Evaluating a Dutch Scheme for Encouraging Research & Development

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ABSTRACT. This paper contains an evaluation over the period 1984—1988 of an important instrument of Dutch technology policy: a generic subsidy on R&D labor costs which especially favours small firms. The evaluation is based on surveys among nearly 3000 subsidy-using firms and on empirical analysis. The surveys show that the subsidy effectively strengthened the R&D activities of small firms in particular. It can be concluded from the empirical analysis that the subsidy generated between 40 and 150% of additional R&D spending. Given the large spill-over effects of R&D this probably means that the social benefits of the subsidy outweigh the costs. The 'incubation period' of subsidies like the Dutch scheme require consistency and continuity of governmental (R&D) policies in order to influence corporate strategies, in particular those of small firms.

Introduction

An important instrument of technology policy in the Netherlands is the so called INSTIR (Innovation Stimulation Scheme): a scheme for subsidizing research and development (R&D) by firms. The INSTIR is a government subsidy on the labor costs incurred in research and development activities. In this scheme, which was introduced in October 1984 and phased out in October 1989, two bands are applied:

- a 40% grant is awarded for eligible costs up to *f* 300,000 per six months;
- a 25% grant is awarded for eligible costs in excess of this amount to a maximum of *f* 2,500,000 per six months.[1]

The subsidy can be received for *internal* as well as *external* (i.e., contracted out) R&D. The entire budget available for the INSTIR in the period 1984—1989 was *f* 1.4 billion or an average of *f* 280 million annually.

The subsidy is generically based, i.e., not attached to specific R&D projects. It can be obtained for any R&D activity undertaken in a period of six months. This means a firm can apply every six months for a subsidy on labor costs for personnel engaged in R&D activities without any further limitations. The only condition for an application is whether or not the firm is involved in R&D.

In 1989, the Dutch government agreed that the INSTIR should be continued on a modified basis. Firms can now apply for a 30% subsidy on labor costs for R&D-personnel of up to *f* 150,000 per six months. This means the follow-up scheme is more heavily geared towards the small and medium-sized firms. The prolongation of the INSTIR in a different way was agreed in the light of four developments:

(1) According to the evaluation of the INSTIR (which is discussed in this paper), the contribution of the scheme towards the strengthening of R&D activities was more pronounced among the small and medium-sized firms than among the large firms.
(2) Successful dissemination or adoption of new technology is a central theme in the Dutch technology policy. This "small step" technical development (for example to modify new basic technologies to produce new products) necessitates R&D. Therefore a generic R&D scheme is considered to be an essential element in the diffusion-oriented technology policy of the Netherlands.
(3) Other important OECD countries have maintained or expanded generic R&D incentives.

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(4) The available budget for the INSTIR was reduced. For the modified scheme a budget of *f* 170 million is available for a one year period.

Our paper will address what we consider to be the *key question*: has the Dutch INSTIR during the period 1984—1989 been effective in increasing R&D in firms? The paper will try to answer this question in a series of sections dealing with the following issues.

Section I briefly summarizes the economic rationale for subsidizing R&D by firms in a world in which (producer) subsidies are increasingly challenged. Section II contains an overview of generic stimulation of R&D by firms in some OECD countries. In Section III we present an evaluation of the Dutch R&D subsidy scheme. This section forms the central part of our paper. It examines the results of two recent surveys among firms using the subsidy (around 3000 firms) and in addition offers an impression of the possible quantitative impact of the INSTIR on R&D spending by firms. Finally, Section IV summarizes our main results and tries to derive some conclusions for technology policy in OECD countries from the experience gained from the R&D subsidy scheme in the Netherlands.

I. Why subsidize R&D?

Ever since the seminal work of Arrow (1962), it has been widely recognized that knowledge is a good with special features, differing from goods like soap or cars. To a considerable extent, knowledge can be considered to be a public good. For this paper it will suffice to focus on one important element of the public good nature of knowledge, namely the *appropriability problem*. This problem refers to the well-known fact that a firm (or industry) does not reap in full the fruits of the knowledge it generates. In other words, there are considerable positive *externalities* in the process of creation of new knowledge. This implies that the market mechanism (where decision-making is based on private costs and benefits), if left entirely to itself will generate too little new knowledge. As R&D is the process of creating new knowledge, this conclusion also implies that there will be too little R&D.

There is now extensive empirical evidence which supports the public good nature of knowledge. This empirical work mostly tries to measure private and social rates of return on R&D. The social rates include the so-called "*inter-industry spillovers*" of R&D. We will not enter into a discussion of the interesting literature in this field, see Mansfield *et al.* (1977) and more recently Bernstein (1989), Jaffe (1989) and Mohnen (1989). For our purpose, it is sufficient to echo the conclusion drawn by the U.S. Council of Economic Advisers in its 1989 Report. This conclusion is, first, that the *private* rates of return on R&D seem to be substantially above those on physical capital (ranging from 20 to 50%) and, second, that the *social* rates of return on R&D appear to be on average twice the private rates of return (Chapter 6). Approaching the problem from a different angle, the externalities impose a huge *implicit* tax on technology development. In a lucid treatise Baily and Chakrabarti (1988) have recently tried to illuminate the often underestimated magnitude of this problem by the following powerful analogue:

> ... if a private firm invests in R&D, it is analogous to setting up a new factory and then discovering that its competitors have the right to use the plant free for a half or three quarters of the year. Or it is like selling a product but receiving only a half or a quarter of the purchase price (p. 113).

