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ABSTRACT

There is plenty of evidence for market failures that motivate government intervention for innovation in general and research and development (R&D) in particular. R&D subsidies are a policy tool of major importance – both in theory and practice. The empirical evidence for the effectiveness of R&D subsidies is mixed, with some studies finding them effective and others concluding the opposite. In part this could be because methodological problems plague the literature. Finland and Norway have relied extensively on R&D subsidies in their innovation policy, yet Finland seems to have succeeded where Norway has failed. A comparison of the countries suggests that the difference may be due to the more horizontal nature and implementation of Finnish R&D subsidy policy with regard to both firms and industries, but the Norwegian failure may also be due to a shift in the technological regime.

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Innovation and research policies: two case studies of R&D subsidies

1. Introduction

At least since the 1950s it has been recognised that innovation is central to economic growth. Similarly well appreciated have been the twin facts that, first, although individual innovations are often created within firms, these rely in many ways on central inputs that are external to the firm and, second, the benefits from an innovation are not confined solely to its originator. These twin facts serve as the basic justification for public sector actions today jointly labelled innovation and research policies. Rooted in the policies following the Second World War (e.g., Mowery 1995), they have risen to prominence and taken centre stage, for example, in the Lisbon strategy of the European Union.¹



Otto Toivanen

Subsidies for research and development (R&D) are one of the most important tools of innovation policy in practice (Nevo 1998). As R&D subsidies have also been singled out by the endogenous growth literature as the main policy tool (e.g., Howitt 1999, Segerstrom 2000), it seems worthwhile to consider the theory and practice of R&D subsidy policy.

To this end, this paper essentially has two parts. One – comprising Sections 2 and 3 – reviews theoretical justifications for R&D subsidies, fundamental challenges of implementing an R&D subsidy policy, methodological difficulties in estimating the effects of such policies, and empirical results on the effectiveness of R&D subsidies. Two key messages transpire from this part. For one thing, while the theoretical foundation for R&D subsidies is sound, implementation problems might call into question the wisdom of such policies in practice. A key characteristic of R&D subsidies is that they require active decision making from the agency administering them. This is unlike tax credits, the other popular tool for enhancing R&D investments of firms. This practical requirement might be viewed as being at odds with the supposed horizontal nature of R&D subsidies. For another, R&D subsidies – innovation related activities in general – are more challenging to study than many other economically interesting topics because of the inherent heterogeneity, unobservability, and uncertainty of both the decision making regarding inputs and the output of research and development.

All this sets the stage for the second part – comprising Sections 4 to 6 – which presents two case studies of R&D subsidy policies: Norway and Finland. In Section 4, I provide a few key background statistics on both countries' innovation inputs and outputs to prepare the ground for the country-specific analyses in Sections 5 and 6. The presentation of the Finnish case has two broad goals. One is to describe the policy environment, i.e., what has been called the 'innovation support system' (Section 5.1), including the role of Tekes, that is, the National Technology Agency of Finland (Section 5.2). The second goal is to review the empirical evidence on the effectiveness of R&D subsidies in Finland (Section 5.3) and to analyse the R&D subsidy process, which involves firms' application for subsidies, Tekes' decision to grant them, and firms' subsequent R&D spending (Section 5.4). For Norway (Section 6), I concentrate on the R&D subsidy programme as implemented in the second half the 1980s and first half of the 1990s. The emphasis will nevertheless be on Finland because its innovation and research policies have been regarded as particularly successful. Section 7 concludes.

¹ See <http://europa.eu.int/comm/enterprise/innovation/communication.htm>.

2. Theoretical justification for innovation policies and their challenging implementation

2.1 Theoretical justifications and their empirical relevance

The economic justification for innovation policy rests on various externalities.

The economic justification for innovation policy rests on various externalities. In short, so long as the benefits from innovative activities are not completely captured by whoever conducted them, there is a potential wedge between social and private benefits. Think of a new good, for example: so long as the firm introducing it is not capturing all the surplus generated by the new product, the benefits to society from introducing the new good will be larger than to the firm itself. In this case, society benefits through the increased profits of the firm and the consumer surplus that the new good yields (see Box 1). This example may sound simplistic in that most people would view it as 'business as usual'. But there lies the crux: firms will have less of an incentive to invest in the creation of new goods than society, the reason being that society benefits from them more than

Box 1. A simple model of optimal R&D subsidies

Designing and implementing optimal R&D subsidies requires considerable information. The aim of this box is to briefly illustrate this with a very basic model, which is a greatly simplified version of that studied by Stenbacka and Tombak (1998).

