Evaluation of a major Dutch Tax Credit Scheme (WBSO) aimed at promoting R&D

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Abstract

The Promotion of Research and Development Act (WBSO)[2] took effect in 1994 in the Netherlands. The WBSO provides a fiscal facility that reduces wage costs for R&D employees by reducing wage tax and social insurance contributions. The WBSO has developed in to the most important Dutch measure for the promotion of corporate R&D activities in terms of scope and budget. Its budget amounted to € 337 million in 2001. Given the aim of the WBSO, a central question in the evaluation reported here is whether and to what extent the WBSO leads companies to conduct more R&D activities (1st order effect) and to become more innovative (2nd order effect). A combination of econometric analysis, a telephone survey among WBSO users, semi structured interview and desk research was used.

On the basis of the econometric analysis, we concluded that the WBSO makes a significant contribution towards Dutch R&D intensity (1st order effect), both at the corporate level and structurally, at the macro-level. Among companies that use the WBSO facility, each € 1 of WBSO allowance leads on average to extra expenditure on R&D of € 1.01 to 1.02 in the short term. This does not take account of the expected positive longer-term effects and the substantial social returns associated with additional investments in R&D activities. Neither is included in this evaluation. The size of this 1st order effect is about the same as found in other studies outside the Netherlands. The effect of the WBSO on 'inciting corporate R&D' varies. The bandwidth of the average effect of the WBSO on corporate R&D expenditure lies between 0.7 and 1.3. Overall, additionality is slightly higher than substitution. The survey also indicates a split between WBSO users that assign significant effects to the WBSO at the R&D level and in the R&D process, and companies that primarily perceive the WBSO as an 'extra' or 'reward' for performing R&D activities. The field study also shows that the WBSO plays a role that should not be underestimated in decision-making on to the scale of R&D-activities, the motivation for and organisation or performance of R&D, whether R&D projects are realised and the effects of any loss of WBSO facilities on R&D spending.

The econometric analysis shows that the WBSO makes a significant contribution towards innovation (i.e. 2nd order effect as measured through higher sales from new products) for companies with up to 50 employees. The average for all manufacturing firms is that a 1% higher WBSO funding leads to a 0.19 percent points higher sales volume of new products as a percentage of the total sales volume in the short term. For these firms 1% more in WBSO funding leads to 0.41 percent points higher sales volume from new products as a percentage of the total sales volume. The survey also reveals that for specific groups of WBSO users (companies with up to 50 employees and structural WBSO users), the WBSO contributes significantly more often to the realisation of a number of innovation goals.

In terms of methodology it is concluded that the direction of the causality between the WBSO and the scale of R&D activities can be reasonably assumed, partly on the basis of calculations of an effect on the price of R&D and, therefore, on the volume of R&D. A reduction in R&D wage costs per employee, the objective of the WBSO, leads to additional R&D efforts. The results of the field study confirm this conclusion. However, econometric evaluations of the WBSO and similar schemes would benefit greatly from the availability of panel data over a sufficiently long period. In the future, effects on corporate performance (3rd order effects) can only be determined if longer time series are available for more variables on a disaggregated level. The present dataset can serve as a point of departure here.

[2] The official name of the Act is the 'Act on the Reduction of Wage Tax and Social Insurance Premium Payments, Research and Development Work Section'.

1 Introduction

The Promotion of Research and Development Act (WBSO)[3] took effect in 1994. The WBSO provides for a fiscal facility that reduces wage costs for R&D employees by reducing wage tax and social insurance contributions[4]. The condition is that these employees should work on technological R&D activities aimed at the development of products, processes and software that are new to the company[5]. The WBSO also provides for extra incentives for high-tech start-ups to conduct R&D.

The idea is that by reducing the main item of expenditure for conducting R&D, companies will be (further) encouraged to perform (more) R&D. R&D is seen here as an activity with considerable private and public returns that makes an important contribution to the innovative capacity and competitiveness of the Dutch economy.

With 73,145 applications from 24,754 companies in the 1994-2001 period and a budget of € 337 million in 2001, the WBSO has grown to become by far the most important Dutch measure for the promotion of corporate R&D activities in terms of scope and budget[6].

Aim of the evaluation

In 2002 the WBSO scheme was evaluated. Given the aim of the WBSO, a central question in the evaluation reported here is whether and to what extent the WBSO leads companies to conduct more R&D activities (1st order effect) and to become more innovative (2nd order effect). Additionally the evaluation looked into the: effects of WBSO on firm innovation (2nd order effect); effects of WBSO on firm performance (3rd order effects); degree to which the circumstances that led to the introduction of WBSO still pertain; the WBSO's target group penetration; perceptions of the implementation of the Act (including the use of intermediaries/subsidy advisors) and finally the perceptions of WBSO users regarding potential (budgettary neutral) changes to the design of the WBSO scheme.

Methods used in the 2002 evaluation

In order to answer the questions mentioned above, a combination of methods was used i.e.:

- **Econometric analysis**. In 1998, the Bartels Bureau conducted an analysis of the WBSO, together with Statistics Netherlands (CBS). One of the methodological findings of this analysis was that data restrictions made it difficult to quantify the effects of the WBSO. In this evaluation, an econometric analysis was performed, building on the experience of the aforementioned study and on the basis of an improved dataset on WBSO user profiles, built up over a number of years. This made it possible to evaluate the primary and secondary effects of the WBSO[7]

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3 The official name of the Act is the 'Act on the Reduction of Wage Tax and Social Insurance Premium Payments, Research and Development Work Section'.

4 The scheme also applies for the self-employed involved in R&D-activities, in which case the settlement takes place via income tax. The analyses presented in this study relate only to companies, and not to the self-employed.

5 This complies with the international restricted and 'hard' definition of R&D. Non-technological innovations, such as organisational innovations, do not qualify for the WBSO. Advance feasibility studies and applied scientific research commissioned by businesses do qualify. In the latter case, research institutes apply for WBSO facilities for innovative technological research commissioned by companies. They are expected to pass on 'WBSO discounts'.

6 The figures exclude the self-employed and institutions. They are derived from the Senter database and were processed by the research team.

7 A method of this kind has not previously been used in evaluations of Dutch innovation policy and has only been developed to a modest extent at the international level. In that sense, this evaluation was also largely a survey of the possibilities for quantitative evaluation research. For various reasons, the tertiary effect cannot be determined reliably at present with econometric methods. See also the main report (Brouwer et. al. 2003).

- **Telephone survey**. In a detailed field study, 500 companies (i.e. net response) that use or had used the WBSO facilities were asked about decision-making on R&D, the effects of using the WBSO scheme, experiences with the implementation of the WBSO scheme and potential improvements in its design. In the processing of the results, various dimensions are often distinguished, such as size category, sector, R&D intensity, WBSO intensity, type of WBSO user (e.g. structural, occasional, newcomer), type of project, use of an intermediary/ subsidy advisor and whether or not the company is a high-tech start-up.
- **Desk research**. In addition to a detailed analysis of the WBSO evaluation conducted in 1998, the most recent scientific insights and policy studies in the field of quantitative evaluation research and the use of tax credit schemes was listed and included in the design of the evaluation and analysis of the results. Where necessary, external consultants or individual members of the supervisory commission were consulted.
- **Interviews.** Semi-structured interviews were conducted with representatives of a limited number of companies and research institutes. These interviews served mainly to shed light on the initial insights and to gain further understanding of the use of the WBSO, particularly by companies that were not included in the field study or the econometric analysis[8].

Structure paper
In this paper we will mainly focus on the econometric analysis used to assess the first order and second order effects of the WBSO. Additionally we will present some selected results of the survey. Below we will first discuss three notions that are key when evaluating a scheme like WBSO i.e. substitution, additionality and relabelling (§2). Subsequently a graphical representation of the potential effects of a tax credit scheme like WBSO on R&D labour costs is provided (§3). Then we introduce introduce the econometric model used (§4) as well as the main variables used in the model (§5). Then we deal in two subsequent sections with the first and second order effects of the WBSO respectively (§6-7). Although we emphasise the results of the econometric analysis we also provide some selected results of the survey performed separately. Finally the main conclusions from an empirical as well as a a methodological point are presented (§8).

8 For methodological reasons, companies that are close to the WBSO ceiling (the 'topped-off' companies) are not included in the econometric analysis and the field study. According to statements from Senter, this involves five companies. The current ceiling is an € 8 million wage tax credit allocation on an annual basis.

BOX 1: IS THE RATIONALE FOR INTRODUCING WBSO STILL VALID?

Since 1994, the year in which the WBSO took effect, the level of corporate spending on R&D has improved slightly, the base of companies conducting R&D has broadened and movements in R&D wage cost levels have been relatively modest. Nevertheless, in comparison with competing knowledge economies, there still seems to be sufficient reason to promote private R&D investment through an instruments such as the WBSO.

An instrument such as the WBSO is also an important sign to the companies of the importance attached to R&D and innovation. The social returns of R&D exceed the private returns. This is an important motive for policy that further increases corporate R&D efforts.

Fiscal instruments designed to promote corporate R&D are becoming customary in a growing number of OECD countries.

More specifically, it was determined that:

- The level of corporate R&D spending in the Netherlands is improving again slightly at present, but is still no more than average for the OECD countries and trails the real leaders, even if potential differences in sectoral structure are taken into account.
- The WBSO has already made an important contribution to broadening the base of companies that perform R&D, but there is still a strong concentration of R&D in a small number of large companies.
- Movements in R&D wage costs in the Netherlands in the second half of the 1990s were moderated somewhat in comparison with the main competing knowledge economies. However, R&D wage costs still constitute a major cost item and a barrier for companies to perform R&D, particularly those with up to ten employees.
- The importance of general tax credits in stimulating corporate R&D and thereby innovation is growing within the OECD countries. The disadvantage of not having such an instrument is therefore growing rather than diminishing. A tax credit similar to the WBSO was recently introduced in the UK and Norway, for example. The exact details of such instruments can vary very significantly.

2 Substitution, additionality and relabelling

While the difference between R&D expenditure before and after WBSO has been granted is indicative of the effect WBSO has on R&D expenditure i.e. what WBSO adds to the R&D level without WBSO ('additionality'), other side effects such as relabelling and substitution must also be taken into account in the model's specification. A direct comparison could give rise to overestimating the effect of WBSO on R&D expenditure. Relabelling and substitution will be dealt with in § 2.1 and § 2.2 respectively. Before presenting the assumptions we made regarding additionality and substitution (§ 2.4) we first need to introduce the distinction between incidental and structural users of WBSO (§ 2.3).

2.1 Relabelling

In this particular context, 'relabelling' is when a firm starts to label certain activities as R&D activities because of the subsidy aspect; activities which would not have been labelled as such were they not eligible for WBSO. This implies that WBSO is applied for on 'general' projects, innovative projects for instance. Senter assesses projects on their research and development content and carries out checks. We assume that projects which can be typified as relabelling are not given approval, and that any promised WBSO funding relates to 'bona fide' R&D work. We did not take relabelling into account when analysing the effect of WBSO on R&D expenditure, in other words, we assume that all project applications are 'bona fide' R&D projects.

2.2 Substitution

There is talk of substitution when (a part of the) WBSO funding – as opposed to the firm's own resources – is spent on internal R&D labour costs, being used as it were as to make a 'saving' on one's own expenses. While this is definitely not the intention of the WBSO, it is a side effect that certainly needs to be taken into account. Whereas substitution can have a major effect on the effectiveness of the provision, it is difficult to verify. In practice, only the change in amount of R&D expenditure from one year to another can be observed, including settlement of a previous WBSO grant (if applicable). In section §4.3 we shall deal more explicitly with this problem of 'detection'.

When describing the potential effects of WBSO on R&D expenditure we leave aside whether WBSO funding is spent by the firm in question directly on specific projects or whether it is used in a generic fashion. This is of minor importance when describing the effect of WBSO. After all, even if WBSO funding is spent fully on items other than on the R&D labour costs for which a reduction was applied, it still releases other funds that can then be used by the firm for other R&D projects or supporting activities [9].

2.3 Incidental and structural WBSO users

When describing the potential effects of WBSO on R&D expenditure we distinguish between incidental and structural users of WBSO. The WBSO came into force in 1994. That WBSO was requested for the first time in a given year applies with regard to each firm. For the sporadic firm, this was a one-off application. We refer to firms that submitted applications several times at different intervals as incidental users. This is the group of users we focus on. Firms that applied for WBSO funding in three successive years are referred to as structural users. The difference between the two is important when determining the effect and the role of the so-called 'calculation rule' (see (§2.1 on page 27).

2.4 Assumptions

We make several assumptions in our reflections on substitution and additionality in terms of the WBSO.

i. First and foremost, that there is a direct link between R&D labour costs and the total R&D expenditure. When considering feasible effects, we assume that this ratio is constant and regard R&D labour costs as a proxy for the total R&D expenditure (we do not take the methods used to appropriate WBSO funding into consideration).
ii. Secondly, we assume that – especially among the incidental users – firms with their own R&D expenses (including R&D labour costs) will also apply for WBSO. In other words: we assume that firms that failed to apply for WBSO funding in a given year had no, or an extremely low level of R&D expenditure [10].
iii. Our third assumption is that the planned R&D labour costs in a given year are the decisive factor for the total amount of WBSO R&D labour costs applied for. For easy

[9] From various interviews with firms making use of the WBSO provision we see in many cases that WBSO funding is not spent specifically on the projects for which it had been requested.

[10] This has no effect on the fact that these firms can certainly incur innovation expenses and can therefore be categorised as innovative. However, contrary to a firm's own expenditure on 'firm' R&D, expenses on innovation are not eligible for WBSO.

reference, we assume that firms draw up their plans for R&D projects, plus the associated R&D labour costs, once a year. We also assume that firms apply for WBSO for specific projects depending on whether or not it will be granted [11].

iv. Fourthly, that the reduction received is the same as the reduction applied for. When presenting the levels of R&D labour costs in our diagrams we assume that the applications submitted for WBSO are approved (a 100% granting of all applications), and in this context also assume that the WBSO funding is only made available after the tax year has expired [12]. The definitive assessment of the reduction is established after expiry of the tax year on the basis of the time sheet administration of the hours actually spent on R&D. In the diagrams we assume that the intended schedule has indeed been met.