Moreover, there is reason to believe that small firms face higher obstacles to R&D than large firms due to *economies of scale*. Because of indivisibilities, sunk costs, overhead costs, etc, the R&D process often requires a certain minimum scale. In recent empirical research, considerable economies of scale in R&D are found (Lichtenberg and Siegel, 1989).

With the social rates of return on R&D being so much higher than the private rates, there is in principle a strong case for government intervention in R&D. Furthermore, the economies of scale in R&D might be a reason for governments to put special emphasis on helping small firms to overcome the obstacles to entry into R&D. All in all, it is no surprise that governments in virtually all OECD countries have tried to stimulate R&D by means of subsidies or tax deductions.

II. Overview of generic stimulation of R&D in some OECD countries

From the beginning of the 1980s, all governments

within the OECD countries developed their science and technology policies in order to influence the technological capabilities of their industries (Rothwell and Zegveld, 1981, 1985). Table I illustrates the stronger emphasis on R&D within the private and public sector during these years. The policy mix of the OECD countries includes the encouragement of R&D initiatives by industry through financial incentives (loans, tax-deductions, subsidies), selective R&D funding of particular R&D projects, etc. These instruments have in common the fact that they try to encourage industrial R&D through R&D funds. In this sense, these facilities can be defined as governmental payments that affect relative prices of production factors in order to contribute to a more efficient allocation of national resources.

II.1. *Definition and scope*

Strictly speaking, there is no exhaustive definition of financial aid for innovation. The general macro-economic environment or regional policies will influence innovation. However, a comparison between the overall climate for corporate innovation within OECD countries would be beyond our scope. For this reason, we will concentrate on specific governmental policy measures which intend to provide financial assistance for R&D. Firms act as the main "change-agents" in the economy and make their own decisions on strategy and technology development. This implies that incentives for innovation have to influence corporate strategies in order to be effective. For our purposes we will define financial R&D incentives as a system of financial governmental payments which intends to encourage the volume of R&D within firms by indirect fiscal or direct financial aid (OECD, 1985).

Indirect fiscal aid for R&D covers the measures applicable to the accountancy items corresponding to activities that are intended to implement research and development projects. Tax expenditures reduce or defer taxes and for this reason can be seen as "quasi subsidies" (Gerritse, 1989). Four types of tax reducing measures exist in this field:

- *tax exemptions*: revenue categories which are excluded from the tax base;
- *tax reductions*: deductions from gross revenue to arrive at taxable revenue;
- *tax credits*: sums subtracted from the tax due on the basis of required R&D-investment patterns;

TABLE I
R&D-indicators in 7 OECD-countries

Country	Gross domestic expenditure on R&D (million current $)		Gross domestic expenditure on R&D as a percentage of gross domestic product		Business enterprises R&D expenditure as a percentage of gross domestic product		Percentage of gross domestic expenditure on R&D financed by public sources		Percentage of business enterprises expenditure on R&D financed by government	
	1983	1988	1983	1988	1983	1988	1983	1988	1983	1988
FRANCE	12457.3	17456.0	2.11	2.29	1.20	1.34[b]	53.8	52.9[b]	22.4	22.8[b]
GERMANY (F.R.)	16646.1	24240.6	2.51	2.78	1.79	2.06	38.8	33.3	16.1	12.1
SWEDEN	2305.0	3262.0[a]	2.46	2.82	1.08	1.40	36.6	34.5[b]	10.4	11.2[b]
NETHERLANDS	2947.5	4448.0	2.02	2.33	1.63	1.84	47.2	39.0	8.4	12.2
JAPAN	31218.4	46118.1[b]	2.56	2.87[b]	1.63	1.84[b]	24.0	21.7[b]	1.7	1.7[b]
UNITED KINGDOM	12477.2	15535.1	2.25	2.36[a]	1.38	1.55[a]	50.2	38.9[a]	30.2	19.4[a]
UNITED STATES	89890.0	127685.0	2.66	2.66	1.89	1.87	49.2	50.5	32.4	33.8

Source: OECD/STIID, 1989.
[a] 1986.
[b] 1987.

— *special tax relief through reduced rates*: R&D activities are taxed at lower rates.

Direct financial aid for R&D provides additional financing strictly related to certain types of R&D activities. It intends to mitigate certain deficiencies, by supplementing sources, reducing the degree of risk or lowering certain costs. R&D subsidies, (low-interest) loans, guarantees etc. are the main types of instruments.