Imagine that there is just one firm. It can either succeed or fail in its innovation, and the costs of innovation are a convex function of the probability of success, which – in turn – depends on the intensity of R&D efforts. Profits are higher when the innovation is successful than when it is not. Further assume that the government pays a share s of the firm's R&D costs. So, s is the R&D subsidy. The firm's problem is then to choose the optimal success probability, or research intensity, by maximising the following objective function:

$$(1) \quad \Pi = p\bar{\pi} + (1-p)\underline{\pi} - (1-s)c(p)$$

where Π indicates total profit, p is the success probability, $\bar{\pi}$ stands for profit if the innovation is a success and $\underline{\pi}$ if it is not, and $c(p)$ is the cost of innovation, with $c' > 0$ and $c'' > 0$. Optimising and rearranging gives:

$$(2) \quad c'(1-s) = \Delta\pi$$

where $\Delta\pi = \bar{\pi} - \underline{\pi}$. Equation (2) has a straightforward economic interpretation: the firm chooses the success probability (i.e., research intensity) so that the marginal return to the firm from innovating ($\Delta\pi$) is equal to the firm's marginal cost ($c'(1-s)$) of efforts to increase the probability of success. As long as the left-hand side of (2) is smaller than the right-hand side, it is profitable for the firm to raise the success probability.

The government, while taking firm profits into account, is also interested in consumer surplus (denoted CS). One may think of CS as the spillover effects to other firms without any changes needed in the model. The objective of the government is to maximise social welfare, which is determined by the profit of the innovating firm, the consumer surplus, and the R&D costs. The latter is larger than $c(p)$ if one takes into account that the government probably cannot raise the finance for the R&D subsidy in a non-distortionary way. Specifically, assume the

the firm, but the cost is the same for both as the firm pays all the (R&D investment) costs. Such instances are called externalities, and they make markets, if left alone, fail in allocating resources optimally.

The empirical literature on new goods typically estimates large consumer surpluses from new innovations. Examples of studies with such findings are Trajtenberg's (1989) analysis of computerised tomography scanners and Petrin's (2002) analysis of the introduction of minivans in the United States. It is worth noting, however, that private returns to R&D tend to be highly skewed. This view is backed, for instance, by empirical research on patent value (Pakes 1986, Lanjouw 1998). Put simply: many innovations are of little value to the innovator, but some are very valuable. It is entirely plausible that this holds for the social returns too. To take but one example, Gao *et al.* (2005) analyse early mobile internet services and find that both consumer surpluses and profits are very low.

government faces a shadow cost of public funds, i.e., raising one euro of tax revenue costs $\lambda > 1$ euros. All in all, the government's objective is to maximise society's welfare Γ and its objective function is thus

$$(3) \quad \Gamma = p\bar{W} + (1-p)\underline{W} - \{1 + (\lambda - 1)s\}c(p)$$

where $W = CS + \pi$. Note that for $\lambda = 1$ the cost of R&D to society is simply $c(p)$; for $\lambda > 1$, it is larger than $c(p)$ by a factor of $(\lambda - 1)s$. Optimising (3) and rearranging gives

$$(4) \quad \{1 + (\lambda - 1)s\}c' = \Delta\pi + \Delta CS$$

where $\Delta\pi = \bar{\pi} - \underline{\pi}$ and $\Delta CS = \bar{CS} - \underline{CS}$. Thus, to reach a social optimum, the research intensity (and thereby the success probability) should be chosen so that the marginal return to society from innovating ($\Delta\pi + \Delta CS$) is equal to society's marginal cost of innovating ($\{1 + (\lambda - 1)s\}c'$).

