little importance from a budgetary standpoint, economically it does matter, since in one case it is commissioning firms that are favoured and in the other it is the providers of R&D services (private, but possibly public as well).

Many countries (e.g. France, Singapore, Malaysia) have introduced licensing procedures in respect of R&D service providers in order to limit the number of double credits allowed to businesses. In addition, licensing enhances the reputation of a firm or an organisation. Just as in the case of R&D contracts or subsidies, licensing by a public body for R&D tax credits denotes a firm's scientific and technological capability.

A selection procedure of this sort can vary in the level of demands it makes, or it can favour a particular type of R&D partner. In Australia, for instance, research agencies (RRAs) would appear to be selected by specified type of research. Even more restrictively, some countries (e.g. Japan, Canada)[7] confine subcontracting to public institutions only. This encourages public and university laboratories to work more closely with industry and enables government to avoid double payments to firms, although the risk of duplicative credits for the same academic research remains. Finally, it is Switzerland that has the incentive most focused on scientific and technological interactions: the Swiss R&D tax credit, introduced in 1995, applies solely to subcontracted R&D.

In an original move, Australia has introduced a special syndication mechanism to facilitate the financing of collaborative R&D. Firms pooling together to invest at least A$ 1 million in research and development may obtain tax concessions 12 months before the work is actually carried out. Successful applicants must specify the exact nature of the research, its financing and the apportionment of risks among syndicated parties, as well as the possible market outlets (IR&D, 94). In terms of outcome, this system very much resembles the one based on provisions which was described earlier, its basic purpose being to finance research spending rather than to offset or augment it. As a result, it affects how research is organised rather than the quantity performed, in contrast to most of the other incentives. This measure, which has been gaining momentum since its introduction in 1989, in 1992-93 encompassed some 15 per cent of corporate R&D spending (IR&D, 94).

Groups pose a special problem in that intramural subcontracting of R&D is declared twice, and it too can give rise to double tax credits. Furthermore, back-and-forth R&D flows, transfer pricing and spinning-off can all be used to inflate changes in R&D spending. This is especially troublesome in cases involving incremental tax credits wherein small businesses get their credits refunded if they owe no taxes. This can happen in France, which has no systematic control procedure other than licensing of a group's various subsidiaries. In contrast, Japan limits volume-based tax credits to independent small businesses only. There are two intermediate systems: a tax credit against consolidated tax (Spain), and a groupwide ceiling which can be apportioned freely among subsidiaries (Netherlands). Both systems are exacting, however, since they presuppose a very difficult exercise in consolidation for groups and tax inspectors alike.

More specifically, work performed *abroad* is seldom included in the R&D tax incentive base, in order to foster innovation, production and national competitiveness. Canada's willingness to let firms include current R&D spending abroad is therefore generous, even if R&D tax credits are treated differently for companies under Canadian control and those that are not. In April 1994, Japan introduced a research tax credit of 6 per cent, applicable to co-operative R&D with national laboratories, and in April 1995, introduced a research tax credit applicable to international co-operative R&D with foreign laboratories. The international focus is also present in Denmark's special 30 per cent tax credit for the hiring of a European researcher. Spain's RDTI base includes expenditure on R&D that is performed in the European Union by universities or government laboratories. Interestingly, Australia includes spending abroad up to a limit of 10 per cent of total R&D outlays.

Despite the paucity of research on firms that receive such R&D incentives, we can identify three consequences thereof:

- Institution of *accounting systems*; for example, 87 per cent of Australian firms say they have set up ad hoc accounting arrangements (BIE, 1989).

- A *restructuring of R&D outlays* in favour of items included in the base (Eisner *et al.*, 1984). Nevertheless, the distortion caused by the change in relative prices casts some doubt with regard to relevance.

- A *reclassification (relabeling)* of R&D-related expenses. It is estimated that in the United States and Canada, some 14 per cent of outlays have been affected (Mansfield and Switzer, 1985; Mansfield, 1986). An Australian study confirms this order of magnitude with a rate of 19 per cent (BIE, 1989). Nevertheless, as we have suggested, this reclassification is a partially legitimate process stemming from the very organisation of the process of innovation and from the irregular nature of R&D activity.

In order to achieve some synthesis of all these variables, we have identified six types of incentives[8]:

- Incremental incentives that are quite long-standing and centralised, incorporating financing facilities by way of carry-overs of negative taxes and refunds in cases of zero tax liability. Bases are restrictive and amounts capped. The United States and France constitute this class, the aims and impact of which are intended to be relatively *neutral*.

- Incremental incentives that are very *simple* and aim at promoting either technological or local development. There are no ceilings. Belgium and Denmark have such systems.

- Fairly recent incentives, *with a special emphasis on SMEs*, involving tax concessions or incremental credits. Korea, the Netherlands and Australia are in this class.

- Taiwan, Singapore and Malaysia, like other Pacific rim countries, maintain a *broad definition* of the RDTI base but do not target small businesses in particular.

- Volume ceiling systems with *regionalisation* of rates and fairly narrow bases. This class comprises Italy, Spain and Canada.

- Lastly, Japan is the only country that openly uses both incremental and volume mechanisms, offering several of each type, although tax credit can be applied to companies on a selective basis. But Japanese incentives are not applied to specific regions.

R&D tax incentives and their environment

A system of R&D tax incentives cannot be analysed independently of its institutional environment. RDTIs interact not only with other R&D subsidies, but also with other types of tax incentives and corporate taxation in general. Therefore, while our focus until now has been solely on the "internal coherence" of RDTIs, in this part we shall look primarily at their "external coherence". While tax incentives are often used as a complement to budget provisions to promote R&D, they must be seen in the proper perspective.

Complementary measures

Most countries use budget provisions to promote R&D. The five conventional types of assistance identified below are used to varying extents, depending on the country.

Many countries, for a variety of purposes, use R&D *subsidies*. Some, like Canada (biotechnologies, materials), the United States (semiconductors) and France (computers), concentrate their assistance on specific fields. In many countries, this industrial focus is giving way to specific measures designed to strengthen links between universities or government laboratories and industry (e.g. Canada). Apart from R&D tax incentive systems, small businesses also benefit from numerous special programmes (Germany, Japan, United Kingdom). The United States requires federal agencies to earmark 2.5 per cent of their budgets for projects of firms with fewer than 500 employees.

Many countries assist firms with the *financing* of R&D projects. In most countries, including Australia, Belgium, Canada, Germany, Italy and Spain, this aid takes the form of cheap or, in extreme cases, interest-free loans. France and Sweden offer advances that have to be paid back only in the event of success. Japan and Sweden combine these two practices by granting loans on which the principal remains due but interest is payable only if the outcome is successful. Such practices tend likewise to target specific areas of research. Another practice is for the State to stand surety for a firm so that it may obtain financing. A more radical alternative is for the government to buy into a company (e.g. Spain, Korea).

The amounts involved in *government contracts* for R&D constitute alternative financing for the firms supplying the research. In many cases, incentives are already built into the prices. The beneficiaries of such contracts often get a combination of government payments, government incentives and tax credits (especially if mechanisms are volume-based). This phenomenon seems to be particularly marked in countries where R&D defence contracts account for a large share of aggregate government financing of corporate R&D (France, United States) (Lichtenberg, 1990).

A final means of stimulating research is to introduce *rewards* that increase the expectations of gain for firms investing in R&D. The United Kingdom has been applying this type of measure for a long time (Stoneman, 1991). The SMART programme uses this kind of incentive, but confines it to firms with fewer than 50 employees.

We shall not come back over the systems of *patents* which exist in all of the OECD countries, the disparities of which have been highlighted elsewhere (Foray, 1994).

Like RDTI mechanisms, other measures to promote R&D are also very diverse, underscoring the wide variety of motivations and means that can be used to achieve a single objective. Nonetheless, these other measures are generally adjusted because of tax incentive mechanisms, which in most cases have been introduced more recently.

The place of R&D tax incentives

Tying RDTI mechanisms in with other arrangements is a difficult exercise in which various organisms are seen to be pursuing different objectives. In order to avoid misinterpretation, it has proven useful to quantify R&D tax incentives. From the information available, it would appear that existing mechanisms have very different degrees of impact on corporate financing. These disparities can be analysed in two ways.

As shown by the second column of approximations[9] in **Table 6**, there are major differences from one country to the next with regard to the percentage of total government aid to R&D that tax incentives represent. The rate of cover[10] of corporate R&D expenditure by RDTIs is very low in certain countries -- less than 1 per cent in Italy, Denmark, Japan and the United States. There are average rates of cover, of some 4-6 per cent, in France and the Netherlands. Australia and Canada have far more extensive systems, since their rates of cover for 1991 were about 11 per cent and 19 per cent respectively.

Table 6. Estimated Share of RDTIs in Government Support (GovSup)

Country	GovSup/BERD[a] (1)	RDTIs/BERD[b] (2)	RDTIs/GovSup (2) / (1)
Italy	11.8%	0.01%	0.001
Denmark	7.9%	0.3%	0.04
United States	24.8%	0.8%	0.03
Japan	1.4%	0.9%	0.66
Germany[c]	11.9%	1.6%	0.13
France	22.3%	4.9%	0.22
Netherlands	7.5%	4.3%	0.57
Australia	2.6%	10.5%	4.05
Canada	9.6%	18.8%	0.96

[a] 1991 data; source: OECD (1994a).

[b] Calculated for years for which data were available.

[c] Data for Germany are those published by O. Keck (1993).

Compared to the ratio of government support (GovSup = contracts + subsidies) to domestic business sector expenditure (Table 6, column 1), tax incentives represent a minor share of R&D aid in Italy, Denmark and the United States. Although it covers less than one per cent of business enterprise sector expenditure on R&D (BERD), the Japanese system of tax credits nonetheless provides the equivalent of two-thirds of the aggregate support that the government furnishes in the form of contracts and subsidies. In the Netherlands, RDTIs represent a similar share, even if government support is far more substantial. If RDTIs accounted for 4.9 per cent of BERD in France in 1991[11], they represented less than a quarter of the aid paid out to business enterprises. Tax incentives for R&D are the primary instruments of science and technology policy in Canada and Australia, since they represent respectively two and four times the amounts spent on government R&D contracts and subsidies. Apart from the intrinsic differences between them, RDTI mechanisms also show great disparities in terms of the proportion of overall aid that they represent.

The coherence of R&D policies

The coherence between RDTI mechanisms and all other measures to promote R&D can be observed with respect to how the base of the tax incentive is defined. Two principles of coherence emerge -- as regards policy and financial aspects respectively.

Compared to the conception of R&D in America, Europe and Japan, that of Korea, Malaysia, Taiwan and Singapore includes the cost for broader activities in experimental R&D. For the latter, industrial development and the problems encountered in producing and marketing new processes and products represent knowledge that a firm can accumulate, and development usually takes precedence over research. As a result, tax incentive mechanisms of this sort encourage interaction between R&D, production and marketing; they remain effective for any recombination of previously acquired knowledge and for incremental innovations. These contrasting conceptions of innovation are reflected in the various national laws on intellectual property rights (see Foray, 1994 for an account). There would thus seem to be a strong similarity between the two sub-systems constituted by patents and R&D tax incentives.

A second principle of coherence that emerges from an analysis of existing mechanisms -- and one that has greater practical significance -- is the *non-redundancy* of assistance measures and other incentives. An R&D tax incentive is presumably combinable with other forms of assistance. As in the case of financial flows between private firms, the risk is that the same research will be paid for several times over. Defensible as this principle is in the context of promoting co-operative research, governments seem to be limiting the pluralities by restricting tax incentives. R&D subsidies are therefore in most cases deducted from the R&D budgets of firms. In France, this principle sets the real ceiling for the RDTI mechanism, since large firms get so much government money that fewer than 50 companies are affected by the FF 40 million ceiling. Similarly, the payments received from government agencies for R&D work are also generally deducted (except in France). Separation of the bodies responsible for granting subsidies or low-interest loans from those responsible for awarding R&D tax incentives, their varying degrees of centralisation and their lack of co-ordination make overlaps inevitable, however.

Ensuring coherence entails a proper balance between RDTIs and other R&D aid mechanisms. If the proportion of both are roughly the same, there is bound to be more duplication and conflicting objectives. Table 6 suggests that, from this standpoint, the coherence of R&D policies poses a particular challenge in Japan and Canada, but not in countries where the ratio of RDTIs to other forms of aid is either low (as in the United States and France) or very high (as in Australia).

R&D tax incentives and overall tax policy

Many countries, even if they have not introduced R&D tax incentives as such, have specific tax relief mechanisms to promote research and development. Exceptional tax deductions, reductions and exemptions are such measures which are alternative or complementary to R&D tax credits. Earlier on, the Australian and Korean incentives were equated with tax credits insofar as they allowed deductions in excess of the expenditure incurred by firms. In fact, these incentives are special deductions allowed to firms that conduct R&D, and they do not directly reduce the amount of corporate tax. Their effect is to inflate upstream expenses so as to reduce the taxable profits of firms and hence ultimately their tax liability.

Finally, there is the deductibility of a proportion of current spending on R&D. As already seen, the deduction may be as much as 200 per cent; in the United Kingdom it is applied at the rate of 100 per cent. In Korea, for example, current spending is deductible, and tax credits may be taken as well. In parallel, capital goods may be depreciated at preferential annual rates which would seem to range from 23 per cent in Korea to 100 per cent in the United Kingdom. Buildings given over to R&D are in many countries depreciated at an accelerated annual rate (33 per cent in Australia, for example) or allowed an exceptional depreciation rate for the first year (25 per cent in Taiwan and 50 per cent in France), with standard rates thereafter. This last arrangement would seem to be advantageous for firms with heavy financial constraints.

These *exceptional deductions* are ultimately closely akin to volume-based tax credits (Van Reenen, 1995). With a tax incentive similar to France's (Warda, 1994), the United Kingdom now seems disinclined to shift to a special system of tax credits. Two questions arise here: the first is whether the very term "tax credit" constitutes a signal whereby tax assistance is identified, understood and used; the second is whether the accounting definition of R&D is more effective than the R&D tax credit as a deterrent to unlawful reclassification of expenditure. Deduction rates, like the rates of R&D tax credits proper, can be regionalised. Belgium, Germany, Greece, Italy and Japan appear to use this particular arrangement to promote science and technology development in certain regions.