II.2. *Overview of instruments*

Tax incentives. Table II offers an overview of various indirect tax incentives promoting corporate R&D (OECD, 1988). As can be seen in this table, many countries have special tax treatments of R&D expenditures. Accelerated depreciation and extra R&D allowances are common instruments, except in the Netherlands where there are no tax incentives for private R&D. In some countries we see extra allowances for incremental R&D or innovative activities by small and medium-sized enterprises (SME's). In the USA, Canada and France, tax credits are fairly important instruments in encouraging business enterprise R&D. Not mentioned in Table II, but nonetheless very

TABLE II
Fiscal aid for R&D within 6 OECD countries (1988)

Countries	Tax exemptions	Tax reductions[a]	Tax credits	Special reliefs
France	For research collectives no corporate tax	Accelerated depreciation R&D buildings and equipment (50% annually)	50% of increment up to FF 5 mln. per year	Tax rate of 16% on royalties and licenses
Germany		Special depreciation allowance 40% for investment in R&D, 15% in fixed assets Extra R&D allowance on capital expenditure of 20% up to DM 500,000 and 7.5% over		Reduced tax rate on royalties inventions
Sweden[b]	Investment reserves and renewal funds	All R&D costs 100% deducted in year of investment from taxable income		Foreign researchers in first 3 years 30% wage and income tax rate
Netherlands	Research collectives and non-profit institutes pay no value-added or corporate tax			
United Kingdom		100% depreciation in first year of R&D investments and equipment Extra R&D allowance of 20% for SMEs		
United States		3 year write-off	Increment of 25% over previous 3 year average 6% equipment tax-credit	

[a] If there is no entry, treatment does not differ significantly from treatment of other capital expenditures.
[b] 1985.

remarkable are the total deduction rates on R&D investment, which are higher than 100% (in 1988) in Australia (150%) and Austria (105%).

Direct financial aid. Table III illustrates the differences in direct financial measures. We can categorize the different stimuli in:

— subsidies for R&D labor costs;
— credits and (low interest) loans which (some-

TABLE III
Direct financial R&D support in 6 OECD countries (1988)

Countries	R&D labor costs (lc)	Credits/loans	(Project) subsidy in defined areas	Others
France	50% subsidy on lc young researchers for 3 years	Risk-credits up to 50% of project costs	Subsidies up to 50% for R&D-projects dealing with industrial policy	Subsidies 5—25% high-tech equipment Subsidy up to 50% for research in laboratories (private and public: FRST)
Germany	40% subsidy on lc (max. DM 120,000/year) 55% incremental lc in SME (max. DM 250,000/ year) Subsidy for young researchers for 3 years (50%)	Risk-credits up to 75% with additional interest of 2% on capital market rate	40—50% subsidy for specific projects	Technological start-ups: up to 90% subsidy research-projects and 50% risk-capital Up to 100% subsidies for collaborative research
Sweden[a]	50% subsidy on incremental lc	40—50% risk-credits and participations	Subsidies for innovation in SME's	Start-up facilities Subsidies for collaborative research and collectivities
Netherlands	25—40% subsidy on lc and external R&D (max. *f* 2.5 mln. project costs)	60% risk-capital with 5% interest	37.5% of project cost via call for tenders	50% subsidy for collaborative strategic feasibility and research projects (max. *f* 2.5 mln.) 50% subsidy for external R&D for SME's within TNO A small SBIR-initiative
United Kingdom	100% subsidy for young researchers for 2 years	Guarantees of up to 70%	Subsidies of up to 50% within the Link-project	Up to 100% subsidy on advisory and consultancy services
United States				Industry-University cooperative research projects Small Business Innovation Research (SBIR): 30—50% (Phase I: max. $50,000, Phase II: max. $250,000) for high risk, advanced projects

[a] 1985.

times) have to be paid back depending on the rate of return on the project;
- subsidies for specific R&D projects within defined technology fields; and
- others, such as facilities for collaborative research.

III. An evaluation of the INSTIR

III.1. *How are the resources allocated?*

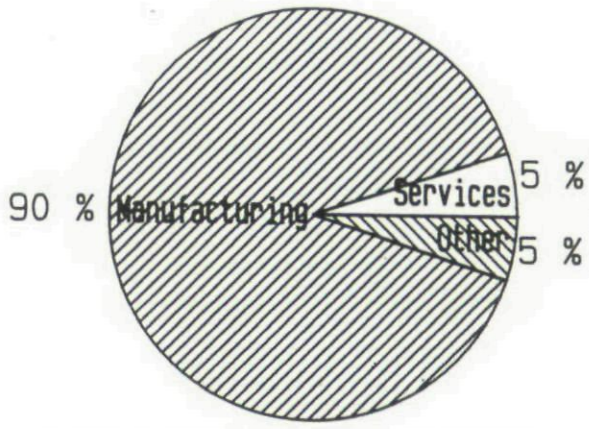
In this paragraph we will give a short description of the main characteristics of the INSTIR applicants, based on a survey among INSTIR-using firms (TNO, 1988). First, however, it is useful to mention some relevant features of the Dutch economy.

