

Do subsidies have positive impacts on R&D and innovation activities at the firm level?¹

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Abstract

The main aim in this paper is to analyze whether “research” and “development” subsidies influence private R&D activity. The results show that “research” subsidies stimulate private R&D activity mainly by increasing research expenditure, while “development” subsidies in comparison substitute private R&D activity mainly by decreasing development expenditure. At the theoretical level we find empirical support for the market failure argument that private R&D expenditure is best stimulated in areas where the gap between the social and the private rate of return to R&D is high. A policy implication is that technology programs should support research projects in the private sector in order to stimulate to more R&D.

Version of 10.8.2007

TIK Working paper on Innovation Studies No. 20070615

*This paper is part of the project "Innovation, Path-dependency and Policy" (IPP) carried out at the Centre for Technology, Innovation Culture (TIK), University of Oslo with the support of the Norwegian Research Council (Contract no. 154877). However, the Centre, University and Research Council are not responsible for the content of the paper, which is the sole responsibility of the author(s).

Introduction

It is currently a major policy goal among the member states of the European Union – as well as for non-members such as Norway – that total expenditures on research and development (R&D) should constitute 3 % of the gross domestic product (GDP) by 2010. Two-thirds of these expenditures should be financed by the private sector. As a part of the objective to increase private sector spending on innovative activities a traditional – and current – policy response has been to offer R&D subsidies to firms. Although it is debated whether subsidies in general stimulate private R&D spending (David et al, 2000; Hall, 2005), even less is known in the evaluation literature about what impact different types of R&D programs have upon recipient firms (David & Hall, 2000; Blanes & Busom, 2004).

An important area for further research is thus to explore what types of firm projects policymakers should support in order to maximize the impact of the subsidy upon private R&D spending. As argued by a recent review, there is high policy interest in finding some favourable design of R&D programs (Aerts et al, 2006). Based upon a new taxonomy of R&D programs, this paper contributes to the literature by exploring what impact two different types of subsidies have upon the quantity, quality and type of R&D done at the firm level. The taxonomy classifies whether R&D programs in Norway support uncertain firm projects “far from the market” or whether projects “close to the market” are subsidized (Rye, 2002). There is a rather large overlap between the concepts “research” and “far from the market” on the one hand, and “development” and “close to the market” on the other hand. These concepts can be used rather interchangeably. Whether subsidies have been effective in stimulating more R&D has been the topic of several scholarly papers (for reviews see David et al, 2000; Klette et al, 2000; Hall, 2005, Aerts et al, 2006; David & Hall, 2000). We thus start by analyzing whether “research” and “development” subsidies stimulate private R&D and innovation spending.

Private R&D spending has been the preferred dependent variable in prior research, as discussed above. It is noteworthy that few attempts have been made to analyze how subsidies affect the composition of the private R&D budget. Whether subsidies stimulate private expenditure on research or development is an important question for both innovation theory and policy. This is the second topic we will address. A related issue is the fact that subsidies can have a positive impact upon the quality of R&D done at the firm level. This has been a missing dimension in the empirical literature. At first sight most innovation policy documents seem to emphasize the quantity of R&D. On closer inspection, innovation policy strategies, such as the Lisbon Agenda, are concerned about the quality of R&D done at the firm level as well. Whether subsidies have an impact upon the quality of R&D emerges as an important dimension when evaluating the effects of R&D policy interventions. This is also addressed in the paper.

According to recent discussions subsidies should not only stimulate the input side of the innovation process. At least two concerns are raised. First, we know little about whether subsidies are accompanied by a change in firm behaviour and technology strategy (OECD, 2006; Aerts et al, 2006). Related, and secondly, we know hardly anything about whether subsidies have long term impacts upon recipient firms (Aerts et al, 2006; Georghiou, 2003). This is the last issue we will address.

This paper is organized as follows: In the next section we will briefly discuss the market failure argument that has justified public allocation of R&D subsidies to firms. We will also discuss recent studies and suggestions for future research set forth in the literature in that section. Features of the public support system for R&D and innovation in Norway are discussed in section 3 in relation to the technology program taxonomy. The methodology and

data are discussed in section 4. The analysis is conducted in section 5 and will be accompanied by a discussion of the results. We will finally draw some conclusions and implications for further research in section 6.

Public R&D subsidies and firm performance

There is little disagreement today about the desirability of subsidizing private R&D activities among researchers and policymakers. All OECD countries are currently spending significant amounts of public money on programs intended to stimulate innovative activity (Klette et al, 2000). Public R&D programs have generally been designed to support commercial R&D projects with large expected social benefits but with inadequate expected returns to private investors (Klette et al, 2000). The “logic” behind this reasoning has been clearly expressed in the traditional market failure argument. According to the market failure argument firms will not invest (enough) in R&D because the benefits of innovative activities can not be fully reaped due to incomplete appropriability and knowledge spillovers between firms (Arrow, 1962). A large theoretical and empirical literature has accordingly argued that firms face insufficient incentives to invest in R&D from the point of view of society (Hall 2002a).

Contemporary R&D and innovation policies are to a large extent based upon this reasoning. A central objective in these policies has been to “close the gap” between the private – and the social – rate of return to R&D investments. In principle this can be accomplished by offering subsidies or tax-credits to firms. Tax-credits and subsidies can reduce the private cost of investing in R&D (Hall, 2002ab). Private R&D spending can on the other hand only be stimulated if subsidies cause firms to undertake R&D projects that would be unprofitable in the absence of a subsidy (Jaffe, 2002; Wallsten, 2000). Has this been the case? A recent review has concluded that despite decades of research no general answer has been provided as

to whether or not subsidies stimulate or substitute private R&D investments (David et al, 2000). Whether subsidies stimulate or substitute private R&D spending is an empirical issue. Institutional and other differences between countries can have an impact upon subsidized firms' decision to spend additional amounts of funds on R&D (David et al, 2000).

A look at the most recent studies reveals that most research has been done using data from Spain, France, Belgium, Finland, USA, Germany, Israel, Ireland, Sweden and Denmark (Aerts & Czarnitzki, 2004; Almus & Czarnitzki, 2003; Busom, 2000; Czarnitzki & Fier, 2002, 2002; Czarnitzki & Hussinger, 2004; Duguet, 2004; Heijts & Herrera, 2004; Hussinger, 2006; Lach, 2002; Wallsten, 2000; González et al 2005; Kaiser, 2004; Löf & Hesmati, 2005; Hujer & Radic, 2005; Görg & Strobl, 2005). There is no recent Norwegian study on this subject. In one of the few Norwegian studies conducted so far, Klette & Møen (1998) found that R&D subsidies neither stimulated nor substituted private R&D efforts. Their study was based upon a sample of high tech business units and they did not control for the endogenous nature of the subsidy in the micro-econometric evaluation which by now is common in the literature. We will take this "endogeneity problem" into account, and this paper is thus one of the first attempts to reveal whether R&D subsidies have a positive impact upon private R&D spending for firms in Norway. We will also use a sample of firms which is representative of most industries in Norway, and not just focus upon high – tech industries. Hence, our first research question is as follows: Do subsidies stimulate or substitute private expenditure on R&D at the firm level in Norway?

According to recent advances in the measurement of R&D and innovation (OECD, 2005), we will also analyze whether R&D subsidies have a positive impact upon innovation activities other than R&D spending at the firm level. With the exception of a recent study (Czarnitzki &

Fier, 2002), private R&D spending has been the preferred dependent variable in the literature. Our second research question is thus as follows: Do R&D subsidies have a positive impact upon innovation activities other than R&D at the firm level? To our knowledge no prior study has compared whether R&D subsidies stimulate private R&D and innovation spending at the same time. We will thus explore whether subsidized firms increase their R&D spending by reducing the amount of funds devoted to other innovation activities, and vice versa.

Most evaluation studies have taken the traditional market failure argument developed by Arrow (1962) and others as a theoretical point of departure. It is noteworthy in this context that no attempt has been made to analyze how subsidies affect the composition of the private R&D budget. According to a recent study by OECD (2006), few efforts have been made to analyze whether R&D policy interventions influence what *type* of R&D private firms conduct. Whether subsidies stimulate or substitute private expenditure on research or development is an important question for both innovation theory and policy. This issue has been neglected in the empirical literature.

The classical papers on this subject argue quite strongly that firms are especially reluctant to invest in research activities. According to Nelson (1959) firms are likely to under-invest in research because the benefits and outcome(s) from such investments are very hard to appropriate. This is complicated by the fact that the time lag from “basic science discovery” to profit is long for most firms. While Arrow (1962) in general argues that firms will, left to their own, under-invest in invention, he adds that: “This underinvestment will be greater for more basic research” (p 619). Hence, it is a shortcoming that we do not know whether subsidies affect the composition of the private R&D budget at the firm level.

From an innovation policy perspective this issue is important. Studies have shown that although firms need to balance their research and development efforts, most firms will focus on development (exploitation) over research (exploration) (March, 1991). Exploratory R&D projects are also more likely to have a greater pay-off in the long run (Nelson, 1959). Firms with research activities are more likely to escape suboptimal lock-in situations (Arthur, 1994). Griliches (1986) has further demonstrated that firms with a higher share of their R&D budget devoted to research (especially basic research) enjoyed far higher productivity growth. The research part of R&D is also believed to be important for firms “absorptive capacity” (Cohen & Levinthal, 1989).

Because research activities can result in technical knowledge that can not be fully appropriated by private firms, these projects are more likely to be unprofitable without public support. Hence, the “gap” between the social and private rate of return to research projects is high. Subsidies can (strongly) stimulate private spending in this context. As such we expect subsidies to stimulate expenditures on research activities compared to development activities. Development activities are similar to practical and firm specific problem-solving activities. The “gap” between the private and social rate of return is smaller in this context. Hence, subsidies are less likely to strongly stimulate private spending. We will test these expectations empirically by looking at whether subsidies impact both research and development spending. Our third research question is thus the following: Do subsidies stimulate private spending on research and / or development activities at the firm level?