Most of the newly industrialising countries have active policies for importing technology, and particularly R&D results and patents. In Korea, there is a special tax incentive for such imports, since they result in a *lesser tax burden* (Kim, 1993). A third mechanism, used by Belgium, Malaysia, Singapore and Taiwan, is to exempt a firm from tax under certain conditions. This *exemption* is often long-term. For example, if the firm undertakes to perform R&D for ten years, it may be granted this benefit. The purpose of such exemptions is undoubtedly to obtain a regularity of R&D efforts over a long period and to avoid investment cycles. However, the advantage of such a measure over a volume-based R&D tax credit seems limited.

Vertical coherence may be gauged from two perspectives: how the various R&D tax incentives tie in, and how RDTIs fit in with the overall business tax system. The same principle of *non-redundancy* applies here: if governments do not want to assist businesses more than once for the same R&D, they have to ensure that tax credits cannot be combined with any of the other types of tax breaks mentioned above.

Analysis of RDTIs as they relate to corporate taxation provides insight into possible *interdependence* and, to a lesser degree, the possible effects of such a mechanism on corporate behaviour. Three aspects of this interdependence need to be emphasised:

- Tax incentives are not confined solely to corporate R&D outlays. For example, tax credits exist as incentives for investment (Japan, Italy), energy conservation and environmental protection (Germany, Australia, United States, Italy, Japan) and training (Sweden, France). While an analysis of these different systems would be beyond the scope of this paper, the fact that the problems of definition, application and evaluation are so similar argues in favour of a comparison. The principle of non-redundancy applies here as well, in that firms must not be allowed to classify the same expenditure as being for training, R&D and pollution abatement.

- The higher the rate of corporate income tax, the more firms have an incentive to make use of tax incentive systems to reduce their liability. In contrast, countries with low corporate tax rates (e.g. Taiwan, Korea, United Kingdom) provide little such incentive. As a result, RDTI rates cannot be analysed in isolation, with no regard to corporate tax rates.

- The interdependence between RDTIs and tax systems would appear to involve more than the incentive or disincentive effects of corporate tax rates. In their general reform of corporate taxation, Finland, Germany and Sweden simply did away with RDTIs. This denotes a certain *de facto* primacy of the rationality of tax policies over that of science and technology policies. The assumption is that the tax reform will ultimately benefit the firms best able to pursue R&D.

The complexity of these interactions makes it harder to delve any deeper into the coherence of the tax system as a whole, or even into the real impact of RDTIs; in conclusion:

- Extreme prudence is called for in making international comparisons, since the mechanisms put in place are not all the same, nor are tax systems. For this reason, neither the social benefits derived from R&D investment, nor the incentives, are the same either. With regard to this latter point, only Warda (1994) tries to take the entire tax system into account and simulates, under certain assumptions, the various incentive options available to a given firm in various countries. Here, Canada and Australia come first, ahead of the United States, Korea, France and the United Kingdom (Taiwan, Singapore and Malaysia are not taken into account).

- The interaction between RDTIs and their environment is an issue often neglected by economists and tax experts. In order to make a meaningful assessment of these incentives, further efforts are needed to improve methodologies and harness the complementarity between the various monographs and statistical and tax studies (*Financial Times*, 1994).

- The numerous criteria that enter into R&D investment decisions lessen the likelihood of tax-induced significant international transfers of R&D activities. In particular, when multinationals relocate their research facilities the aim is seldom to maximise tax benefits but rather to be closer to markets and to provide technical assistance to production units (Pearce and Singh, 1992; Hines, 1994).

NOTES

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2. On two occasions (1962-75, 1978-83), Canada introduced an incremental measure which it subsequently abandoned. Japan, in 1976, lowered the rate of its incremental mechanism and later brought in others that were based on volume. This co-existence of incremental and volume mechanisms was also to occur in France, in 1988 (for three years).

3. Here the base amount is equal to average turnover over a four-year period multiplied by average intensity of R&D expenditure relative to turnover (over three years).

4. The increment is calculated on the basis of the average expenditure over the previous two years.

5. Norway, Sweden, Finland, Austria and Denmark have similar mechanisms (BIE, 1989; IR&D, 1994).

6. Moreover, economists are divided as to whether or not pre-competitive co-operation can lead to competitive co-operation.

7. In the United States, expenditure on R&D commissioned to universities qualifies for tax incentives for "fundamental research".

8. Switzerland and Norway have not been included in the analysis, since too little information is available about them.

9. Most RDTI amounts were obtained at the OECD meeting. However, internal corporate expenditure is generally not available for such recent years. Data on government financing of firms are those provided by the OECD for 1991. The purpose of this table is therefore not to give exact figures, but to indicate orders of magnitude. Even though we have not elaborated on the German system, which has recently been abandoned, O. Keck's article (1993) enables us to estimate RDTIs for 1989. In this case, the first column has been calculated using Keck's data for 1987.

10. Expressed as aggregate tax incentives divided by national corporate R&D expenditure; because data are sparse and denominators not available for recent years, percentages are intended merely as orders of magnitude.

11. RDTI volumes were very substantial in France in 1991. The slowdown in activity since then has reduced credit allocations.

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NATIONAL R&D TAX SCHEMES

THE AUSTRALIAN 150 PER CENT TAX CONCESSION FOR R&D

Gordon NEIL, Former Counsellor, Permanent Delegation of Australia to OECD

Background

On 1 July 1985, the Australian Government introduced a tax concession for research and development expenditure undertaken by companies in Australia. The tax concession enables eligible companies to deduct 150 per cent of eligible expenditure incurred on research and development (R&D) activities against their taxable income. Subsequently, the incentive was reviewed by different Government agencies: in 1993 and 1994 by the Bureau of Industry Economics (BIE) and in 1995 by the Australian Industry Commission. The motivation for the introduction of a broadly based tax concession came from concern about the low level of R&D performance in Australia in comparison to other OECD countries and, in particular, the very low and declining level of R&D performance as a percentage of GDP in Australia's business sector.

Conditions and objectives of the concession

The tax concession is generally available to all firms incorporated in Australia and applied to all of their Australian R&D effort. The concession is not limited to some notion of an incremental increase over a previous period.

The value of the incentive is in inverse relation to the corporate tax rate. At the time of the introduction of the concession the tax rate was 46 cents for each dollar of taxable income. In subsequent years the tax rate first rose to 49 cents in the dollar but then fell to 39 cents and finally 33 cents in the taxable dollar. Under the original tax regime, the effective cost for R&D for a firm able to utilise the tax concession was reduced to 31 cents in the dollar. After the final reduction in the tax rate the cost of R&D for the same firm had increased to 50.5 cents in the dollar. Prior to the introduction of the 150 per cent tax concession for R&D, such expenses were deductible at a rate of 100 per cent. Thus the effective cost of R&D for a firm with sufficient tax liability to utilise the deduction was 54 cents in the dollar immediately prior to the introduction of the scheme.

The declared objectives of the tax concession were: to make Australian companies more innovative and internationally competitive through:

- (a) increasing companies' investment in R&D;
- (b) encouraging better use of Australia's existing research infrastructure;
- (c) improving conditions for the commercialisation of new process and product technologies developed by Australian companies; and
- (d) developing a greater capacity for the adoption of foreign technology.

The general requirements are that expenditure should exceed $ 20 000 before a claim can be made; the R&D should be performed in Australia (under certain circumstances up to 10 per cent of expenditure can be overseas); eligible R&D must involve appreciable novelty (i.e. innovation) or technical risk; results should be exploited for the benefit of Australia; and there should be a high Australian content (to prevent simple relocation of R&D equipment and personnel).

Associated eligibility requirements were that:

- claimants must register with the IR&D Board annually (and report);
- a company must be undertaking the R&D activity on its own behalf and not as a trustee or nominee of another entity;
- the company must incur a financial risk, control the conduct of the R&D and have effective ownership of the results.

Provision was also made for syndication of research to provide for pooling of risk in the case of expensive, high risk research. This provision is now used to enable tax loss companies to exchange losses for R&D funds (threshold $ 500 000). This was not anticipated in the original design of the scheme.

R&D performance over the period

In the lead up to the introduction of the tax concession the available data showed that business enterprise R&D (BERD) had generally declined both as a per cent of GDP from 0.42 per cent in 1971/72 to 0.26 per cent in 1978/79 and in constant dollar terms from $ 889 million to $ 665 million over the same interval.

The first results in the 1980's appeared to confirm this trend. However the results in subsequent periods of the 1980's showed a substantial but not uniform improvement. The BIE review (1993) could find no simple explanation for the dramatic increase in BERD from 0.25 per cent of GDP in 1981/82 to 0.34 per cent of GDP in 1984/85. They suggested that elements of an explanation could include: changes in definitions to include software; "gearing up" for the introduction of the tax concession; the effect of other government initiatives; and increased awareness of science and technology.

The BIE further suggested that the growth observed in 1985/86 might in part be explained by the incentive to reclassify activities previously not reported as R&D. Much of this reclassification may in fact have been entirely valid as firms now had a financial incentive to more fully report their performance. The further growth in 1986/87 may have been explained by the impact of the substantial deregulation within the economy and reduced protection which were part of the Government's economic reform initiatives.

The international comparison also tells an interesting story. At the time of the decision to introduce the tax concession, Australia had one of the lowest BERD performance figures in the OECD. This low relative position was a telling point in convincing the Government of the need for a significant and broad-based incentive. The growth in Australia's BERD during the 1980's was dramatic. Australia's average growth rate of BERD of 13 per cent was highest in the OECD (but behind that of South Korea, Singapore and Taiwan).

However, despite our strong performance throughout the 1980's our ranking climbed only one place from 17th to 16th amongst those countries ranked according to their R&D as a per cent of GDP. The continuing low ranking among OECD countries is largely explained by the fact that most of the countries ranked near Australia also experienced rapid growth through the 1980's.

Of course the BERD of any country is related to its industry structure and Australia's manufacturing sector is characterised by its relatively small size and orientation towards low technology sectors and a tendency for Australian firms to be in the low and medium R&D intensive industries within the manufacturing sectors. The BIE review specifically rejected the popular assertion that the high degree of foreign ownership in Australia had contributed to a lower R&D performance by firms. However one might expect ownership to affect the balance in the types of R&D undertaken.

Outcomes of the BIE review

The BIE was able to draw on a unique data base of information derived from the compulsory registration of firms wishing to have access to the tax concession. This extensive data base was supplemented by questionnaires to the registrants to gain a better understanding of the influences on their decision making. At the most basic level, the analysis showed that relatively few, approximately 5 per cent, of manufacturing firms undertook R&D. The firms which performed R&D tended to be concentrated in a few product fields (notably software, telecommunications, motor vehicles and parts, industrial machinery and equipment, computer hardware, pharmaceutical, and mining and other electronic equipment).

In addition, amongst those firms performing R&D, the bulk of the R&D was concentrated in a small group of large firms. The largest 5 per cent of R&D performers accounted for 63 per cent of total R&D. However, perhaps surprisingly, three quarters of the growth in real R&D expenditure over the observed period was accounted for by small and medium firms. This was in part due to the product fields in which the small and medium firms operated (i.e. high growth fields). One third of registrants for the concession were in a tax loss position and these firms accounted for a similar proportion of eligible expenditure. Thus a significant proportion of eligible R&D is undertaken by companies which are unlikely to be able to take immediate advantage of the tax concession.

Did the concession meet its stated objectives?

1. Did the scheme encourage more companies to do R&D?

The analysis showed no upward trend in the number of firms claiming the concession since the first year of the scheme. Around 200 new "consistent" performers entered the scheme each year. However this was roughly equal to the drop out rate and as a result there was in general no net increase of the pool of some 2 000 claimants. In this period it was estimated that there were some 48 000 manufacturing firms and some 550 000 enterprises in the economy.

2. Did the scheme encourage existing performers to do more R&D?

R&D expenditure of claimants appeared to have increased only slightly since the commencement of the scheme. One limitation of the review exercise was the relatively short time frame over which the concession had operated (1985/86 to 1989/90) at the time of review. It was estimated that the concession encouraged some 23 per cent of companies to do more R&D and that this translated to a 10 per cent to 17 per cent increase in R&D performance.

Overall it was estimated that the concession generated $ 0.6 to $ 1.00 additional R&D per $ 1.00 of tax revenue forgone. The low return was said to reflect the transfer effect or "gift giving" component (83 per cent to 90 per cent of research would have happened without support).

The BIE concluded that the challenge was to develop “incentive compatible schemes”. That is to find a method to encourage additional research without a transfer of funds to research which would be undertaken without support. The simple incremental approach was not considered workable under Australia’s corporate law (i.e. it would lead to rorting and “paradoxical” behaviour).

The BIE survey of R&D performers confirmed that the tax concession (or R&D cost) was only one factor in determining the level of R&D investment. Technical and market opportunities are clearly major factors. Nevertheless, the BIE concluded that on its best estimates the Net Social Benefits (i.e. sum of private benefits and spin-offs) the result is positive -- based on their best estimate of the multiplier effect. Their conclusion is however equivocal -- “on balance”.

Interestingly they are much more confident in the context of the more controversial syndicated R&D arrangements. Syndicated R&D was the subject of a BIE report in 1994 (Research Report 60) and is not the focus of this presentation. Here they suggested that the multipliers are much higher because the transfer effect is much less i.e. firms were less likely to perform the research in the absence of the funding and must demonstrate a greater commitment to a positive outcome.

A simplified model of syndicated R&D is as follows: the company with a tax credit derived from its performance of R&D effectively sells $ 10 million of tax concession in return for $ 2 million of R&D funding through a notional $ 10 million dollar sale of core technology plus the funds for R&D. The benefit of this process is that it brings forward the R&D for the firm by allowing them to realise the benefit of their tax credit earlier than they would otherwise have done. An additional benefit is that the scheme actually provides the funding and does not simply reduce the eventual cost of the R&D.