3 A graphical representation of the potential effects of a tax credit scheme like WBSO

In this section we will after introducing the diagram structure (§ 3.1) focus our attention on four (theoretical) 'situations', i.e. a situation of full substitution, a situation in which the WBSO effect is neutral, a situation in which there is a question of additionality, and last of all, a situation in which WBSO has a negative effect on R&D labour costs. We will do so for incidental WBSO-users (§ 3.2) and structural WBSO-users (§ 3.3)

3.1 Diagram structure

In the diagrams we make a distinction between three periods: a t_{-1} period (or $t_{<}$ in the diagram for structural users) in which the average level of R&D labour costs is represented over the previous years. For the sake of simplicity, in the schematic representation of the potential effect of WBSO on investments in R&D (R&D labour costs) we assume a firm which has a stable R&D labour costs pattern over a certain period [13]. The trend can be neutral, incremental or decremental, it makes no difference for the illustration of the WBSO's effect on R&D labour costs; the main aspect of concern here are any deviations from the trend. For the incidental users we assume that the R&D labour costs are (very) low prior to the WBSO application. The t_{-1}-t_0 period thus represents the situation in which a firm has **not yet** applied for WBSO. On date t_0 the plans are drawn up for the R&D work which will be carried out in the period t_0-t_1 and WBSO is subsequently applied for (and granted) on date t_0. On date t_1 the WBSO funds (or reduction) is made available to the firm [14]. We subsequently assume that when planning their R&D work in the period t_1-t_2 they take the WBSO funds (from the previous period) into account, and that they partly base their R&D labour costs on the reduction [15]. The effect to be estimated of the WBSO on R&D labour costs is expressed in the diagrams by the change in observed level of R&D labour costs on date t_1.

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[11] In fact this is concerned with the issue of causality: does the WBSO influence R&D labour costs or is the application for WBSO dependent on the R&D labour costs already planned. For a further explanation of this see also §4.1.

[12] In actual fact this is incorrect. Firms can always request interim reimbursement.

[13] In practice it appears that quite a substantial amount of volatility can be observed in the number of projects and the amount of R&D labour costs for which WBSO is applied for. This also applies with regard to firms applying for WBSO in successive years. We make grateful use of this fact in the econometrics (see appendix). We have not taken this volatility into account in the diagram for the sake of simplicity.

[14] This can take longer in practice depending on the time when the (provisional) assessment of the year in question is established by the tax authorities. In our figures we do not take into account the possibility of a provisional refund.

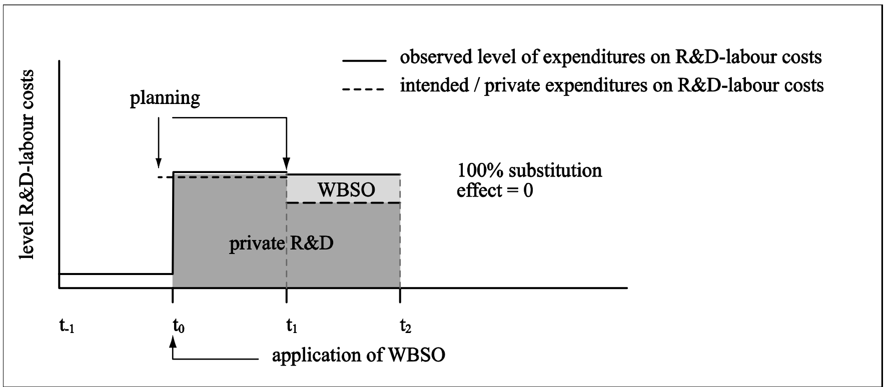
[15] This can also be seen as if a firm assesses its R&D projects at the end of the year on the basis of the results achieved and the expenditure involved, including the WBSO reduction. Plans are made for the subsequent period on the basis of this evaluation (internal cost-benefit analysis) and it becomes clear how, and to what extent, the WBSO has influenced the R&D labour costs. Here we assume an unambiguous sequentiality (causality). This will be (much) less the case in reality.

3.2 Substitution and additionality among incidental WBSO users

Substitution

The difference in levels of R&D labour costs in the periods t_0-t_1 and t_1-t_2 are important when assessing the effect. In the period t_0-t_1 we take only the 'own' R&D labour costs into consideration, in the period t_1-t_2 this is a combination of a firm's own expenditure and the WBSO reduction. In period t_0-t_1 the intended level coincides with the observed (actual) level of R&D labour costs (after all, the promised WBSO reduction is only paid out to some firms after the project has been completed). We show this in Figure 4-1 by setting out the lines of the *observed* level of R&D salary expenditure and the *intended* R&D salary expenditure adjacent to one another, while theoretically the one ought to traverse the other. On date t_1, upon completion of the submitted project, the WBSO funding is paid out and an internal cost-benefit analysis is drawn up for use as the basis for the R&D project plans in period t_1-t_2. In this diagram, the WBSO funding is used to reduce the firm's own R&D expenditure. If, as in Figure 1, there is no absolute increase or decrease in the total R&D expenditure, then it is a case of substituting one's own R&D expenditure for WBSO funds.

Figure 1 Schematic representation of the link between WBSO and investments in R&D (R&D labour costs) in the event of 100% substitution by incidental WBSO users



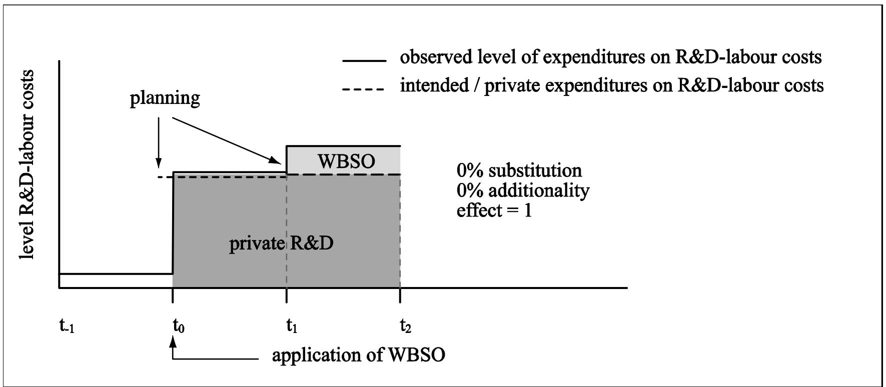
Of importance when assessing R&D expenditure levels is that in the case of **total** substitution, the effect of the WBSO on the firm's own R&D expenditure is in fact negative, i.e. while the internal R&D labour costs decrease, on balance the level remains the same. The more WBSO funding is used less as a substitution for a firms own R&D expenditure, the R&D labour expenditure will be higher than in the previous period. The degree of substitution can be expressed as a numeral or an effect. In the case of total substitution then that numeral or effect is 0 and each Euro in WBSO is used to reduce the firm's own R&D expenditure. The total level of R&D expenditure is apparently equal and in that case the WBSO does not lead to extra R&D expenditure either at operating level or at the macro level. This is the situation shown in Figure 1. On average, the less the degree of substitution, the effect will approach *unity*. For instance: a value of 0.7 indicates that a firm is using about 30% of its WBSO funding to 'save' (or substitute) its own R&D expenditure. In such a case, the average 'additionality' is 70% of the reduction granted. Basically, there is talk of substitution if an increase is observed in the R&D labour expenditure which remains under the 'calculation rule' [16].On average this is 18% of a firm's own R&D expenditure.

Neutral effect

In this study we speak of a neutral effect if the actual (observed) R&D labour costs on date t_1 increase by the amount received in WBSO (18% on average) compared to the level in the period prior to the period in which the WBSO funding was received (t_1-t_0). The effect is then exactly the same as *unity*.

In a neutral situation, whereas the firm's own R&D expenditure remains at the same level as in the previous period, the WBSO funding is used to make extra investments in R&D (salaries). On balance, the observed level increases by approximately the sum of the 'calculation rule'; this is 18% on average. In practice, there is talk of a gradual transition from total substitution to additionality. Particularly for the estimates, discussed later, the main element here is 'averages'. At an effect of about 0.9 there will be a large number of firms in which there is a question of additionality. A small number of firms used WBSO funds in such a situation as 'a means of saving'.

Figure 2 Schematic representation of the link between WBSO and investments in R&D (R&D labour costs) with a neutral effect (neither substitution nor additionality)



If we look at this situation on the macroeconomic scale then we see an element of leverage come into play, the total amount of expenditure on R&D is the sum of the firm's own WBSO funding. However, spillover effects could possibly have a positive effect and thus an increase in prosperity can be expected in due course. Spillover effects are not restricted to this situation alone but also play a role in the other situations, as is also the case for additionality. If the positive effects of spillovers are taken into account, and the societal yield from private R&D is assumed to be in the range of 35%, then it could be a question of additionality if the effect is greater than 0.7 [17].

Additionality

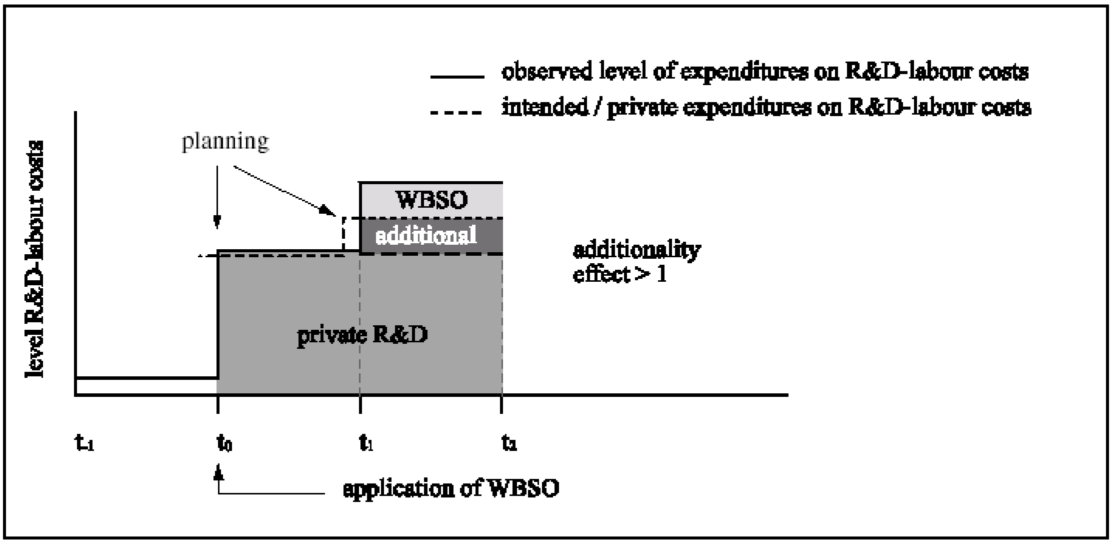
Here we speak of additionality if the observed level of expenditure on R&D increases more than is received in WBSO funding. In such a situation the firm's own R&D expenditure increases even further after receiving the WBSO contribution. The granting of WBSO is based on the firm's own expenditure on R&D salaries in the period t_0-t_1. However, an observed difference in expenditure need not necessarily deviate from the (incremental) trend that commenced in the years previous. Of importance in this situation is to establish whether

[16] The calculation rule is that a firm receives on average *one* Euro in WBSO for every *five* Euro it spends on R&D labour costs.

[17] See Jones & Williams (1990).

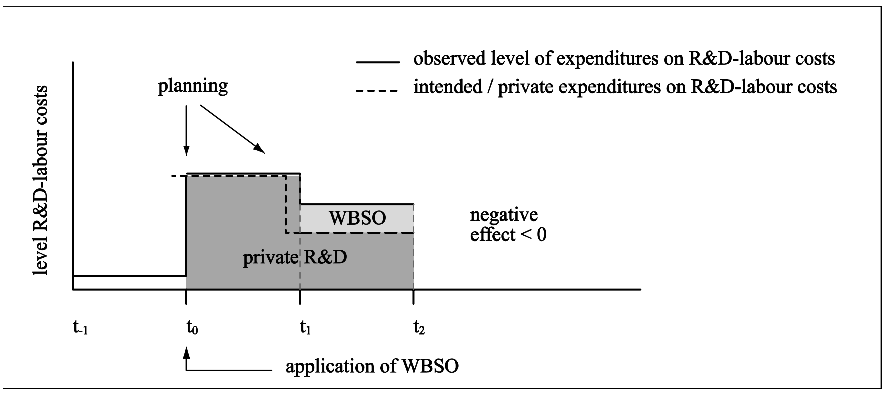
the increase in the firm's own R&D labour expenditure is the result of WBSO or that the firm decided to raise their salary expenses, for instance on grounds of favourable market prospects or competition (for that matter this also applies in the case of the other situations too). Causality is an important element here and must be taken into account. We devote attention to the aspect of causality in §4.3.

Figure 3 Schematic representation of the link between WBSO and investments in R&D (R&D labour costs) if WBSO has an additional effect.



Negative effect
Finally, we still have the theoretical possibility that after WBSO has been granted, the level of R&D labour expenditure decreases compared to the previous period. Here too is it important to establish whether there is a causal link. Such a causal link is unlikely. Practical experience shows that other factors also play a role, especially that numerous firms are unable to realise their plans for a variety of reasons. A decrease in R&D expenditure can be a combination of adjusting (too ambitious) plans made in the previous period, and the fact that less WBSO funding has been received than expected. We assume in this respect that there are entrepreneurs who anticipate future WBSO funding when planning their future R&D activities.

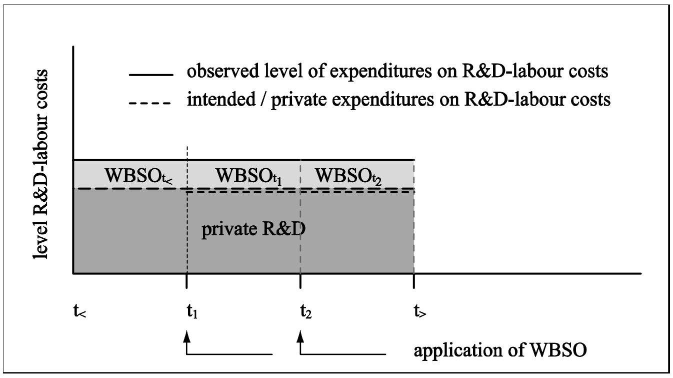
Figure 4 Schematic representation of the link between WBSO and investments in R&D (R&D labour costs) if WBSO has an additional effect.



3.3 Substitution and additionality among structural WBSO users

In the above cases we have given a schematic representation of the possible effects among the incidental users of WBSO. We now turn to firms that have made use of the WBSO over a period of three or more successive years. Generally speaking, it will be the larger firms that carry out R&D on a more or less permanent basis. The level of R&D expenditure in preceding periods is consequently not zero, or at least very low, as is assumed for the incidental users of WBSO, but is (substantially) higher. More important, however, is that the observed level of R&D labour expenditure over period $t_<$ is in the firm's 'own' R&D in part, and in part in WBSO reduction. This applies in all the periods.