Subsidies can also have a positive impact upon the quality of R&D done at the firm level. This is another missing dimension in the literature. At first sight most innovation policy documents seem to emphasize the quantity of R&D. On closer inspection, policy documents

such as the “Kok report” (EU 2004) and the Lisbon Agenda are concerned about the educational qualifications of R&D workers and the quality of R&D done at the firm level as well. The overall policy goal in the Lisbon Agenda is to make the EU the most competitive and dynamic knowledge-based economy in the world. Norway has to a large extent adopted this policy goal (NHD, 2006). It is thus important to explore whether subsidies have an impact upon the quality of R&D done at the firm level. In this paper we are interested in whether or not subsidized firms have a higher number of R&D man labour years conducted by workers with a Masters or a PhD degree. We assume that the educational level of R&D workers is closely linked to the quality of R&D. Our fourth research question is thus the following: Do subsidies have a positive impact upon the quality of R&D done at the firm level?

It has lately been argued that evaluation studies should not only analyze how subsidies impact the input side of the innovation process, such as R&D spending. The “effect” policymakers and academics have been interested in, is whether government R&D expenditures and company financed R&D behave like substitutes or complements (David & Hall, 2000; Georghiou & Roessner, 2000). We know less about whether subsidies have longer term effects upon recipient firms (Aerts et al, 2006; Georghiou, 2003). A particular important issue is whether subsidies are able to change firms’ behaviour and technology strategies. This is the so called behavioural additionality effect. It is generally defined as the difference in firm behaviour resulting from the policy intervention (Buisseret et al 1995; Luukkonen, 2000; OECD, 2006).

The behavioural additionality effect has generally been ignored when researchers have analyzed what impact subsidies have upon recipient firms (Georghiou, 2003). Recent studies and reviews of the literature have thus recommended future research to focus more on the

potential behavioural additionality effects arising from public support (Aerts et al, 2006; OECD, 2006). The main objective in studies of behavioural additionality is to identify changes in firms' technology strategies due to public support (Georghiou, 2003). A vital aspect of most technology strategies is to decide what kind of products and services the firm will develop and subsequently profit from. In this paper we are interested in whether subsidies have an impact upon firms' R&D investment plans. A decision to increase the R&D investment budget is an important strategic act because it will increase firms' profit opportunities in favour of R&D intensive product development. This is an important objective in contemporary innovation policy, perhaps most clearly expressed in the Lisbon Agenda. We will shed some empirical light on this issue as well. Our fifth research question is thus as follows: Do subsidies increase the private R&D investment budget?

Most studies on the "effectiveness of R&D subsidies" have evaluated whether the average effect of all R&D programs – or a single program within a country - stimulates or substitutes private R&D spending. Only one study from Spain by Blanes & Busom (2004) explores whether different R&D programs support different kinds of firms. That study focused only on the participation stage however. We know little about what impact subsidies allocated from different R&D programs have upon recipient firms (Aerts et al, 2006; Blanes & Busom, 2004). Evaluation studies are recommended to use taxonomies in order to understand how R&D programs differ and how differences can be related to private R&D spending (David & Hall, 2000). Responding to these shortcomings we will draw upon a taxonomy in the analysis. The "taxonomy" is discussed below, accompanied by a presentation of the most important R&D programs in Norway.

R&D support to firms in Norway

The public support system for R&D is a defining feature of the national innovation system (OECD, 2006; Lundvall & Borrás, 2005). In Norway the public support system has a distinct character. Based upon a review of 12 important evaluation studies of the public support system in Norway over two decades, Rye (2002) argues that a “division of labour” between R&D programs in Norway has emerged. Two main types of R&D programs exist in Norway. These programs subsidize different kinds of private projects according to the phases in the project cycle. The first type of technology program supports firms with projects “far from the market”, whereas the second type of R&D program supports firms with less uncertain projects “close to the market”. The taxonomy discriminates between technology programs according to the degree of uncertainty private R&D projects face. It captures a fundamental source of heterogeneity among R&D programs in Norway. The taxonomy was refined and up-dated in a companion paper (Clausen, 2007).

Heterogeneous selection criteria at the level of technology programs can influence the extent to which subsidies stimulate private R&D spending. A Spanish study found for instance that support from basic R&D programs was associated with a lower percentage of free-riding firms (Heijts, 2003). In comparison, a R&D program described as “closer to the market” (p 451) supported a higher number of free-riders. Free-riding was in this context defined as subsidized firms whose innovation projects did not depend upon public funding. According to Wallensten’s (2000) description of the well-known Small Business Innovation Research Program (SBIR) in the USA, this program did not encourage program managers to fund marginal projects that did not receive adequate funding from private sources. The SBIR program had instead formal selection rules that favoured R&D projects with technical merit and a high potential for commercial success. These criteria were close to what “a private

investor might use” (p 86). To us, the description of the SBIR program is in line with a technology program that supports firms with “close to the market” projects. Interestingly, Wallsten (2000) showed that the SBIR program did not encourage firms to do additional R&D efforts. Funding from this technology program did in fact substitute private R&D spending.

This brief discussion suggests that it is important to take into account how technology programs are designed when evaluating the effectiveness of R&D subsidies. Below we will present the most important public R&D programs in Norway, their related taxonomy, and discuss recent evaluations of these programs. Towards the end we will summarize our expectations as to how each type of subsidy will influence private R&D activities:

- (1) SND – is the State Industrial and Development Fund. SND was established in 1993 by merging the “Industry fund” (Industrifondet), the “SME fund” (Småbedriftsfondet) and the “Development fund” (Distriktenes Utviklingsfond). Especially the Industry fund and the development fund were originally established with a policy aim in mind to support private development activities. According to Wicken (2000) this included a strong policy focus to ensure that the private rate of return from public R&D support was high. SND has to a large extent continued this policy focus (Wicken, 2000). Rye (2002) concluded in her review that SND mainly supports firm projects “close to the market”. In a companion paper we found that both SND and Ministries supported firms with “close to the market” projects (Clausen, 2007). Subsidies from these two policy agencies are therefore merged into one type of subsidy called “close to the market”.

- (2) NRC – is the Norwegian Research Council. NRC was established in 1993 when 5 different research councils were merged. NRC allocates mainly R&D grants to firms. Firms can mainly decide for themselves how to use the subsidy. According to the review by Rye (2002) NRC supports firms with projects “far from the market”. In a companion paper we showed that also FUNN and EU supported such kinds of projects (Clausen, 2007). Policy support from these technology programs is therefore merged into one type of subsidy called “far from the market”.
- (3) Ministries – Firms can also get support directly from Governmental Ministries. In the survey policy support from Ministries includes subsidies from local and regional authorities. Far less is known about what impact subsidies from Ministries have upon recipient firms in Norway. We found in a companion paper however that Ministries and SND tend to support the same kind of private R&D projects (Clausen, 2007).
- (4) European Union (EU) – Norwegian firms can also get support from the European Union. Less is known about the role of EU financing in the Norwegian innovation system. For instance, EU funding is not classified as public R&D finance in the official R&D statistics (Statistics Norway, 2007). What we know is that funding from EU and NRC are allocated to the same type of private innovation projects, as shown in a companion paper (Clausen, 2007).
- (5) FUNN – is the predecessor to the current R&D tax credit policy called SkatteFUNN in Norway. FUNN was however operated as a subsidy scheme by the NRC where the main policy goal was to provide firms with an “easy and un-bureaucratic” access to public R&D financing. Because FUNN was managed by NRC, it is perhaps not surprising that this technology program finances the same type of projects as other R&D programs within NRC. This was demonstrated in a companion paper (Clausen, 2007).

A large commercial research institute sector in Norway evaluates what impact subsidies have upon firm performance. Recent evaluations show that subsidies allocated to projects by NRC have a high private and social rate of return (Hervik 2004; Hervik et al, 2004; 2005). Evaluations of the other major technology program in Norway, SND, have basically concluded the same (Madsen & Brastad, 2006; 2005; Hatling et al 2000, Hauknes et al 2000). In her review Rye (2002) found that “far from the market” subsidies were associated with a higher additionality rating compared to “close to the market” subsidies. These results suggest that subsidies allocated from the two most important technology programs in Norway stimulate firms to undertake additional R&D efforts.

Most evaluation studies in our Norwegian context are however based upon self-assessment reports where managers of subsidized firms are asked to rate whether the subsidized project would have been initiated without policy support. The use of self-assessment reports of payoff has been criticized for the following reason: Respondents are likely to report a high payoff in order to make the R&D program look successful, and thus, have a good chance at obtaining further funding in the future (Klette et al, 2000; see also the discussion in Georghiou & Roessner, 2000). Few studies have used more advanced evaluation designs where subsidized firms are compared to a control group of non-subsidized firms.

Klette & Møen (1998) represents a healthy exception in this case. They used a panel database of high-tech business units and a quasi-experimental control group design in order to evaluate whether subsidies stimulated or substituted private R&D spending. The study concluded that subsidies neither stimulated nor substituted private investments. Although differences among technology programs were explored in this regard, none of the technology programs performed significantly better or worse than the others. Since this interesting analysis the

public support system for R&D and innovation has undergone a large scale re-organization. Different types of research councils and industry funds have been merged, as discussed above. This warrants a new analysis.

Compared to the majority of earlier studies from Norway we will estimate effects in an econometric quasi-experimental design. Subsidized firms will be compared to a control group of non-subsidized firms. Objective performance measures, and a sample of firms that is representative of most Norwegian industries, are used. We will strive to ensure that subsidy effectiveness is estimated in an unbiased way. Most R&D policy evaluations in Norway have not “corrected” for the likely possibility that firms either self-select or are non-randomly picked by policymakers to participate in technology programs. As discussed by Klette et al (2000), this will most likely lead to biased conclusions about the effectiveness of the subsidy under evaluation. Our study will complement evaluation studies based upon self-assessment reports.