Investors inject $ 12 million into a syndicate and benefit from a reduced tax liability of $ 12 X 0.33 million or $ 3.96 million. Of the $ 12 million paid by the investors, the company retains $ 2 million and finally returns $ 10 million to the investors when the R&D company buys the syndicate at the prior agreed price. The overall return to the investor is:

$$\$\ 3.96M + \$\ 10M - \$\ 12M = \$\ 1.96M.$$

The BIE estimated that the net benefit to revenue forgone was over 50 per cent, while the net benefit to social cost is around 150 per cent.

3. Did the tax concession encourage a better use of infrastructure?

The researchers concluded that the role of the tax concession in increasing linkages between companies and the existing research infrastructure was small overall but was influential for a small not insignificant number of firms (15 per cent). Firms more often cited the need for specific skills or technical facilities as more important reasons for contracting out R&D.

4. Did the concession support the “commercialisation” innovation?

The BIE concluded that the concession could only have an indirect effect on these goals if one narrowly defined commercialisation as a final stage in the innovation process. However they observed that if one included the cost of R&D in the costs of commercialisation then the conclusions were different. In 30 per cent of the innovations (12 per cent by value) surveyed by the BIE the R&D costs constituted 75 per cent or higher of the cost of the whole innovation process -- in these cases the concession was viewed as a significant support. At the other extreme when non-R&D elements constituted 75 per cent or more of the cost of innovation as occurred in 21 per cent of cases (or 55 per cent by value) surveyed, the role of the concession was relatively minor. In the case of syndicated R&D, the subject of a BIE study (no. 60) in 1994, the conclusions were more sanguine about the concessions encouragement of commercialisation (narrowly defined) but only in certain cases.

5. Did the concession support the adoption of foreign technology?

The surveys of claimants suggested that the concession had little influence on the acquisition of foreign technology. Recipient and non-recipient firms had similar levels of foreign technology acquisition. Size of firm and foreign ownership were more strongly associated with acquisition of foreign technology. The tax concession provided more direct support for work associated with acquiring or modifying acquired foreign technology.

6. Did the concession contribute to making Australian firms more innovative and internationally competitive?

The BIE concluded that the concession “probably” contributed to improve competitiveness of industry through its encouragement of innovation. On balance “evidence” suggests that the concession has net benefits but the confidence level is low.

Review by the Industry Commission 1995

In September 1993 the Government commissioned the Australian Industry Commission to do a complete review of the role of R&D in industrial competitiveness and innovation, the effectiveness and efficiency of government programs in support of research and development and the role of government research agencies. The draft report was released in early 1995.

The Commission concluded that the tax concession has a number of desirable features:

- it allows firms to decide for themselves what R&D to undertake and when;
- it has relatively low administration and compliance costs; and
- the fact that is generally available limits the opportunities for firms to lobby for special treatment.

The disadvantages were:

- the assistance it provides can vary with changes to the tax rate;
- the benefit can also vary among recipients depending on dividend decisions of companies and the tax status of shareholders;
- the concession discriminates against companies in tax loss; but
- it can not discriminate against projects that would have gone ahead without the support it provides.

The Commission undertook its own quantitative assessment, using an economic model incorporating R&D. Their results were consistent with the BIE’s findings that the withdrawal of the tax concession would lead to a reduction in GDP. The Commission concluded that the 150 per cent tax concession has brought net benefits to the Australian economy and recommended its retention.

Conclusion

Two very detailed reports have concluded in favour of the continuation of the tax concession. They have indicated that the returns on investment are positive but not dramatic. As they point out the cost is only one factor in the decision to invest in R&D. Among the multiplicity of factors that must be considered are market opportunity, response to competition and technical imperative. However, the Australian experience, since the introduction of the tax concession, is that business expenditure on R&D has (despite some annual variation) increased substantially, from 0.34 per cent in 1984/85 to 0.71 per cent in 1993/94. In addition the average rate of increase of BERD of approximately 13 per cent is the highest in the OECD and twice the OECD average.

It must be acknowledged that over the same period Australia has undergone substantial economic reform which would have strongly influenced firm behaviour. However, it is worth noting that those countries with perhaps the most similar experience in terms of economic reform over this period, the UK, Canada and New Zealand, do not exhibit the same response of their BERD. It seems clear that although the tax concession was originally introduced as a temporary measure to provide an initial boost to business investment in R&D, it is now an integral and broadly accepted part of the total R&D system and likely to persist for some time to come. It should be noted, however, that it has been proposed by the government to reduce the level of the tax concession to 125 per cent.

This paper was largely based on the work of the Australian Bureau of Industry Economics, Research Report 50, *R&D, Innovation and Competitiveness* - *An evaluation of the research and development tax concession*, August 1993.

FISCAL POLICY TOWARDS R&D IN THE UNITED STATES: RECENT EXPERIENCE

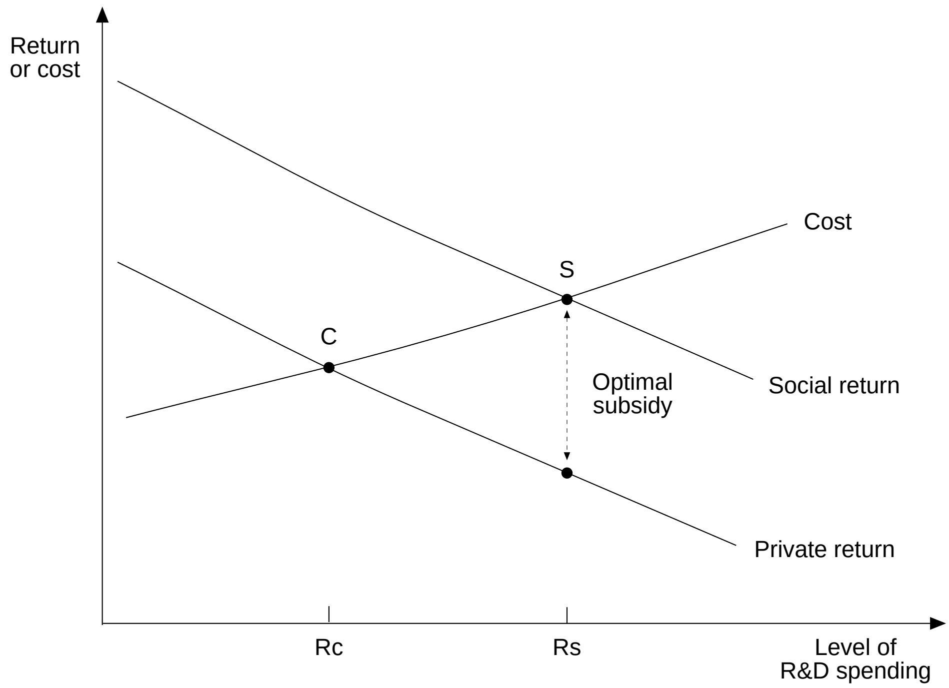
Bronwyn H. HALL, Assistant Professor of Economics,
University of California, Berkeley, United States[1]

This short survey has two parts: the first part is a review of the economic rationale behind the arguments that governments ought to have a fiscal policy toward innovative activity by private firms. The second part of the paper focuses on the US experience with the R&D tax credit, which the United States has now had in place for approximately 13 or 14 years[2]. The primary source for the results discussed in the second half of this paper is Hall (1993), a detailed, somewhat academic and technical examination of the performance of the tax credit in the United States[3]. This study covers data that goes through 1991, so that the results are slightly dated, but still of interest. Before presenting them, I will briefly review the market failure argument for government support of Research and Development spending. Professor Albert Link and Dr. John van Reenen have already discussed this argument today; I will expand further on what we mean when we say that the common policy evaluation tool used here, which is to compare induced expenditure with tax cost, doesn't necessarily give us the answer to the question we are really interested in. This discussion is followed by an overview of the types of government policies that the United States pursues in the Research and Development area because the tax credit is only part of the story. Finally I'll review what we in the United States have learned from our experience with the tax credit.

The market failure argument for R&D subsidies

Figure 1 is intended to show you the basic argument why many economists think that there is a very strong role for government policy in Research and Development. Here I am using R&D spending as a proxy for innovative input[4]. This graph focuses on Research and Development spending in a particular sector or industry, without specifying which one. On the horizontal axis is the dollar amount being spent and on the vertical axis is the marginal return to the last R&D dollar. The downward sloping curve shows the decline in returns as each additional R&D dollar is spent; that is, there are diminishing marginal returns to R&D in each sector (the best projects are chosen first). On the cost side, the assumption is that there is a flat or possibly slightly rising cost of each dollar that will be spent on R&D. A typical firm faces a whole menu of projects that it can undertake and if it is a well-managed firm, it will usually try to undertake the ones with the higher returns first. The graph indicates that if the firm does a small amount of R&D, it will choose the best projects first (those yielding high expected rates of return), gradually tracing out the curve as it expands its Research and Development activity up to the point where the cost of that Research and Development is being paid for by the return it expects to receive on the investment. I am abstracting here from all details that have to do with the intertemporal nature of the decision. Firms facing these curves should locate themselves somewhere at point C; they will do exactly the amount of Research and Development that they can pay for with the returns on the margin.

Figure 1 **The private and social return to R&D**

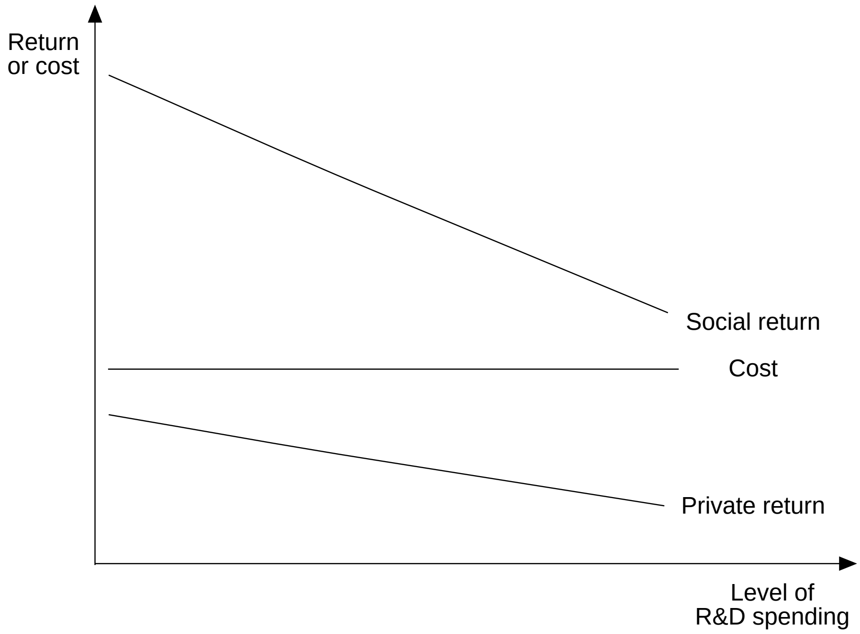


The view of most economists who have investigated the returns to innovative activity is that the returns to society from the research at point C are much higher than those received by the firm. There is a large amount of case study evidence on this in different industries and there is also quite a bit of econometric evidence. What this means is that most firms are not successful in capturing all the returns to their Research and Development, for two reasons: first, other firms learn something from the output of the R&D, become more productive or produce better products, and take away some of their market. Second, in many cases, for example, in the computing hardware industry today in the United States, the people who receive a large share of the returns are the consumers of products in that industry, rather than those who manufacture them. This occurs because the industry is highly competitive and the quality-adjusted price for this particular technology has fallen dramatically over the last ten years. In some other research, it is clear that most of the technical change in the computer industry has gone to price decreases, and not to returns to the firms that were undertaking research in that industry[5]. What I am trying to underline here is the idea that the returns to society from Research and Development activity in the computing hardware industry (among others) may be quite a bit higher than the returns to individual firms. Figure 1 shows this return as the higher curve and indicates that the optimal *social* level of R&D, the point of intersection of cost and return S, is quite a bit higher than the optimal *private* level of R&D.

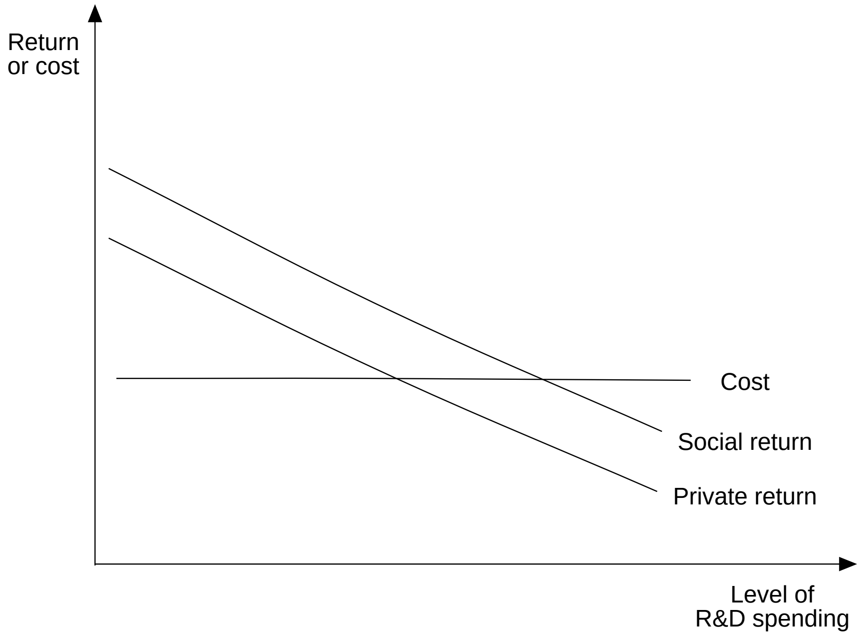
What the graph immediately tells you is that were you to try to get firms to undertake the optimal social level of R&D, you would want to figure out the gap between the actual cost of R&D at point S and the private rate of return to that level of R&D (this optimal subsidy is shown on the graph). The point S is a counter-factual point, so it is difficult to figure out the magnitude of the gap precisely and to subsidise each firm by exactly the amount that will cause it to choose the level of R&D spending at point S. Professor Link already referred to something that I think is rather important and which none of the policies I'm familiar with are entirely successful in: the magnitude of this gap may vary enormously across countries, industries, and types of technology. It will definitely vary across different kinds of

Figure 2 **Optimal subsidy to different kinds of industrial R&D**

(a) **Basic research (or generic technology)**



(b) **Development (or proprietary technology)**



Research and Development. **Figure 2** gives a couple of examples of this phenomenon. **Figure 2a** shows what I refer to here as basic research or science, but might also be generic technology. This graph is a very extreme picture, where the cost of doing Research and Development of the basic or generic type is always higher than the private return. In this extreme example, the firm will perform no basic research, whereas society would actually like a lot. The alternative is shown in **Figure 2b**: the development part of Research and Development or the proprietary technology part. This is the part for which firms are quite capable of capturing a large share of the returns (via patents or trade secrets, for example) and you get something where the social return is close to the private return and the gap between the difference in the two levels is going to be rather small, possibly not even of a size to worry a policymaker. These two figures are just illustration of a point that Professor Link was making[6].