The question, then, is which amount of R&D subsidy would ensure that the firm chooses the socially optimal R&D level. The optimal R&D subsidy (s^*) can be derived from (2) and (4) by taking into account that the c' in (2) must be the same as the c' in (4). Using this and slightly rearranging yields

$$(5) \quad s^* = \frac{\Delta CS}{\lambda \Delta\pi + \Delta CS}$$

Equation (5) offers important insights. First, if there are no R&D spillovers to the domestic economy ($\Delta CS = 0$), there is no reason to subsidise R&D activity. Second, the larger the expected spillovers, the higher the optimal subsidy. Third, the larger $\Delta\pi$ (i.e., the bigger the increase in firm profits), the lower is s^* . Fourth, the shadow cost of public funds has a decreasing effect on the optimal subsidy. Finally, although derived from the simplest of models dealing with the question of optimal subsidies, equation (5) illustrates the heavy informational requirement for designing and implementing optimal policies for promoting R&D: the government needs to estimate the shadow cost of public funds (often estimated at around 1.2) and the expected increase in firm profits and consumer surplus. Estimating all this is far from straightforward. In particular, note that to estimate $\Delta\pi$ and ΔCS , the government needs to know not only profits and consumer surplus when the firm innovates successfully, but also when it fails.

The informational requirement for designing and implementing optimal R&D policies is substantial.

Knowledge spillovers are another externality commonly linked to R&D. There is considerable empirical evidence of knowledge spillovers between universities and firms and between firms. The seminal paper of Jaffe (1986) found that other firms' R&D affects the productivity of firm R&D positively. Jaffe (1989) found that university R&D has a positive direct effect on commercial innovation (measured by patents) – at least in some industries, and a positive indirect effect by raising industrial R&D. Jaffe *et al.* (1993) looked at patent citations and found that citations from later patents to earlier ones are greatly affected by geography, so that a new patent is more likely to cite a patent that was granted to an applicant geographically close to the new applicant. In a recent paper, Cassiman and Veugelers (2002) use Belgian data to show that firms that put more weight on external information in their innovation process are more likely to engage in cooperative R&D joint ventures with other firms.

Externalities possibly justifying innovation support policies include: knowledge spillovers, other benefit spillovers, and financial market imperfections.

Yet another market failure is that the firm owning the innovation has to share its rents with its employees. There may be various efficiency reasons for doing so, but at least in some instances such rent sharing will lead to diminished incentives to innovate. It is this type of an argument that lead van Reenen (1998) to study the relationship between (quasi-) rents and wages with a long panel of British manufacturing firms. Finding that innovation (measured by innovation counts) leads to significantly higher wages, he concluded that the most plausible explanation is rent sharing between the firm and its employees.

A prominent market failure related to innovation policy is that of financial markets. Indeed, various policies aimed at supporting private sector R&D have been motivated by the perceived failure of financial markets to provide adequate financing to firms. Notice that this is a market failure that comes on top of externalities that exist in the product market. In other words, if firms do not reap all the benefits from their innovation and face difficulties in financing R&D, their investments are even further away from what would be optimal from society's viewpoint. Himmelberg and Petersen (1994) tested this hypothesis by studying the sensitivity of R&D investments to cashflow using data from small US firms and found evidence of financial constraints.

Finally, it is important to mention that several of the above mentioned market imperfections might take added relevance if technologies are what Bresnahan and Trajtenberg (1995) label general-purpose technologies – GPT for short. To cite them (pp. 84): "Most GPT's play the role of 'enabling technologies', opening up new opportunities rather than offering complete, final solutions." An important characteristic of GPTs is that they foster complementary innovations. They, in turn, may lead to improvements in the GPT, which in turn benefits other (unrelated) complementary innovations. Often cited examples of GPTs are the steam engine, electricity, and semiconductors. GPTs give an extra role to innovation policy in that they easily feature multiple equilibria. In practice, when GPTs are important, it is possible for a country's industry to either stay in a low-activity equilibrium, or be pushed, by carefully implemented policies that foster coordination among firms' R&D decisions, to a high-activity equilibrium.

The theoretical arguments for innovation policy might lead one to think that there is plenty of scope for government action, with any identified market failure calling for government intervention of some sort. However, such a conclusion makes strong demands on governments' ability to design policies that would rectify identified market failures. Especially with regard to R&D, it is very questionable whether a government has all the information needed to design 'perfect' policies. In real life, governments face informational constraints that might be as or more severe than those of firms. Modern economic theory offers an alternative benchmark: markets are said to be 'interim efficient' if a benevolent social planner (designing policies with the goal of maximising social surplus) could not improve on the market outcome if she is subject to the same informational

problems as the market.² Many phenomena considered market failures when comparing the actual state of affairs to the outcome of perfectly competitive markets cease to be market failures when using this more realistic but still demanding benchmark. As an example (see Box 1), to design perfect R&D subsidies for an individual R&D project, a government should be able to calculate the present value of expected firm profits and consumer surpluses from a yet-to-be-made innovation. This is, to say the least, a highly demanding task.