The taxonomy used in this paper describes two main types of technology programs that support projects “far from” and “close to” the market. It is important to see the taxonomy in relation to the uncertainty private R&D projects face. Whether a subsidy stimulates private R&D spending is inherently linked to the uncertainty of the subsidized R&D project. Projects “far from the market” are uncertain. These projects can result in knowledge that is not fully appropriable by the firm. Without public funding, “far from the market” projects will in most cases be unprofitable. The gap between the social and the private rate of return to R&D will be large in such contexts. Hence, we expect that “far from the market” subsidies will have a positive impact upon mainly research activities. Because such projects are uncertain, we expect subsidized firms to devote highly skilled science and engineers (S&Es) to these

projects. This should be captured in our analysis by the number of conducted R&D man labour years with a Masters or PhD degree. “Far from the market” projects also require future R&D investments. By financing such projects with a temporary subsidy we believe that firms will increase their R&D investment budget in response (Klette & Møen, 1998). Because these subsidies are allocated to projects far from the commercialization phase we do not expect them to have a positive impact upon private development spending or upon activities “near the market”. In the long run commercialization activities might be expected however.

Projects “close to the market” face less technological uncertainty. We therefore do not expect such subsidies to stimulate the research side of R&D. Positive impacts upon development expenditure and innovation activities “close to the market” are expected however. Because development spending usually dominates the R&D budget, “close to the market subsidies” can stimulate private R&D spending for this reason as well. These expectations are based upon the fact that “close to the market subsidies” support the commercialization of products that already have been researched and have moved into a development and maybe even a commercialization stage. The methodology and data we will use in order to test whether these expectations hold are discussed below. But before that, a word of caution.

The evaluation of subsidy effectiveness and of the agencies implementing contemporary innovation policy in Norway presented above, refers to the impact R&D subsidies have upon privately financed R&D and innovative activities. Innovation policy covers more than just allocating R&D subsidies to firms. Public agencies usually have other policy goals than just stimulating spending on innovative activities in the private sector, as discussed in a companion paper (Clausen, 2007). That said, R&D subsidies are one of the major policy instruments in contemporary innovation policy. To detect whether R&D policies are

efficient, and under what circumstances, is important for both innovation theory and policy practice (Mytelka & Smith, 2002).

Method, data and variables

The traditional method to estimate the impact of public funding on private R&D spending has been to regress a measure of private R&D on the subsidy, while controlling for other variables in an OLS regression (David et al, 2000). This method assumes more or less that R&D subsidies are allocated to firms in a random fashion. Randomness is a strong assumption when there are reasons to suspect that firms self-select and are picked by policymakers to participate in technology programs (David et al, 2000; Klette et al, 2000; Aerts et al, 2006).

There is an element of self-selection into R&D programs: Firms have an incentive to apply for subsidies in order to reduce the cost of doing R&D, even though public support is not necessary to complete innovation projects (Jaffe, 2002; Blanes & Busom, 2004). Public agencies and R&D programs are also embedded in an institutional context where they fight over scarce resources. Program managers face strong pressures for high “success rates”. Politicians are unlikely to support programs where a lot of the projects “fail”. This can lead to a situation where program managers decide to “pick the winners” by supporting innovating firms and commercially attractive project proposals (Aerts, et al, 2006; Wallsten, 2000). The criteria for allocating subsidies to firms will in both cases be correlated with high-expected rates of return to private R&D funding (David et al 2000; Lach, 2002). Because high expected success is correlated with current R&D spending the subsidy becomes an endogenous variable. Estimates will be biased and inconsistent if this is not addressed in an econometric framework (Aerts, et al 2006; Busom, 2000). R&D policies will in this case be falsely

credited for “success”. Hence, it is important to take the possible endogeneity of the subsidy variables into account.

There are different ways of tackling the existence of an endogenous subsidy variable in policy evaluations (for a review see Aerts et al, 2006). In our case, information about the actual amount of the subsidy firms receive is available. The amount of the subsidy is the possible endogenous variable in our econometric effect evaluation. One rather easy and powerful way to estimate the unbiased and consistent effect of the subsidy on R&D spending in this case is to use instrumental variables (IV) regression. IV regression has previously been used by Wallsten (2000) in his evaluation of the SBIR program in the US. The method was also used by Lichtenberg (1988) in his analysis of whether non-competitive and competitive R&D contracts stimulated private spending in USA.

Our effect estimation draws upon these studies. The main methodological problem in our effect estimation is that the amount of the subsidy can be correlated with the error term in an OLS regression. In order to “remove” this correlation we will estimate a system of equations where we instrument for the endogenous subsidy. The general point in an IV regression is that the correlation between an independent variable (the subsidy) and the error term can be corrected for and removed if the researcher has access to one or more variables that are correlated with the subsidy, but uncorrelated to the error term in the R&D outcome equation. As will become evident from the discussion below, we have 2 endogenous subsidy variables and 4 instruments that are believed to be correlated to the subsidy but uncorrelated to unobserved firm factors. This enables us to test for over-identification where the main goal is to see whether the instruments are uncorrelated to unobserved firm factors. The equations we estimate are described below after we have presented and discussed the data and the variables.

Data

The research in this paper builds upon a novel database. The main part of the data is based upon the third version of the Community Innovation Survey (CIS 3) and a R&D survey, which was conducted in Norway in 2002. The questions refer mainly to the time period 1999-2001. This combined survey contains information about firms' innovation activities (CIS survey) and questions about how firms finance their R&D activities (the R&D survey). The research in this paper benefits from a range of questions that were posed to the firm manager about current and planned R&D efforts. Questions include how much the firm spends, and will spend in the future, on R&D activities. In addition, firms are asked to estimate how much of their R&D efforts that have been devoted to development, applied research and basic research activities. Information about the educational degrees of all R&D workers is also provided.

It is important to highlight that our data possess some important qualities not shared by the recent literature: Because firm managers were asked how much money they got from the most important technology programs in Norway, we have access to the actual amount of the subsidy. In the recent literature only Hussinger (2006) has access to the same information. It is important to have information about the amount of the subsidy in order to evaluate whether subsidies stimulate or replace private finance (David et al, 2000). Further, and no less important, we know what type of innovative activity policymakers subsidize, namely internal R&D activity. Most of the recent literature uses the questions posed about R&D subsidies in the CIS questionnaire. According to the CIS "core questionnaire" developed by Eurostat, firm managers have to reply to whether or not their firm has received public financial support for innovation in the time period 1998-2000. As innovation activities can include a wide array of different activities it is seldom known in evaluation research what type of innovation activities

that are being subsidized. This reduces the precision in the evaluation. Another important aspect is that most studies using the CIS survey only have information about public funding for innovating firms. This is not the case in our study as all surveyed firms – innovators as well as non-innovators - had to respond to the questions in the R&D survey. Hence, the database underlying the research in this paper does not suffer from some of the “usual” shortcomings.

The combined questionnaire was directed to a representative sample of Norwegian firms with 10 employees or more and conducted by Statistics Norway (SSB). It was returned by 3899 firms which constitutes a response rate of 93 %. In addition to the information collected through the survey, the responding firm’s annual accounts have been collected as well. Because not all firms have reported their annual accounts the total sample size drops by approx. 10 - 15 % when variables constructed from the annual accounts database are used in the analysis. Although this non-response is mainly due to the fact that not all types of firms in Norway are required to file their annual accounts, we can not exclude the possibility that some firms do not report their annual accounts although they are obliged to do so under Norwegian Law. The annual accounts data is provided by the credit-rating agency Creditinform on the basis of an official firm registry in Norway.

The information has been used to create a novel database where the effects of public R&D subsidies can be evaluated. The analysis is constrained to those firms with a positive private internal R&D budget in 2001 (total internal R&D expenditure – total subsidy). This constraint makes it easier to evaluate what impact subsidies have on private R&D spending. The main reason is that one does not have to take firms’ decision to not do R&D into account. Although this constraint is common in the literature (see for instance Busom, 2000; Hussinger

2006²; Lach, 2002; Lichtenberg 1988; Almus & Czarnitzki, 2002), it could underestimate the impact of the subsidy upon private R&D spending. The reason is that firms that do R&D only if they are subsidized are excluded from the analysis.

Because our sample is constrained to firms with internal R&D activity we will allow for the possibility that subsidized firms can outsource some of their technology projects. This is done by analyzing whether subsidies have positive or negative impacts upon the private budget devoted to external R&D. The analysis is thus constrained to 1074 firms with a positive internal R&D budget. Approximately 50 of these firms are missing in the analysis due to missing values on one – or more – of the variables discussed below. This represents less than 5 % of the sample and should as such not constitute an important source of selection bias (Berk, 1983).

Variables

As we discussed above, neither subsidies nor the amount of public funding are allocated randomly to firms. It is thus important to control for initial differences between subsidized and non-subsidized firms that are related to both the amount of public funding and to R&D spending. The theoretical and empirical literature points to a number of factors that are correlated to the probability of receiving a subsidy and to firm level R&D spending. Prior research has found that several firm characteristics, such as age, group, size, diversification, foreign ownership, firm growth, regional location, cash-flow, debt, past R&D and innovation efforts, export activity, investment funding difficulties and industry, are correlated with public funding and R&D spending (Aerts & Czarnitzki, 2004; Almus & Czarnitzki, 2003; Busom, 2000; Blanes & Busom, 2004; Czarnitzki, 2001; Czarnitzki & Hussinger, 2004; Czarnitzki &

Fier, 2002; Duguet, 2004; Heijs & Herrera, 2004; Wallsten, 2000). These variables are in turn discussed below.

Main independent variables

The two main independent variables in this study are (1) “far from the market subsidies” and (2) “close to the market subsidies”. These two subsidies are spent in 2001 by firms to finance internal R&D activity. Because our two subsidy variables are believed to be correlated with the error term in an R&D equation, we will use IV regression. As such we need measured instruments that are correlated with the amount of the subsidy, but uncorrelated with unobserved firm factors. The search for valid instruments is both theory and data-driven. It is theory driven because we will use instruments proposed and used in the literature. It is data-driven in the sense that we will actively test the validity of the instruments in the analysis. We will discuss each proposed instrument in more detail below.