In comparison to other European countries, the economy of the Netherlands is characterized by:

- a highly developed agricultural sector;
- a large services sector (nearly half of GDP);
- a high percentage of very small firms (99% of firms have less than 100 employees);
- about 75% of R&D funded by the private sector is accounted for by five big multinational corporations.

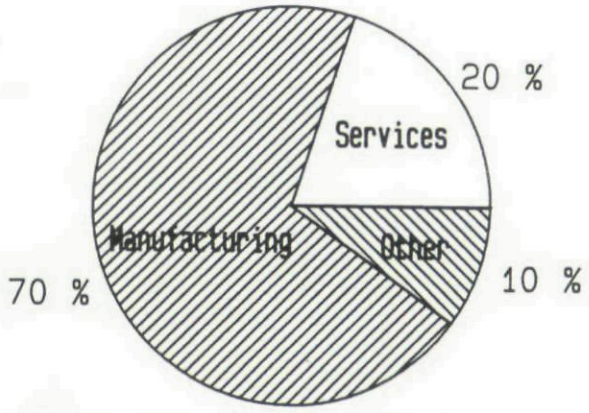
Between 1985 and 1989 a total of 4000 separate firms (roughly 1% of all Dutch firms) applied at least once for the INSTIR-subsidy. Within that time period, the annual number of firms using the INSTIR increased from more than 1100 to 3300. According to the available statistics, roughly 2600 Dutch firms were engaged in R&D activities in 1985/1986 (more recent statistics are not available). In these years, already around 2000 of them applied for INSTIR. This implies that after an incubation period a large number of firms with R&D activities make use of the INSTIR. This increase in the take-up rate is mainly caused by a growing participation of small firms (i.e., fewer than 500 employees). The allocation of the INSTIR budget according to the size of firm shows that small companies also receive a growing amount of the budget: about 70% now, compared to 65% in the first year of the scheme.

Figures 1 and 2 show the sectoral allocation of the private R&D and of the INSTIR funds. Because of the ceiling in the INSTIR scheme the large firms, which are mainly in the metal and the chemical industries, receive relatively (related to the amount of R&D) less subsidy than the smaller firms. Therefore, the allocation of the INSTIR funds does not reflect the allocation of R&D undertaken in the private sector.



Source: Buck Consultants International, 1989, p. 32.

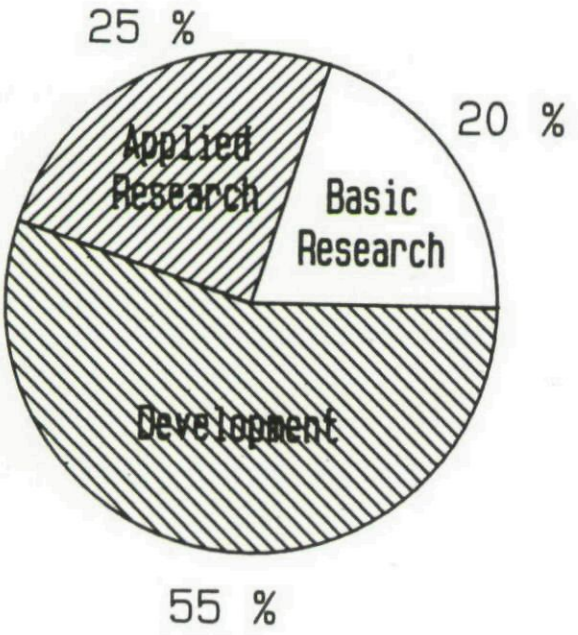
Fig. 1. Sectoral allocation of business enterprises R&D expenditures in the Netherlands (1987).



Source: Central Bureau of Statistics (CBS) in the Netherlands.

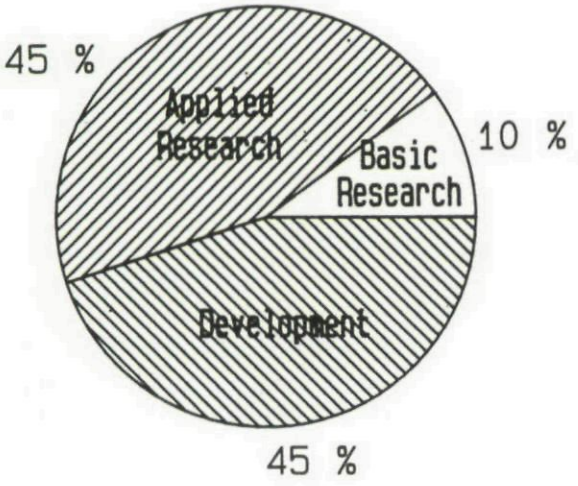
Fig. 2. Sectoral allocation of INSTIR funds in the Netherlands (1987).