Things need not be as bleak as one might be tempted to conclude. The government is in a unique position because it does not necessarily need to cover the costs of information gathering and dissemination by the revenues so generated. So, an active government could in some circumstances be able to achieve better than interim-efficient outcomes. Whether such outcomes are achievable in practice is a separate question.

2.2 Challenges of implementation

The constraints a government faces in gathering relevant information raises another important point, namely that of heterogeneity. Firms, R&D projects, and innovations are highly heterogeneous. A policy that is optimal in the strict sense of achieving Pareto-efficiency should vary not only from firm to firm, but also within a given firm depending on the particular R&D project in question. Such policies might be homogenous *ex ante*, i.e., the terms are the same for all firms, but heterogeneous *ex post*, meaning that although the rules of allocating R&D subsidies are the same for all, the actual R&D subsidies are likely to vary considerably. Whether or not this state of affairs is compatible with demands for horizontal government aid is a question this essay does not attempt to answer.

Strictly speaking, optimal innovation support policies should vary not only from firm to firm, but also within a given firm depending on the particular R&D project in question.

Further problems arise if innovation policy takes more active forms, such as venture capital financing. To illustrate, in Finland, the state has been an active venture capitalist in the last 15 years or so. Without taking a stand on how successful the policy has been, it is nonetheless clear that the people administering government venture capital operate under a very different set of incentives than private sector venture capitalists. Briefly, private sector venture capitalists are driven by powerful monetary incentives (through profit-sharing schemes) so that they choose the best investments and manage them as best as they can. What is more, venture capital funds have a limited lifespan, and private sector venture capitalists (at least those who do not retire after the current financing round) need to raise financing for their next fund. This provides an additional incentive for private sector venture capitalists to perform well with their ongoing investments. Government civil servants on fixed salary, no matter how intelligent, hard working, and diligent, face no such incentives. One is therefore bound to question, for example, government venture capitalists' ability to cut financing for underperforming firms.

Worries about how governments are even in principle able to substitute a perceived or genuine lack of private venture capital funding (or other forms of active financing) are not idle. For example, the Finnish government has in the last couple of years both started a new venture capital financier (within Finnvera, see Section 5.1) and become more active as a direct investor through an existing venture capital fund (Finnish Industry Investment).

Good design of government policy takes such constraints into account and seeks to choose such roles for government and its officials where their relative strengths lie. Finnish innovation policy provides an example of such an activity: the Finnish government finances the Foundation for Finnish Inventions, which provides expert advice to private inventors and small and medium-sized

² This concept was introduced by Holmström and Myerson (1983).

enterprises (SMEs) when they seek to patent their inventions. The very fact that it is an impartial government employee (operating under strict non-disclosure agreements) might be what makes such an activity feasible. A privately run agency would always be subject to the suspicion of trying to capture the invention from the inventor.

In sum, while a quick reading of the economics of innovation suggests a large scope for government intervention to rectify market failures, modern economic theory points to many pitfalls, both of principal and practical nature, that lead to a more restrained view of what the possibilities and potential of government intervention are. Good policies necessitate careful consideration.

3. Empirical methods and results on the effectiveness of R&D subsidies

3.1 Methodological issues

The empirical literature on R&D subsidies goes back at least until the early 1980s, and by now some surveys and methodological papers exist.

The empirical literature on R&D subsidies goes back at least until the early 1980s, and by now some surveys and methodological papers exist (e.g., David *et al.* 2000 and Klette *et al.* 2000). A useful way to categorise the literature is by the type of data used. Some studies use macro (nation-level) data, others use industry data. Yet another group comprises papers using firm-level data. If anything, there is a trend towards less aggregate data – studies using firm-level data have become more common in recent years.

Another way of categorising the studies is by the dependent variable. Many studies look at how R&D subsidies affect private R&D investment. Here the central question has been whether public funding crowds out private investment, i.e., whether one euro of subsidy leads to an increase in firms' investment (the sum of private investment and public support) of less than one euro. A considerable number of other studies take the productivity effects of publicly (and privately) funded R&D as the dependent variable. In the next sub-section, I will mostly concentrate on the former type of studies that use firm-level data. There is compelling reason for focusing on the effects of R&D subsidies on private R&D investments: it is the very basic question that needs to be answered first when examining the impact of R&D subsidies; obviously, evidence on complete crowding out would imply that R&D subsidies have no (positive) effects on firm conduct – unless, that is, one is willing to entertain the idea that subsidies lead to a different, economically more beneficial type of R&D.