Firm size, age and market structure

The relationship between firm size and innovation dates back to the Schumpeterian hypothesis, where R&D activities rise disproportionately with larger size and industry concentration (Levin et al 1985; Acs & Audretsch, 2003). This “stylized” fact can be explained by the fact that small and start-up firms face a higher cost of capital than larger firms. Larger firms are more able to use internally generated funds in their R&D process, whereas younger firms are much more “cash constrained” (Hall, 2002b). Larger firms are further more likely to benefit from economics of scale and scope, and for instance Klette (1996) found that there are significant R&D spillovers across lines of businesses within firms. Hence, smaller and younger firms have a stronger incentive to apply for a subsidy compared

to larger firms. On the other hand, all firms have an incentive to reduce the private cost of doing R&D by getting access to subsidies (Jaffe, 2002).

Evaluation studies suggest however that larger firms are more likely to be subsidized. With the exception of Busom's (2000) study of a single R&D program in Spain, prior research has found that larger and older firms are more likely to get access to public funding. Research from Germany (Hussinger, 2006; Czarnitzki & Fier, 2002; Almus & Czarnitzki, 2003; Czarnitzki & Hussinger, 2004), from France (Duguet, 2004), from Spain (Herrera & Heijs, 2004), from Belgium (Aerts & Czarnitzki, 2004) and from the US (Wallsten, 2000), shows that larger size is positively related to the probability of being subsidized. Empirical studies have in addition found that older firms are far more likely to get access to subsidies (Busom, 2000; Hussinger, 2006; Czarnitzki & Hussinger, 2004). Although some studies have found that age does not matter for the probability of getting access to subsidies (Herrera & Heijs, 2004; Almus & Czarnitzki, 2003), being a young firm has never been found to be a significant positive predictor variable in the recent papers on this topic. Hence we will expect that older and larger firms are more likely to be subsidized.

Group membership and diversification

Diversified firms and / or a firm with a corporate parent are more likely to be able to apply for a subsidy because resources at the corporate level, such as information, expertise and funds, are made available to the applicant. Further, diversified firms are believed to be more likely to innovate due to complementarities that arise from uniting different knowledge from two or more industries in the R&D and innovation process. Two previous studies however did not find group to be significantly related to successful obtainment of subsidies for Belgian and

German firms (Aerts & Czarnitzki, 2004; Czarnitzki & Hussinger, 2004), although it still might be an important predictor variable in the R&D equation.

Past innovation activities

Firms that have successfully innovated in the past might be more likely to receive public funding, especially if policymakers follow a “pick the winner” strategy in their technology policy. It is often assumed that firms which (successfully) innovated in the past are also likely to be innovators in the future. Research has shown that previous innovation activities, proxied by patents and R&D departments, are positively related to the probability of being subsidized. (Aerts & Czarnitzki, 2004; Blanes & Busom, 2004; Czarnitzki & Hussinger, 2004; Hussinger, 2006; Wallsten, 2000). Hussinger (2006) further found a significant positive relationship between past innovation activities and the amount of the subsidy firms received from German technology programs. Based upon these results we expect firms with one or more patents in Norway to be more likely to receive higher amounts of public funding.

Ownership and foreign capital

According to Archibugi & Iammarino (1999) governments must make a choice about whether or not to give affiliates of foreign firms access to national R&D subsidies, and this decision might also influence firms’ R&D spending. The dividing line is believed to go between governments emphasizing ownership, and those who do not, in relation to the technological knowledge developed as a result of (public) R&D investments. While the United States seems to follow a policy where foreign firms can get access to subsidies (Archibugi & Iammarino, 1999), studies from several European countries show that affiliates of foreign firms are a lot less likely to get access to subsidies in Europe (Almus & Czarnitzki, 2003; Herrera & Heijs, 2004; Busom, 2000; Aerts & Czarnitzki, 2004 Hussinger, 2006). Empirical research has

further found that public R&D grants to foreign establishments neither have stimulation nor substitution effects, at least in Ireland (Görg & Strobl, 2005). An explanation is that affiliates of foreign owned companies may benefit from R&D developed in the home country of the mother company, and as such have no incentive to engage in R&D activities in the host country. Another reason might be that affiliates of foreign firms are denied access to subsidies in foreign countries. We therefore expect a negative correlation between foreign ownership and the amount of the subsidy.

Export and competitiveness

Firms that export some, or all, of their products or services usually face strong international competition, and are likely to strengthen their competitiveness through innovation. Further, policymakers are believed to be inclined to subsidize R&D projects with high expected commercial success in order to promote and enhance the competitiveness of national champions (Blanes & Busom, 2004). With the exception of Busom's (2000) study of a single R&D program in Spain, prior evaluation research has shown that exporting firms are more likely to get access to subsidies (Almus & Czarnitzki, 2003; Aerts & Czarnitzki, 2004; Hussinger, 2006; Czarnitzki & Hussinger, 2004). As Norway has a small and open economy, where a lot of firms export their goods, we expect R&D programs in Norway to subsidize export oriented firms with significantly higher amounts of public funding.

Industry and technological opportunity

Industries vary considerably in terms of technological opportunities, generally defined as advances in science and technology, and to the extent to which the economic value of innovations can be reaped (appropriability conditions) (Klevorick et al, 1995; Levin et al 1987). Industry is thus an important variable in evaluation research because it controls for

differences in technological opportunities and appropriability conditions between firms (Klette et al, 2000). We will include a set of dummy coded industrial sectors variables to capture this.

Financial characteristics

As discussed above, small and young firms are likely to be (more) “liquidity constrained” compared to large and old firms (Hall, 2002b). Firms with a better cash-flow are thus believed to be more likely to divert resources into R&D activity (Klette & Møen, 1998). As cash-flow approximates the internal resources that can be used for R&D purposes, firms with better cash-flow should be less inclined to be subsidized by policymakers. Following Aerts & Czarnitzki (2004) we take this into account by including cash-flow divided by the number of employees in 2000 as a predictor variable. Further, high growth firms could be more inclined to be subsidized, especially if R&D policies aim to support the development of national champions and “winning” firms (Blanes & Busom, 2004). When it comes to the empirical evidence, cash-flow has not been found to be a significant predictor of R&D efforts in the empirical literature on the effectiveness of R&D subsidies or to be related to the probability of being subsidized (Czarnitzki, 2006; Aerts & Czarnitzki, 2004). Further, prior research has not analyzed whether faster growing firms also receive significantly more public funding.

Other variables (not measured)

In the literature the following variables are identified but not included due to lack of data: Importance of publicly funded R&D (Duguet 2004), firms’ R&D funding history (Hussinger, 2006), investment capacity (Herrera and Heijs 2004) and past public support (Duguet 2004). Firms’ R&D funding history, as well as future prospects of obtaining a subsidy, are arguably the most important omitted variables. Investment capacity should be closely linked to cash-

flow so this should not constitute an omitted variable bias. Because we are also looking at planned increases in R&D spending, anticipated subsidies are important omitted variables that can be correlated to the received subsidy amount. It is thus important to take into account the possibility that the subsidy variables can be correlated to unobserved factors in our estimated regression equations.

Discussion of excluded instruments

In this section we will discuss the instruments that are excluded from the R&D outcome regression. This is one vital aspect of the IV regression. The fundamental assumption in IV models is that the excluded instruments should be (1) correlated to the (amount of the) subsidy, but (2) uncorrelated to unobserved firm factors. Our excluded instruments are based upon previous research as discussed below:

Amount of industry funding

Lichtenberg (1988) proposed that a good instrument for the endogenous subsidy variable is the number of awards or subsidies that are potentially available to firms. Drawing upon Lichtenberg (1988) we argue as follows: The budgets of the R&D programs in this study are the outcome of political processes at mainly the national or supranational level. The actual subsidy amount a firm can receive is linked to the total budget controlled by technology programs. The budget that our technology programs control should not be correlated with unobserved firm factors.

Based upon this logic we experimented with two types of instruments: (1) The total amount of funding allocated to industries by technology programs and (2) the average subsidy amount allocated to industries by the technology programs in our study. Based upon results from

statistics robustness tests (discussed in more detail later) we choose to add two instruments to our analysis³: (1) the total amount of public funding at the industry level from NRC, EU and FUNN (far from the market industry funding) and (2) average public funding from SND and Ministries at the industry level (close to the market industry funding). This is a somewhat data-driven approach, although it is based upon prior research. The variables are created by aggregating information at the firm level up to the 2. digit industry level using weights generated by Statistics Norway. The variation in public R&D funding at the industry level is thus believed to be correlated to the amount of the subsidy firms receive but uncorrelated to unobserved firm factors. The reasoning behind the use of these instruments builds, to a large extent, upon Lichtenbergs (1984) argument that public R&D may be viewed as an exogenous factor at the industry level.

A somewhat similar instrumental variable has been used by Wallsten (2000) in his evaluation of the Small Business Innovation Research (SBIR) program in the US. A better instrument would arguably be to use the amount of public funding per technology field at the industry level (Jaffe, 2002). The reason is that firms in different industries can have related technologies. Unfortunately we do not have information about the amount of public finance per technology field. Our “industry funding” instruments follow the logic in the published literature however (Lichtenberg, 1984, 1988; Wallsten, 2000).

Distance to R&D program

Distance to the labour market training centre is frequently used as an instrument in evaluations of labour market training policies (see discussion in Wooldridge, 2006). In this literature it is assumed that physical closeness to the training centre is correlated with participation but uncorrelated with labour market outcomes. We draw upon this literature and

include firms' distance to the headquarter of NRC in Oslo, and the distance to the closest regional headquarter of SND. The SND regional headquarters are located mainly in the regional capitals in Norway's 19 counties.