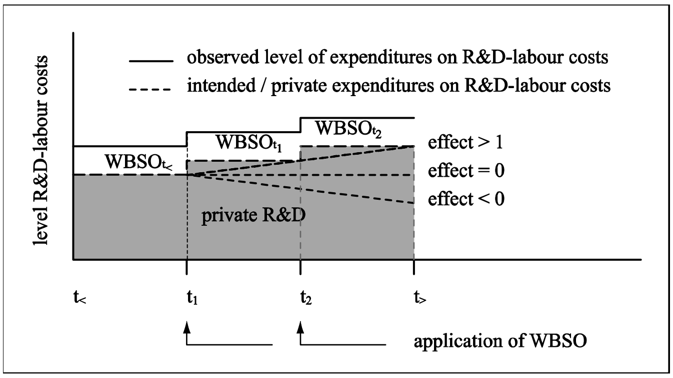
Figure 5 Schematic representation of the link between WBSO and investments in R&D (R&D labour costs) among structural WBSO users.



No immediate conclusions can be drawn as to substitution or additionality from possible changes in the observed level of R&D expenditure among the structural users of WBSO. After all, during the period of WBSO granting, this level consists of a combination of R&D labour expenditure and WBSO reduction from a previous period. It is possible that this has an influence on the planned level of R&D labour costs. For instance: on date t_1 a firm draws up its plans for the coming period. However, there is no information as to whether future WBSO funding is or is not taken into account in the planning process (anticipatory behaviour). It may be assumed that structural WBSO users will take future WBSO funding into account, yet it cannot be deduced from the observed level whether the WBSO has a stimulatory effect or whether the level of planned R&D labour costs are determinative for the WBSO application. This becomes even more complex among those firms that have to deal with the WBSO ceiling.

Without an additional assumption, concerning the aspect of causality, it is impossible to make any statements as to the significance of a possible effect. Figure 6 shows, assuming that WBSO reduction has a moderating effect on the costs of R&D, how the effect of WBSO can manifest itself, and thus can lead to the planned level of R&D labour expenditure.

Figure 6 Schematic representation of substitution and additionality and the link between WBSO and investments in R&D (R&D labour costs) among structural users of WBSO



The situation shown in Figure 6 is one in which the development of the observed R&D labour costs give reason to assume additionality (effect > 1). Also shown is what the size of the effect would be if there was a neutral (0) or a negative effect (<0) of WBSO on the planned R&D labour costs. There is a question of substitution if the effect is between zero (100% substitution) and unity (the borderline between substitution and additionality). In all cases, the calculation rule plays a role in the observed level. This will need to be taken into account in the modelling process.

4 Econometric model used

4.1 Modelling of the first order effect of WBSO on R&D labour costs

Model specification

A model was chosen that takes into account the postponed and indirect influence of WBSO on R&D expenditure in order to analyse the first order effects of the WBSO. Because of the available data, the model was estimated such that the volume of R&D in 1998 had to be accounted for, inter alia, on the basis of the R&D expenditure in 1997 [18]. The model is as follows:

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[18] We estimated several models and specifications to allow us to make an estimate of the first and second order effects. In addition to regression models (least squares) we also estimated probability models, Tobit and Heckman models, in an attempt to estimate the effect of the WBSO in comparison with a zero group of incidental users. The following specifications were estimated:
a) initial differences estimated (y_1-y_{t-1}), it was in fact the change that was estimated;
b) log-log specification, the coefficients in the comparison then become elasticities;
c) the variable to be accounted for is thus explained, inter alia, by a lag in the variable to be accounted for.
The latter specification gave the most robust and plausible estimate. Plausible in the sense that the outcomes correspond with the (empirical) literature. This specification is very similar to initial differences but the outcomes are generally better because in the 'initial differences' the restriction is imposed that the coefficient of the lagged term is equal to unity. Subsequently, if we do not pin down this coefficient we can also estimate the increase in R&D and the increase in sales volume from new products as a percentage of the total sales volume. Consequently, this specification does not have our preference. However, when measuring the first order effect we are faced with the problem of the calculation rule. By estimating the R&D labour costs for all the firms that had applied for WBSO in 1998, the effects of the WBSO on R&D are quite substantial. This is due to the fact that the firms had received no WBSO in the previous year (the 'jump' from t_{-1} to t_0 in Figure 4-1 for example). For these firms the ratio is 1 to 5. In other words, the effect for this group is that 1 Euro in WBSO generates 5 Euro in R&D labour costs. In short, this model in fact calculates the average granting and is unsuitable for calculating the effect of WBSO on potentially extra R&D, which is the exact purpose of the exercise. This calculation rule can be circumvented by now carrying out a regression only (OLS) for firms that have R&D labour

1) $$S\&O_{i,t} = \alpha_0 + \alpha_1.S\&O_{i,t-1} + \alpha_2.WBSO_{i,t-2} + \alpha_3.WBSO^2_{i,t-2} + \sum_{k=4}^{K} \alpha_k.X_{k,i} + \varepsilon_i$$

In which:

$S\&O_{i,t}$ = R&D labour costs in the year 1998 for firm i (endogenous variable)

$S\&O_{i,t-1}$ = R&D labour costs in the year 1997 for firm i (lagged endogenous variable)

$WBSO_{i,t-2}$ = WBSO in the year 1996 for firm i. (exogenous variable)

$WBSO^2_{i,t-2}$ = WBSO to the power of two in the year 1996 for firm i. (exogenous variable)

$\sum_{k=4}^{K} \alpha_k.X_{k,i}$ = all other exogenous variables and associated coefficients

ε_i = disturbance term

α_k = the coefficients to be estimated k=0..K

In the above equation WBSO with a 2-year lag is included in the model [19]. Using this model, the link is determined between the R&D labour expenditure in 1998 and the WBSO funding received in 1996 on the basis of the R&D expenditure statements made in 1997. A quadratic term for the WBSO granted in 1996 is also included in the model. This models the diminishing effect in the case of higher internal R&D expenditure. It is only fair to assume a diminishing effect because the WBSO is intended to encourage R&D among the smaller firms in particular (a higher percentage reduction on the first band), as well as the presence of a ceiling (although this is only relevant for a very few firms). The higher – in absolute terms – a firm's own R&D expenditure, the greater the reduction – in relative terms – in the potential WBSO contribution.

Differentiating the above equation according to WBSO allows us to calculate what one Euro in WBSO yields in the case of the least squares (OLS): namely ($\alpha_2 + 2.\alpha_3.WBSO_{t-2}$) Euro of extra R&D. This is indicated in the foregoing figure by effect (for structural users see Figure 6). If the term $\alpha_2 + 2.\alpha_3.WBSO_{t-2}$ is negative, then there is a question of substitution or crowding out. An effect with a value between zero and unity is indicative of substitution more-or-less. The closer the effect comes to unity, there is a combined situation in play; in some firms there is a question of substitution, and in others, additionality. A value above unity generally indicates additionality. In other words, the effect represents an average for all firms.

Alternative specification (Tobit model)

If, when estimating the effect of WBSO on R&D labour costs, firms not receiving WBSO are also taken into account, use can be made of a Tobit model. One complicating factor of a Tobit model is that the effects cannot be calculated directly because negative R&D expenditure is out of the question. We correct this by using the Tobit model. To determine the effect of one Euro of WBSO (given that a firm receives WBSO) then the calculation should be made as follows:

costs in 1998, 1997 and 1996 and that submitted applications for WBSO. However, the disadvantage here is that we are then only able to make statements for firms that receive WBSO on a structural basis.

19 The WBSO was included with an extra lag of one year (1996 instead of 1997) in order to take endogeneity into account as much as possible. Strictly speaking, WBSO should be drawn up in 1997. Further down in the text it will be made plausible that in 1996 the WBSO is a good instrument for the WBSO in 1997.

$$\frac{\delta E\left(S\&O_{98} \mid S\&O_{98}>0\right)}{\delta WBSO_{96}}=\left[\hat{\alpha}_1+2\hat{\alpha}_2\cdot WBSO_{96}\right]\left[1-\frac{\varphi\left(\frac{S\hat{\&}O_{98}}{\hat{\sigma}}\right)}{\Phi\left(\frac{S\hat{\&}O_{98}}{\hat{\sigma}}\right)}-\left\{\frac{\varphi\left(\frac{S\hat{\&}O_{98}}{\hat{\sigma}}\right)}{\Phi\left(\frac{S\hat{\&}O_{98}}{\hat{\sigma}}\right)}\right\}^2\right]$$

in which:

$S\hat{\&}O_{98}$ = the estimated R&D equation

$\hat{\sigma}$ = the estimated standard deviation

φ (.) = the standard normal distribution with argument (.)

Φ (.) = the estimated cumulative normal distribution function with argument (.)

4.2 ‘Bandwidth’

When estimating the model the matter of concern is not only the value of the effect but also the reliability intervals, i.e. within which interval the effect has a reliability of 95%. The reliability of the effect is the calculated value of the effect plus or minus twice the standard inaccuracy of the effect. The calculation of the effect is dependent on the method of estimation and model specification used. For an OLS, the effect is the same as $\hat{\alpha}_1+2\hat{\alpha}_2\cdot WBSO_{96}$. Because WBSO and R&D expenditure are not normally distributed it is necessary to transform the available data. Additionally, the sum of R&D expenditure and WBSO is scaled with the sales volume in order to correct the heteroscedasticity.

The variables in the model can be estimated for a large number of the firms by using the method of the least square (OLS). To do this it is essential that the R&D data of both 1998 and 1997 are available. In the other cases, OLS will be insufficient and thus we make use of a ‘Tobit model’. This model estimates the likelihood of a firm being engaged in R&D activities, and subsequently the expenditure. Both effects are defined by a single coefficient per variable. This is consequently the reason why the coefficients from a Tobit model cannot be interpreted directly.

4.3 Causality

Among other aspects of methodology, causality plays a role when specifying this model. It is generally assumed that granting WBSO implies a reduction in a firm’s R&D labour costs and that firms can therefore be encouraged to set up (more) R&D activities. The WBSO is based on planned R&D activities. This is specified as such in the model. Nevertheless, it can also be argued that especially innovative firms with R&D labour expenditure use WBSO with the intention of saving on already planned R&D projects (reverse causality). In this case, WBSO can be regarded as ‘coming too late in the day’. The effect estimated is that the effect of previous (internal) R&D expenditure on the extent to which firms submit applications for WBSO. Although the scheme is focused on planned R&D projects (firms must keep, inter alia, a time sheet administration of the hours spent on the projects under way for which WBSO has been applied for), reverse causality cannot be excluded. To tackle the issue of causality in terms of econometrics we would need to have panel data for all the required data. Moreover, information must be available on innovative firms over a period for the WBSO [20].

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[20] Prior to the introduction of WBSO, other incentive measures had already been in force such as the INSTIR. One general ‘problem’ in terms of econometrics is that a substantial part of Dutch trade and industry makes structural use of a variety of provisions specifically set up to encourage innovation.

Such a data set is not (yet) available. Strictly speaking, we are unable to investigate the issue of causality directly with the data we have using the chosen model specification.

4.4 Testing causality

In an indirect fashion, it can be made quite plausible that a reduction in R&D labour costs has a positive effect on R&D labour expenditure. One way to gain more clarity into the aspect of causality is to find out whether the WBSO has an effect on the price level of R&D labour costs. Entrepreneurs could decide to invest more in R&D if the WBSO led to lower R&D costs, which is the actual objective of the WBSO. An estimate of the price elasticity provides an insight into how the link between WBSO and R&D develops.

To estimate the aspect of price elasticity of WBSO we looked at other studies, including the study conducted by Bloom, Griffith & van Reenen (2000) [21]. In this article, R&D price elasticity is determined on the total R&D. To do this they estimated five equations in which the total R&D is accounted for on the basis of: total lagged R&D, R&D labour costs and output. This analysis was carried out for nine OECD countries over the period 1979-1997, but excluded the Netherlands. In this article, the coefficients were estimated by using a panel set. In addition to these variables, year and country dummies were also included in the estimates of Bloom, et al. It goes without saying that country and year dummies were not used for the estimates for the Netherlands because they were based on a cross section file as opposed to a panel data set as used by Bloom, et al. In order to have an estimate for the Netherlands available, for our study we made this analysis for the Netherlands at the level of the firm for 1998-1997. The outcomes for the Netherlands, and those for 9 OECD countries as a reference, are shown in Table 1.

The most important result of the analysis is that the coefficient of 'R&D labour costs per R&D employee in 97' is both negative and significant. The result of our analysis shows that the short-term price elasticity is equal to –0.11. This implies that if the price level of R&D drops by 1%, then the total R&D expenditure increases by 0.11%. In the long term, price elasticity is equal to 1.12%. From this we can deduce that WBSO lowers R&D labour costs significantly and thus our assumption is supported that the causality runs from WBSO to R&D labour costs.

We also wish to point out here that the estimated price elasticities of both studies are more or less identical. The price elasticity of R&D in the Netherlands is 0.11 and for the OECD countries this is 0.14. Furthermore, the other elasticities were more or less the same in both studies. The table also gives the long-term price elasticities for both studies. For the Netherlands, this is equal to 1.12 and for the OECD, 1.09.

[21] See Bloom, Griffith & van Reenen, (2000)

Table 1 Regression outcomes in which the R&D labour expenditure in 98 is explained on the basis of R&D prices, etc. All effects are elasticities. Outcomes for the Netherlands and for 9 OECD countries.

Log (R&D labour costs in 98)	Estimate NL 1998-1997		Estimate 9 countries 1979- 1997* OECD	
Variable	Coefficient	t-value	Coefficient	t-value
Total R&D labour costs in 97	0.902	48.83	0.868	20.19
R&D labour costs per R&D employee in 97	-0.110	-4.50	-0.144	-2.67
Sales volume 97	0.053	4.17	0.143	0.88
Reference: dummy =1 pavitt-jong sector.: scientific based				
Dummy =1 pavitt-jong sector.: scale intensive	-0.107	-2.55		
Dummy =1 pavitt-jong sector.: specialised suppliers	0.029	0.64		
Dummy =1 pavitt-jong sector.: supplier dominant firms	-0.122	-2.31		
Dummy =1 pavitt-jong sector.: infrastructural services	-0.300	-2.53		
Dummy =1 pavitt-jong sector.: added value services	-0.021	-0.27		
Dummy =1 pavitt-jong sector.: *presp. services	-0.116	-2.29		
Dummy =1 pavitt-jong sector.: ad hoc services	0.049	0.68		
Constant	1.823	8.61		
Long-term effect on labour costs per R&D employee	-1.116		-1.088	-45.33
Number of firms	1751		155	
Adjusted R^2	0.76			

*Source: Bloom, Griffith & van Reenen, 2000, pp. 16.