The overwhelming part of the R&D subsidized by the INSTIR is reported to be in applied research and development.[2] Only 10% of the INSTIR budget is spent on basic research.[3] As Figures 3 and 4 show, the allocation of the INSTIR budget over particular R&D activities does not reflect a similar allocation of private R&D in the Netherlands; the INSTIR seems to be



Source: Central Bureau of Statistics (CBS) in the Netherlands.

Fig. 3. Allocation of business enterprises R&D expenditures in the Netherlands.



Source: Buck Consultants International, 1989, p. 53.

Fig. 4. Allocation of INSTIR funds over R&D activities in the Netherlands (1987).

particularly helpful to the application and utilization of R&D.

About 60 percent of the INSTIR applicants reports difficulties with regard to investment in R&D. Particularly very small firms (less than 250 workers) encounter more obstacles (67%) than larger firms (56%).

As Table IV shows us the most important barriers for firms is in attracting financial means for R&D. A second major obstacle is the high labor costs of R&D employees. This suggests that the INSTIR is an appropriate instrument in the case of the Netherlands: by offering financial support for R&D and, in particular, by lowering the labor costs of R&D employees, it tackles the main obstacles to innovation that in particular very small firms face.

In short, after an incubation period, the INSTIR reaches virtually all firms with R&D activities. In particular the take-up rate of small firms and of firms in the services sector has risen rapidly. The INSTIR seems to stimulate applied R&D more than other R&D activities. Furthermore, at this moment the scheme seems an adequate reply to the reported obstacles faced by Dutch firms (especially small ones) which invest in R&D.

III.2. *Measuring the effectiveness of the INSTIR*

III.2.1. *Results of a questionnaire.* The above mentioned growth in numbers of applications for the INSTIR gives rise to two important conclusions. First, the introduction of new incentives will be confronted with an incubation period in which the implementation agencies and the target group

TABLE IV
Percentage of INSTIR applicants which reported barriers (1988)

Barriers	Percentage of INSTIR applicants
1. Financial means for R&D	21
2. High labor costs of R&D employees	19
3. High equipment costs	16
4. Recruiting new qualified personnel	13
5. Qualifications of employees	12
6. Technical information and know-how	10
7. R&D management	9

Source: Buck Consultants International, 1989, p. 58.

of firms need to find the proper ways to interact. This element of learning implies that the effectiveness of instruments like the INSTIR is highly influenced by operational time. A second conclusion could be that, after some time, the effectiveness might show up in higher awareness, additional R&D, etc. By means of a questionnaire among INSTIR-using firms, we tried to obtain more insight in the impact of the scheme on the strategic R&D management of these firms. Of course, it should be noted that this type of questionnaire has its limitations. Strategic response behavior is one of these limitations. Nevertheless, it can be conjectured that questionnaires are a useful method in evaluation research and, as such, widely applied (see, e.g., Mansfield and Switzer, 1985).

It is clear, of course, that decisions on strategic R&D management are influenced by a number of factors and that government schemes to encourage R&D are only one of them. Nevertheless, the INSTIR seems to have a considerable impact on the R&D behavior of Dutch firms. The results of the questionnaire indicate that the INSTIR influenced not only the scale and allocation of R&D activities, but also their organizational structure. Some of the main results are as follows (Buck Consultants, 1989):

Higher R&D-funds:
- 80% of the INSTIR-users initiated more R&D; for three out of four of these firms the INSTIR has contributed to this increase in R&D;
- 70% of the INSTIR-users contracted out more R&D; for more than two out of three firms the INSTIR encouraged this decision;
- nearly 70% of the INSTIR-users recruited additional R&D-personnel; almost two out of three firms reported that the INSTIR contributed to this increase;
- over 50% of the INSTIR-users started with R&D; for two out of three of these firms the INSTIR influenced this decision.

Speed-up of R&D:
70% of the INSTIR-using firms said they speeded up planned research projects which accelerated technological developments. One out of two firms reported that the INSTIR had an impact on this decision.

Higher qualification of R&D-personnel:
65% of the INSTIR-using firms recruited higher qualified R&D personnel. For more than one out of two of these firms the INSTIR played a significant role in this increase in quality.

More important role for R&D management:
- 75% of the INSTIR-using firms reported an improvement of R&D management; two out of three of these firms said the INSTIR contributed to this improvement;
- 85% of the INSTIR-using firms reported that the INSTIR made them more aware of the importance of R&D activities. This implies that for these firms R&D management became more relevant to the corporate strategy;
- almost 45% of the INSTIR-users institutionalized their R&D activities by setting up a separate R&D department, which implies an integration of R&D activities into the overall business strategy. For more than one out of three of these firms the INSTIR exercised an influence on this strategy adaptation.

The impression one gets from these results is that the INSTIR had a substantial impact on the R&D activities of firms. Encouraged by the INSTIR, R&D activities were extended, upgraded and accelerated. In addition, the INSTIR strengthened the role of R&D management. The results of the questionnaire indicate furthermore that the impact of the INSTIR was, in general, greater for small than for large firms.[4] This greater impact on small firms is most prominent in the INSTIR's contribution to, first, the start-up of R&D, and second, the contracting out of R&D. Nevertheless, there were also two ways in which the INSTIR turned out to be more important for large firms, i.e., the impact of the scheme on the recruitment of additional, as well as of more highly-qualified R&D personnel.