We assume that "distance to headquarter" is correlated to participation but uncorrelated to unobserved firm factors. To what extent is this assumption valid? Comments on an earlier draft of this paper argued that distance to the NRC headquarter in Oslo also measures the distance to relevant knowledge spillovers etc. If so, it can be problematic to exclude this variable from the structural R&D outcome equation. A look at the firm level distribution of R&D and innovative efforts per region in Norway reveals however that only 28 % of total R&D⁴ is done by firms in the Oslo region. Firms in this region are not more innovative or more inclined to do R&D compared to firms in other regions in Norway (Gundersen, 2003). Further, universities and university colleges are by no means concentrated in the Oslo region but scattered around Norway. We believe that "distance to NRC" is an instrument that can predict participation status in technology programs but that distance is uncorrelated to R&D activity at the firm level. This assumption will also be tested.

Dependent variables

We have 8 dependent variables that are analyzed separately using the same sample of firms. The first dependent variable is the amount of private internal R&D expenditure in 2001 (the amount of the subsidy has been subtracted). Other "expenditure variables" are the amount of funds devoted to research (applied and basic research) and development activities in 2001. Anticipated R&D expenditure in 2002 is used as a measure of firms' planned R&D investment budget. We include expenditures on innovation activities other than R&D as a dependent variable, for short called innovation expenditure. The "innovation expenditure"

variable follows the guidelines in the Oslo Manual (OECD, 2005) with the exception that we have subtracted internal and external R&D expenditures from the variable. This is done in order to analyze whether subsidies stimulate internal R&D activity by reducing the private innovation budget or vice versa. Innovation expenditure is also a measure of innovation activity “close to the market”.

The numbers of R&D man labour years conducted by workers with a Masters Degree or higher (including PhD Degree), and only with a PhD degree, are included as two measures of the “quality” of R&D. Expenditure on external R&D is included as a dependent variable in order to analyze whether subsidized firms spend additional amounts of funds on internal R&D simply by reducing the external R&D budget (or vice versa). Dependent variables are used in logs to take into account that the original variables suffer from some skewness. This is a normal procedure in the literature (see for instance Aerts & Czarnitzki, 2004; Czarnitzki 2006), and will mitigate problems that might arise from extreme observations and heteroskedasticity (Wooldridge, 2006). All variables are defined in table 1 below, and descriptive statistics are displayed in table 2:

[TABLE 1 ABOUT HERE]

[TABLE 2 ABOUT HERE]

Analysis

The analysis is done in a two stage least squares regression using the IVREG 2 procedure in STATA 9.0. Our primary equation of interest is the structural equation (1) below:

$$(1) \quad Y_1 = B_0 + B_1Y_2 + B_2Y_3 + B_3X_1 + B_4X_2 + B_5X_3 + B_6X_4 + B_5X_5 + B_8X_6 + B_9X_7 + B_{10}X_8 + B_{11}X_9 + E_1$$

Where Y_1 is one of our 8 R&D activity variables, for instance private internal R&D expenditure, Y_2 is “far from the market” subsidies, Y_3 is “close to the market subsidies”, X_1 is size, X_2 is age, X_3 is group, X_4 is diversification, X_5 is patent, X_6 is export activity, X_7 is cash-flow, X_8 is growth, X_9 is foreign ownership, and E_1 is the error term (industry dummies also included in the estimations but not shown). In equation 1 above the subsidy variables Y_2 and Y_3 are believed to be correlated with the error term, and might thus be endogenous. To estimate the equation with 2 stage least squares we need access to at least two exogenous variables that are not correlated with unobserved firm factors, but are correlated with Y_2 and Y_3 . We have access to 4 variables that are believed to satisfy this criterion, as discussed above. To check the assumption that our instruments are in fact correlated with the subsidy variables we will estimate the reduced form equation for Y_2 and Y_3 :

$$(2) \quad Y_2 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} + B_{11}X_{11} + B_{12}X_{12} + B_{13}X_{13} + E_2$$

In equation (2) Y_2 is “far from the market subsidies”, X_1 is size, X_2 is age, X_3 is group, X_4 is diversification, X_5 is patent, X_6 is export activity, X_7 is cash-flow, X_8 is growth, X_9 is foreign ownership, X_{10} is distance to NRC, X_{11} is distance to SND, X_{12} is “close to the market industry funding”, X_{13} is “far from the market industry funding”, and E_2 is the error term (industry dummies also included in the estimations but not shown).

$$(3) \quad Y_3 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} \\ + B_{11}X_{11} + B_{12}X_{12} + B_{13}X_{13} + E_3$$

In equation (3) Y_3 is “close to the market subsidies”, X_1 is size, X_2 is age, X_3 is group, X_4 is diversification, X_5 is patent, X_6 is export activity, X_7 is cash-flow, X_8 is growth, X_9 is foreign ownership, X_{10} is distance to NRC, X_{11} is distance to SND, X_{12} is “close to the market industry funding”, X_{13} is “far from the market industry funding”, and E_3 is the error term (industry dummies also included in the estimations but not shown).

As is evident from the above section, the instruments “distance to SND”, “distance to NRC”, “far from the market industry funding” and “close to the market industry funding” are excluded from the structural equation (1) but included in the reduced form equations (2) and (3). In table 3 below the “first stage” results from equation (2) and (3) are reported:

[TABLE 3 ABOUT HERE]

We will first discuss the variables that significantly explain why some firms receive more “far from the market” public funding compared to others. These results are reported in the first two columns in table 3. According to table 3, larger firms and companies with proven innovation capabilities receive significantly more public R&D financing from technology programs that support firm projects “far from the market”. Firms also react to the amount of public funding at the industry level. The amount of available “far from the market public funding” at the industry level is positively correlated with the actual subsidy amount firms are able to obtain from technology programs that support research projects. It is interesting to see that when the average amount of “close to the market funding” that is available to firms at the

industry level increases the subsidy amount firms receive from “far from the market” R&D programs decreases. This suggests that our two types of technology programs target different segments of the firm population.

Only three variables are significantly correlated with the ability to get access to “close to the market” subsidies. According to the third and fourth column in table 3, foreign owned firms and diversified companies receive significantly less public R&D financing from technology programs that support firms with “close to the market” projects. Distance to NRC is also a significant predictor. When the distance to NRC increases firms are more inclined to apply and get access to a higher amount of public financing from “close to the market” technology programs.

From a methodological point of view it is important to note that three of our excluded instruments in the structural equation are significantly correlated with the subsidy variables. This satisfies one important assumption behind IV and 2 SLS regression models. The pseudo R^2 is somewhat low in the first stage regressions however. The results reported in table 3 suggest that it is far from simple to predict why some firms get access to a higher subsidy amount compared to other firms. We did however test for the relevance of the excluded instruments. The test suggested that the excluded instruments are relevant (discussed towards the end). With this in mind, we will move on to analyze what impact the subsidy variables have upon R&D activities at the firm level. It is also important to emphasize in this context that the explained variance in the second stage in an IV model is not very informative and can be negative (Wooldridge, 2006). The results are reported in table 4 below.

[TABLE 4 ABOUT HERE]

The pattern in table 4 is quite clear: “Far from the market” subsidies have significant and positive impacts upon all our expenditure variables except for development and innovation expenditure. Hence, this kind of subsidy stimulates private R&D spending, mainly by increasing the amount devoted to research activities. “Far from the market” subsidies also have a positive and significant impact upon the private R&D investment budget. “Close to the market subsidies” do not have any positive and significant impacts upon the same set of performance indicators. Actually, this latter type of subsidy “crowds out” private R&D spending, mainly by reducing the amount spent on development.

The same pattern partly repeats itself when we look at the R&D activity variables in table 4. “Far from the market” subsidies have a strong positive and significant impact upon the number of R&D man labour years conducted by R&D workers with a Masters or a PhD degree, while “close to the market subsidies” actually seem to significantly reduce R&D activity done by highly educated R&D workers at the firm level. One could argue that “close to the market subsidies” reduce R&D activity by educated R&D workers as these are put to work by the firm management to commercialize R&D projects, activity not captured by our R&D activity variables in table 4 above. This argument does not seem to be valid. “Close to the market subsidies” have a non-significant impact upon private innovation spending.

Our expectations were as such generally confirmed, with one notable exception. We expected “far from the market subsidies” to have a positive impact mainly upon the research part of R&D. In comparison we expected “close to the market subsidies” to have positive impacts upon the private development expenditure as well as upon innovation expenditure. According to the results reported in table 4 it is clear that “close to the market subsidies” reduce the private amount devoted to development and have a non-significant impact upon innovation

expenditures. It is also clear from table 4 that “far from the market subsidies” do not stimulate internal R&D activity by reducing the private budget devoted to external R&D. Actually; this type of subsidy has a positive and strong impact upon external R&D spending as well. Although we did not expect “far from the market subsidies” to stimulate innovation expenditure, it is nevertheless interesting to note that firms with such subsidies do not reduce the innovation budget in order to increase the R&D budget.

The analysis reported in table 4 is a log-log model. In our analysis we found that the elasticity of internal R&D spending with respect to “far for the market subsidies” is 0,36 and the equivalent for “close to the market subsidies” is -0,66. This means that when the amount of the subsidy from the first type technology program is increased by 1 %, private internal R&D spending is increased by almost 0,36 % in response. Because the private R&D budget is much higher than the value of the subsidy (in average), a 0,36 % increase in the internal R&D budget will generate substantial additional R&D efforts by recipient firms. This finding has to be contrasted with the fact that when the amount of the subsidy from the latter type of technology program is increased by 1 %, firms reduce their internal R&D spending by 0,66 %. Although we have few – if any – studies to compare with, the findings demonstrate that it is important to be able to distinguish between different types of R&D subsidies when evaluating the efficiency of R&D policy interventions. In this context it is interesting to note that 1 % increase in “far from the market funding” leads to a more than proportional increase in research spending by private firms (about 1,34 % in average to be exact).

Research on the effectiveness of R&D subsidies has been constrained by the lack of information about (1) the subsidy amount firms get access to, (2) lack of information about what kind of innovation activity that is subsidized, and (3) lack of knowledge about the

technology programs that allocate subsidies to firms in the first place. These shortcomings have made it difficult to estimate whether subsidies stimulate or crowd-out private R&D spending (David et al, 2000; Aerts et al, 2006) and to achieve any degree of precision in our knowledge about how subsidies interact with the private R&D and innovation budget (David & Hall, 2000).