4.5 Volatility and lagged WBSO as an instrumental variable

To circumvent the problems of the calculation rule when estimating the effect of WBSO on R&D labour costs we used an 'instrumental' variable in the model specification to estimate the effect. 'Instrumental' variables are used in econometrics if a variable entered as an exogenous variable should really be seen as endogenous. In the case of WBSO, the reduction applied for is more or less determined by the expenditure on R&D in a previous period. Among other things this can be seen in the schematic representation of the link between planned R&D expenditure, the WBSO applied for, and its ultimate appropriation (see §3 and §3.3). The instrument used for the WBSO applied for in 1997 is the WBSO application in 1996. The use of 'lagged' exogenous variables as an instrument is quite common. Nevertheless, some people claim that this is incorrect, or at least that certain risks are involved [22]. In the case of WBSO, a lagged WBSO as instrument would be erroneous if firms were to submit applications for roughly the same amount of WBSO year after year. In that case, WBSO in 1997 would be approximately the same as in WBSO in 1996 or 1995. In other words: more or less a 'constant' and not a valid instrument for WBSO in 1997.

[22] See, inter alia, Angrist & Kruger (2001)

The Senter database was used to look at how big (or small) the volatility is in WBSO use. This was examined first by looking at the differences in the number of hours for which applications had been made. The results are presented in Table 2 for firms that made applications in 1998 and 1997 and gives the difference in number of hours applied for as percentages.

Table 2 Volatility of WBSO: change in R&D hours in 1998 compared to 1997 per firm, given that a firm conducted R&D activities in both years.

	Size category (employees)					
Change in R&D hours in category compared to the previous year	1-5	5-10	10-50	50-200	200plus	total
Reduction >60%	7%	6%	6%	6%	9%	7%
Reduction between 40-60%	10%	8%	9%	9%	8%	9%
Reduction between 40-20%	13%	14%	13%	14%	15%	14%
Reduction between 20-10%	8%	6%	9%	9%	11%	8%
Reduction between 10.5%	3%	4%	5%	5%	5%	5%
Change between minus 5 and plus 5%	23%	18%	18%	15%	18%	19%
Increase between 5-10%	4%	2%	3%	5%	3%	4%
Increase between 10-20%	7%	7%	8%	7%	6%	7%
Increase between 20-40%	6%	9%	9%	9%	10%	8%
Increase between 40-60%	5%	6%	5%	6%	4%	5%
> 60% increase	15%	18%	15%	14%	11%	15%
Number of firms in calculation	1640	603	2145	1315	611	6314

Source: Senter

One important conclusion that can be drawn on the basis of the results shown in Table 2 is that there is quite a substantial amount of volatility [23]. In a total of 19% of the firms that applied for WBSO in 1997 and 1998 it is apparent that the difference between the two years was limited to minus 5 and plus 5%. In approximately 30% of the firms the number of hours applied for increases by 20% or more. The differences are significant [24, 25].

The analysis of volatility is concerned with firms that have submitted an application in two successive years. The relatively high level of volatility consequently seems to be in conflict with the view that R&D is part and parcel of a firm's strategic policy. One would be more likely to expect that the level of volatility would be low given that firms spread their R&D activities over several years. One explanation for the relatively high level of volatility could lie in the fact that the WBSO focuses on projects which are new for the firm. A substantial part of R&D work relates to somewhat routine development work, incremental adjustments and improvements on existing products, and less to typically innovative 'research work'.

4.6 Implications for the model specification

On the grounds of these results we conclude that there is a high level of volatility in practice. It is also evident from the analysis of the 'price elasticity' of R&D labour costs that the more

[23] The analysis was also used on other years, as well as on the labour costs applied for in different successive years. However, the outcomes differ by degrees only.

[24] With the help of a t-test we tested whether the difference was equal to zero. A rejection of this hypothesis implies that the number of hours applied for in 1998 differs significantly from those in 1997.

[25] We see virtually the same picture if we look at the reduction granted. In 21% of the firms the granted reduction decreased by 20% or more, in 37% of the firms the amount of reduction granted increased by more than 20% when adjusted for inflation. For approximately 17% of the firms, the amount remained more or less the same. If we look at the size category, then we see that the increase took place in the larger firms in particular, and that there is more of a decrease among the smaller firms.

R&D labour costs increase per employee (R&D employees become more expensive) the more the total R&D expenditure will decrease in subsequent years. We can deduce from this that a decrease in R&D labour costs, the objective of the WBSO, will lead to more R&D expenditure in subsequent years. This makes it plausible that the WBSO has an influence on R&D labour costs in subsequent years, as also specified in the model. Field study results also point in the same direction. The field study shows that there are specific groups of WBSO users who indicated that WBSO played a decisive role in their investment decisions. We therefore also assume that lagged WBSO can be used as a valid instrument; this implies that the model specification using the WBSO as an instrument for (the endogenous) WBSO 1997 is most probably correct.

5 Main variables and dataset used in the model

From the model specification it is apparent that, like lagged WBSO, R&D labour expenditure in a previous year is an important explanatory variable for R&D labour costs in the year 1998 (endogenous variable). Other explanatory variables will also be included in the model specification (other exogenous variables). The question is: which? In general, reference is made to three groups of explanatory variables that are of influence on R&D expenditure and R&D output (first and second order effects) namely: business characteristics, market structure and general characteristics of innovation and sector characteristics.

Business characteristics are variables that relate to the firm's size, whether or not it is an independent firm, or whether it belongs to a parent firm in a foreign country. A link can generally be found between the degree of innovation and market structure. General characteristics of innovation, such as technological trajectories, also play a role. For instance, one could think in terms of differences between innovation in the pharmaceutical industry and innovations in the processing industries for example. Sector characteristics relate mainly to demand (how demand develops), technological opportunity and appropriability conditions. In addition to these groups of explanatory variables there are also variables which are specific for the evaluation of WBSO, such as type and category of projects submitted. With regard to type, the submitted projects are broken down into feasibility studies, development projects or technical and scientific. Projects submitted are broken down into: software, process or miscellaneous projects.

In the empirical literature on R&D investments [26] reference is made to three groups of explanatory variables (factors) that may be of influence for R&D intensity (R&D labour costs divided by the total sales volume) i.e. explanatory variables that relate to:
a) Business characteristics.
b) Market structure, size and innovation.
c) Sector characteristics.
First we give a brief explanation of these three groups of explanatory variables. We then devote attention to those variables that fall outside these three categories but which are still of importance for the WBSO evaluation.

5.1 Business characteristics

In the category of business characteristics we are concerned with those variables such as size, branch of trade or industry, other business characteristics such as collaboration in the field of

[26] See Kamien & Schwartz (1975, Cohen (1995), The latter title is an up-to-date version of: Cohen, & Levin (1989).

R&D, independence, and permanent versus incidental R&D. The relationship between the size of a firm and investments in R&D is important. Generally speaking, larger firms are more innovative than smaller ones; one of the reasons being economies of scale and scope. Larger firms are able to divide up their R&D investments and additional investments, in marketing for instance, over a higher sales volume and a wider variety of products. However, the relationship between a firm's size and R&D investments is more or less branch-specific. When explaining R&D investments a correction must be made for branch effects to be able to estimate the effect of WBSO on R&D investments properly. Other business characteristics also have an influence on R&D investments.

5.2 Market structure and innovation

Of importance for investments is the extent to which, and the period over which, the investment costs can be recouped. Certainly in the case of R&D investments, which more than other sorts of investment are characterised by uncertainties of a technical and financial nature, are the prospects of profitability important. The larger the margin to be realised, the higher the incentive to invest in R&D.

The margin to be achieved on new products and services is to a large extent determined by the market structure. Market structure refers in the first place to market concentration. The structure of a market, or the market concentration, is determined by dividing the size of the firms in a certain market. According to Schumpeter [27] it can be deduced from the fact that profits form a major incentive for R&D, that large firms – in particular those with a monopoly-like market power – should be able to benefit the most from technological development. This implies that not the markets with absolute competition, but the monopolistic / oligopolistic markets are the most favourable for technological development. Moreover, monopoly profits are used to finance new innovations and this can lead to an escalating effect. Sectors with a high degree of concentration should consequently be more innovative than other sectors [28]. Opposing Schumpeter's views are those of Arrow [29]. The conclusion on the basis of Arrow's findings is that a monopolistic market structure is less favourable for product innovations and more favourable for cost-reducing process innovations. Higher rents can be obtained in a market of absolute competition, but the incentives to innovate are by far the largest in an oligopolistic market.

One practical contribution to this study can be found in the empirical work of Scherer [30] who detected a U-turn between market structure and innovation.

5.3 Sector characteristics

Sector characteristics relate to characteristics such as: demand (demand development), technological opportunity and appropriability conditions.

Demand (development)

The relationship between demand development and innovation is (was) the subject of intensive debate. Schmookler [31] stated that technological developments were the outcome of profit opportunities for firms. The idea being a pool of scientific knowledge and technologies which, depending on the demand (market prospects used to select the sort / type of

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27 Schumpeter (1942).
28 Philips (1966).
29 Arrow (1962).
30 Scherer (1967), Scherer (1967).
31 Schmookler. (1962).

innovation), can be made suitable for specific products and services by different firms putting in a certain amount of additional R&D. Market conditions steer the innovation process to such an extent that technologies with the highest market potential receive the largest share of private R&D investments. Also the level of R&D investments in general is dependent on market trends. In a market with a strongly growing demand there will be less incentive to innovate, while in a tighter market, innovations aiming to save on costs are a means of retaining or regaining one's profitability.

Technological opportunity
Opposing the idea of innovation being demand driven is the idea of innovation being driven by more or less autonomous technological development. The development of new technologies is a lengthy and uncertain process which is not easy to adjust to changing economic trends. The reasoning behind this is that technological development makes new products and services possible and thus generates new demand. The relationship between technological development and R&D investments is that in certain areas of technology, in which major breakthroughs are expected or in which new technologies offer new market opportunities, firms will make relatively high investments in innovation. In this view, fields of technology are a strong indicator of R&D investments and consequently of the R&D intensity among firms. No convincing empirical evidence has been found for both these views, i.e. the general consensus is that both demand and technological development are of influence on innovation and R&D investments [32].

Appropriability conditions
Of importance when deciding to invest in R&D is whether the investments can be recouped. In other words, appropriability conditions are among the necessary conditions under which firms are able to cash the results of the innovation themselves and prevent other firms from benefiting from their R&D investments either in whole or in part (limiting the number of spillovers and free-riders). In markets in which firms are able to limit the number of spillovers, the incentive to innovate will be greater than in those markets in which this is (much) less the case. Teece [33] states that there are two factors which are decisive as to what extent firms are able to cash the results of their R&D: first the extent to which, and the rate at which a firm is able to transform innovations into commercial products (time to market). Secondly, the opportunities for a firm to defend itself against imitators by limiting the number of spillovers. One way to limit spillover, or at least to protect the usufruct of one's own R&D, is to make use of patents [34].

Unfortunately, we have no information on the time to market aspects of innovations. However, the use of patents as an indicator of appropriability is also limited [35]. One major shortcoming in the use of patents as an indicator is that patents are only allowed on certain types of innovation [36]. The costs involved in applying for and enforcing patents are also relevant, especially the act of defending a breach of patent involves high costs. On financial and organisational grounds it would be the smaller firms in particular that would not patent their innovations. In short, the analytical value of a variable regarding patents is limited. One exception in this respect could be the pharmaceutical industry. The combination of lengthy obligatory clinical tests and strict requirements for the release of drugs to the market in

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32 See, inter alia, Kleinknecht & Verspagen (1990).
33 Teece (1986).
34 For an overview of appropriability conditions see, inter alia, Tidd,. Bessant & Pavitt.
35 See, inter alia, Acs. & Audretsch (1989), Bound, Cummins, Griliches, Hall, Jaffe (1984).
36 See, inter alia, Scherer (1983). For the Dutch situation see: Brouwer. (1997).

combination with patents calls for specific strategic behaviour aimed at ‘the winner takes all’ in this sector of industry. This means that there is a strong incentive to engage in R&D activities and then to protect that knowledge by taking out patents. Firms operating in this sector with patents are expected to have a high R&D intensity.

Variables from each of the three groups of explanatory variables (exogenous) have been incorporated in the model. One factor that played a role here was that some of the variables can be placed in two or more groups. For instance: the sector or branch of industry under which a firm can be categorised. Dummies for a branch of industry are relevant in the group of business characteristics plus the group of sector characteristics. For reasons of actually being able to make an estimation, explanatory variables may not be correlated too strongly.

The variables included to estimate the first and second order effects are presented in the table below. Use was made of the Senter database, data from production statistics and innovation data were taken from the large-scale innovation survey carried out by the CBS (Central Bureau of Statistics), CIS2 and CIS2½. The Senter data relates to the use of WBSO in the period 1994-2001. The production statistics, which include background information such as sales volume, employment, added value, etc., relate to the period 1995-1998. Innovation data are available for the year 1996 and/or 1998 [37]. For the model to account for the first order effect we limited the (least squares) estimates to the group of firms that took part in both CIS surveys as well as those firms that applied for WBSO in 1996 up to and including 1998. The main restriction that the data enforced upon us was the availability of innovation data. The absence of these data for several years was the reason why a panel analysis was out of the question. To estimate the first order effects of the WBSO as thoroughly as possible we made use of the R&D labour costs recorded by Senter. The firms categorised by the CBS as innovative that had not submitted applications for WBSO were not included in the analysis to determine the first order effect. The reason being that the estimated first order effect would then be influenced to the least possible extent by any omissions in the linkage. Possible doubts regarding the magnitude of the first order effects were thus eliminated by not taking this group into consideration.

[37] Not all firms took part in both surveys, e.g. due to some firms not being included in the random check in both years.