The key problems in studying the effectiveness of R&D subsidies are that (i) there is no agreed-upon theoretical model of how R&D subsidies affect firm behaviour,³ (ii) there are good reasons to suspect that unobserved firm heterogeneity causes various problems in carrying out such research, and (iii) the (changes in) behaviour of subsidised firms might affect the non-subsidised firms. The first problem means that empirical researchers have mostly relied on models that have only an indirect link to economic theory. While such research can be useful, it limits the number and type of questions that can be addressed. Especially regretful is that such reduced-form analysis cannot answer counterfactual 'what-if' questions. But many important policy questions are of this type.

The second problem is empirical and can be illustrated by the following two examples. For a start, suppose that firms vary in the quality of their R&D personnel. It seems reasonable to think that firms

³ This situation may be compared to the widespread use of Mincer wage equations in the research on returns to education (see e.g., Angrist and Krueger 1991).

with better R&D engineers spend more on R&D (e.g., by having higher-paid engineers). Imagine also that the civil servants granting R&D subsidies can with some accuracy find out the quality of R&D engineers. For example, it seems plausible that better engineers write better applications. The implication of this set-up is twofold: first, firms with better engineers invest more in R&D with or without subsidies and, second, they are more likely to get subsidies. Just 'explaining' R&D investments of a firm by R&D subsidies is therefore going to lead to a high positive (partial) correlation coefficient. But the true cause for this coefficient might be the differences in the quality of the R&D engineers, something difficult for an economist to observe – let alone quantify.

Imagine then that for a given firm with a given set of R&D engineers the quality of ideas varies from year to year. The better the idea, the more the firm invests in developing it. The engineers are capable of describing the quality of their ideas to the civil servants who decide on R&D subsidies. If the civil servants are more likely to grant subsidies to good ideas, we again will observe a positive partial correlation coefficient between subsidies and firm R&D. And *vice versa*: if the civil servants are less likely to grant subsidies to good ideas, we will observe a negative partial correlation coefficient between subsidies and firm R&D. But in both cases it would be false to give such a correlation a causal interpretation. The firm would have invested more in R&D in the year(s) when it had good ideas anyway – regardless of getting a subsidy. This type of issue has risen to prominence only lately, despite examples of earlier work where researchers took steps to control for these problems (e.g., Lichtenberg 1988).

The third problem has been given different names in different contexts, but is most often called the assumption of 'no general equilibrium effects' (e.g. Heckman and Smith 1995). To my knowledge, essentially all the work on R&D subsidies (and many other government policies) relies on this assumption. Its central meaning is that the model used assumes that a given R&D subsidy for a given firm only affects that firm, but no other firms. This condition is, however, very likely violated in the case of R&D subsidies for three reasons. First, if R&D generates informational spillovers between firms, for instance, R&D subsidies will affect these spillovers and, by implication, other firms' behaviour. Second, in many countries (e.g., Finland), R&D subsidies are a prominent part of innovation policy, and one therefore cannot rely on the argument invoked in other settings that the group of awardees is so small as not to affect economic aggregates. Third, it is possible that awardees and non-awardees compete against each other in the product market and/or in the input market. The proper way of accounting for such effects is to explicitly model them.

A final methodological note concerns the increased use of so-called matching methods in evaluating R&D subsidies. These methods, developed in labour economics to assess labour market policies, rely crucially on the assumption that all aspects of a firm that affect the probability of getting an R&D subsidy are observed and controlled for by the researcher.⁴ The current view in labour economics is that matching methods are in practice rather sensitive to violations of this and other assumptions. Clearly, applying these methods in an R&D context calls for great care as many of the features determining the success and quality of R&D are inherently unobservable – or at least nonmeasurable – by the economist. To take one example, it seems hard to quantify the quality of the R&D engineers of a particular firm. Yet such quality may well be observable and recognisable to a well-trained civil servant deciding on subsidies. That said, it is surely beneficial for the research programme on the effectiveness of R&D subsidies to remain open-minded, though critical, about new research methods applied to the questions at hand.