III.2.2. *Indirect estimates.* The approach focuses on econometric estimates of the behavioral response to the reduction in the user cost of R&D brought about by the INSTIR. Therefore, the first question to address is by how much the INSTIR reduces the user cost of R&D. For small firms (up to 500 employees) which, in general, do not reach the maximum subsidy per firm, the INSTIR covers on average 35% of the total R&D labor cost. From

the regular surveys of the Dutch Central Bureau of Statistics (CBS), we know that labor costs now make up around 50% of total R&D costs. Combining these two figures we conclude that, on average, the INSTIR reduces the user cost of R&D for small firms by 18%. A similar calculation is impossible for large firms. Instead, we estimate the user cost reduction for large firms in a crude manner by relating the total amount of INSTIR they receive as a group to their total R&D expenditures. Thus, for large firms one obtains an estimate of nearly a 2% R&D user cost reduction caused by the INSTIR.

Now that the *size* of the incentives is known, the second question arises, i.e., what is the behavioral response to this R&D cost reduction? To answer this question we need evidence on the price elasticity of R&D. For this, the results of earlier empirical studies can be applied. According to Cordes (1988, 1989), the estimates of the elasticity of R&D with respect to the user cost have generally ranged between −0,2 and −0,5. However, Baily and Chakrabarti (1988) mention a range of −0,3 to −1,0. For the sake of simplicity, we will use the average of these elasticity ranges −0,5.[5] Recalling that the INSTIR cuts the user cost of R&D by 18% for small firms and by 2% for large firms, we obtain an estimate for the induced increase in R&D spending by firms of 9% for small and 1% for large firms. Based on 1985 levels of private R&D spending (*f* 730 mln. for small firms[6] and *f* 4390 mln. for large firms), this amounts to an induced increase in R&D of *f* 66 mln. for small firms and *f* 44 mln. for large firms, adding up to a total of *f* 110 mln. per annum (or 2.1% of private R&D).

III.2.3. *Direct estimates.* We have performed a very simple time series analysis in order to obtain direct estimates of the effect of the INSTIR on R&D spending of firms. It is common business practice to determine R&D spending as a percentage of company sales or output. Recently, it has also been established that the relationship of R&D to sales at the firm level is remarkably stable over time (Franko, 1989). Therefore, it seems acceptable to perform a simple regression analysis relating current R&D spending to output. To investigate whether the introduction of the INSTIR did have a discernable impact we added a dummy variable to the regression. This dummy takes the value of 1 in the years the INSTIR is fully operational. We obtained the following results (*t*-values in parenthesis):

$$BERD = 0.015\ Y + 1206.99\ D_{86-88} - 5.91$$
$$\qquad (21.86) \qquad (6.92) \qquad (-0.043)$$

Estimation period = 1969—1988, $DW = 1.90$, $R^2 = 0.985$. *BERD* = Business Enterprise Research and Development; Y = Output of firms; D = dummy (= 1 in period 1986—1988).

These regression results show a statistically significant impact of the dummy variable in the years 1986—1988. This suggests a marked difference in R&D spending of firms in the years after the introduction (and incubation period) of the INSTIR. This substantial difference is also found in the more commonly used regression analysis we now turn to (Mansfield and Switzer, 1985; Cordes, 1988 and 1989). In this analysis, a very simple linear regression is used to generate projections of R&D spending of firms. These projections can consequently be compared to actual R&D spending. The results of this comparison are shown in Table V.

Again we see a remarkable increase in R&D spending of firms in the years after the introduction of the INSTIR. Another observation that can

TABLE V
Projected and actual R&D spending of firms (1970—1988)

Year	Actual R&D[a] (*f* million)	Projected R&D[b] (*f* million)	Difference (*f* million)
1970—1974 (average)	1727	1729	−/− 2
1975—1978 (average)	2148	2161	−/− 13
1979—1983 (average)	3551	3522	29
1984	4222	4278	−/− 56
1985	4914	4452	462
1986	5580	4603	977
1987	5937	4709	1228
1988	6275	4846	1429
1985—1988 (average)	5677	4653	1024

[a] Firms with > 50 employees.
[b] Projections are derived from the regression:
$BERD = 0.0042\ Y + 0.72\ BERD_{-1} + 150$.

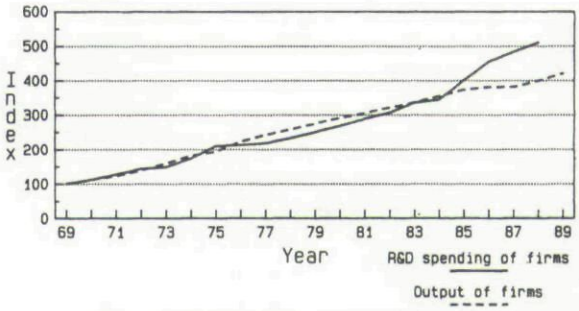
be made is that the gap between actual and projected R&D steadily widens, which might have something to do with the afore-mentioned incubation period. On an average annual basis, R&D spending appears to be *f* 1 billion higher than would have been expected.