Table 3 Origin and significance of the main variables used in the model

Variables	Source	Year	Definition
The endogenous (to be accounted for) variables			
R&D 98	Senter, CBS	98	R&D labour applied for (Senter) in 1998, divided by the sales volume in 1998 (Senter & CBS, PS)
Sales_np98	CBS	98	Sales volume of new products as a % of the total sales volume in 1998 (CBS, CIS2.5). Only industry
The exogenous (explanatory) variables (lagged)			
R&D 97	Senter, CBS	97	R&D labour applied for (Senter) in 1997, divided by the sales volume in 1997 (CBS, PS)
Sales_np96	CBS	96	Sales volume of new products as a % of the total sales volume in 1996 (CBS, CIS2). Industry only
WBSO 96	Senter, CBS	96	Total granted reduction in Dutch Guilders (Senter) in 1996, divided by the sales volume in 1996 (CBS, PS)
WBSO_96 * size category	Senter, CBS	96	WBSO_96 * size categories (10-20, 20-50, 50-100, 100-500, and reference group 500 employees and above) (CBS, CIS 2)
Determinants of innovation			
R&D a permanent activity	CBS	96	Dummy =1 if R&D is a permanent activity (CBS, CIS 2)
% purchase of sophisticated equipment, machines, computers	CBS	96	Purchase of sophisticated equipment, machines, computers as a % of the total innovation expenditure (CBS, CIS 2)
% sub-contracted research	CBS	96	Sub-contracted research as a % of the total innovation expenditure (CBS, CIS 2)
% technical preparation of production processes	CBS	96	Expenditure on the technical preparation of production processes as a % of the total innovation expenditure (CBS, CIS 2)
% expenditure on licenses / patents	CBS	96	Expenditure on the acquisition of licenses / patents as a % of the total innovation expenditure (CBS, CIS 2)
% marketing activities	CBS	96	Expenditure on marketing activities for innovations as a % of the total innovation expenditure (CBS, CIS 2)
% expenditure on training, refresher courses for the personnel	CBS	96	Expenditure on training courses, refresher courses for personnel as a % of the total innovation expenditure (CBS, CIS 2)
The firm has applied for a patent	CBS	96	dummy =1 if the firm has applied for a patent (CBS, CIS 2) (how many and for what is not apparent)
The firm has a knowledge contact	CBS	96,98	The firm does or does not have a knowledge contact with regard to R&D / R&D joint venture, CBS, CIS 2+2.5)
Areas of technology (16 areas)	Senter	97,98	The areas of technology have been combined into 16 areas (Senter)
Business characteristics			
Employees in several categories	CBS	97	Number of employees in 6 categories (CBS, PS)
Dummy is or is not an independent firm	CBS	96,98	The firm is or is not a subsidiary of a parent firm (CBS, CIS)
Dummy head office is or is not in the Netherlands	CBS	96,98	The firm's head office is or is not established in the Netherlands (CBS, CIS)
Export quote	CBS	97	Export divided by sales volume (CBS, PS)
Sector characteristics			
Herfindahl index	CBS	97	Herfindahl equivalent (a measure for market structure, see also the note on the selection of variables) calculated to 3 digits =(the sum of sales in the square of all firms within a sector)^(-1) (CBS, PS)
Pavitt & de Jong sector categorisation (8 sectors)	CBS	97	Dutch Services and Industry are divided into 8 sectors (PS)

6 First order effect outcomes

6.1 Determinants for the first order effect

Table 4-4 shows the outcomes of the first order effect. In this comparison the R&D labour costs in the year 1998 are accounted for by the R&D labour costs in the previous year, the reduction applied for in 1996, and other characteristics.

Table 4 Factors of influence on the R&D labour costs in 1998 (first order effect)*. Results for OLS and TOBIT

Determinants of:	OLS estimate coefficient	OLS estimate sig**	Tobit estimate sig**
R&D and WBSO in the past			
R&D labour costs in the year 97	0.62	++++	++++
Applied for reduction on labour costs in 96 (WBSO)	1.03	++++	++++
Applied for reduction on quadratic labour costs in 96 (WBSO)	0.00		----
Business characteristics			
sales volume per employee in 97	0.00	-	
reference: firms employing between 20 and 50 workers			
Dummy =1 if the firm has between 10 en 20 employees	-7.98	----	
Dummy =1 if the firm has between 50 en 100 employees	-4.02	--	
Dummy =1 if the firm has between 100 en 500 employees	-3.14	-	+
Dummy =1 if the firm has more than 500 employees	-3.08	-	
Dummy =1: if the firm has a knowledge contact	1.61	+	
Export quotas (export divided by sales volume)	2.31	+	
Dummy =1 if the firm is independent (no parent firm)	1.25		++
Dummy =1 if the firm has its head office in the Netherlands	-0.85		-
Sector characteristics			
reference: dummy =1 pavitt-jong sector.: scientific based			
Dummy =1 pavitt-jong sector: scale intensive	-0.73		
Dummy =1 pavitt-jong sector: specialist suppliers	1.05		
Dummy =1 pavitt-jong sector: supplier dominant firms	0.17		
Dummy =1 pavitt-jong sector: infrastructural services	-0.57		----
Dummy =1 pavitt-jong sector: added value services	4.95		
Dummy =1 pavitt-jong sector: *presp. Services	-0.94		
Dummy =1 pavitt-jong sector: ad hoc services	8.18	+++	+++
herfindahl equivalent	0.00		

Cont. Table 4

Determinants of:	OLS estimate coefficient	OLS estimate sig**	Tobit estimate sig**
reference: dummy =1 technology area miscellaneous			
Dummy =1 area of technology measuring/testing	2.11		-
Dummy =1 area of technology chemistry	1.14		-
Dummy =1 area of technology the environment	-0.09		-
Dummy =1 area of technology agriculture	2.60		
Dummy =1 area of technology nutrition	4.76	+	
Dummy =1 area of technology electrical engineering	0.32		
Dummy =1 area of technology communications	12.08	++++	+
Dummy =1 area of technology process control	-3.23		
Dummy =1 area of technology mechanical engineering	1.29		-
Dummy =1 area of technology metal	1.15		-
Dummy =1 area of technology transport	1.06		
Dummy =1 area of technology building	2.04		
Dummy =1 area of technology materials	4.41	+	
Dummy =1 area of technology chemicals technology	1.06		
Dummy =1 area of technology wood and paper	0.51		--
Constant	1.07		
Adjusted R^2		0.82	
Vealls and Zimmerman R^2			0.69

* OLS estimates were made for structural WBSO users. These firms had applied for WBSO in 1995, 1996 and 1997. Firms that have reached the WBSO ceiling were excluded from the analysis.
Variables of no significance are:
- WBSO expenditure broken down into size category and sector;
- year dummies for WBSO use (modelling the effect of WBSO adjustments, the 'natural experiment') [38];
- standard deviations in WBSO received in the past;
- differentiation between product, process and software related R&D;
- use of an intermediary when applying for WBSO.

** Significance of reliability intervals
---- negatively significant at 99% reliability;
--- negatively significant at 95% reliability
-- negatively significant at 90% reliability
- negatively significant at 70% reliability
not significant
+ positively significant at 70% reliability
++ positively significant at 90% reliability
+++ positively significant at 95% reliability
++++ positively significant at 99% reliability

6.2 Effects of WBSO on R&D labour expenditure

In Table 5 we show the results of the estimates in the form of the effects of WBSO on R&D. One Euro in WBSO leads to an expenditure in firms of 1.01 / 1.02 Euro on R&D labour [39]. This implies that the group of firms making use of the WBSO spend an average of one to two Eurocents extra in R&D labour expenditure themselves (for each Euro in WBSO the firm invests an average of 1.01 / 1.02 Euro on R&D). Given the inclusion of a lag in R&D expenditure, a long-term effect could in principle also be calculated. However, this variable was only incorporated as a means of verification in order to show the increase in R&D. We therefore cannot calculate the long-term effect using this model.

[38] For an empirical working out of the use of 'natural experiment' as a method for estimating the effect of a policy measure see: Harmon, C. & I. Walker (1995), 'Estimates of the Economic Return to Schooling for the United Kingdom', The American Economic Review, vol 85, no. 5 (Dec. 1995), pp. 1278-1286. The effect of interim adjustments made to the WBSO (extending the first band and adjusting percentage decreases, 'the natural experiment') was not demonstrated for R&D expenditure. There are two important reasons for this outcome. First, adjustment of the percentages takes place in arrear, i.e. firms cannot anticipate them. Secondly, the adjustments are relatively low compared to a firm's total R&D expenditure (on average the WBSO is 18% of the R&D labour costs which are a part of the total R&D expenditure).

[39] Although we make a comparison over several years, deflating is unnecessary given that R&D and WBSO are both divided by the sales volume. We assume here that the price movements in R&D labour costs and WBSO are equal.

Taking into account the high average of the social yield of R&D investments in general (estimated at 35% extra factor productivity [40]), the actual social yield is greater than what initially seems only a modest one to two Eurocents. This effect is dependent upon the size category and the branch of trade and industry.

The short-term price elasticity for the Netherlands is estimated in the appendix at 0.11%. This means that if the price of R&D labour falls by 1% then the R&D labour costs increase by 0.11%. Given this price elasticity, the reader might be tempted to validate this outcome with the outcome of the effect of 1 Euro in WBSO on the R&D labour costs. After all, WBSO can be seen as a reduction in labour costs. Strictly speaking, this is not so since in micro research the effects obtained from an equation cannot be simply be multiplied with macro data and subsequently compared with the outcome from another model. The correlations between equations and variables are not equal to zero. Also, other effects such as derivatives and elasticities are very sensitive to change. They too are only valid in the case of marginal changes. These effects are extremely valuable in models but if the outcomes are manipulated with data from outside the model, then the effects thus obtained are less reliable. If the price elasticity of 0.11 is still used to validate the outcome of the WBSO, then the following calculation can be made. Given that in the Netherlands a firm receives on average 18 Eurocents reduction for every Euro it spends on R&D labour costs, this means that the effect of one Euro in WBSO on R&D labour expenditure equals 0.61 [41]. This value falls just outside the reliability interval of 0.70 to 1.30 calculated for the WBSO. That this calculation results in a lower effect than the 1.01 / 1.02 is hardly surprising. After all, a change in R&D labour costs per employee of 1% has – from the firm's point of view – less of a major effect than if the firm were to be given a 40% or 20% reduction on the labour costs. It is thus hardly surprising that the effect for the WBSO is greater than the effect from the model in which the price elasticity is calculated.

There are major differences from one firm to another regarding the extent to which WBSO provokes extra R&D rather than substitutes existing R&D. The bandwidth of the effect is between 0.7 and 1.3. This bandwidth indicates that there is a group of firms for whom the WBSO does indeed give rise to extra R&D (for these firms it is a question of additionality). These firms cannot be distinguished from one another on the basis of the variables in the model. The field study shows that the difference between the firms is determined more on the basis of the firm's orientation towards R&D.

Table 5 also includes a breakdown into firm size category. From the calculated effects (OLS) it appears that the effect of WBSO declines the larger the firm. For firms with 10 to 20 employees, the elasticity is 0.37; for firms employing 500 or more, the elasticity is reduced to 0.14. A similar pattern is seen in the Tobit estimate.

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[40] See Jones, C.I. & J.C. Williams (1998).

[41] The derivative (dy/dx) is equal to the price elasticity multiplied by the average sum spent on R&D labour costs divided by the average received reduction. Thus 0.11*(1/0.18).

Table 5 Calculated effects of WBSO on R&D (short term)

	OLS estimate	Tobit estimate
Estimated coefficients		
R&D labour costs in the year 97	0.623	0.825
Reduction on labour costs applied for in 96 (WBSO)	1.028	2.032
Reduction on labour costs, quadratic, applied for in 96 (WBSO)	-0.001	-0.001
Calculated effects		
Increase in R&D Euro if the WBSO increases by 1 Euro (derivative)		
For all firms in the analysis	1.02	1.01
Lower limit effect at a 95% reliability interval **)	0.71	0.70
Upper limit effect at a 95% reliability interval	1.32	1.33
Increase in R&D in % if the WBSO increases by 1% (elasticity)		
For all firms in the analysis	0.24	0.21
10-20 employees	0.37	0.23
20-50 employees	0.25	0.16
50-100 employees	0.26	0.21
100-500 employees	0.19	0.18
More than 500 employees	0.14	0.19
Firms with no R&D in 1998		226
Firms with R&D in 1998	602	816

*) Because we divided the R&D labour costs and the WBSO by the firm's sales volume we must be very cautious with the derivative. After all, in the quadratic term (of WBSO) the division is actually by the sales volume squared. The coefficient.α_3 should then not be multiplied by 2.$WBSO_{t-2}$, but by 2.$WBSO_{t-2}$ divided by the sales volume $_{t-2}$.

**) Intervals calculated on the basis of the coefficient underlying the reliability interval.

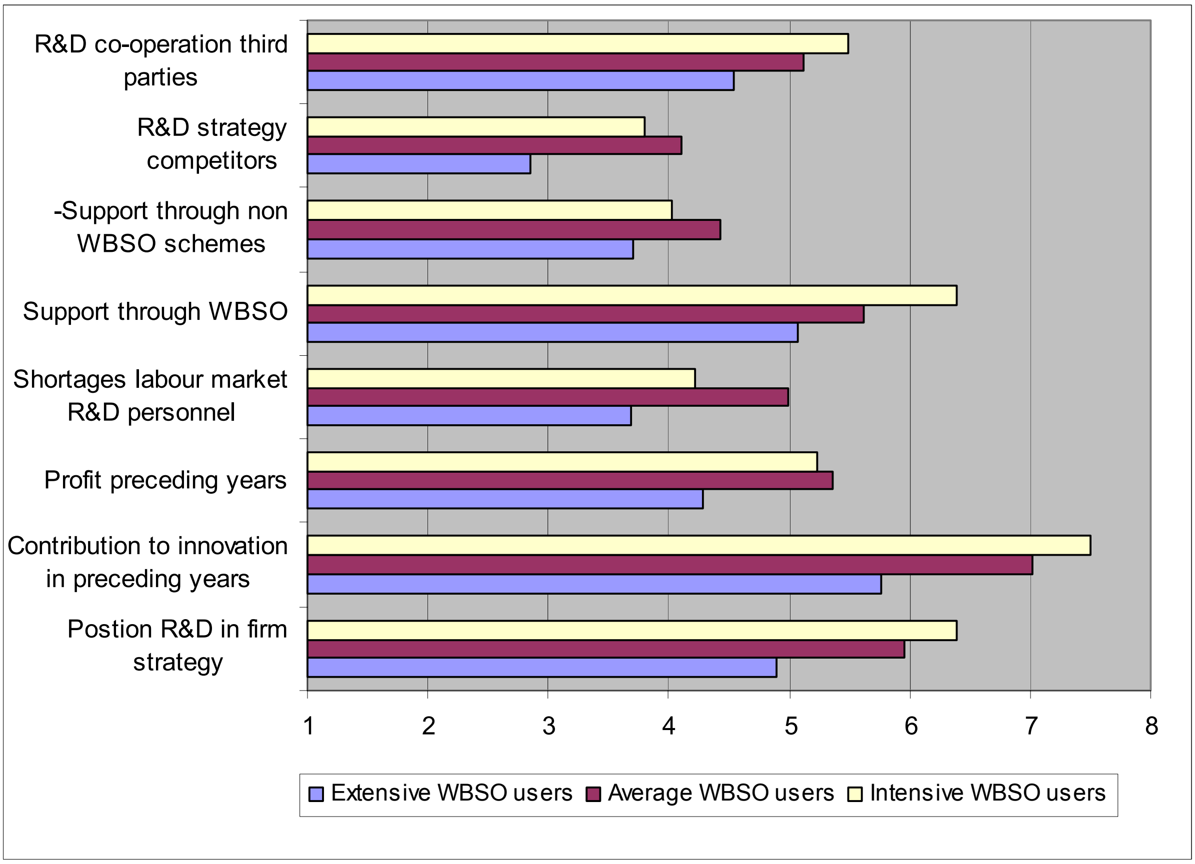
6.3 First order effects as derived from the survey

Overall the survey results seem to confirm the results of the econometric analysis. This implies that for some of the companies, the WBSO generates little extra R&D. In these cases, there is substitution (an effect of less than one) to a greater or lesser extent. This means that they do not use all the WBSO funds for extra R&D, but apply a proportion as a saving on their existing R&D wage costs. For other WBSO users, the scheme does actually generate extra R&D (effect of more than one). These cases result in additionality. On average, additionality occurs slightly more often than substitution in the entire population of companies that make use of the WBSO facilities.