Key methodological problems in studying the effectiveness of R&D subsidies are: lack of agreed-upon theoretical model, unobserved firm heterogeneity, and presence of general equilibrium effects.

⁴ For a recent textbook treatment see Cameron and Trivedi (2005). See also Smith and Todd (2005).

3.2 Empirical results

The relatively recent survey of David *et al.* (2000) lists 33 empirical studies on the effects of R&D subsidies on private R&D investment. Of these, 19 were conducted using firm-level data while the remaining 14 used either industry or macro data. Of the 19 studies using firm-level data, nine found a crowding out effect, i.e., on average, a subsidy of one euro led to an increase in overall R&D investment of less than one euro. Things cannot be solved by a simple count of results, however, and two important points should be kept in mind. First, studies should be evaluated on a case-by-case basis on the methods and data they used. Second, there is little reason to believe that the result should be universally the same over different countries, industries, and time periods. A more convincing starting point is that there is a lot of heterogeneity in how firms invest and succeed in R&D and, therefore, one should expect such heterogeneity to also prevail in firms' reactions to R&D subsidies even within narrowly defined sets of firms. In what follows, I mainly concentrate on papers published after the survey of David *et al.* (2000).

Recent empirical research often finds that R&D subsidies foster innovation, but this does not necessarily mean that they are welfare enhancing.

Two important papers are those by Lerner (1999) and Wallsten (2000), both studying the US Small Business Innovation Research Program (SBIR).⁵ Lerner, using matching methods discussed above, finds that SBIR grants led to higher growth and employment, especially for firms in areas where venture capital financing is available. In contrast, Wallsten finds, controlling for the endogeneity of R&D subsidies, that there is essentially complete crowding out. The suspicion that Lerner's findings might result from not controlling for all firm characteristics that determine (non-)participation in the SBIR programme has been voiced earlier – by Klette *et al.* (2000), for instance. Gonzalez *et al.* (2005) study the effects of R&D subsidies in Spain. Controlling carefully for the endogeneity of subsidies, they find no evidence of crowding out. In fact, they find that subsidies induce firms that (i) would not have conducted R&D to embark on it and (ii) would have spent on R&D anyway to spend more.

Lach (2002) studies the Israeli R&D subsidy system. He uses a so-called difference-in-difference estimator to take firm heterogeneity into account. He finds that subsidies have a substantive positive effect on the private R&D investments of small firms, but a negative albeit statistically insignificant effect on large firms.

While Lach's paper uses repeated observations on 136 firms, Hussinger (2003) uses a cross-section on almost 4,000 German firms. Because her data is a cross-section, her estimation methods also differ, but she also uses methods that consider the endogeneity problems. Using a variety of estimators, she finds a 'positive treatment effect', i.e., that firms increase their own R&D investment in response to a subsidy.

Czarnitzki and Fier (2002) also use a cross-section of German firms. Their sample consists of around 1,000 services-sector firms. In contrast to Hussinger (2003), they resort to sophisticated matching methods that nonetheless rely on the potentially problematic assumptions discussed above. They find 'additionality', i.e., private R&D investment increases when a firm receives a subsidy.

To conclude, the more recent empirical research is more often than not encouraging from a policy viewpoint: it often reports significant positive effects of R&D subsidies. It is critical to keep in mind, however, that the type of study surveyed above does not provide an answer as to whether such programmes are welfare improving or not. A more structured approach is needed, and I will elaborate on one such attempt in Section 5. But let us first turn to some basic facts about innovation in Norway and Finland.

⁵ See <http://www.sba.gov/sbir/indexsbir-sttr.html>.