How are we to assess these regression results? First and foremost, it should be emphasized that our time series analysis is very simple. Limitations of the analysis lie, for example in a lack of control variables. However, one should recognize that empirical analysis in this area is still in its infancy. It should nevertheless be borne in mind that the limitations of our analysis may imply an overestimation of the programme's effects. With this proviso, we now turn to the interpretation of our tentative results.

It would of course be naïve to claim that the observed structural shift in R&D spending is *entirely* due to the INSTIR. It may well be that a more important cause of this shift is an increased commitment of firms to R&D (or, for that matter, an increased weight being given to other determinants of R&D). However, we lack solid evidence pointing to this. In addition, it should be borne in mind that the introduction of a subsidy always induces some "reclassification" of activities ("creative bookkeeping"). Therefore, the INSTIR has undoubtedly led some firms to classify certain activities as R&D that do not deserve this title. But this effect should not be exaggerated.

On the basis of research in different countries, Mansfield (1986) finds that this effect accounts for no more than 14% of the observed rise in R&D spending. When we apply this figure as a deduction to our results, we are still "left" with a genuine structural increase in R&D spending of approximately *f* 860 million. In our view it would be equally unjustified to assume that the observed surge in R&D spending is *not* partly stimulated by the INSTIR, the more, since there is a remarkable synchronization between the two, as Figure 5 makes clear.[7]

However, we should acknowledge that in the years 1984—1988 the INSTIR was an important new element of Dutch technology policy, but not the only one. In other words, more initiatives have been taken which in one way or the other might stimulate R&D spending of firms. The most conservative estimate is that the INSTIR has



Source: OECD/STIID, 1989; CEP, 1989.

Fig. 5. R&D spending and output of firms (1969—1988, both in nominal terms; 1969 = 100).

accounted for at least 50% of the rise in financial stimulation measures geared to R&D spending of firms. All in all, it would seem fair to consider 50% of the genuine structural increase in R&D spending of firms, i.e., *f 430 million per annum* (or 8.4% of private R&D in 1985) as an upper estimate of the impact of the INSTIR. It should be stressed that this very conservative estimate allows for an equally high increase in the R&D intensity caused by other factors than the INSTIR (other technology policy measures, increased commitment to R&D etc.).

Since the results of our regression analysis point in the direction of a structural rise in the R&D intensity (R&D as a percentage of output) of the enterprise sector, we also investigated whether specific developments in R&D intensities could be observed at lower aggregation levels. Up to now, however, we failed to find significantly diverging trends for small firms as opposed to large firms or for "high-" as opposed to "low-tech" sectors. This does not exclude the possibility that the contribution of the INSTIR to the rise in R&D intensity is more substantial for, e.g., small firms than for large firms. It could be speculated that the INSTIR helped small firms to overcome the obstacles to entry in R&D and this enabled them to experience a similar rise in R&D intensity as large firms. More research is needed here in order to test this hypothesis.

III.2.4. *Is the INSTIR "target efficient"?* In summarizing the evidence presented above, we now have estimates of the impact of the INSTIR on R&D spending of firms which range between *f 110 million* and *f 430 million* per annum. This implies

that the INSTIR may have generated between *f* 0.40 and *f* 1.50 of additional R&D spending per each *f* 1 of government expenditure.

This figure is substantially higher than the results found by Mansfield and Switzer (1985) for the U.S., Canada and Sweden.[8] More recent studies however point to ratios at around or even above 1.0, see Bernstein (1986), OECD (1988), Vickery (1988/89) and Baily and Chakrabarti (1988). Nevertheless, there is a possibility that the amount of additional R&D is lower than the budgetary cost of the INSTIR. Does this mean that the INSTIR is not "target efficient"? We think this yardstick is not appropriate here, for it has been clearly demonstrated that there are large external benefits or spillover effects to R&D (see Section I). These spillover effects make the social rate of return on R&D roughly twice the private rate. When we take the external benefits into account the INSTIR seems to be a stimulation scheme that offers "value for money", i.e., benefits outweighing budgetary costs. In this respect, our conclusion is very much the same as that of Baily and Chakrabarti (1988) on the American R&D Tax Credit.

If the costs are calculated to include bureaucracy costs[9] and the "excess burden" of the taxation necessary to finance the subsidy, this assessment perhaps only holds firm when the ratio of induced R&D to government expenditure is nearer to the upper rather than the lower boundary of our estimates.

IV. Conclusions

Economic activities become increasingly knowledge-intensive. Both the private and public sector have to invest large funds in R&D. Although the private rates of return on R&D investments are high (20 to 50%), a serious policy problem arises from the tendency to underinvestment in R&D from a macro point of view. The production of knowledge as a result of R&D activities has several characteristics of a public good. The social rates of return on R&D are at least twice the private rates. In this paper the inappropriability features and externalities of private R&D investments were mentioned as an important rationale for governmental action. Special emphasis on small firms might be warranted due to the economies of scale in R&D.