As the survey was quite extensive – on average 20 minutes interviews - quite some detailed information on the sort of trade offs made by WBSO-users in relation to their R&D behaviour could be observed. The following outcomes for example were drawn from the survey.

- In decision-making on the scale of R&D activities, 'support via the WBSO' is the third most important criterion that WBSO users cite, after 'contribution to innovation in earlier years' and 'position of R&D in corporate policy' (see figure 7 below). It is remarkable to see that factors that are more about the external environment such as R&D strategy of competing firms ar shortages on the labour marker for R&D personnel are considered to be less important for decisionmaking on the actual size of R&D efforts.

Figure 7 Degree to which WBSO-users considers factors that affect scale of R&D efforts to be important, by level of R&D intensity (1= totally unimportant, 10 very important)[42]



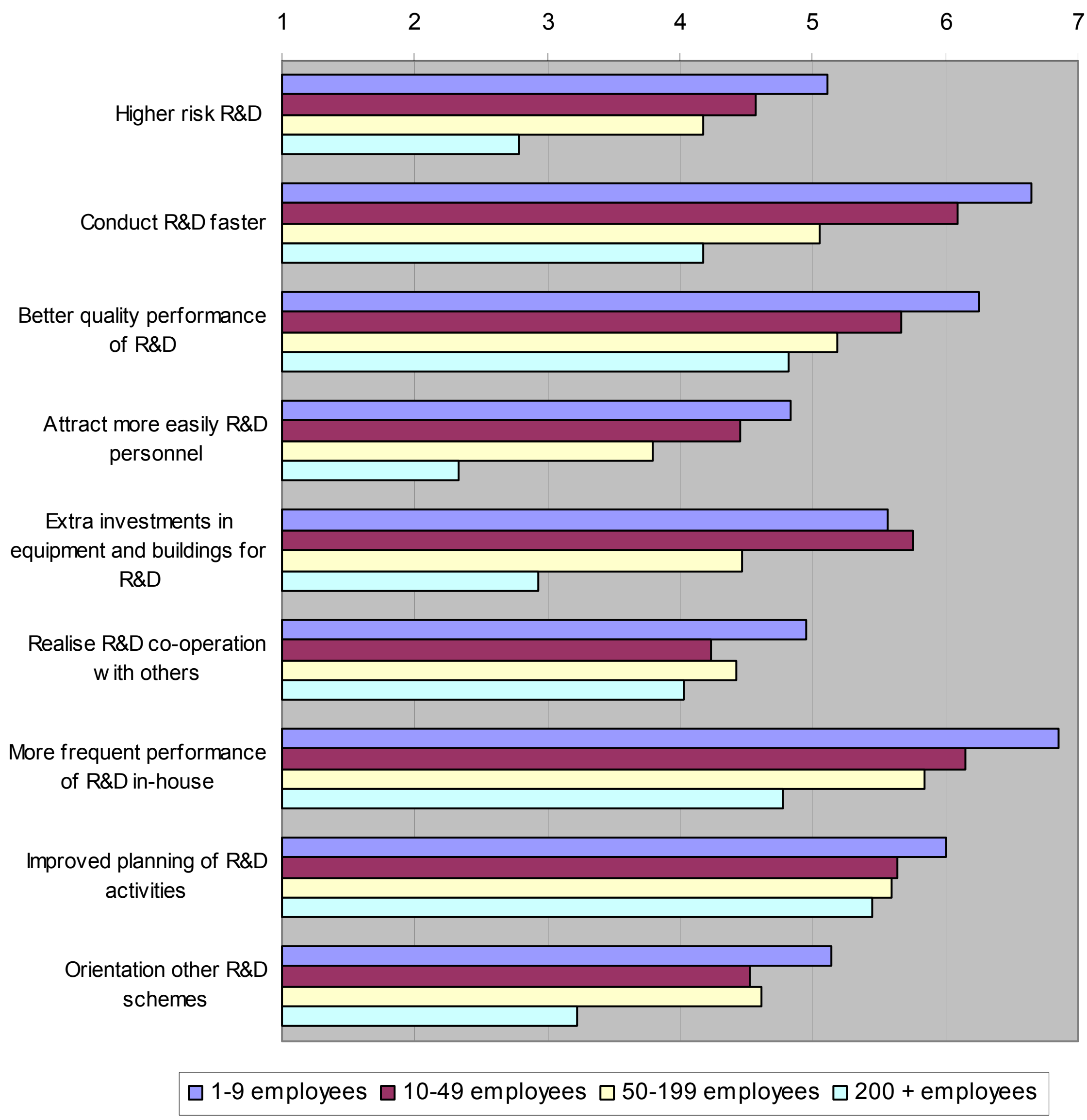
- Half of WBSO users state that the WBSO has 'some significance' in whether individual R&D projects are implemented. A further 18% even say that the WBSO is a 'decisive factor'. A substantial group of 31% of users (including a significantly higher proportion of companies with 200 or more employees) report that the availability of the WBSO has 'no influence' on whether individual R&D projects are implemented. This is not surprising: the larger the company, the more that R&D holds a strategic position and that R&D objectives and budgets are fixed for longer periods. Another significant factor is that the WBSO contribution is relatively lower for larger companies.
- 58% of WBSO users state that R&D expenditure would diminish somewhat or sharply if the WBSO facilities were not granted or were unavailable for other reasons. The WBSO has a significantly lower influence on the R&D expenditure of larger companies. This can be explained by the fact that the nature or the design of the WBSO leads to relatively stronger stimulation of R&D conducted by small businesses than by larger companies. The planning horizon for R&D, which is often longer in larger companies, could also play a role here[43].
- In addition to stimulating the performance of R&D by reducing R&D wage costs (a *de facto* lowering of barriers to the performance of R&D), the WBSO also has significant other (side) effects on the act of performing R&D for many users, particularly for R&D-

42 Results are weighted. Number of respondents is 500.

43 Larger companies more frequently regard the WBSO as an aid to reducing R&D costs. This is certainly a factor that should not be underestimated among very large companies with R&D centres world-wide, as there is also a market for R&D within these companies, that is driven partly by differences in cost levels.

intensive companies. As is illustrated in figure 8 below, the scheme not only contributes to higher-risk R&D, the ability to conduct R&D faster and better quality performance of R&D, but also to 'extra investments in equipment and buildings for R&D', more frequent 'performance of R&D in-house' and 'improved planning of R&D activities'. So apart from pecuniary effects there more qualitative effects on the way R&D is performed and the sort R&D that is performed can be noted.

Figure 8 Degree to which firms agree/disagree as to the contribution of WBSO to various aspect of conducting R&D, by firm size (average scores; 1=totally disagree; 10=totally agree)[44]



44 Results are weighted. Number of respondents is 500.

7 Second order effect of WBSO

7.1 Model specification

The second order effect (the effect of WBSO on innovation) is in principle estimated by using the same model as for the first order effect. The most important difference is that it is now not the magnitude of R&D that is accounted for but the sales volume of new products as a percentage of the total sales volume (Sales_np). This is a common indicator of R&D output [45].

The quadratic term for the WBSO was also excluded from the equation because this does not add anything to the model's explanatory capability. Nevertheless, to still be able to test the effect on the size category of firms we have now included the WBSO per size category as a cross term. It is interesting to use this to find out whether the efficiency of the used WBSO on the output of innovation differs from one size category to the next. The differences in efficiency are expressed because the coefficient for each size category can differ in the equation. A relatively high value (high compared to the coefficients of the other size categories) means that this group of firms use their WBSO funding more efficiently. This specification was also considered when determining the first order effects, but because the cross terms were evidently insignificant they were removed from the model ultimately presented. When modelling the second order effect we also crossed R&D intensity with the size category. However, these terms were also insignificant and we subsequently removed them from our analysis too.

In brief, the model used to determine the second order effects is as follows:

$$Sales\_np_{i,t} = \alpha_0 + \alpha_1.Sales\_np_{i,t-1} + \alpha_2.WBSO_{i,t-2} + \alpha_3.S\&O_{i,t-1} + \sum_{k=4}^{7}\alpha_k.WBSO_{i,t-1}.Grootkl_{i,j} + \sum_{k=8}^{K}\alpha_k.X_{k,i} + \varepsilon_i$$

In which:

$Sales\_np_{i,t}$	= endogenous variable, sales volume of new products as a percentage of the total sales volume in year t for firm i
$WBSO_{i,t-2}$	= WBSO in the year 1996 for firm i.
$S\&O_{i,t-1}$	= R&D intensity: R&D labour costs applied for in 1997, divided by the sales volume in 1997
$\sum_{k=4}^{7}\alpha_k.WBSO_{i,t-1}.Grootkl_{i,j}$	= WBSO per size category (10-20, 20-50, 50-100 and 100-500 employees, 500 plus is the reference group)
$\sum_{k=8}^{K}\alpha_k.X_{k,i}$	= all other exogenous variables and the associated coefficients
ε_i	= disturbance term
α_k	= coefficients to be estimated k=0..K

The model used to estimate the variables was the Tobit model; a model that is very suitable in this case because there are numerous firms that do not generate sales volume from new

45 See, inter alia, Kleinknecht, A.H., K. van Montfort & E. Brouwer (2002), 'The non-trivial choice between innovation indicators', Economy, Innovation New Technology, vol. 11, pp. 109-121

products [46]. Table 4-6 below shows the estimated coefficients of the second order effect. The equation was only established for industry because the sales volume of new products was not asked for in both CIS surveys.

In addition to WBSO, the WBSO cross terms with size category were also included. Contrary to the first order effect, we now estimate a percentage, i.e. the sales turnover of new products as a % of the total sales volume. It goes without saying that it is obvious that we should now estimate the quasi-elasticities. In this particular case, this quasi-elasticity shows the effect in percent points on the increase in sales volume of new products as a percentage of the total sales volume if the WBSO increases by 1%. The effect is calculated as follows:

$$\frac{\delta E\left(Sales\_np_{98} Sales\_np_{98} > 0\right).WBSO_{96}}{\delta WBSO_{96}} =$$

$$\left[\hat{\alpha}_2 + \sum_{k=4}^{7} \alpha_k .Grootkl_{i,j}\right].\left[1 - \frac{\varphi\left(\frac{Sal\hat{e}s\_np_{98}}{\hat{\sigma}}\right)}{\Phi\left(\frac{Sal\hat{e}s\_np_{98}}{\hat{\sigma}}\right)} - \left\{\frac{\varphi\left(\frac{Sal\hat{e}s\_np_{98}}{\hat{\sigma}}\right)}{\Phi\left(\frac{Sal\hat{e}s\_np_{98}}{\hat{\sigma}}\right)}\right\}^2\right]$$

BOX 2: ASSESSING THIRD ORDER EFFECTS

The third order effect cannot be determined using the sources of information currently available. The approach taken was the same as in the models used for the first and second order effects, only this time instead of R&D labour costs, the gross added value was determined. Here too did we decide to use lagged added value. Unfortunately, there are so many factors that play a role regarding the change in added value that the explanatory capability of the model is insufficient to make any reliable statements. Apparently those variables that do have a significant effect on the variables to be accounted for were lacking in the model. This means that the estimated coefficients are not reliable and therefore they cannot, nor may not, be interpreted. We feel that the third order effects can only be determined in the future if longer time periods are available and there are more variables such as market expectations. We now have a Senter-CBS database which covers almost the entire services sector and the whole of industry. The number of observations made is upwards of 500,000 but the toll that must be paid is the low number of variables available in the database. It is quite possible to make a sound analysis to determine the third order effect, but that will relate to a part of the Dutch economy only given that the production statistics still differ for each industry.

7.2 Outcomes of the second order effect

The WBSO has an apparent influence on the sales volume of new products (see the appendix for an explanation). The average for all firms is that 1% additional WBSO leads on average to a 0.19 percent points higher sales volume from new products as a percentage of the total sales volume in the short term.

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46 We also estimated a Heckman model. This is more advanced than a Tobit model because the likelihood and the magnitude of sales volume from new products are explained by different coefficients. The disadvantage is that the estimate of Full Maximum Likelihood is not always simple because the correlation between likelihood and magnitude may not be *unity*, and that the effects of WBSO on % of new sales volume is not easy to calculate. An alternative is to estimate a Heckman by a two-stage approach, yet this approach is a less elegant one to take. We chose for a Tobit because of the simplicity of the effects.

There is also a major difference between large and small firms. The WBSO only has a significant second order effect on firms employing fewer than 50 employees. The second order effect of WBSO for firms with more than 50 employees on the payroll is more or less zero [47]. The effect is the greatest for firms employing between 10 and 20 employees. For these firms, a 1% higher WBSO leads to a 0.41 percent points higher sales volume from new products as a percentage of the total sales volume in the short term. In addition to the WBSO, the level of the R&D activities also influences the second order effect.

Using the model we also looked at the link between innovation expenditure as stated in the CIS survey and the growth in sales volume from new products (WBSO second order effect).

Firms that spend the most on marketing and education are also those that show the strongest growth in sales volume from new products.