Alternatives to tax policy towards R&D

In this section, I briefly review the alternatives to tax policies towards Research and Development; most of these policies exist in practice and work in parallel with fiscal policies. I have termed these policy solutions for under-investment in Research and Development, but what I've really done here is just categorise the standard economist's response when he or she sees a market failure like the one in Figure 1. The first two policy responses are classed as what economists call "internalising the externality". In other words, create legal structures that let the firms capture the returns completely and keep them from spilling over to each other or consumers. One way to do that is to allow R&D joint ventures. Another possible response is both older and more widely used: the government creates a property right in the output of innovative activity, such as patents, trademarks, copyrights, in order to allow firms or individuals to keep others from benefiting from their R&D.

The final policy response is the one that we are focusing on today: subsidising the activity. You will usually get more of it if the government pays for some of it. There are two alternatives here: one of them is direct government subsidy and the other one is tax incentives, for example, an R&D tax credit. Direct government subsidy is widely used and is an important part of the policy picture in the United States as it is in other countries. It is used for science and basic research (Figure 2a) and also for defence, space, and health Research and Development. My paper is not about direct subsidy, but that is not meant to imply that this is not an extremely important policy area. There is a substantial amount of evaluation evidence, mostly for the United States, that demonstrates that in certain sectors, such as the aircraft sector or the communication satellites sector, there are important spillovers from this type of research for commercial firms[7].

Tax policy and research and development

From the perspective of the firm, the tax system as a whole is very complex. Even the tax treatment of Research and Development has at least four components, of which the R&D tax credit is only part. There are other features of the tax system that have quite a bit of impact on firms for whom technology is important.

The first component of tax policy towards R&D in the United States and in many other countries existed before there was an R&D tax credit and by itself represents a substantial financial support to Research and Development activity. This is the fact that Research and Development spending may be expensed for tax purposes, corresponding to a 100 per cent write-off of the expenses associated with an investment that does not generate the corresponding income immediately. This means that R&D is subject to a kind of accelerated depreciation. 100 per cent would be the economic depreciation rate only if the returns to

Research and Development spending dissipated within one year, which is not a very realistic picture of most R&D. Thus by itself, expensing is already a tax incentive to R&D activity.

The second component of US R&D tax policy is the treatment of the income and expenses of multinational firms. In the recent past, we have had a rather complex and frequently changing tax law relating to the allocation of Research and Development expense against foreign source income. R&D is a problem for the framers of tax law precisely because of the information property of R&D: as an investment it creates an asset whose use for generating foreign source sales does not preclude its use in generating domestic sales. Therefore it is conceptually unclear how to allocate the associated expense. Allocation rules are an important issue because the tax rate that firms face on foreign source income is sometimes higher and sometimes lower than the tax rate they face on domestic source income. So it makes a difference whether you can deduct R&D expense against that income. It affects the after-tax cost of that R&D. These features of the tax system have been carefully reviewed and studied by James Hines of the Harvard Kennedy School of Government in a series of papers[8]. The conclusion he reached from his studies is that because of the way the taxation of foreign source income takes place, this rule tends to operate as an incentive biasing firms towards doing Research and Development which they can then transfer as technology to foreign locations. In other words, it gives the firms an incentive to do Research and Development that is targeted for sales in foreign countries. So these tax rules have an effect on the composition of R&D, but we have no idea whether it is positive or negative from a social point of view.

The third component of US tax policy that has implications for R&D investment is not commonly thought of in that regard, but I think it could be rather important. Much of industrial Research and Development in the United States in the last twenty years has been performed in the capital equipment industries, broadly speaking, that is, computers, motor vehicles, and almost any kind of machinery or equipment industry. This means that tax support to investment in capital equipment (such as an investment tax credit) have an impact on the demand for the output of the capital equipment industry, and *via* that route, also have an impact on the demand for industrial Research and Development. This is an aspect of the tax system that is not normally considered in the same breath as R&D, but could be quite important.

The final component of US tax policy toward R&D is, of course, the incremental R&D tax credit, which in the US cuts across all industries and all types of firms, including large firms. I believe that this is an important difference between the US policy and policies in some other countries; the credit is less targeted by firm type. The next section of the paper reviews what we have learned since the credit was installed in 1981.

The incremental R&D tax credit in the United States

This part of the paper reviews the evidence given in my (1993) paper on the effectiveness of the R&D tax credit in the United States and then gives some insights into the problems of design and implementation based on what we have learned. For those of you who are not familiar with it, the R&D tax credit in the United States is described in detail in Hall (1993). That paper gives every law change in the US since 1981 when the credit was first enacted. In its initial form it was a 25 per cent tax credit for “incremental” Research and Development: incremental meant the amount that the firm’s Research and Development spending increased over the level in the previous year. As time went on this increase was to be measured over the average of the previous three years. Over the 1980s, the rate was tinkered with continuously. From our perspective today the other important feature is that there was an attempt to target it towards what we might call purely technological Research and Development. Certain types of research in the social sciences and humanities were excluded and, as time went by, the definition of eligible R&D expenses was tightened to gear it towards technology; not towards generic or proprietary technology

Table 7. History of R&D tax treatment in the United States, 1981-91

Period	Credit rate	Corporate tax rate	Definition of base	Qualified expenditures	Section 174 deduction?	Foreign allocation rules
Jul. 81 to Dec 85	0.25	0.46 (0.48 in 1981)	Max. of previous 3-year average or 50 per cent of current year	Excluded: Research done outside US; Humanities & social sciences; Research funded by others	None	100 % ded. against domestic income
Jan. 86 to Dec. 86	0.20	0.34	Same	Narrowed definition to "technological research". Exclude leasing	None	Same
Janv. 87 to Dec. 87	0.20	0.34	Same	Same	None	50% ded. against dom. inc. 50% alloc.
Jan. 88 to Apr. 88	0.20	0.34	Same	Same	None	64% ded. against dom. inc. 36% alloc.
May 88 to Dec. 88	0.20	0.34	Same	Same	None	30% ded. against dom. inc. 70% alloc.
Jan. 89 to Dec. 89	0.20	0.34	Same	Same	None	64% ded. against dom. inc. 36% alloc.
Jan. 90 to Dec. 91	0.20	0.34	84-88 R&D to sales ratio times current sales (max. ratio of .16); .03 for startups	Same	None	Same

specifically, just towards technology in general. In practice what that has meant is that across most firms about 65 per cent of overall Research and Development spending as reported to the Internal Revenue Service and as reported in the public statements of the companies is actually eligible for the tax credit on average. The eligible portion will vary by firm, but it is difficult from public data to know by how much.

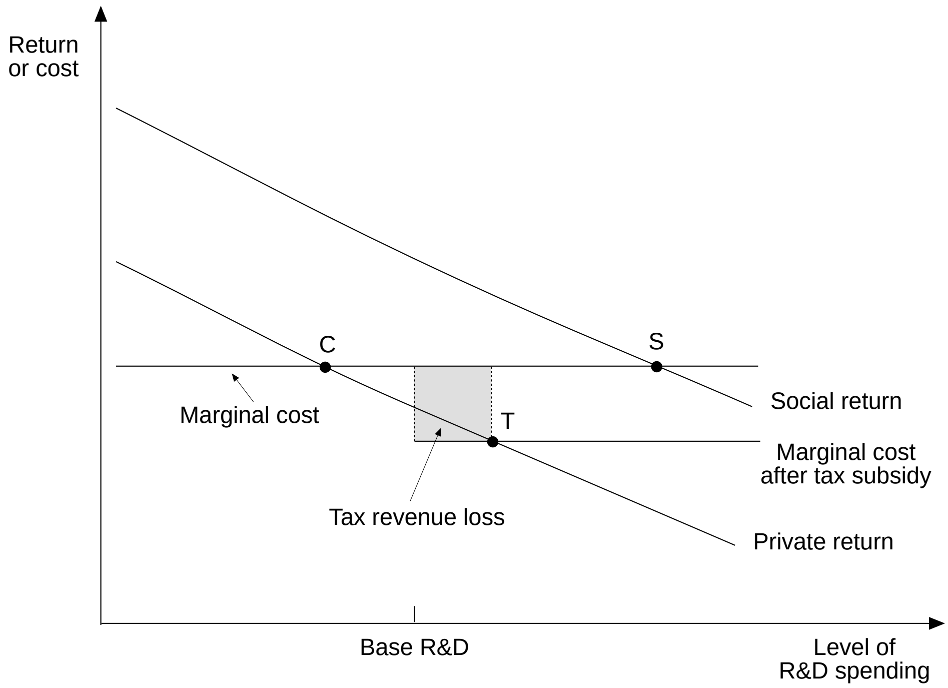
Figure 3 shows the Return-R&D schedule for a representative firm. The effect of the tax incentive on the cost of R&D in the United States is first to lower the average cost of that R&D over the range of R&D spending between the base level and twice the base level, and then to flatten it out after that. Base R&D is a level which is based on the firm's past behaviour. In this picture I have assumed that before the tax incentive the firm was at point C doing the optimal private amount of R&D. After the tax incentive they locate themselves at point T, and perform a somewhat higher level of R&D. The figure is not to scale; I have exaggerated the increase so that we can see it easily. The first point is that if the R&D tax credit were not incremental, the firms would face a lower cost all the way from zero R&D, and the tax revenue loss would be much larger than the shaded rectangle shown. An incremental tax credit is designed to do something rather sensible from the point of view of fiscal administrators, that is, to give the firm back only a small piece of the R&D, the part that will influence its behaviour, and to forget about all the inframarginal spending that is not going to change its decisions but will cost the treasury money.

The second point to be made with Figure 3 is that from the policy perspective, what we would really like to know is whether the social return equals the social cost at the current level of R&D, not the cost after the tax incentive, but the cost before. The usual measure for policy evaluation is completely different; it is the amount of incremental industrial R&D compared to the loss in tax revenue. That is only very loosely connected with the magnitude of the gap between the social and private returns at S, if at all. It might be that the social return from additional Research and Development is very high. If it is very, very high one may be willing to give up more tax dollars than the actual industrial R&D induced by the tax incentive. On the contrary, if the social return is only slightly higher than the private return, more industrial R&D might move the firm to a point where the social return is actually quite low. In this case, even though the tax credit induces more industrial R&D than the lost tax revenue, it would not be a good idea, because one could have spent that tax revenue on some other activity which had a higher social return.

What have we learned?

The first thing we've learned from our experience in the United States with the tax credit is that it works, in the sense that there is a response of industrial Research and Development to an effective reduction in the cost of that R&D faced by the firm (what we call a tax price). The tax price elasticity of industrial R&D in my results is larger than unity, which means that a 5 per cent effective R&D tax credit leads to a slightly greater than 5 per cent increase in Research and Development at the firm level on average. That number has been confirmed by Hines (1993) using different methods and focusing on the foreign and domestic source allocation rules. It has also been confirmed in work by Martin Baily and Robert Lawrence using macroeconomic data[9]. Unlike the these two papers, which relied on data for approximately 100 multinational corporations and data on two-digit industries respectively, my estimate is based on variation

Figure 3 **The incremental R&D tax credit**



across about 1 000 individual firms, mostly the largest US manufacturing corporations. That is, it comes from the fact that the effective benefit of the tax credit firm by firm in the United States is highly variable depending on tax positions of firms, and because of this, some firms will find R&D cheaper to perform than others; the evidence is that these firms actually do more of it, other things equal. The paper itself has a rather dramatic picture which shows the dispersion in effective tax prices. Some firms could see as much as 25 per cent reduction in price from the tax credit, while other firms actually see an increase in price. That is, there are few firms for which the tax credit was perverse; this usually happens when they do not benefit from the credit currently because they are tax-exhausted, but increases in spending raise their future R&D base level, thus costing them the credit in future years.

The incremental design of the tax credit and the variation in rates it produced is good news for the researcher because it makes estimation of responses feasible in a cross section of firms; on the other hand, it is actually bad news for policymakers. That is really not the way you want to run your policy on R&D: to have the impact depend on the tax position of individual firms. The bottom line in my paper was that the tax revenue cost by the late 1980s about a billion dollars a year, approximately equal to half the incremental industrial R&D induced by the credit (about $ 2 billion a year). So by the traditional evaluation method, the benefits exceeded the costs.

The second thing we have learned from the R&D tax credit concerns the longer run response of R&D spending. There are two pieces of evidence here: the first is that there is pure econometric evidence (based on the response by firms over time) that the longer term response is larger than the short-term. Second, as the R&D tax credit began to look quasi-permanent, the response was larger in the second half of the time period in the late eighties than it was in the first part of the time period[10]. That is, the firms took some time to learn about and believe in the tax credit. People who are familiar with the process of industrial innovation are very aware of the fact that spending at the firm level is frequently very slow to adjust, for obvious reasons. Half of the spending is on the salaries of highly paid scientists and engineers, whom you cannot hire and fire freely without some of the value of your Research and Development because a great deal of what has been created is knowledge embodied in the scientists and engineers themselves. Therefore we should not find the slowness of response to the tax credit surprising, and we should expect that permanent tax instruments of this kind should be more effective than temporary tax cuts.