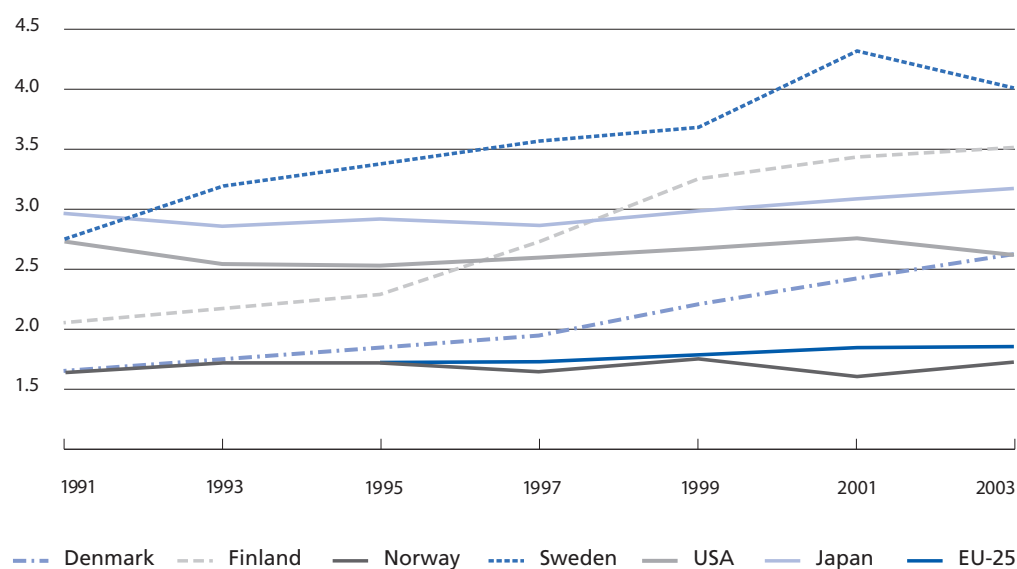
4. Innovation in Norway and Finland

Norway and Finland are very similar in many ways and this is reflected in the structure of their economies. Both are wealthy countries with a well-educated, well-paid, and highly-taxed workforce. Government support to the tertiary education sector is one element of regional policy. In both countries, R&D activities are characterised by active government involvement and planning and by the dominance of a few large firms.⁶ In both countries, innovation policy follows the practice set forth in other sectors of the economy: the various interests groups are actively involved and explicitly included in the policy formation process.

There is no need here to dwell on the Norwegian and Finnish economies and their political systems. Rather, a few facts about R&D inputs and outputs are worth highlighting. To start with inputs, as Figure 1 shows, Finland is one of the countries exhibiting a consistent upward trend in R&D expenditure, measured in percent of GDP. Moreover, it is one of the most R&D-intensive economies, surpassed only by Sweden. By contrast, in Norway, the ratio of R&D expenditure to GDP – virtually constant since the early 1990s – is way below that of other Nordic countries. In fact, Norway currently spends less on R&D than the average EU country, with this average including the relatively poor new member states of Central and Eastern Europe.

R&D activities in Finland and Norway are characterised by active government involvement, dominance of a few large firms, and involvement of various interests groups in the policy formation process.

Figure 1. Trends in R&D expenditure (% of GDP) in selected countries

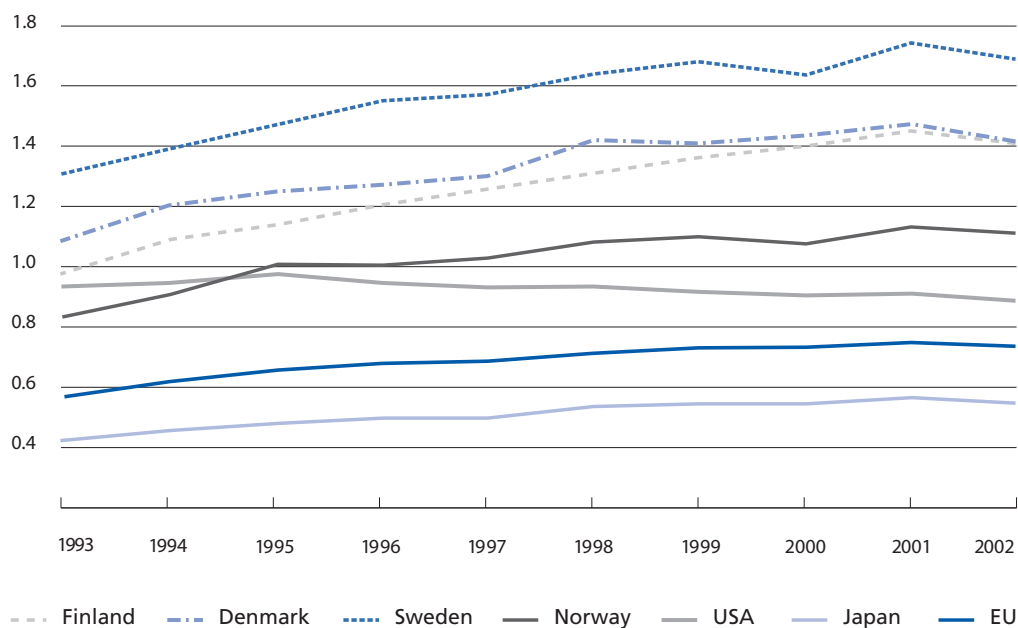


Source: www.research.fi

Turning to the R&D output, Figure 2 shows the number of scientific publications per 1,000 inhabitants. Norway and Finland produce a relatively large number of publications considering the size of these countries – both outperform the United States, for example. Although both countries exhibit a growing trend, Finland has consistently done better than Norway, producing 30-40 percent more publications per inhabitant.