From the beginning of the 1980s all governments within the OECD countries developed R&D policies in order to influence the volume of industrial R&D by offering the firms subsidies or fiscal aid. From an overview of these generic stimuli, it can be concluded that in spite of a general tendency in OECD countries of tax reforms and retrenchments in subsidy-schemes, aid to R&D is generally maintained.[10]

In assessing the evidence gathered to date about the effectiveness of generic R&D stimulation, we saw that econometric evaluations show considerable effects on private R&D spending. Estimated price elasticities of demand for R&D fluctuate around −0.5. Most of the econometric studies deal with American and Canadian tax incentives. In our paper we tried to evaluate a generic Dutch subsidy on R&D labor costs which particularly favours small firms: the so-called INSTIR. First we summarized some qualitative results from the surveys among nearly 3000 INSTIR-using firms:

- after an incubation period the INSTIR effectively reached large numbers of firms engaged in R&D;
- the INSTIR showed a high take-up rate among small firms and services firms;
- the scheme seems to be an adequate reply to the difficulties these firms face when investing in R&D;
- the INSTIR especially stimulated applied R&D;
- to a considerable extent, the INSTIR succeeded in extending, upgrading and accelerating R&D activities and strengthening strategic R&D management of firms, especially in very small firms (up to 250 employees).

Next, we tried to measure more precisely the impact of the INSTIR on total private R&D spending. It is clear that the INSTIR, being a subsidy on R&D labor costs with a ceiling, reduces the user cost of R&D in small firms (up to 500 employees) by far more than in large firms (18% versus 2%). We thus obtained a lower estimate for the induced increase in total R&D by firms of *f* 110 mln. Our second exercise was based on a very simple (though in this field commonly used) time series analysis by linear regression. Although the limitations of this tentative analysis should be borne in mind, we did find a remarkable increase

in R&D spending in firms in the years after introduction of the INSTIR: on an average annual basis, R&D spending seems to be f1 billion higher than would have been expected. Taking into account a certain amount of "creative bookkeeping" and other possible determinants, f430 mln. per annum can be considered as a conservative upper estimate of the impact of the INSTIR. Thus, the INSTIR encouraged a structural rise in the R&D intensity (R&D as % of output) of enterprises. This rise apparently occurred across a broad range of firm sizes and industrial sectors. Perhaps this may be interpreted as an indication that the INSTIR helped small firms to overcome the barriers to entry in R&D. Weighed against the costs of the corresponding amount of taxation that has to be raised to finance the subsidy, we conclude that the INSTIR may have generated between f0.40 and f1.50 of additional private R&D spending per each f1 of government expenditure. Compared to generic R&D schemes in other OECD countries this seems to indicate a satisfying degree of effectiveness for the INSTIR, although recent American studies find similar results for the U.S. R&D Tax Credit. Furthermore, it should be stressed that the spillover effects of R&D are very large. We therefore conclude that the INSTIR offers "value for money", i.e., the benefits to society might well outweigh the costs.

We conclude with a final remark on the interaction between government policy and business strategy. In our view, the effectiveness of generic R&D stimulation can be increased when the uncertainty about available budgets is reduced within programmes for several years. Only through consistency and continuity of governmental (R&D) policies can there be hope for significantly influencing corporate strategies, in particular those of small firms.

Notes

[1] f1 = around $ 0.5.

[2] Applied research is defined as research which is focussed on a solution of a specific practical problem. Development is the stage in which results from applied research are carried into commercialisation.

[3] Basic research is defined as research which increases scientific or technical knowledge, but is not focussed on specific practical problems.

[4] Mansfield and Switzer (1985, pp. 100—101) found a similar difference in the impact of the R&D tax credits and allowances in Canada.

[5] Although we feel there are good reasons to believe that the price elasticity of R&D is higher for small firms than for large firms, we lack solid empirical evidence to support this.

[6] This figure is calculated by adding up the R&D expenditures of firms with 50—500 employees in 1985 (which is an annually available figure) and the estimated R&D expenditures of firms with 5—50 employees. This estimation is based on a unique survey for 1986. The R&D figure obtained by this survey has been decreased by the annual growth rate of the R&D expenditures for the group of firms with 50—500 employees in order to arrive at a crude estimate for the level of R&D spending of very small firms in 1985.

[7] This is in contrast to the experience in the U.S., where a structural rise in R&D spending took place *before* the enactment of the new R&D Tax Credit in 1981, see Cordes (1989), pp. 130—131.

[8] Mansfield and Switzer report ratios of tax incentive induced increase in R&D expenditure to the foregone government revenue of 0.3 to 0.4.

[9] These costs are quite low for the INSTIR, probably no more than 2% of the average annual budget.

[10] See for the same conclusion, Vickery (1988/89).

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