With the research in this paper we have contributed to the scholarly knowledge about how public and private R&D interacts at the firm level. We believe that it is an important avenue for further evaluation research to recognize that R&D is a heterogeneous measure. It is telling that in her well known review of the funding gap for R&D, Hall (2002b) does not distinguish between research and development. We believe that the “funding gap” will differ according to whether firms are engaged in research or development activities. R&D policy interventions can have partly different impacts in these two domains as the research in this paper has shown.

Future research can improve and extend upon our work in several ways. A more rigorous analysis would include the firms that do not do R&D as well as more financial variables, such as firms’ credit index included by Czarnitzki (2006). Related to this discussion, our cash-flow variable did not have any significant impacts upon the 8 dependent variables. We subsequently dropped the variable from the analysis reported in table 4. The results with cash-flow are presented in the appendix for the interested reader. The insignificant impact of the cash-flow variable suggests that liquidity constraints are not a serious problem for the firms in our sample. Our analysis is on the other hand constrained to the firms with a positive internal R&D budget. Although this has been common in the literature, “cash-constraints” can still be an obstacle to innovation for firms without R&D efforts. Subsidies can easily have

positive impacts upon R&D activities at the firm level in this context, and this is a topic for further research.

The results have implications for both research and policy. Comparing the research in this paper to the empirical literature, one novelty is that we have been able to analyze how subsidies affect the composition of the private R&D budget. Two related novelties are that we have looked at the quality of R&D done at the firm level, as well as upon the R&D investment budget. These topics have largely been unexplored in the prior literature on the effectiveness of R&D subsidies. The analysis suggests that “far from the market subsidies” strongly stimulates the research part and the quality part of R&D done at the firm level. This type of subsidy also has a positive impact upon the private R&D investment budget. These findings have important implications: “Far from the market subsidies” do not stimulate research activities by (1) substituting expenditure on development activities or by (2) reducing the budget devoted to external R&D or (3) by reducing the amount of funds devoted to innovation activities besides R&D.

This suggests, as first argued by Nelson (1959), that researchers working on the frontier of basic science discovery think of what type of practical application their research efforts have. “Far from the market” or “research” subsidies will as such not reduce the private development or innovation budget. These results are also an empirical confirmation of the traditional market failure argument set forth by Arrow (1962) and others. Subsidies have stronger stimulation effects in areas where the gaps between the private and social rate of return from R&D investments are larger.

There are also some implications for policymakers in Norway, as well as in EU countries, who currently worry about whether the goals in the Lisbon Agenda can be reached. One of the major goals in the Lisbon Agenda is to have a R&D to GDP ratio of 3 % by 2010. Although this goal seems increasingly hard to reach, the results from this paper suggest that policymakers should subsidize firms with novel and uncertain projects “far from the market” in order to stimulate the quantity and quality of R&D done at the firm level. Contemporary evaluation studies from EU countries do not distinguish between what types of subsidy firms are allocated or between development and research spending. Needless to say the scope for improvement is large. Such information has the potential to shed interesting light on how R&D policies should be implemented in Europe.

At the very least, policymakers should rethink what type of R&D spending they want to stimulate. Studies have argued quite strongly that research activities are an integral part of firms’ absorptive capacity and that research projects will have higher payoffs in the longer run (Nelson, 1959; Cohen & Levinthal, 1989). It is important to highlight that the scope for innovation policy is large. Policymakers can change firms tendency to “exploit” rather than to “explore” (March, 1991) by establishing technology programs that subsidize “far from the market” activities at the firm level. Such technology programs also have an impact upon the quality of R&D done at the firm level. “Far from the market” subsidies stimulate firms to put highly qualified R&D workers to work in order to solve complex technological problems far from the commercialization stage. This suggests, in line with a behavioural additionality argument (OECD, 2006), that policymakers can have an impact upon firm behaviour and the organization of R&D within the enterprise. “Research” subsidies are instrumental in this regard.

A main result in table 4 is that “far from the market subsidies” have a significant and positive impact upon the R&D investment budget. This type of subsidy is able to change firms’ technology strategies in favour of R&D intensive product development. Hence, policymakers are able to change firms profit opportunities in favour of knowledge based economic activity. As such, “far from the market subsidies” help policymakers to reach one of the most important goals in contemporary innovation policy: Temporary subsidies seem to have a positive effect upon firms’ future R&D commitment. Positive dynamic effects are at play. Positive dynamic effects mean that policymakers’ are able to increase firms’ long term R&D efforts by awarding temporary subsidies (Klette & Møen, 1998). Hence, “far from the market subsidies” have longer term impacts upon recipient firms by changing their technology strategies.

This finding demonstrates that it is important to take into account how subsidies change firms’ behaviour and technology strategies when evaluating the effectiveness of technology programs, as suggested by a small – but increasing – literature on behavioural additionality (Georghiou, 2003; Georghiou & Roessner 2000; Luukkonen, 2000; OECD, 2006). Prior research has in comparison mainly focused on the input side. As such, important information for evaluating the “efficiency” of various R&D policies has been lost. Our measurement of behavioural additionality is crude. The R&D investment budget is closely linked to R&D as an input. The decision to increase future R&D efforts is on the other hand an important strategic act in most technology strategies. Qualitative differences also exist between “development” and “research” in this regard.

Implicit in most contemporary innovation policies is the notion that it is “good” innovation policy to change firms’ profit opportunities in favour of R&D intensive product development. Behavioural additionality effects of the sort reported in this paper make it more likely that the

private sector will increase future R&D spending – and make it more plausible that some goals in the Lisbon agenda can be reached. The rather implicit assumption that R&D will enhance firm performance in most contemporary innovation policies should be tested and analyzed. This is a direction for future research. It is also an important avenue for future research to analyze how subsidized firms are able to spend additional funds on R&D activities. In this paper we showed that “far from the market subsidies” do not stimulate internal private R&D activity by reducing the innovation or external R&D budget. A natural follow-up question is thus “where does the money come from”? Where do “close to the market subsidies” end up? Do firms with this kind of subsidy simply pass it along to the owners? Or is it used in a beneficial way (to society) not captured by the performance indicators in our analysis?

A theoretical implication of the results is that it is important to take the design of R&D programs into consideration when evaluating the “efficiency” of R&D subsidies. As argued by reviews of the literature, taxonomies are “theoretical tools” that can be used in order to understand how technology programs differ, and how differences are related to R&D spending. The research community knows fairly little about what effect different types of subsidies have upon recipient firms (Aerts et al, 2006; David & Hall, 2000). By using a new taxonomy of R&D programs we have contributed to the literature. A direction for future research is to use the taxonomy presented in this paper and apply it to other settings in order to test whether results hold across institutional and country contexts. It is important to note in this context that our taxonomy follows institutional borders. We can not rule out the possibility that EU and NRC are better at picking the “right” private projects compared to SND and Ministries. Subsidies can only stimulate private R&D if policymakers fund the best of the privately unprofitable innovation projects (Wallsten, 2000). To analyze how technology

programs, and policymakers and people within technology programs, are able to identify and pick projects where there is a large gap between the social and the private rate of return to R&D is an important avenue for further research.

A methodological implication is that the econometric effect estimations reported here only provide partial support for the self-assessment reports underlying Ryes (2002) review. She concluded in the review that “far from the market subsidies” had a higher additionality rating compared to “close to the market subsidies” but that also the latter type of subsidy was deemed by respondents to have positive effects. As we have shown in this paper “close to the market” subsidies did not stimulate additional R&D effort. As such, some “bias” might be involved when managers in recipient firms are asked to rate the payoff from subsidies, as argued by Klette et al (2000). Managers might on the other hand have broader performance measures in mind besides R&D efforts when they report the payoff due to subsidies. Future research should evaluate what kind of impact “research” and “development” subsidies have upon other performance dimensions besides R&D and commercialization efforts. The introduction of product and process innovation is one such performance dimension (Aerts et al, 2006).

A limitation with this study is that only short term effects are analyzed. It would thus be interesting to analyze whether our two types of subsidies have a longer term impact upon recipient firms. For this purpose it would be beneficial to use panel data as a large part of the evaluation research in this tradition, including this paper, use cross-sectional data. This will however require panel data with a descent time lag between the allocation of a subsidy and firm performance measure (Aerts et al, 2006). To collect and use better data is thus almost always a safe option in order to advance research on this topic. Linking R&D and innovation

surveys from different years can be a practical solution to this challenge. In future work we will seek to explore this and take advantage of recent efforts that are being made to link R&D and innovation surveys using Norwegian data.

Several measures were also taken to test the robustness of the analysis. We first tested for the relevance of our excluded instruments using the Anderson canonical correlations likelihood-ratio test. This is a test of whether the excluded instruments are relevant (Baum et al 2003). The null hypothesis of the test is that the equation is under-identified and a rejection of the null hypothesis indicates that the model is identified. It is a chi-square distributed test, with 3 degrees of freedom in our case. A test statistic of more than 7,81 (critical value) would lead us to reject the null hypothesis using a 95 % confidence level. The test statistic reported from running the regressions in table 4 above returned a test statistic of 15,2 with 0,002 in associated p-value which is higher than the critical value. As such we can reject the null-hypothesis that model is under-identified, and conclude that the excluded instruments are relevant.

Equally important, we actively tested for over-identification. This was done using a Sargan test implemented in the IVREG 2 procedure in Stata. This test statistic is chi square distributed with the number of over-identification restrictions as the degrees of freedom. Having two endogenous explanatory variables, and 4 exogenous instruments, we have two degrees of freedom. The null hypothesis of this test is that instruments are un-correlated with the error term in the structural equation, and that the excluded instruments are correctly excluded from the estimated equation (Wooldridge, 2006; Baum et al, 2003). A Sargan test statistic of more than 5,99 would thus lead us to reject the null hypothesis using a 95 % confidence level. The test statistic reported from running the 8 regressions in table 4 above

returned Sargan test statistics in the range from 0,03 - 2,3 with associated p-values in the range 0,31 - 0,99. Because the reported test statistics are lower than the critical value, we do not reject the null hypothesis that the instruments are un-correlated with the error term, and that the excluded instruments are correctly excluded from the estimated equations. We further made the regressions reported in table 4, and the statistics tests discussed here, robust to heteroskedasticity using the robust option in IVREG 2. No substantial changes were discovered. Below we will discuss other variants of the analysis that were conducted in order to provide the reader with some information for what we have done and why.