Firms permanently engaged in R&D activities have a higher than average increase in % of sales volume from new products (this is indicative of the learning by doing effect).

The same applies with regard to those firms that have submitted an application for a patent. Nonetheless, because the purpose of the patent and the use thereof were not taken into account in the analysis, the interpretation of the analysis must be used very cautiously.

Firms that have a knowledge contact (a public or private party involved in R&D) have a higher increase in the percentage of sales volume from new products than firms that have no knowledge contacts. This effect was also seen in the report entitled '*Samen innoveren*' [Innovating together] [48]. The difference being that in that report a distinction is made between public-private and private-private knowledge contact.

The increase in % of new sales volume is the highest for firms employing between 50 and 100 workers, followed by firms with between 10 and 20, and then by firms with between 20 and 30 workers. Firms employing upwards of 100 workers generated no significant increase in the % of new sales volume.

47 At first sight, the outcome that WBSO would have a significant effect on sales volume from new products and services in firms employing up to 50 workers can be due to the fact that the R&D intensity was not crossed with size category. And because it is generally accepted that WBSO and R&D are strongly correlated that we discovered illusory associations. This is not so. We also made an alternative estimate in which R&D intensity was crossed with size category. However, all the cross terms with R&D are insignificant and the coefficients of the relevant variables do not change to an extent worthy of mention if these cross terms are added to the equation. Only the t value of R&D intensity is reduced by half. Our findings therefore remain unchanged.

48 Poot & Brouwer (2001).

Table 6 Estimate of % of new sales volume from new products* in the year 1998 (industry only) on the basis of the dominants described in Table 4-4. Estimates made using the Tobit model.

Determinants of:	Coeff. scaling	Tobit Coeff. estimate	Tobit estimate Sig *
Sales volume from new products in the past, R&D and WBSO			
% sales volume from new products in 96	1	0.45	++++
Reduction in labour costs applied for in 96 (WBSO)	1000	0.00	
Innovation activities			
R&D total expenditure (source CBS) / sales volume in 97	0.01	0.63	++
dummy =1 if R&D is a permanent activity	0.01	0.13	++++
Purchase of sophisticated equipment, machines, computers as a % of the total innovation expenditure	0.1	0.29	+++
Sub-contracted research of the total innovation expenditure as a % of the total innovation expenditure	0.1	0.23	
Technical preparation of production processes as a % of the total innovation expenditure	0.1	0.04	
Acquisition of licenses / patents as a % of the total innovation expenditure	0.1	-1.17	-
(Sub-contracting) marketing activities as a % of the total innovation expenditure	0.1	1.17	++++
Internal (external) training, refresher courses for personnel as a % of the total innovation expenditure	0.1	0.70	+++
dummy =1 if the firm has applied for a patent	0.1	0.25	+++
dummy =1 if the firm has an R&D knowledge contact	0.1	0.35	++++
Reduction applied for, crossed with the size category			
Reference group: size category starting at 500 employees			
Reduction in firms with 10-20 employees 96	1000	0.13	+++
Reduction in firms with 20-50 employees 96	1000	0.08	+++
Reduction in firms with 50-100 employees 96	1000	0.01	
Reduction in firms with 100-500 employees 96	1000	-0.01	
Business characteristics			
reference: firms with more than 500 employees			
dummy =1 if the firm has between 10 and 20 employees	0.1	0.16	+
dummy =1 if the firm has between 20 and 50 employees	0.1	0.13	+
dummy =1 if the firm has between 50 and 100 employees	0.1	0.25	++
dummy =1 if the firm has between 100 and 500 employees	0.1	0.09	
Sales volume per employee in 97	0.1	0.00	
Export quotas (export divided by sales volume)	0.1	0.16	+
dummy =1 if the firm is independent (does not belong to a parent firm)	0.1	-0.42	--
dummy =1 if the firm's head office is established in the Netherlands	1	-0.34	
Sector characteristics			
reference: dummy =1 pavitt-jong sector.: scientific based			
dummy =1 pavitt-jong sector.: scale intensive	0.1	0.11	
dummy =1 pavitt-jong sector.: specialist suppliers	0.1	0.15	
dummy =1 pavitt-jong sector.: supplier dominant firms	0.1	-0.29	--
dummy =1 pavitt-jong sector.: infrastructural services	0.1	-0.60	-
dummy =1 pavitt-jong sector.: *presp. services	0.1	-0.96	--
herfindahl equivalent	100	1.00	+
Constant	0.01	-0.15	----

Cont. Table 6

Calculated effects	Average	Lower limit	Upper limit
Effect on % sales volume from new products in percent points if WBSO increases by 1%			
Average for all firms	0.19	0.16	0.22
Effect for firms with 10-20 employees	0.41	0.27	0.55
Effect for firms with 20-50 employees	0.36	0.27	0.44
Effect for firms with 50-100 employees	0.13	0.11	0.15
Effect for firms with 100-500 employees	0.00	0.00	0.00
Effect for firms with more than 500 employees	0.13	0.08	0.18
Number of firms with no sales volume from new products			1696
Number of firms with sales volume from new products			1014
Vealls and Zimmerman R^2			0.33

* The analysis is limited to all industrial firms that took part in both CIS surveys. This implies that innovative firms were excluded from the analysis. Firms that have reached the WBSO ceiling were also excluded from the analysis.
Variables of no significance are:
R&D intensity, broken down into size category;
WBSO expenditure, broken down into sectors;
WBSO squared;
use of an intermediary when applying for WBSO;
ratio of investments to depreciation.

** See legend in Table 4-1.

7.3 Second order effects as derived from the survey

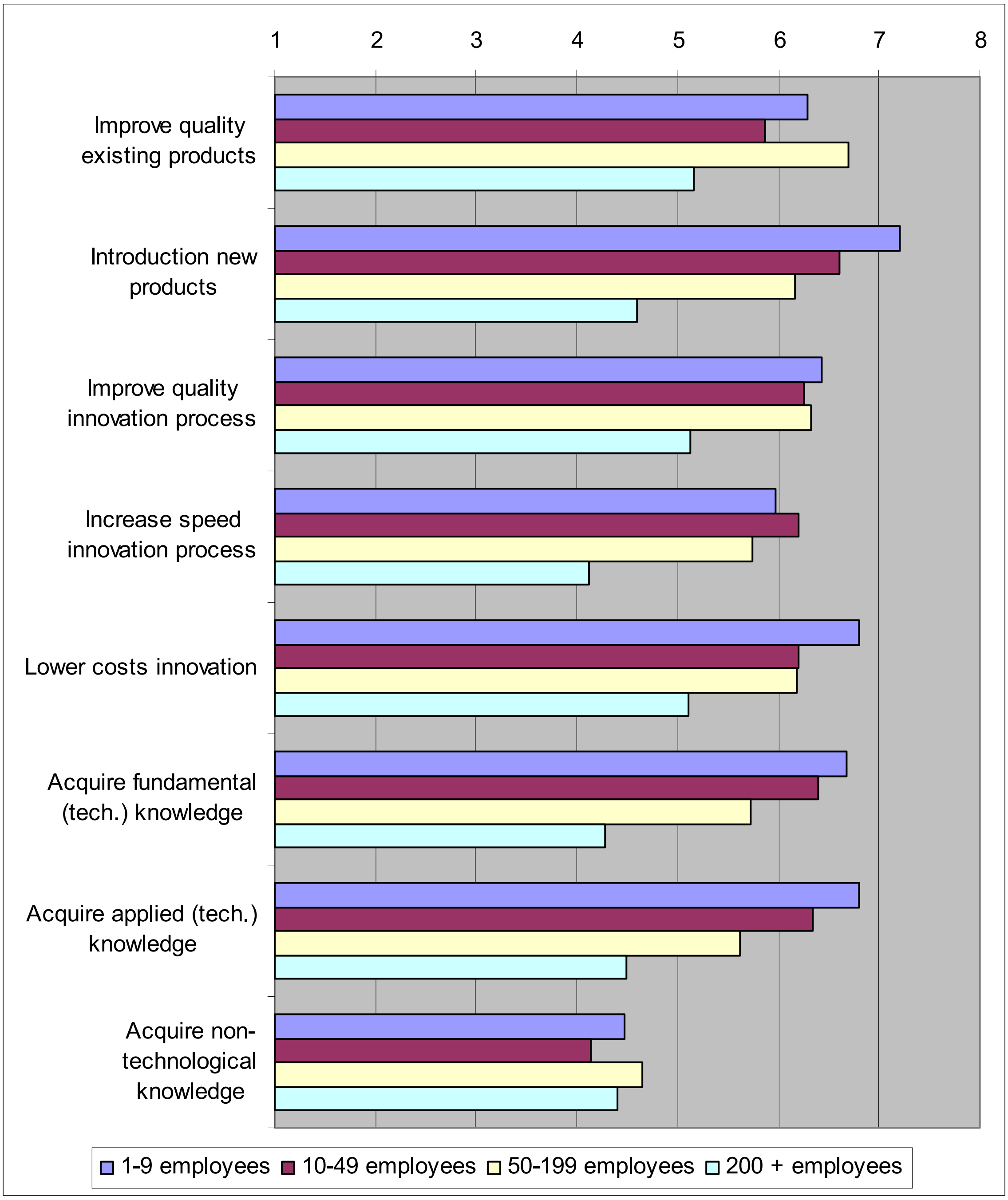
Although the survey like the econometric analysis focussed most dominantly on first order effects some observations stemming from the survey on the link between WBSO-use and innovativeness are worth mentioning. Respondents were for example asked whether WBSO contributed to a number of given innovation goals (see figure 9 below). In decreasing order respondents mentioned ‘introduction of new products on the market’; lowering costs of innovation’; acquisition of more (fundamental and applied) technological knowledge’; improvement quality exiting products’; ‘improvement quality innovation process’; ‘improved speed innovation process’ and finally ‘acquisition of non-technological knowledge’.

Simply presenting average scores tells only part of the story and on the basis of more detailed regression analyses we were able to show that:

- WBSO users up to 50 employess in comparaison to WBSO users with 50 and more employees considered WBSO significantly more often as important in realising almost all innovation goals. Possibly smaller WBSO users perceive WBSO more often as a direct help in setting innovation and its execution on the agenda. Of course the fact that the relative amount of support through WBSO is higher for smaller firms also plays a role here.
- Structural WBSO users regard the WBSO scheme as important to the realisation of a substantial number of innovation goals significantly more often than other WBSO users. Possibly the more experienced WBSO users have already experienced the fact that WBSO may contribute to more than just simply reducing the costs of R&D personnel.
- WBSO users requiring a relatively higher number of working days to submit a WBSO application attribute a significantly smaller contribution of the WBSO scheme to the realisation of a number of innovation goals. This may either refer to companies with projects that are less compatible with the basis for the WBSO or their lack of experience with WBSO results in higher transaction costs and thus a lower appreciation of the

contribution of WBSO to innovation.

Figure 9 Degree to which WBSO users consider WBSO to contribute to various innovation goals, by firm size (average scores; 1=centainly no contribition, 10= very substantial contribution)[49]



Various respondents voiced the opinion that the effects of the WBSO on innovation are hard to assess as it takes a much longer period (several years) before extra R&D investments

49 Results are weighted. Number of respondents is 500.

materialise in higher innovativeness.

BOX 3: TARGET GROUP PENETRATION

- Although the WBSO does reach the majority of technologically innovative companies, in 1998 there was still a group of such companies, mainly smaller ones and service-sector businesses, that were not reached. Recent figures from Senter show strong growth (22% in all during the 1999-2001 period) in the number of companies applying for WBSO facilities.
- The group of companies that potentially qualify for WBSO tax credits have the character of a 'moving target' to some extent, as this is a highly dynamic population of companies (start-ups, mergers and splits).
- Some 75% of the companies with their own R&D expenditure applied for WBSO facilities in the 1996-1998 period. This rises to 86% in industry and in the 'other' sector, which includes utilities and the construction industry, to almost 80%. In the service sector, 'only' 51% of companies with their own R&D expenditure actually applied for WBSO tax credits. From the survey we (amongst other things) we learned that service companies are significantly more likely to regard the requirements for the WBSO scheme, particularly those relating to software, as complex. They also consider that the WBSO contributes less to realising a number of innovation goals. This can be explained partly by the bais of the WBSO which, after all, is designed to facilitate technological innovation, while in service companies, organisational innovation often has relatively greater importance.
- Just under 61% of companies with 10 to 50 employees applied for WBSO facilities, compared with 70% of larger companies.
- Partly because of the high dynamism among companies that potentially qualify for WBSO tax credits (new companies, mergers and acquisitions), substantially higher penetration can only be facilitated at high marginal costs.

8 Conclusion

Although we treated some additional elements of the evaluation in the three boxes presented spread over this paper we will focus here on three categories of stylised conclusions i.e. effects on R&D spending (1st order effects), effects of firm innovation (2nd order effects) and some practical methodological consideration when evaluating a scheme like WBSO.

Effects of WBSO on R&D spending (1st order effects)

On the basis of the econometric analysis, we can conclude that:

- The WBSO makes a significant contribution towards Dutch R&D intensity, both at the corporate level and structurally, at the macro-level.
- Among companies that use the WBSO facility, each € 1 of WBSO allowance leads on average to extra expenditure on R&D of € 1.01 to 1.02 in the short term. This means that the group of companies that use the WBSO spend an average of one to two euro-cents extra on R&D wages themselves[50]. These results are consistent with the outcomes of similar econometric analyses of fiscal measures designed to promote corporate R&D, as reported in the (scientific) literature.
- This effect is fairly independent of size categories and sectors[51]. The econometric analysis thus confirms the general character of the WBSO.
- The effect of the WBSO on 'inciting corporate R&D' varies. The bandwidth of the average effect of the WBSO on corporate R&D expenditure lies between 0.7 and 1.3. Overall, there is additionality. The model does not exactly indicate the number of firms for which additionality or substitution occurs.
- This figure of € 1.01 to 1.02 does not take account of the expected positive longer-term effects and the substantial social returns associated with additional investments in R&D activities. Neither is included in this evaluation.
- When the high average social return on R&D investments is taken into account – other companies benefit indirectly from the extra knowledge obtained with the R&D expenditure through 'spill over' effects – the actual social return is higher that one to two Eurocents, which appears modest at first glance[52].
- The WBSO also has a 'macro-effect'. Through the WBSO, corporate R&D expenditure is raised to a structurally higher level, at least by the amount involved in the WBSO (the final tax credit). After all, on average, companies stimulated by the WBSO spend higher (extra) amounts on R&D than those they receive via the WBSO. In 1999, for example, this involved a sum of at least € 272 million. Through the provision of WBSO tax credits, corporate R&D spending has even increased structurally by at least € 272 million.