A third area in which the United States gained some experience during the past ten years is in the area of enforcement, or the relabeling of expenses. When you subsidise an activity such as R&D, does it encourage firms to relabel things as Research and Development that weren't really Research and Development, causing a loss to the tax authority without a concomitant actual increase in R&D? The answer here is based on evidence from Internal Revenue Service (Treasury) auditors. Relabeling does occur but the amount is fairly small. I am relying on a study by the Government Accounting Office of the US Government, where they surveyed the auditors of over half the firms in my sample; that is, a very large number of firms actually got audited in fact on the R&D tax credit, but with relatively small result.

The fourth thing we have learned is that incremental design is very difficult. The law as written in the US means that the effective credit that firms faced was a 5 per cent reduction in their expenses on average, even though the targeted number in the legislation was 25 per cent. In fact, a normal firm that pays taxes every year and whose R&D is growing at a slow pace receives a 5 per cent credit on the margin and not 25 per cent. The reason is the incremental design where the base level of R&D is the firm's own past history. Every firm is different and every firm is unique, which makes it difficult to do anything other than use the firm's own data to determine its base level of R&D. It is extremely difficult to establish an industry standard R&D ratio because every firm is in a slightly different industry, has a different mix of products, etc. But once you start using a firm's own R&D pattern to set the base level you get strategic behaviour on the part of the firm, which will blunt the effect of whatever tax credit instrument you have designed. In 1989, the US Congress responded to this problem by setting the base at the level of spending for each firm in 1984-1988 and keeping it there. This will work for a few years; in fact the evidence is that it had the desired effect of raising the effective tax credit by eliminating strategic behaviour, at least temporarily. The problem is you can't do this forever because the world is changing, firms change what they do, and it is impossible to engrave in stone in the tax code that what these firms did in the late 1980s in Research and Development is what we will use in perpetuity as the base for their R&D. I don't have a clever solution for this. Using industry mean R&D to sales ratios is the only solution that suggests itself.

The final point is that the whole tax system matters. This R&D tax credit interacted with alternative minimum tax in the US system in such a way as to reduce its effectiveness, particularly for firms without profits and particularly during recessions when the AMT was more likely to apply. It also interacts with the foreign source income allocation rules. Therefore, when you're thinking about this particular policy, at least in the United States, and I suspect also in other countries, you have to think about what's happening in the rest of the tax system too.

NOTES

1. This paper was written while the author was a guest at INSEE/CREST, Paris. The hospitality of INSEE is gratefully acknowledged.

2. The correct term for this tax instrument is the “Research and Experimentation Tax Credit”, but it is commonly referred to as an R&D tax credit.

3. HALL, Bronwyn H. (1993), “R&D Tax Policy During the 1980s: Success or Failure?”, *Tax Policy and the Economy* 7, pp. 1-35.

4. R&D spending is only a proxy for innovative activity, it is not the whole story. It is the most quantifiable number we have and many of us who have worked in this field for a long time have spent a great deal of time trying to use other numbers, mainly things like counts of innovations, counts of patents, other types of numbers. Those numbers turn out to be highly correlated with this number. Therefore statements you make about this number (the dollars being spent on Research and Development in a particular sector or a particular industry) usually are statements which you would make if you were trying to measure other innovative inputs or outputs, but not always. Since the tax credit is also targeted toward the R&D spending number, it is the sensible thing to focus on here.

5. MAIRESSE, Jacques, and Bronwyn H. HALL (1995), “Estimating the Productivity of Research and Development: An Exploration of GMM Methods Using Data on French and United States Manufacturing Firms”, forthcoming in VAN ARK, Bart and Karin WAGNER (eds.), *International Comparisons of Productivity Growth.*

6. In the design of the tax credit and policy in the United States, this point that some of Research and Development is more worthy, so to speak, of public support than other R&D is taken into account via the definition of eligible R&D but the instrument is quite imperfect.

7. See, for example, HERTZFELD, Henry R. (1985), “Measuring the Economic Impact of Federal Research and Development Investments in Civilian Space Activities”, or MOWERY, David C. (1985), “Federal Funding of R&D in Transportation: The Case of Aviation”, Papers commissioned for a Workshop on The Federal Role in Research and Development, National Academies of Science and Engineering, Washington, D.C., November 21-22.

8. HINES, James R. (1993), “On the Sensitivity of R&D to Delicate Tax Changes: The Case of Multinationals”, in *International Taxation*, ALBERTO, Giovannini, R. GLENN HUBBARD, and Joel SLEMROD, eds. (Chicago: University of Chicago Press). Also, HINES (1994), “No Place like Home: Tax Incentives and the Location of R&D by American Multinationals”, *Tax Policy and the Economy,* Volume 8, pp. 65-104, and HINES (1994), “Taxes, Technology Transfer, and the R&D Activities of Multinational Firms,” National Bureau of Economic Research Working Paper No. 4932 (November).

9. BAILY, Martin Neil, and Robert Z. LAWRENCE (1987), “Tax Policies for Innovation and Competitiveness”, (Washington, D.C.: Study commissioned by the Council on Research and Technology). Also, BAILY and LAWRENCE (1992), “Tax Incentives for R&D: What Do the Data Tell Us?”, (Washington, D.C.: Study commissioned by the Council on Research and Technology).

10. The tax credit is not yet permanent in the US, but it has been renewed every year, often in the omnibus budget reconciliation act for the new fiscal year in September in which Congress tends to tie up the loose ends that they didn’t manage to pass into law earlier.

TAX CREDIT FOR RESEARCH ("CREDIT D'IMPOT RECHERCHE") IN FRANCE

Jeanne SEYVET, Head of the Industrial Research Promotion Department,
Ministry for Higher Education and Research, France

The tax credit for research (CIR) was introduced in 1983 and the reasons behind the decision at that time can be summarised as follows. First, industrial research and development expenditure as a percentage of GDP was relatively low in France. We also felt that action was needed specifically to promote industrial research, and that at the same time we had to reduce the excessive concentration of such research within major firms and some high-tech sectors; we therefore sought to implement wide-ranging measures, unlike the direct budget appropriations used in more conventional policies.

In 1982 we also realised that the existing scheme for promoting research and technology transfers would not be sufficient to disseminate technological know-how throughout the economy; in other words, research did not irrigate enough of the industrial fabric because it was concentrated in certain enterprises and high-tech sectors; we also wanted to target other firms and sectors through simple, industry-wide measures that did not require prior control -- hence the choice of a tax credit mechanism to promote investment in R&D. As in the US system, the mechanism is an incremental one. It is available to industrial, commercial and agricultural enterprises, and therefore to a very wide range of firms. The activities concerned are basic industrial research, applied research and experimental development.

The tax credit base comprises labour costs, current expenditure and other items which I shall come back to in a moment. But I should like to point out first of all that the tax credit as it now stands is calculated as half the difference between research expenditure in the current year and average expenditure in the two previous years, and that it is capped at FF 40 million per firm (**Table 8**).

The R&D tax credit can be positive or negative (**Table 9**). If it is positive, it is deducted from corporate profits tax and, where it exceeds the profits tax, the surplus can be spread over the next three years; any surplus at the end of this period is refunded by the government. In the case of new firms, however, any surplus is immediately refunded. If the tax credit is negative, it is carried forward from one financial year to another until it can be deducted from a positive tax credit. Another point to be borne in mind is that a firm is not required to refund a negative tax credit.

Table 8. **Calculation of the R&D tax credit in 1995**

$$50\% \left[(n) - \frac{(n-1)+(n-2)}{2}\right] \quad \text{with a ceiling of FF 40 million}$$

Example:

R&D (year (n-2))*index = 500
R&D (year (n-1))*index = 600
R&D (year (n)) = 600
TCR (year (n)) = 0.5*(600 - (600+500)/2 = 25

With regard to the tax credit base (**Table 10**), the breakdown of research expenditure shows that labour costs plus current expenditure (which is set at a flat rate of 75 per cent of labour costs) account for over 75 per cent of the total tax credit base; the mechanism therefore mainly concerns labour costs. Another important item (15 per cent of the base) is the expenditure on research conducted by approved outside bodies. Another breakdown showing expenditure expressed as a percentage of labour costs is given in Table 10 purely for comparative purposes, as the nominal rates for some tax credits are related more directly to labour costs.

Table 9. **Positive and negative R&D tax credit**

Positive tax credit (RTC>0)

- It is deducted from the corporate tax.
- If it is superior to corporate tax, the surplus is deferred to the three following years. At the end of three years the surplus will be reimbursed by the government.
- As an exemption, new enterprises get the reimbursement for the first year.

Negative tax credit (RTC<0)

- It can be deferred perpetually and will be deducted from the positive tax allowance of the next year
- No reimbursement is requested from enterprises

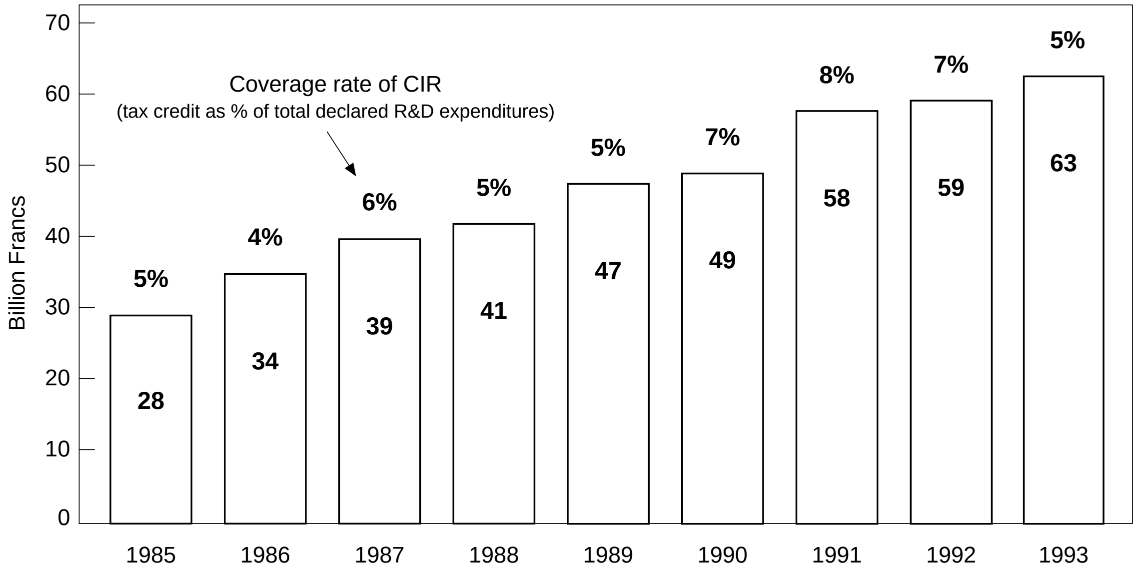
Table 10. **Breakdown of R&D expenditures covered by the CIR scheme**

Type of expenditure	% to total R&D expenditures	% to labour costs
Labour costs	43.2%	100%
Other operating costs (= 75% of labour costs)	32.6%	75%
Expenses for contract-out research	15.5%	36%
Provisions for amortisation	6.9%	16%
Expenses for patenting	1.6%	4%
Expenses for standardisation	0.2%	0.4%
Total	100.0%	230.7%

Figure 1 gives the data for research expenditure actually declared for tax credit purposes. It shows that the scheme is still expanding, since we are at a declared research expenditure of FF 60 billion and coverage rates of 5 to 7 per cent, depending on the year -- close to the US rate of 5 per cent. To give you an idea of what this means -- and here it is rather the figure of 65 per cent quoted for the United States which serves as a reference -- **Figure 2** shows two curves, one depicting company R&D expenditure as recorded by the usual statistical surveys, the other the much lower expenditure declared in connection with the tax credit. Some precautions must obviously be taken when comparing these figures. First, the populations are different, since the R&D survey is based on the Frascati Manual and therefore includes all enterprises with at least one full-time equivalent researcher, while this is not at all a criterion for the fiscal measure. There are also differences in the base which explain the quite substantial gap between the two curves.

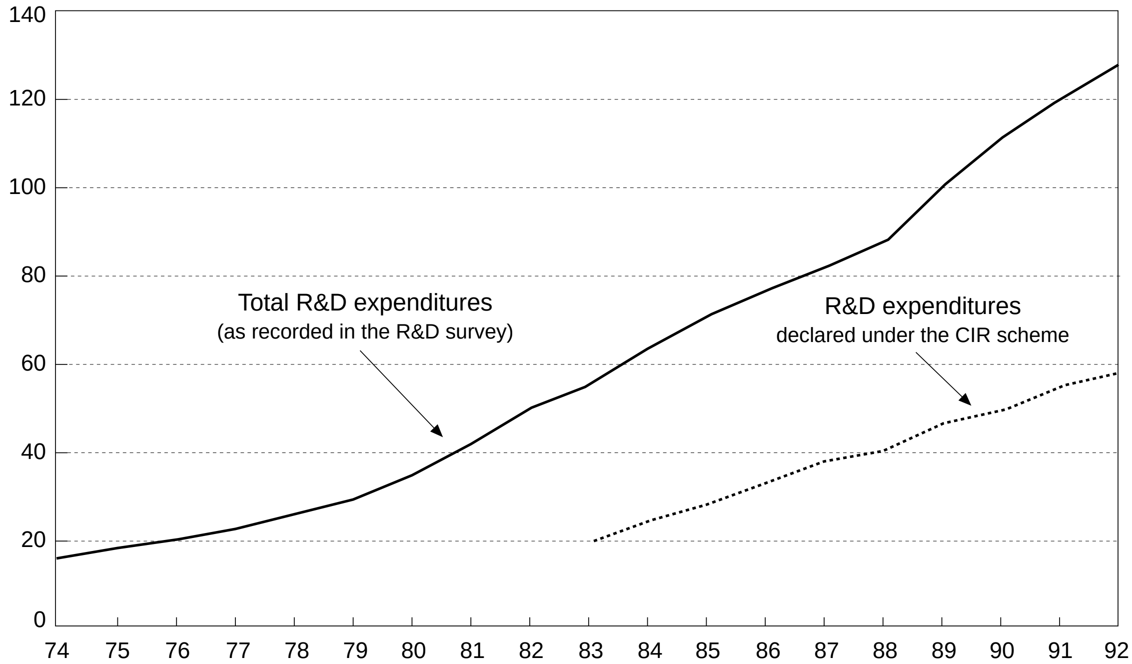
Figure 3 shows the number of firms affected by the R&D tax credit mechanism: the first curve depicts all firms making a declaration, i.e. all firms in the scheme, including those obtaining no benefit from it since their tax credit was negative in the year concerned; the second, however, refers only to firms actually benefiting from the scheme. It may be pointed out that the number of actual beneficiaries and, to a lesser extent, the number of firms submitting declarations have decreased in recent years.