In an initial analysis we used the R&D variables and the subsidy variables in their original measurement scale. In this analysis the problem was that the excluded instruments in the structural equation did not have a strong enough impact on the dependent variable (the subsidy variables) in the first-stage regression. Although this could suggest that the results reported in table 3-4 are somewhat sensitive to the logarithmic transformation of the subsidy and R&D variables, doing this transformation is preferable because it is known to make the regression model to more closely satisfy assumptions behind regression analysis (Wooldridge, 2006). Further, a look at the recent literature reveals that reporting the dependent variables in logs is one of the standard procedures. In order to check whether the logarithmic transformation of the subsidy variables affected the analysis in any way we ran an analysis which was essentially similar to the one reported in table 3-4 but where binary subsidy variables were used. The results were substantially similar to those reported in table 3-4. In that analysis we also tested for the relevance of excluded instruments, whether the instruments were un-correlated with the error term and whether the excluded instruments were rightfully excluded from the structural equation. The tests came out favourable. As such, we can “conclude” that our logarithmic transformation of the two subsidy variables did not affect the

analysis reported in table 3-4 in a substantial way. We also tried to use firm sales in 1999 as a measure of firm size instead of number of employees. No substantial changes occurred however.

A concern raised on a previous draft of this paper was that subsidies from the Ministry of Defence, which are included in the “close to the market” subsidy, could drive the negative or non-significant results reported. In order to shed some light on this issue we removed all firms in the military sector from our database and re-ran the analysis⁵. One substantial change could be observed: “Far from the market subsidies” was a significant and positive predictor of internal R&D at the 0,05 level and not only at the 0,1 level as shown in table 4.

Conclusion

In this paper we have analyzed whether subsidies have a positive impact upon R&D and innovative activities at the firm level. The results showed that “far from the market subsidies” stimulate private R&D spending, mainly by increasing expenditures on research activities. This type of subsidy also has a positive impact upon the quality of R&D done at the firm level and upon firms’ future commitment to R&D. We found in comparison that “close to the market subsidies” substitute private R&D spending, mainly by decreasing the budget devoted to development activities.

Three implications arise. First, that it is important to take the design of R&D programs into consideration when evaluating the efficiency of R&D subsidies. Hence, taxonomies should be used to a greater extent in evaluation research as demonstrated in this paper. Second, the amount, quality and type of R&D undertaken in the private sector can be increased by subsidizing novel but uncertain projects far from the commercialization phase. Third, by

subsidizing such projects policymakers can change firms' technology strategies and profit opportunities in favour of R&D intensive product development. Subsidies targeting the research side of R&D can help policymakers to reach some of the goals in the Lisbon Agenda.

Notes

¹ I would like to thank Bronwyn Hall, Jarle Møen, Dirk Czarnitzki, David Mowery, Bart Verspagen, Jan Fagerberg, Martin Srholec, Svein Olav Nås, Magnus Gulbrandsen and Pierre Mohnen for helpful comments and suggestions on a previous version of this paper. Geir Petterson from Statistics Norway has provided valuable help in order to get access to the R&D and innovation data used in the paper. Creditinform has kindly provided the annual accounts data. Financial support from the Norwegian Research Council, the Ruhrgas Foundation and P.M. Røwdes Foundation is gratefully acknowledged.

² Hussinger (2006) and Almus & Czarnitzki (2002) base their analysis upon the sub-sample of innovative firms.

³ We simply choose the combination of instruments that generated the highest value for the Anderson canonical correlations likelihood-ratio test (over-identification tests were also done).

⁴ Own calculation based upon Gundersen (2003).

⁵ We removed all firms with NACE code 29600 (production of weapon and ammunition).

⁶ The letter "e" is sometimes placed in front of some reported numbers. For instance, the value "7.99e-06" is equal to 0,00000799

⁷ These numbers have been rounded-off a little due to space considerations.

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Appendix

In table 5 and 6 below we report the results from re-running the equations where we have included cash-flow as a predictor variable. The results from the first stage are reported in table 5 below.

[TABLE 5 ABOUT HERE]

[TABLE 6 ABOUT HERE]

A comparison of the results in table 4 and 6, suggests that excluding the cash-flow variable from the analysis reported in table 4 does not substantially affect the results when compared to the results in table 6.

We also tested for the relevance of our excluded instruments in the analysis reported in table 6 using the Anderson canonical correlations likelihood-ratio test. As discussed above, the null hypothesis of the test is that the equation is under-identified and a rejection of the null hypothesis indicates that the model is identified. It is a chi-square distributed test, with 3 degrees of freedom in our case. A test statistic of more than 7,81 (critical value) would lead us to reject the null hypothesis using a 95 % confidence level. The test statistic reported from running the regressions in table 6 above returned a test statistic of 13,8 with 0,003 in associated p-value which is higher than the critical value. We can as such reject the null-hypothesis that model is under-identified, and conclude that the excluded instruments are relevant.

Equally important we actively tested for over-identification. This was done using a Sargan test implemented in the IVREG 2 procedure in Stata. This test statistic is chi square distributed with the number of over-identification restrictions as the degrees of freedom. Having two endogenous explanatory variables, and 4 exogenous instruments, we have two degrees of freedom. The null hypothesis of this test is that instruments are un-correlated with the error term in the structural equation, and that the excluded instruments are correctly excluded from the estimated equation (Wooldridge, 2006; Baum et al, 2003). A Sargan test statistic of more than 5,99 would thus lead us to reject the null hypothesis using a 95 % confidence level. The test statistic reported from running the 8 regressions in table 6 above returned Sargan test statistics in the range from 0,05 to 1,56 with associated p-values in the range 0,46 to 0,98. Because the reported test statistics are lower than the critical value, we do not reject the null hypothesis that the instruments are un-correlated with the error term, and that the excluded instruments are correctly excluded from the estimated equations.

Table 1: Definition of the variables used in the analysis

Natural extraction	NACE codes = 10,11,12,13,14
Food & Beverage	NACE codes = 15,16
Fish	NACE codes = 5
Textiles	NACE codes = 17,18,19
Wood products	NACE codes = 20,21,36
Chemical, rubber, plastics	NACE codes = 24,25
Metals	NACE codes = 26,27,28
Machine products	NACE codes = 29,30,31,32,33,34,35
Recycling	NACE codes = 37
Electricity & water	NACE codes = 40,41
Construction	NACE code = 45
Retail	NACE codes = 51
Transportation	NACE codes = 60,61,62,63
KIBS	NACE codes = 64,65,66,67,72,73,74
Employees (log)	Number of employees in 1999. Defined as log of (employees + 1).
Age (log)	Number of years from when the firm was established. Defined as log of (age + 1).
Group	Binary variable where value 1 indicates that a firm belongs to a group.
Foreign ownership	Binary variable where value 1 indicates that a firm is foreign owned. Location of headquarter is used as a proxy for "nationality".
Diversification	Binary variable where value 1 indicates that a firm is diversified.
Export intensity	Exports in 1999 / turnover in 1999
Patent	Binary variable where value 1 indicates one or more valid patents in 2001
Cash-flow	Cash-flow in 2000 / number of employees in 2000
Far from the market subsidy	Amount of subsidies a firm receives from NRC, EU and FUNN. Used in logarithmic form defined as the log of (subsidy + 1).
Close to the market subsidy	Amount of subsidies a firm receives from SND and Ministries. Used in logarithmic form defined as the log of (subsidy + 1).
Close to the market industry funding	Average public funding at the industry level from SND and Ministries in 1000 NOK based upon weighted data.
Far from the market industry funding	Total public funding at the industry level from NFR, EU and FUNN in 1000 NOK based upon weighted data.
Anticipated R&D exp.	Amount of anticipated funds that are planned to be used on R&D. Used in logarithmic form defined as log of (expected expenditure + 1).
Innovation expenditure	Expenditures on acquisition of machines & equipment directly related to the development of new products and processes, acquisition of external knowledge (such as patents, licenses), training of personell directly aimed at the development or introduction of new innovation, market introduction of innovation (such as marketing activities), and design. Defined as log of (innovation expenditure + 1).
Growth	Percentage growth in employment from 1999 – 2001
Master	Number of R&D man labour years conducted by workers with a master's degree or higher. Used in logarithmic form defined as log of (master + 1).
PHD	Number of R&D man labour years conducted by workers with a PhD degree. Used in logarithmic form defined as log of (PhD + 1).
External R&D	Expenditures on external R&D in 2001. Also used in logarithmic form defined as log (external R&D + 1).
Private internal R&D	Private expenditure on internal R&D in 2001 (total internal R&D – subsidy). Used in logarithmic form defined as the log of (private internal R&D).
Research exp.	Amount of funds allocated to research activities (applied & basic research) in 2001. Used in logarithmic form defined as log of (research expenditure + 1).
Development exp.	Amount of development expenditure in 2001 as provided by the firm manager. Used in logarithmic form defined as log of (development expenditure + 1).

Table 2: Descriptive statistics

	Non-subsidized firms		Subsidized firms	
	Mean	Std.dev	Mean	Std.dev
Size	162,2	392,2	313,6	1165,5
Age	18,6	20,1	18,9	19,1
Group	0,7	0,4	0,7	0,4
Foreign ownership	0,2	0,4	0,1	0,4
Diversification	0,3	0,5	0,3	0,5
Export intensity	0,2	0,3	0,3	0,3
Patent	0,3	0,5	0,4	0,5
Close to the market subsidy	0,0	0,0	1938,9	19694,9
Far from the market subsidy	0,0	0,0	894,9	2118,9
Distance to SND	0,5	0,7	0,6	0,7
Distance to NRC	3,8	3,4	4,5	4,1
Close to the market industry funding	3200	4300	3000	4600
Far from the market industry funding	16000	11600	15800	12200
Anticipated R&D exp	6035,7	28814,8	15918,2	47983,1
Innovation expenditure	1558,9	5869,0	4304,9	17417,8
Growth	2,19	29,68	0,3	2,21
Master	5,6	26,1	14,3	49,9
PHD	0,4	2,9	1,5	6,7
External R&D	2105,0	9539,3	3651,6	17598,2
Private internal R&D	7213,0	38507,1	13375,8	39708,6
Research expenditure	2129,5	32143,2	4260,8	24068,5
Development expenditure	5083,5	16999,6	9115,0	23546,1
N	741		278	

Table 3. Results from the first stage (equation 2 and 3 above)⁶.