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[50] The results relate to companies (excluding the self-employed and institutions) that applied for WBSO tax credits in the 1996-1998 period.

[51] However, the field study did reveal a scale effect in relation to the primary effects of the WBSO.

[52] See Cornet, M. (2001), 'De maatschappelijke kosten en baten van technologiesubsidies als de WBSO' (*The social costs and benefits of technology subsidies such as the WBSO)*, CPB Document 8, CPB, The Hague, and for the macro-effects, Jones, C.I. & J.C. Williams (1998), 'Measuring the social return on R&D', The Quarterly Journal of Economics, pp. 1119-1135, among others.

On the basis of the survey – of which we only reported a fraction here – we can conclude that:

- There is a split between WBSO users that assign significant effects to the WBSO at the R&D level and in the R&D process, and companies that primarily perceive the WBSO as an 'extra' or 'reward' for performing R&D activities.
- The WBSO plays a role that should not be underestimated in decision-making on to the scale of R&D-activities, the motivation for and organisation or performance of R&D, whether R&D projects are realised and the effects of any loss of WBSO facilities on R&D spending.
- In decision-making on the scale of R&D activities, 'support via the WBSO' is the third most important criterion that WBSO users cite, after 'contribution to innovation in earlier years' and 'position of R&D in corporate policy'
- Half of WBSO users state that the WBSO has 'some significance' in whether individual R&D projects are implemented. A further 18% even say that the WBSO is a 'decisive factor'. A substantial group of 31% of users (including a significantly higher proportion of companies with 200 or more employees) report that the availability of the WBSO has 'no influence' on whether individual R&D projects are implemented.
- 58% of WBSO users state that R&D expenditure would diminish somewhat or sharply if the WBSO facilities were not granted or were unavailable for other reasons. The WBSO has a significantly lower influence on the R&D expenditure of larger companies.
- Particularly for R&D-intensive companies (and increasinglo so for smaller firms) the WBSO scheme not only contributes to higher-risk R&D, the ability to conduct R&D faster and better quality performance of R&D, but also to 'extra investments in equipment and buildings for R&D', more frequent 'performance of R&D in-house' and 'improved planning of R&D activities'

Effects of WBSO on firm innovation (secondary effect)

On the basis of the econometric analysis, we can conclude that:

- The WBSO makes a significant contribution towards higher sales from new products for companies with up to 50 employees[53].
- If the WBSO facility increases 1% extra for a company, the share in turnover from new products increases 0.19 percentage points (from 5% to 5.19% on average).
- In contrast to the primary effect, econometric analysis does make a distinction in terms of size categories for the secondary effects of the WBSO. It was found that smaller companies benefit more from the WBSO than larger ones. The effect steadily diminishes with company size, with the exception of companies with 500 employees or more[54].

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53 The results of the econometric analyse relate to all companies in industry with 10 or more employees that took part in both innovation surveys, regardless of innovative capacity.

54 The fact that a slight (non-significant) positive effect occurs in companies with 500 employees or more can probably be explained by economies of scale and the fact that in larger companies, more large-scale and/or long-term R&D projects are likely to take place, which may lead to sales from new products only after several years (more than the three years assumed in the econometric analysis). Process innovation (not measured) will also play a relatively larger role more frequently.

The survey reveals that

- WBSO users with up to 50 employees regard the WBSO as important to the realisation of almost all innovation goals significantly more often than those with 50 or more employees.
- Structural WBSO users regard the WBSO scheme as important to the realisation of a substantial number of innovation goals significantly more often than other WBSO users.
- WBSO users requiring a relatively higher number of working days to submit a WBSO application attribute a significantly smaller contribution of the WBSO scheme to the realisation of a number of innovation goals.

Practical methodological concluding remarks

- This evaluation used a better dataset than that used in the 1998 evaluation. The 1st order and 2nd order effects of the WBSO were quantified on this basis. However, this updated dataset still has limitations that affect the econometric analysis.
- One of the most important points for attention concerns the issue of the causality between the WBSO and an increase in the scale of corporate R&D activities. This point received an exceptional amount of attention in this evaluation[55].
- Although no definitive proof of the direction of the causality can be found in the econometric analysis, its probability is shown, partly on the basis of the survey, by calculating an effect on the price of R&D and thereby, on the volume of R&D. The WBSO instigates additional R&D expenditure through a reduction in R&D wage costs per employee. The results of the field study confirm this conclusion.
- A more definitive finding on the causality will require panel data enabling companies to be monitored over a longer time period.
- It is not possible at present to determine the effect of the WBSO on company performance by econometric means56.
- Econometric evaluations of the WBSO and similar schemes would benefit from the availability of panel data over a sufficiently long period.
- In the future, effects on corporate performance (tertiary effects) can only be determined if longer time series are available for more variables on a disaggregated level, for example with regard to market expectations. The present dataset can serve as a point of departure here.

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[55] The available data does not allow for an extensive analysis of the causality issue.

[56] In the survey we found that a significant group of WBSO users (42%) state that in the period in which they made use of WBSO facilities, sales increased and that many of these companies (51%) attribute this to the market launch of an innovative product. The level of innovation is the main determining factor for sales here, and the WBSO therefore has an indirect impact of firm performance only.

Literature

Acs, Z.J. & D.B. Audretsch (1989), 'Patents as a measure of innovative activity', Kyklos, vol. 42, pp. 171-180,

Angrist, J.D. & A.B. Kruger (2001), 'Instrumental variables and the search for identification: from supply and demand to natural experiments', The Journal of Economic Perspectives, vol. 15, nr 4, pp. 69-85

Arrow, K.J. (1962), 'Economic welfare and the allocation of resources for invention'. In: R.R. Nelson (ed), 'The Rate and Direction of Inventive Activity: Economic and Social Factors', Princeton University Press for the NBER

Aydalot, P. & D. Keeble (1988), 'High-Technology Industry and Innovative Environments in Europe: An Overview. In: 'High-Technology Industry and Innovative Environments, The European Experience, P. Aydalot & D Keeble (eds), Routledge, London, pp. 1-21,

Bloom, N., R. Griffith & J. van Reenen, (2000): 'Do R&D tax Credits work? Evidence from a panel of countries 1979-97', pp 16, Research Policy

Bound, J., C. Cummins, Z. Griliches, B.H. Hall, A. Jaffe (1984), 'Who does S&O and who patents?'. In: Z. Griliches (ed.), 'S&O, patents, and productivity', NBER, The University of Chicago Press, pp. 21-54.

Brouwer, E. (1997), Into innovation, determinants and indicators, academic Ph.D., SEO-rapport nr. 424.

Brouwer, E., P. Den Hertog, T. Poot, P. Segers (2003), WBSO nader beschouwd;Onderzoek naar de effectiviteit van de WBSO(WBSO evaluation report), Report Ministery of Economic Affairs, The Hague

Cohen, W. (1995), 'Emperical Studies of Innovative Activity'. In: P. Stoneman (eds), Handbook of the Economics of Innovation and Technological Change, Blackwell, Oxford (UK), Cambridge (USA), pp. 182-247.

Cohen, W. & R.C. Levin (1989), 'Emperical Studies of Innovation and Market Structure'. In: R. Schmalensee & R. Willig (eds), Handbook of Industrial Organization, Amsterdam, North Holland, pp. 1060-1098

Cornet, M. (2001), 'De maatschappelijke kosten en baten van technologiesubsidies als de WBSO', (The social Cost and benefit of technological R&D subsidies), CPB-document 8, CPB, Den Haag,

Cornet, M & M. Rensman (2001), 'The location of R&D in the Netherlands, trends, determinants and policy', CPB Document 14, CPB, Den Haag,
'Corporation tax and innovation', Innovation papers no. 19, European Commission.

Hall, B. en J. Van Reenen, (2000), 'How effective are fiscal incentives for R&D?: A review of the evidence', Research Policy, vol. 29, pp.449-469.

Harmon, C. & I. Walker (1995), 'Estimates of the Economic Return to Schooling for the United Kingdom', The American Economic Review, vol 85, nr 5

Jones, C.I. & J.C. Williams (1998), 'Measuring the social return to R&D', The Quarterly Journal of Economics, pp. 1119-1135.

Kamien, M.I. & N.L. Schwartz (1975), 'Market Structure and Innovation: A Survey, Journal of Economic Literature, vol. 13, issue 1, pp. 1-37

Kleinknecht, A.H. & B. Verspagen (1990), 'Demand and innovation: Schmookler re-examined', Research Policy 19, pp. 387-397.

Kleinknecht, A.H., K van Montfort & E. Brouwer (2002), 'The non-trivial choise between innovation indicators', Economics of Innovation and New Technology, vol. 11(2), pp. 109-121.

Louter, P. et. al. (2001), 'Buitenlandse bedrijven en kennisintensiteit', (Foreign companies and knowledge intensities) TNO-rapport 01 5R 023 51471, TNO-Inro, Delft.

M.E.E.T.: Monitoring en Effectmeting van het EZ Technologie instrumentarium. (Monitoring & measuring Effects of Ministery of Economic Affairs instruments), The Hague

OECD (2001), OECD Science, Technology and Industry Scoreboard. Towards a knowledge-based Economy, Paris

Philips, A. (1966), 'patents, potential competition, and technical progress', American Economic Review 56, pp. 301-310.

Poot, A.P., E. Brouwer (2001), 'Samen innoveren' (Cooperative innovation) , beleidsstudie Technologie en Economie nr. 35, Ministry of Economic Affairs, The Hague

Scherer, F.M. (1967), 'Research and development resource allocation under rivalry', Quarterly Journal of Economics',

Scherer, F.M. (1967), 'Market structure and the employment of scientists and engineers', American Economic Review, vol 57, pp. 524-531

Scherer, F.M. (1983), 'The propensity to patent', International Journal of Industrial Organization, vol 1, pp. 107-128.

Schmookler, J. (1962), 'Economic sources of inventive activity', Journal of Economic History 22, pp. 1-10,

Schmookler, J. (1966), Invention and Economic Growth. Cambridge, Mass., Harvard University Press.

Schumpeter, J.A. (1942), Capitalism, Socialism, and Democracy, New York, Harper

Teece, D.J. (1986), 'Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy', Research Policy 15, pp. 285-305

Tidd, J., J. Bessant & K. Pavitt, Managing Innovation: integrating technological, market and organizational change. first edition, Wiley, pp. 93-97.

Wintjes, R., (2001), Regional-economische effecten van buitenlanse bedrijven. (Regional economical effects of foreign companies), Nederlandse Geografische Studies 286, Utrecht).

Appendix 1: the linking of Senter and CBS files

Data is required on the use of WBSO (R&D labour costs applied for), business characteristics such as size of the firm, branch of industry, sales volume per employee and data on a firm's innovation activities in order to carry out the econometrics analysis. To this end, data from Senter were linked to those of CBS [57]. Senter data relate to the period 1994-2001 and covers all firms that made one or several applications for WBSO during this period (this excludes self-employed persons and institutions). Data on business characteristics were derived to a large extent from the CIS2 and CIS2½ surveys [58].
There are several reasons why a direct linkage of Senter data and CBS data was not without problem. One of the main reasons was because of a difference in the definition of a 'firm'. In Senter terminology a firm is the fiscal entity responsible for the payment of wage withholding tax and national insurance contributions. These are the entities known to the tax authority. CBS uses the definition of 'a firm' based on the ABR (General Business Register). The ABR is based partly on data from the Chamber of Commerce, i.e. listing in the Commercial Register. According to Senter, in the case of larger firms, the fiscal entities are not always the same as the business entities of CBS.

Moreover, the CBS database poses the additional problem that reporters in firms with several branches can respond differently, i.e. some firms report for all their subsidiaries collectively, while others report on the level of the individual subsidiary.

One special problem is seen among smaller firms. For firms employing fewer than 50 workers, CBS takes a random sample from the ABR. The firms randomly selected are then surveyed. Firms employing 50 workers or more are contacted integrally. Another factor is that not all firms respond. The consequence is that not all firms in the Senter database can be linked to the CBS data.

Overview of several cases
In the following table we present a quantitative overview of a number of firms in the combined file. In the period 1994-2001 a total of 73,145 applications were submitted on an annual basis for WBSO by a total of 24,754 different firms (excluding self-employed persons and institutions, Table A-1). In Table A-1 the figures are given for the individual files, both prior to and after the linkage. In the figures after linkage only the combinations seen in practice are shown, i.e. the structure of the linked file. Also shown is which key was used for linking the files. Although the individual files are relatively large in terms of size, after linking them together we still had 3,230 firms left over, of which Senter, PS and innovation data could be combined. How did we get so many firms?

[57] Details regarding the technical aspects of the linkage, as well as an exhaustive description of the file will soon be published in a separate paper.
[58] For an exhaustive explanation, see 'Kennis en Economie' edition 1998 (CIS2) and 2000 (CIS2½), CBS, Voorburg, the Netherlands.

Table A-1 Number of applications for WBSO per annum (cases contained in the Senter database 2001)

Number of applications for WBSO year	cases
1994	4,822
1995	6,094
1996	7,569
1997	9,585
1998	9,985
1999	11,450
2000	11,659
2001	11,981
Total number of cases	73,145
Total number of firms	24,754

Source: Processing of Senter data we were supplied with.

After the linkage and a check for erroneously linked business entities, we were left with a total of 17,900 firms that had both a unique Senter business code and a unique CBS business code (including 1,436 firms with several Senter business codes). This file was used to link the PS and the innovation data. After making the linkage we had a file that comprised a total of 491,458 firms (484,509+1,235+5,714). Of these 491,458 firms we only have Senter data for 5,714 firms (these firms are not included in the CBS data), 459,739 firms are only to be found in the PS and cannot be linked to Senter or innovation data (combination 3). That a large number of firms covered in the production statistics cannot be linked with Senter and innovation data is hardly surprising. The majority of Dutch firms are not engaged in R&D activities. This applies in particular to the smaller firms and firms engaged in trading and the (commercial) services sector and in the (semi) public sector.

A total of 12,584 firms are to be found in the PS and CIS2/CIS2½ only and not in the Senter database. One of the main reasons for these firms not being included in Senter data is that many of these firms are not innovative or do not have any own R&D expenditure (see also the section on target group scope) [59]. The ultimate result was 3,744 firms with references in all four files. The econometric analysis was carried out on the basis of this file. The linkage is shown in Table A-1.

[59] Both CIS2 and CIS2½ cover firms that had stated they were not engaged in innovation activities.

Figure A-1 Number of firms in files both prior to and after linkage.