Figure 1 **The "Crédit d'Impôt Recherche" (CIR) in France**
Evolution of total R&D expenditures which are declared for tax credit and coverage rate of tax credit



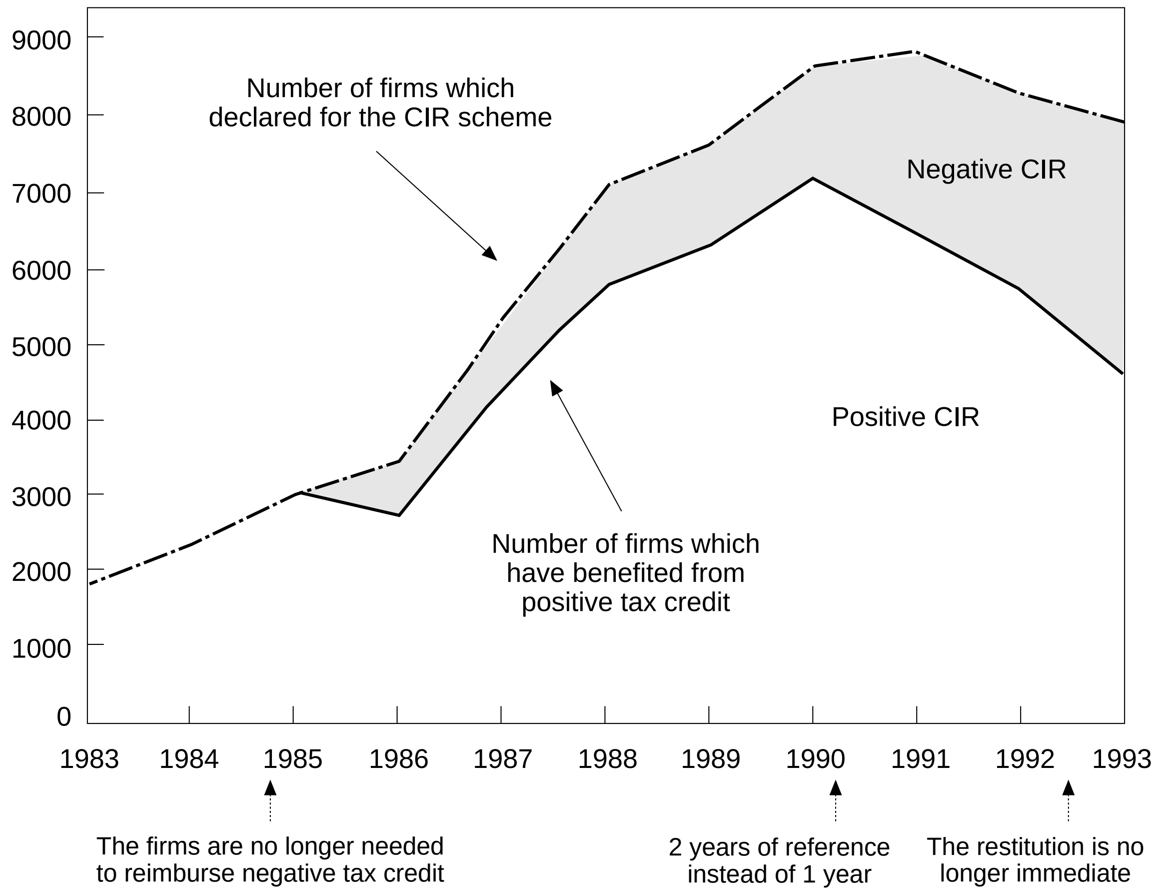
Source: MESR/DDRI

Figure 2 **R&D expenditures reported in the R&D survey compared to R&D expenditures declared under the "Crédit d'Impôt Recherche" (CIR) scheme**
(billion Francs)



Source: MESR/SDSP

Figure 3 **The "Crédit d'Impôt Recherche" (CIR) in France**
Number of declaring and benefiting firms

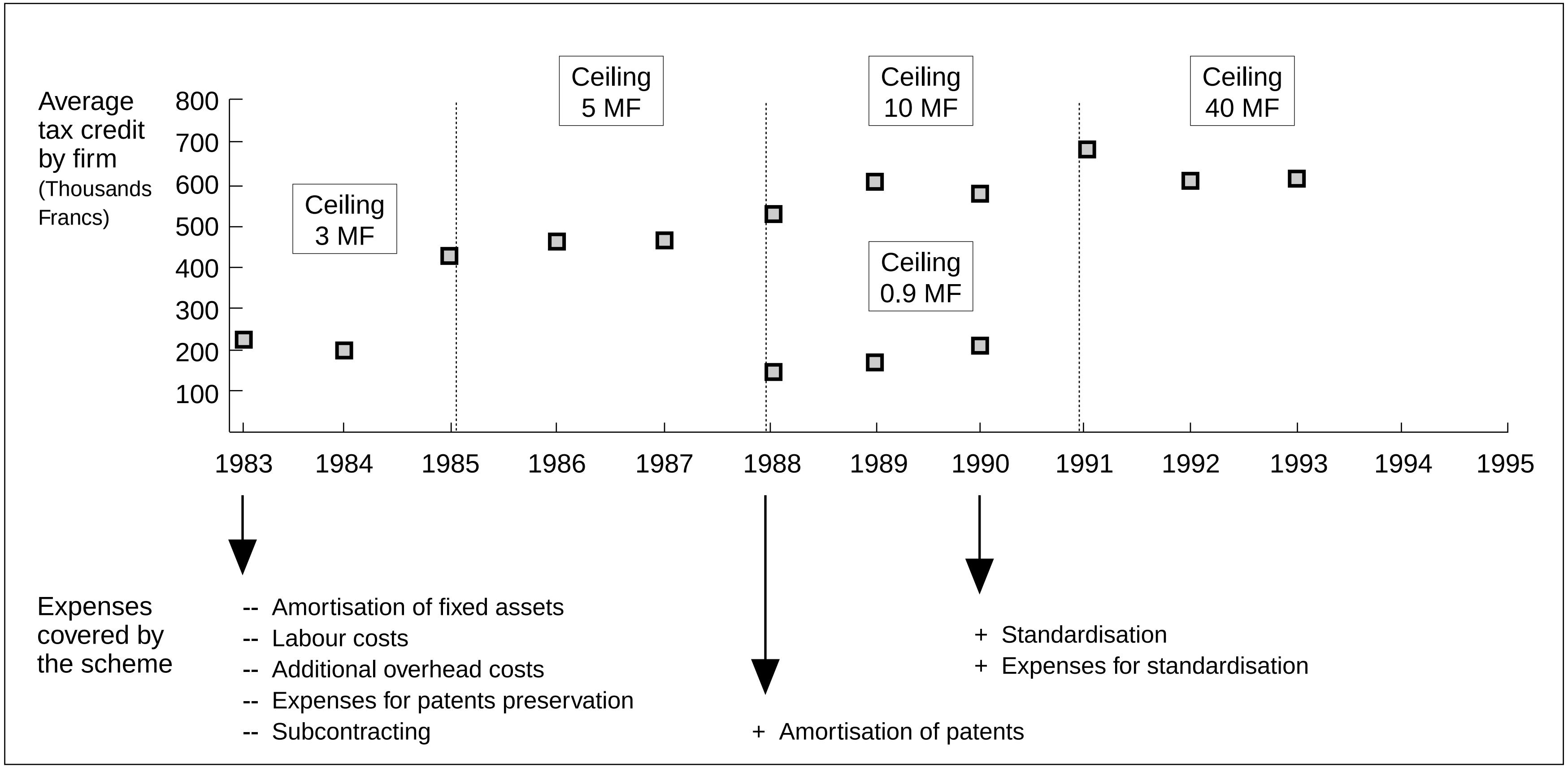


Source: MESR/DDRI

It can be seen that the tax credit is very sensitive to the country's general economic climate, as shown by the effect of the recession in the early 1990s; this sensitivity is also apparent with regard to other parameters, in particular the amounts of tax credit awarded (**Figure 4** also shows the main changes to the scheme over the years).

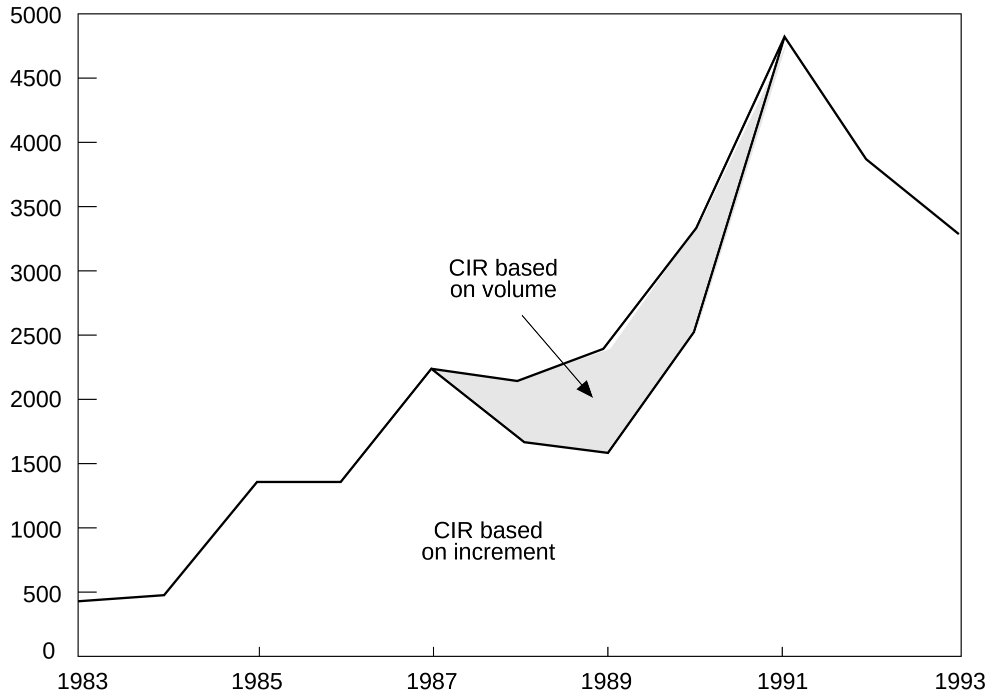
The cost to the government of the R&D tax credit is shown in **Figure 5**. It amounted to FF 3.5 billion in 1993. The darker section of the Figure covers a three-year period during which we had a somewhat different type of tax credit, which was calculated with respect to the increase in R&D expenditure between a given year and the 1987 financial year. This tax credit was introduced for small firms and was restricted to FF 0.9 million per firm, or much less than the FF 40 million to which I previously referred. During this period the incremental tax credit declined because of substitution between the two options. This decline testified to the limits of the formula based on an expenditure increase: as firms cannot increase their R&D expenditure indefinitely, the decline in tax credit entitlements observed on the Figure is no doubt partly attributable to the measure's reduced impact at that time.

Figure 4 **Evolution of the "Crédit d'impôt Recherche" (CIR) in France**



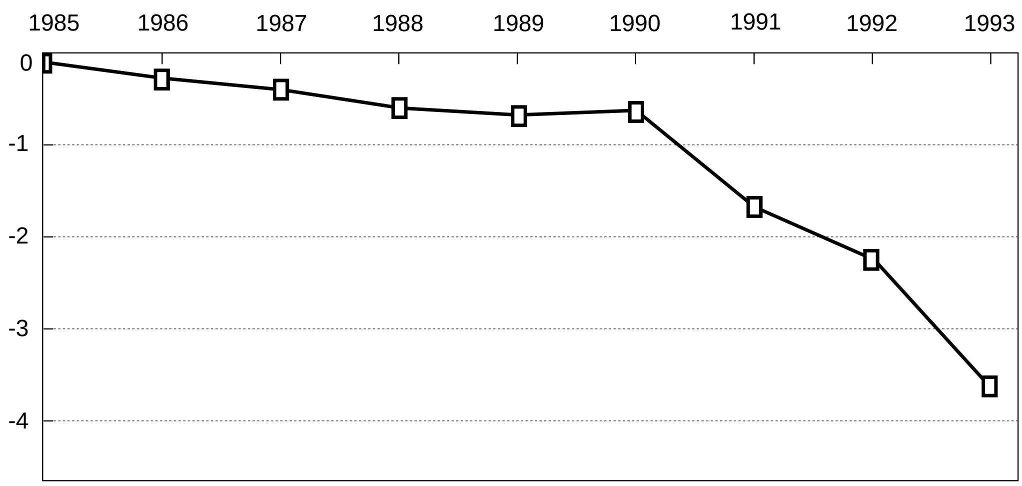
Source: MESR/DDRI

Figure 5 **Total cost to governement of the CIR**
(million Francs)