	Amount of “far from the market” subsidies (log)		Amount of “close to the market” subsidies (log)	
	B	Std. err	B	Std. err
Size (log)	.4920285***	.0815794	.0608165	.0713361
Age (log)	-.04747	.0916433	.0152466	.0801364
Group	-.1804257	.1917583	.0222827	.1676808
Foreign ownership	-.0577762	.2146758	-.4233661***	.1877207
Diversified	-.1687737	.1878363	-.2727831*	.1642512
Patent	.6861225***	.1767301	.039737	.1545396
Export intensity	.0780577	.2662444	.1934081	.2328143
Growth	.0002734	.0029048	-.0009242	.0025401
Distance to SND	.1622705	.1193016	.1038634	.1043218
Distance to NRC	-.0072151	.0222181	.0617382***	.0194284
“Far from the market” industry funding	.0000342***	.0000105	7.99e-06	9.20e-06
“Close to the market” industry funding	-.0000926***	.0000245	1.24e-06	.0000214
Constant	-1.108214	.4277799	.1366847	.3740671
R ²	0.12		0.04	
N	1019		1019	

* sig at the 0,1 level, ** sig at the 0,05 level, *** sig at the 0,01 level

Table 4. Results from the second stage⁷

	Private R&D exp. (log)		Development expenditure (log)		Research expenditure (log)	
	B	Std. err	B	Std. err	B	Std. err
Close to the market subsidy (log)	-.662540***	.24788	-.667775**	.28923	-.246018	.497780
Far from the market subsidy (log)	.364787*	.198279	.145737	.231352	1.34681***	.398163
Size (log)	.421912***	.117426	.50032***	.137012	.031835	.235802
Age (log)	-.052154	.077373	-.01680	.090278	-.089231	.155372
Group	.291447*	.16708	.278321	.194949	.234967	.335512
Foreign ownership	-.201416	.21513	-.452987*	.251015	.142110	.432003
Diversified	-.188462	.172999	-.157434	.201856	.028455	.347398
Patent	.538703***	.205399	.700167***	.23966	.084816	.412462
Export intensity	.893588***	.229159	.98459***	.267383	.557149	.460172
Growth	.008167***	.002431	.008737***	.002836	-.001214	.004881
Constant	5.96974	.374364	5.52215	.43681	.970285	.751759
R ²	Neg.		Neg.		Neg.	
N	1019		1019		1019	

* sig at the 0,1 level, ** sig at the 0,05 level, *** sig at the 0,01 level

Table 4 continued.

	Master & PhD R&D man labour years (log)		PhD R&D man labour years (log)		R&D investment budget (log)	
	B	Std. err	B	Std. err	B	Std. err
Close to the market subsidy (log)	-.429877**	.194887	-.030679	.084529	-.244414	.339982
Far from the market subsidy (log)	.507086***	.155885	.259685***	.067612	.453109*	.271944
Size (log)	.12893	.092319	.007215	.040042	.537363***	.161052
Age (log)	-.053562	.060829	-.024600	.026384	-.076819	.106118
Group	.11339	.131357	-.029499	.056974	.195162	.229154
Foreign ownership	-.139711	.169134	.030800	.073359	-.054345	.295057
Diversified	-.012875	.136011	.051684	.058992	-.145829	.237272
Patent	.105126	.161484	.039237	.070041	.432056***	.28171
Export intensity	.591407***	.180163	.152321**	.078142	1.22409	.314296
Growth	.005559***	.00191	.000318	.000829	-.003206	.003334
Constant	.815129	.29432	.00934	.127657	4.20559	.513449
R ²	Neg.		Neg.		0,11	
N	1019		1019		1019	

* sig at the 0,1 level, ** sig at the 0,05 level, *** sig at the 0,01 level

Table 4 continued.

	Innovation expenditure (log)		External R&D expenditure (log)	
	B	Std. err	B	Std. err
Close to the market subsidy (log)	-.554035	.474147	-.790075	.498744
Far from the market subsidy (log)	.516414	.379259	1.08019***	.39893
Size (log)	.016453	.224606	.225305	.236259
Age (log)	-.16491	.147995	-.064045	.155673
Group	.355071	.319583	.810135**	.336162
Foreign ownership	-.574611	.411493	.322421	.432839
Diversified	.333170	.330905	.098086	.348071
Patent	.509729	.392879	.17618	.413261
Export intensity	.301351	.438324	1.29915***	.461063
Growth	.004117	.004649	.012687***	.004891
Constant	3.59487	.716067	1.23605	.75321
R ²	Neg.		Neg.	
N	1019		1019	

* sig at the 0,1 level, ** sig at the 0,05 level, *** sig at the 0,01 level

Table 5. Results from the first stage.

	Amount of far from the market subsidies (log)		Amount of close to the market subsidies (log)	
	B	Std. err	B	Std. err
Size (log)	.4664134***	.0870034	.0982546	.0756035
Cash-flow	.0000678	.0002261	.0000383	.0001965
Age (log)	-.0818266	.1034207	-.0259052	.0898696
Group	-.1764118	.2055041	.0400282	.1785772
Foreign ownership	.0096419	.2261154	-.3964633**	.1964878
Diversified	-.1411217	.1967516	-.285645*	.1709715
Patent	.6679808***	.1866468	-.0214803	.1621907
Export intensity	.0906539	.2749851	.2662841	.2389542
Growth	.0001632	.0029693	-.0006218	.0025802
Distance to SND	.173814	.1252845	.1087177	.1088687
Distance to NRC	-.0069408	.0239019	.0635495***	.0207701
Far from the market industry funding	.0000291***	.0000111	7.24e-06	9.62e-06
Close the market industry funding	-.0000843***	.0000253	2.02e-06	.000022
Constant	-.8863579	.4636467	.0852098	.4028958
R ²	0,11		0,04	
N	940		940	

* sig at the 0,1 level, ** sig at the 0,05 level, *** sig at the 0,01 level

Table 6. Results from the second stage

	Private R&D expenditure (log)		Development expenditure (log)		Research expenditure (log)	
	B	Std. err	B	Std. err	B	Std. err
Close to the market subsidy (log)	-.605233**	.251699	-.61155***	.285765	-.212504	.507129
Far from the market subsidy (log)	.459742**	.224109	.228180	.254442	1.32474***	.451543
Size (log)	.404059***	.125881	.473284***	.142919	.098125	.253629
Cash flow	-.000111	.000186	-.000138	.000211	-.000365	.000375
Age (log)	-.068492	.087616	-.036886	.099474	-.064989	.176532
Group	.268711	.177008	.239720	.200965	.251244	.356639
Foreign ownership	-.166824	.218758	-.37047	.248366	.112130	.440760
Diversified	-.155991	.180917	-.124752	.205404	-.098217	.36452
Patent	.411474*	.219059	.592088**	.248709	.068929	.441367
Export intensity	.949659***	.238561	1.01751***	.270849	.623799	.480659
Growth	.0081***	.002446	.008465***	.002777	-.000545	.004928
Constant	5.96097	.381992	5.58721	.433693	.598625	.769647
R ²	Neg.		Neg.		Neg.	
N	940		940		940	

* sig at the 0,1 level, ** sig at the 0,05 level, *** sig at the 0,01 level

Table 6 continued.

	Master & PhD R&D man labour years (log)		PhD R&D man labour years (log)		R&D investment budget (log)	
	B	Std. err	B	Std. err	B	Std. err
Close to the market subsidy (log)	-.411105**	.211254	-.058939	.090462	-.344535	.362855
Far from the market subsidy (log)	.584569***	.18809	.27235***	.080547	.56403*	.32308
Size (log)	.122909	.105654	.027174	.045243	.505586***	.18147
Cash flow	-.000101	.000156	-.00001	.000067	-.000044	.000268
Age (log)	-.043611	.073537	-.01914	.031489	-.032833	.126309
Group	.112463	.148564	-.049172	.063618	.155254	.255179
Foreign ownership	-.126553	.183606	.008221	.078623	-.109078	.315368
Diversified	-.011617	.151846	.028982	.065023	-.203825	.260815
Patent	.012251	.183859	.023459	.078732	.343625	.315803
Export intensity	.63363***	.200227	.166798**	.085741	1.37264***	.343917
Growth	.005727***	.002053	.000349	.000879	-.003488	.003526
Constant	.730527	.320609	-.047629	.137290	4.16401	.550689
R ²	Neg.		Neg.		0,03	
N	940		940		940	

Table 6 continued.

	Innovation expenditure (log)		External R&D expenditure (log)	
	B	Std. err	B	Std. err
Close to the market subsidy (log)	-.474311	.484692	-.625515	.509572
Far from the market subsidy (log)	.619430	.431565	1.2133***	.453718
Size (log)	.023672	.242408	.181295	.254851
Cash flow	-.000397	.000358	-.000367	.000377
Age (log)	-.087898	.168721	-.131627	.177382
Group	.25181	.340861	.780254**	.358358
Foreign ownership	-.619441	.421259	.472438	.442884
Diversified	.334386	.348389	.194489	.366273
Patent	.482033	.421839	.014207	.443494
Export intensity	.242215	.459393	1.37955***	.482975
Growth	.004865	.00471	.012269***	.004952
Constant	3.28988	.735595	1.26511	.773354
R ²	Neg.		Neg.	
N	940		940	