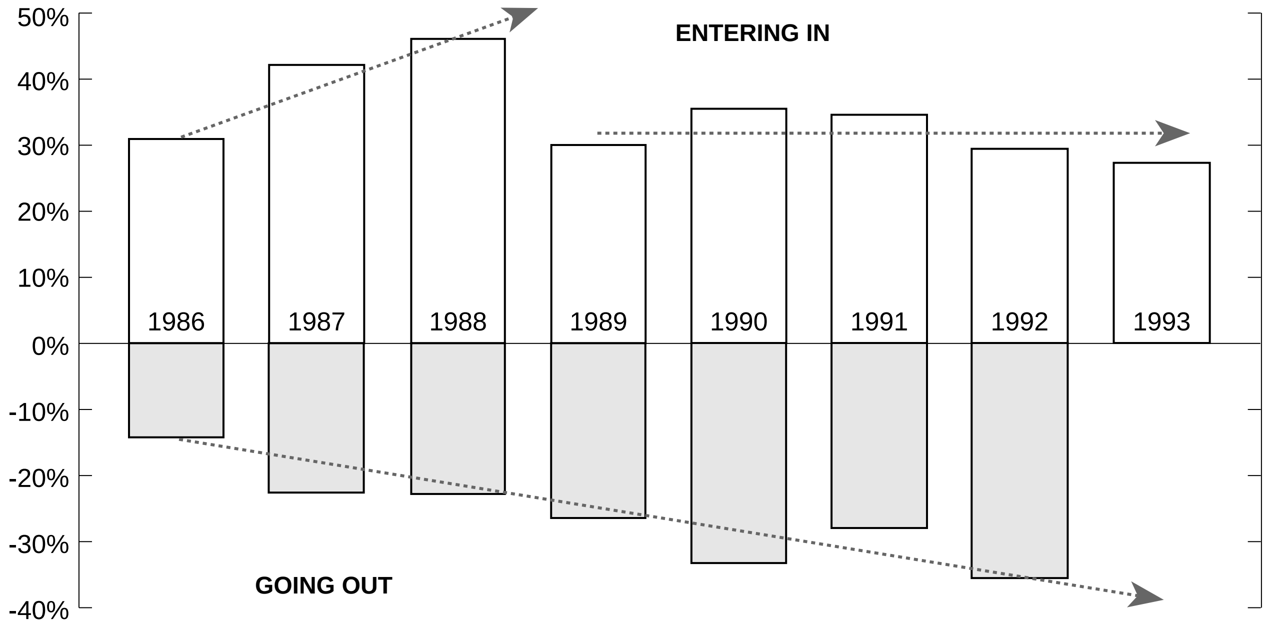
Source: MESR/DDRI

Figure 6 **Evolution of negative tax credit amounts**
(annual cumulative amounts; billion Francs)



Source: MESR/DDRI

Figure 7 **Yearly change of numbers of firms entering in and going out from the CIR scheme**
(percentage to annual declaration)



Source: MESR/DDRI

Let us now look at the trend in negative tax credits (**Figure 6**): they were quite stable for many years and then suddenly accelerated to a very high level of FF 3 billion. This is an extremely interesting development and I shall suggest some possible explanations for it as part of my conclusions.

Another development is worth noting. **Figure 7** shows annual changes in the percentage of new firms entering the scheme (for example, over 40 per cent of the population in the year 1988 consisted of new firms). This raises questions since it means we are getting through to an increasingly wide population of firms -- which was the objective -- but at the same time the number of firms withdrawing from the scheme (for example, over 20 per cent of the population withdrew between 1987 and 1988) is also very high. The number of entries during the first few years rises and then levels off, while the number of exits increases considerably. This is in line with the trend in negative tax credits.

What conclusions can we draw from all this? Firstly, the scheme has obviously resulted in a very substantial increase in the number of firms which declare they are conducting research as defined by the Frascati Manual; the number of small industrial enterprises conducting R&D has risen by a factor of three since the scheme was introduced. The objective of getting through to a new, wider population of firms and of stimulating the development of industrial research in such firms has unquestionably been achieved.

Although it is difficult to assess the impact on the total volume of research expenditure in France, there has been a quite marked structural effect on the breakdown of expenditure by sector of activity and also by firm size, particularly in the least research-intensive sectors. This was also one of the initial objectives which have been achieved. Another positive aspect is that the R&D tax credit is heavily weighted in favour of small enterprises, unlike direct budgetary support. The benefits of the scheme are, relatively speaking, focused more on the SMEs. There is obviously a ceiling effect, but this was intended, and the scheme has been extremely successful in this respect.

Lastly, a population of a particular type of firm emerges from the various indicators I have given: very many small firms that are receptive to innovation make a very fleeting appearance within the present R&D tax credit scheme. They enter the system because they want to carry out innovation: they use it to structure or increase their R&D effort, and even to recruit or train staff in order to acquire new proprietary know-how. But subsequently they are unable to go on increasing their research expenditure and probably build up a negative tax credit, which means that they cannot derive any further benefits from the scheme. So they leave it. We have therefore looked quite closely at this limited, incremental type of innovation, which in small firms is perhaps cyclical, but in any case neither regular nor continuous. We have realised that this kind of activity, which we call “informal research”, has an important place in the French economy.

This gives rise to very many extremely interesting questions with regard to the future of the scheme. It will run to the end of 1995 and its renewal is to be debated by Parliament in connection with the draft Budget for 1996. At the same time the question is what type of firms should be targeted and what type of development we want. I think we have clearly shown two really different types of behaviour: that of large firms which are firmly established within the scheme; and that of more transient users consisting of smaller, very dynamic firms whose efficiency we are trying to measure in order to match support more closely to their needs.

FISCAL MEASURES TO PROMOTE R&D IN JAPAN

Hirohisa HIRAMATSU, Director, Technology Promotion Division, MITI, Japan

In reviewing tax incentives for R&D in Japan, one should keep in mind that the share of private R&D is exceptionally large (**Figure 1**) and private R&D expenditures have been decreasing in recent years (**Figure 2**). Tax incentives are offered for technological development in order to encourage R&D activities in the private sector, as well as other fiscal measures such as low interest loans and subsidies for special purpose R&D.

In Japan, corporate tax is imposed on a company's profit on a fiscal year basis. Companies have to pay basically 37.5 per cent of their profit as corporate tax. This basic rate of 37.5 per cent is relatively high among OECD countries. As a result, as shown in **Table 11**, the ratio of corporate tax to the total amount of tax revenue of the government is in Japan the highest in major OECD countries.

Table 11. Ratio of corporate tax to total tax revenue

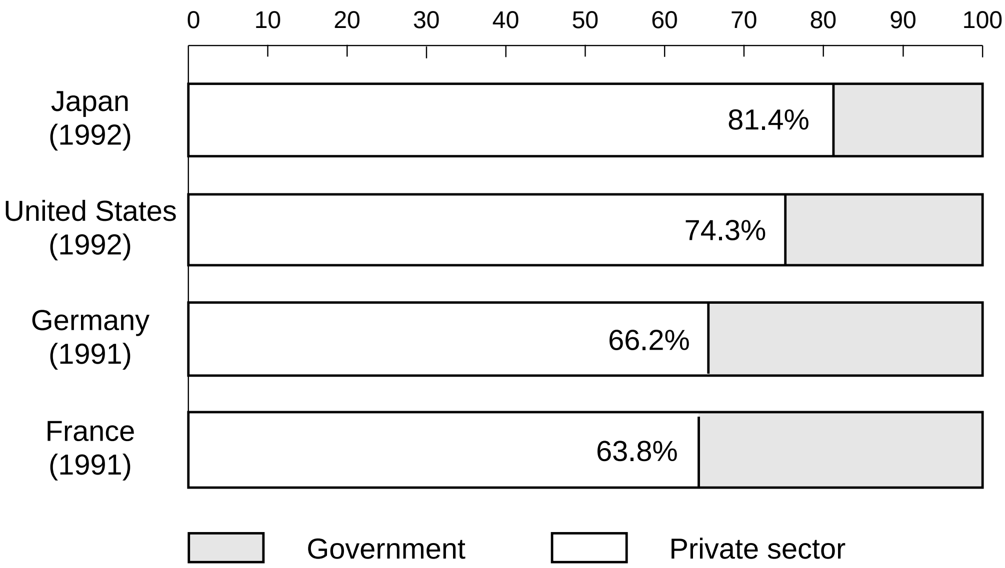
Japan	United States	Germany	France	United Kingdom
24.4%	15.4%	4.9%	9.5%	9.7%

Table 12 summarises tax incentive systems offered for R&D activities in Japan. There are five different categories.

1. Tax credit for increasing R&D expenses

The credit for increasing R&D expenses is the biggest and most important one. The mechanism of this tax credit for increasing R&D expenses is shown in **Figure 3**. An amount equal to 20 per cent of the overrun on current qualifying R&D expenditure over the highest amount of the previous years' R&D expenditure is deductive directly from corporate tax. This system was formulated in 1967, and has considerably contributed to the active R&D efforts of the manufacturing industry in Japan. When this system was started, the rate of deduction was higher than 20 per cent of the excess of company's R&D expenditures. The rate was revised and changed to 20 per cent in 1976, and has not been changed until now. In this system the upper limit of tax deduction has been set up at the level of 10 per cent of corporate tax.

Figure 1 **Share of R&D expenditures financed by the private sector**



Note: Defence-related R&D expenditures are excluded.

Figure 2 **Trend of R&D expenditures by the private sector in Japan**

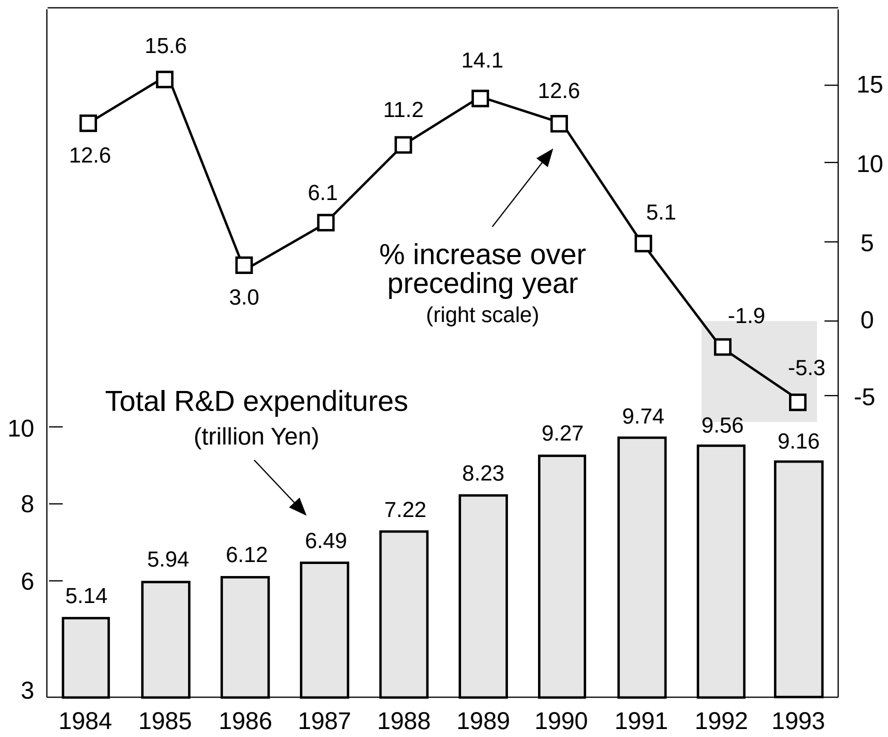


Table 12. Tax incentives for R&D in Japan

1. Tax Credit for Increasing R&D Expenses

2. Tax Credit for R&D by Small and Medium Sized Enterprises

3. Tax Credit for Special R&D Expenses
   a. R&D with National Research Laboratories (and Universities)
   b. R&D with Foreign Research Laboratories
   c. R&D for Special Purpose
      (Efficient Use of Energy, Utilisation of Recycled Resources and Orphan Drugs and Medical Appliances)

4. Tax Credit for R&D Facilities for Fundamental Technologies

5. Tax Incentives for Technological Research Associations
   a. Special Depreciation of Charges Imposed on Members by Associations for the Acquisition of Fixed Assets
   b. Advanced Depreciation of Fixed Assets acquired by Associations

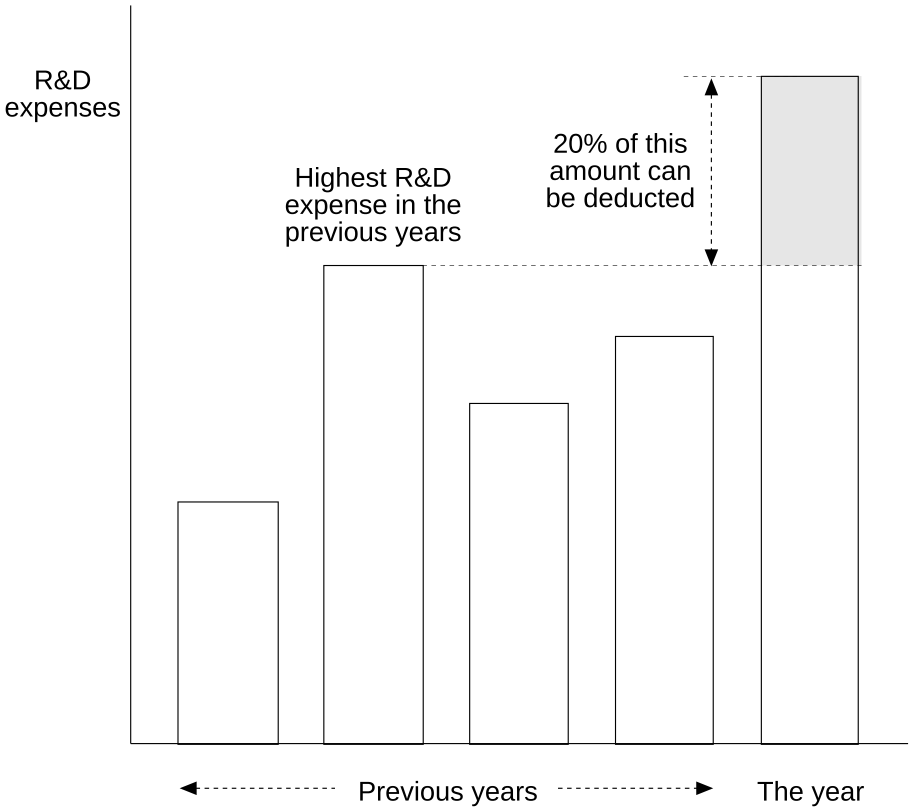
Note: 1, 2 and 3 above can be applied on a selective basis

Nowadays it is estimated that the total amount of incentives by this system is annually 75 billion yen, roughly equivalent to US$750 million. This system is now completely incorporated in each company's decision making process. When a company decides on an R&D plan, this system is always taken into account particularly among financial management staff.

2. Tax credit for R&D by SMEs

In the case of small and medium-sized enterprises, another tax credit system has been prepared. 6 per cent of the R&D expenditure incurred by small and medium-sized enterprises is deductible from corporate tax. The upper limit has also been set at the level of 15 per cent of corporate tax. In this system, the definition of small and medium-sized enterprise is strictly determined by law stipulating that capital should be less than 100 million yen or that the number of employee should be less than 1 000 if they do not have capital stock. An affiliated company of large-scale enterprises is excluded.

Figure 3 **Tax Credit for Increasing R&D Expenditures**



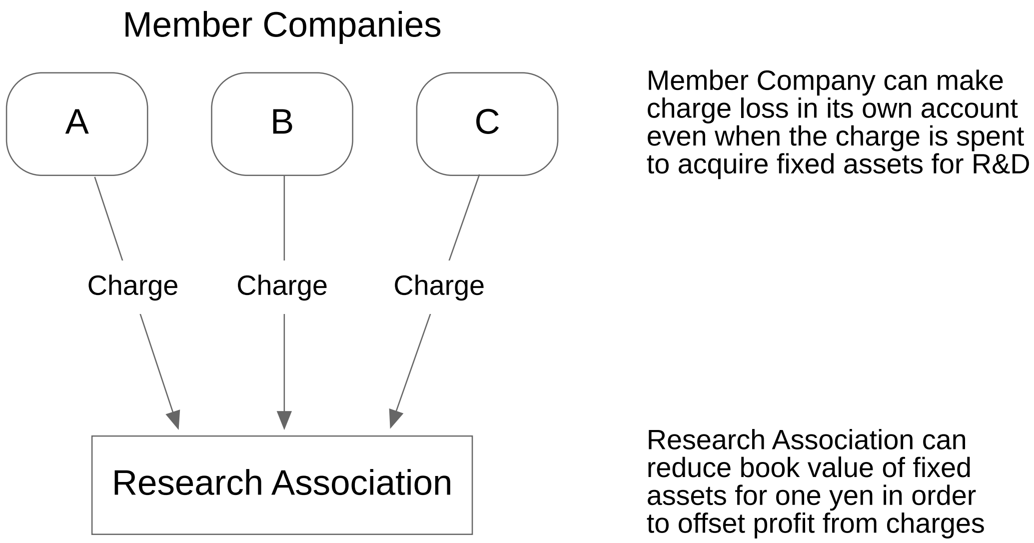
Note: Upper limit of deduction is 10% of corporate

In the case of such small enterprises, it is not easy for them to increase R&D expenditures continuously. In this case, companies do not have to increase R&D expenditure in order to enjoy tax incentives. In stead, the rate of deduction is only 6 per cent of companies' R&D expenditures. It is estimated that the total amount or tax deduction by this system is annually 10 billion yen, roughly equivalent to US$100 million.

3. Tax credit for special R&D expenses

A tax credit system for special R&D activities has been also offered. An amount equal to 6 per cent of total expenditures paid for the following special R&D activities is deductible from the corporate tax. The first case is research expenditures for joint research with national research laboratories. This system was started in 1993 in order to promote joint research between private company and research institute in the field of basic science and technology. At the moment, the total amount of corporate tax deducted by this system is estimated at a few hundred million yen, which is not large.

Figure 4 **Tax Incentives for Authorised Research Associations**



The second case is research expenditure for joint research with foreign research laboratories. This system was started from this fiscal year (1994) in order to promote international co-operation. Therefore, the total amount of tax deduction is not yet available. The third case is research expenditure for special purposes such as the efficient use of energy and the utilisation of recycled resources. Considering Japan’s high dependency on imported energy and imported natural resources, technological innovation in these fields is very important. The above three tax credit systems: tax credit for increasing R&D expenses, tax credit for small- and medium-sized enterprises and tax credit for special R&D activities, can be applied on a selective basis.

4. Tax credit for R&D facilities for fundamental technologies

A tax credit system to promote acquisition of facilities for basic research is also offered. 7 per cent of the acquisition price of facilities for R&D in fundamental technologies is deductible from the corporate tax. Categories of facilities are listed in the notification by the Ministry of Finance. Currently, more than 200 facilities are listed and the total amount of corporate tax deducted is approximately 4 billion yen.

5. Tax incentives for technological research associations

Tax incentives are offered for authorised research associations to promote joint research among enterprises as shown in **Figure 4**. Special depreciation of charges imposed by the research associations for acquisition of fixed assets used for R&D is allowed. This system is applied to member companies’ own accounting. A member company can charge loss in its own account even when the charge is spent to acquire fixed assets for R&D. Advanced depreciation of fixed assets required for R&D is offered for authorised research associations. The book value of such assets can be reduced to one yen. This is a special measure to offset research associations' profit from charges to members and make income zero in accounting, because research associations are basically non-profit making organisations. The total amount of the tax deduction made by special measures for R&D described above is approximately 90 billion yen annually.

THE R&D TAX SCHEME IN THE NETHERLANDS

Jeroen NIJLAND, Ministry of Economic Affairs, the Netherlands

This presentation has five parts: 1) why do we have an imposed R&D tax scheme and why do we have one in this form? 2) how does it work? 3) budget and control, 4) the first results, and finally 5) monitoring and evaluation. The Dutch tax scheme is only six months old, so that the presentation concentrates on the first two points.

Why do we impose an R&D tax scheme in this form?

The first reason for having an imposed R&D tax scheme is to stimulate business R&D. Dutch business R&D has been declining since 1987 in a dramatic sense. The score for 1993 was less than 1 per cent of GDP. That is a drop of 0.4 per cent since 1987. Policy makers in the Netherlands were extremely worried by such a development. Secondly, why did the Dutch government chose a fiscal measure instead of a subsidy? One of the reasons is a kind of matching argument. There are a lot of countries which have fiscal measures to stimulate R&D and we did not have that in the Netherlands until last year. So we thought that a fiscal measure would improve the fiscal business climate in the Netherlands. We also chose a fiscal measure because we found a way to have an immediate link between the actual expense on business R&D on the one hand, and the benefit which companies receive on the other hand.

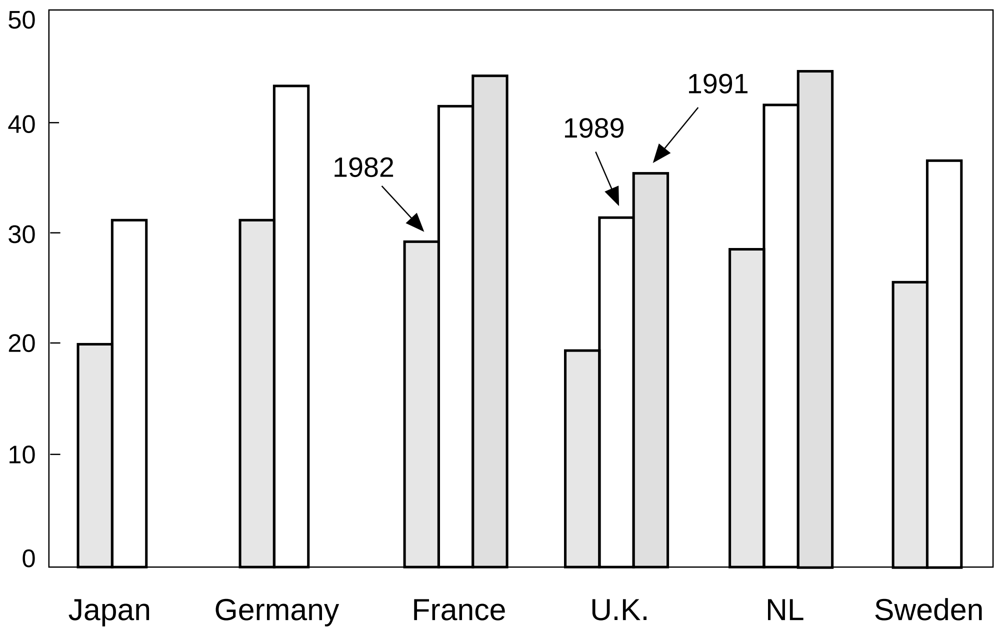
Table 13. Composition of business R&D expenditures

	>50 employees	<50 employees
Labour costs	52%	74%
Capital expenditures	10%	10%
Other	38%	16%

Thirdly, why did the Dutch government chose a wage-based system? One of the reasons is that labour costs are more than half of total R&D costs. When you take a look at small enterprises with less than 50 employees, you will find that labour costs add up to almost 3/4 of R&D costs (**Table 13**). So we thought that it would be very effective to have a reduction in the labour costs. Moreover, as **Figure 1** shows, Dutch R&D wage costs are relatively high when compared to other countries. Together with France, the Netherlands has the highest R&D wage-costs of the countries listed here.

Figure 1 **R&D wages**

($1000 per employee)



Finally, the Dutch government had a discussion on whether they should choose a system which has a deduction on the tax on profits or a system which has a deduction on the tax on wages. The Dutch government chose the latter system because choosing a system with a deduction on the tax on profits only affects the enterprises who are profitable. A lot of R&D takes place in firms which are temporarily loss-making. We did not want to exclude that kind of R&D. Carrying forward could of course be a solution to that kind of problem, but we felt that would only complicate the scheme. Moreover it enlarges the time period between the actual expense of a company and the moment it receives the support. We found a way that makes it possible to have an immediate link between actual expenses and the receipt of the deduction. The last reason why the Dutch government did not choose a system based on profits is that we did not want to exclude research done by universities and other non-profit organisations.

How does it work?

The Dutch R&D tax scheme consists of two parts: R&D rebates and an increased deduction for the self-employed. The R&D rebate is the most important part of the scheme. It takes the form of a reduction of the tax and social insurance contributions paid by the business sector. Anyone who is liable to withhold tax and national insurance contributions is eligible. He has to operate a company as defined in national legislation on income tax and/or corporate tax and of course he has to employ persons who perform R&D. If he does not operate a company as defined by the legislation, he can still be eligible for this R&D rebate as long as the R&D activities which are performed take place on the basis of a written agreement with a company or a group of companies. This is how we include, for example, university research in the R&D

rebate. Secondly, there is an increased deduction for the self-employed which is especially designed for self-employed persons who operate a company and who are entitled to income tax reduction.

Table 14. The R&D rebate

- 2 rebate brackets:
    - R&D wage costs < Gld 100 000 -> 25.0 % deduction
    - R&D wage costs > Gld 100 000 -> 12.5 % deduction
- Maximum rebate: Gld 10 million
- Application: twice a year

Table 14 shows how it works. The amount of reduction is directly related to the labour costs involved in innovative activities. There are two rebate brackets. The first is the R&D wage cost up to Gld 100 000 (roughly comparable to US$60 000). The deduction is 25 per cent. The second bracket is for R&D wage costs exceeding Gld 100 000. The deduction in that bracket is 12.5 per cent. The reason for the two bracket system is that we want to impose a special incentive for small- and medium-sized enterprises in our tax scheme. That is also the reason why we have imposed a maximum on the rebate. The maximum rebate is Gld 10 million. Applications can be made twice a year: once for the entire calendar year (that has to be done before the beginning of January) and one for the second six months of the year (that has to be done before the beginning of July).

Here is an example of the R&D rebate (**Table 15**). Suppose the total R&D wage in the calendar year is Gld 700 000. Then the maximum rebate can easily be calculated as 25 per cent of Gld 100 000 and 12.5 per cent of the amount in excess of Gld 100 000. So the total rebate is a maximum of Gld 100 000 (25 per cent of 100 000 and 12.5 per cent of 600 000). Applicants may take a provisional reduction. In this case, they deduct a commensurable part of the full amount of the R&D rebate. They can deduct that every month. In this example, it would mean that they are allowed to deduct Gld 8 333 every month. This is how the immediate link between R&D expenses and the support is imposed.

Table 16 summarises a case of extra deduction for self-employment. A self-employed person who has more than 875 R&D hours a year can get an extra deduction of Gld 6 000. He also can submit an application twice a year.

Table 15. R&D rebate -- example

- Total R&D wages: Gld 700 000 (1/1 - 31/12)
- Maximum rebate:
  - 25% x 100 000 = 25 000
  - 12.5% x 600 000 = 75 000
- Provisional reduction: 8 333 Gld per month

Table 16. **Extra deduction for self-employment**

- “R&D-hours” > 850 h per year
- Extra deduction: Gld 6 000
- Application: twice a year

Budget and control

The annual budget is about Gld 350 million. This is, of course, a gross budget because it lowers the cost of firms. Therefore tax on profits will rise. There are two organisations implementing this scheme. First is SENTER, an agency of the Ministry of Economic Affairs which implements technology instruments. The tax authorities are also involved in implementing this scheme. There is a three-fold kind of control. A prospective kind of control is imposed during the application phase when SENTER tests the R&D projects against the definition of R&D in our Act. During the calendar year, SENTER can impose a check, for example, by visiting the applicants. This is a random check. At the end of the fiscal year, of course, tax authorities become involved. They control whether the rebate is properly calculated.

The first results

Because the scheme is only six months old, only some first results can be provided. The first results are very encouraging from the government’s point of view. SENTER received more than 5 000 application forms containing over 27 000 R&D projects. Seventy-five per cent of the applications were submitted by small- and medium-sized enterprises (less than 100 employees). 85 per cent of the applications were positive. 25 per cent of the R&D projects are collaborative research projects.

Monitoring and evaluation

The monitoring system consists of a continuous flow of information between SENTER and the tax authorities. There is a regular flow of information between SENTER and the tax authorities on the one hand, and the Ministry of Economic Affairs and the Ministry of Finance, on the other. We conducted an evaluation at the end of 1995.

Furthermore, on 1 January 1996, the Dutch government added an additional feature. Companies or the National Institute for Applied Research receive a rebate against the tax and social insurance obligations for young post-graduates doing PhD-research on a company-demand subject under the scientific responsibility of a university. The maximum rebate is Dfl. 4 500 a year during four years per post-graduate PhD-researcher with an average income of about Dfl. 45 000 a year. The income-costs are to be paid by the companies, either directly to the researcher, or indirectly to the university (in cases where the latter is the employer); the rebate has to be calculated also to the companies. The estimated total costs per annum range from Dfl. 1 125 000 in 1996 to Dfl. 4 500 000 in 1999 and beyond.