⁶ For example, in Finland, the ten top-R&D investing firms account for some two thirds of all private R&D spending according to estimates by Jyrki Ali-Yrkkö, derived on the basis of a survey by the magazine *Tekniikka & Talous* and Ali-Yrkkö's statistics on the share of each firms' R&D carried out in Finland. In Norway, the same figure is over 70 percent (Statistics Norway 2004)

Figure 2. Scientific publications per thousand inhabitants in selected countries



Source: www.research.fi
 Note: EU = EU-15, in contrast to Figure 1.

Table 1 provides further insights into the output of R&D. It shows for a fairly large set of countries, including Finland and Norway, information on the granting of patents in the United States. The first message from the table has been pointed out by Trajtenberg (2001): although it is reasonable to look at statistics scaled by the size of economies, as in Figures 1 and 2, the statistics for the larger economies like the United Kingdom show that scale does have a considerable impact.

Finland succeeded in raising innovation output considerably by increasing R&D inputs. Norway has consistently been on a lower level than Finland on both measures.

What matters in the end is not how R&D intensive or successful an economy is in relative terms, but in absolute terms, especially in technologies where patents are an effective way to protect intellectual property (such as in the pharmaceutical industry). That said, the table shows that Israel and Finland are doing very well considering their size, and – like some of the Asian Tigers – are among the countries that have been able to significantly improve their innovative output as measured by US patents. Norway, too, has increased its average annual patenting, when one compares the 1968-97 and 1992-97 averages, from 101 (roughly half the Finnish number) to 137. The latter, however, is less than one third of the Finnish number. The same relative decline can be seen when comparing patenting per capita, which has remained stagnant in Norway. This trend is visible, too, when comparing annual average growth in US patents: Norway (around 4-5 percent) remained considerably behind Finland (around 9-10 percent) and Israel (around 10-13 percent).

The overall picture emerging from this section is that Finland has succeeded in raising innovation output considerably by increasing R&D inputs to a level seen only in a few other countries – both in terms of scientific (academic publications) and commercial (patents) output. Norway has consistently been on a lower level than Finland on the above measures, and the gap between the two countries has widened during the last fifteen years. With this broad image in mind, I turn to a more detailed analysis of R&D subsidies in Finland and Norway.

Table 1. US patents for selected countries, 1968-97

	Patents per year		Annual patents per 100,000 inhabitants		Annual growth in %	
	1968-97	1992-97	1968-97	1992-97	1968-97	1992-97
G7						
Canada	1,525	2,401	6.1	8.1	3.4	5.5
France	2,423	2,896	4.5	5.0	1.9	0.5
Germany	6,338	7,250	9.8	8.9	2.3	2.4
Italy	937	1,197	1.7	2.1	2.8	0.4
Japan	13,226	23,847	11.5	19	8.4	2.8
UK	2,547	2,494	4.4	4.3	0.2	3.1
USA	46,913	66,325	19.8	25.2	1.6	5.3
Reference group						
Finland	214	438	4.5	8.6	8.6	10.0
Ireland	35	60	1.0	1.7	6.8	5.5
Israel	234	577	5.3	10.2	10.1	13.3
New Zealand	42	61	1.3	1.7	4.9	16.9
Norway	101	137	2.4	2.9	4.9	4.3
Spain	105	173	0.3	0.4	4.2	3.1
Asian Tigers						
Hong Kong	39	95	0.7	1.5	12.5	9.6
Singapore	22	83	0.8	2.6	16.5	10.3
South Korea	443	1,989	1.1	4.4	27.7	27.9
Taiwan	554	2,006	2.8	9.3	33.8	15.7

Sources: Trajtenberg (2001) and author's own calculations using the NBER patent data for Norway.

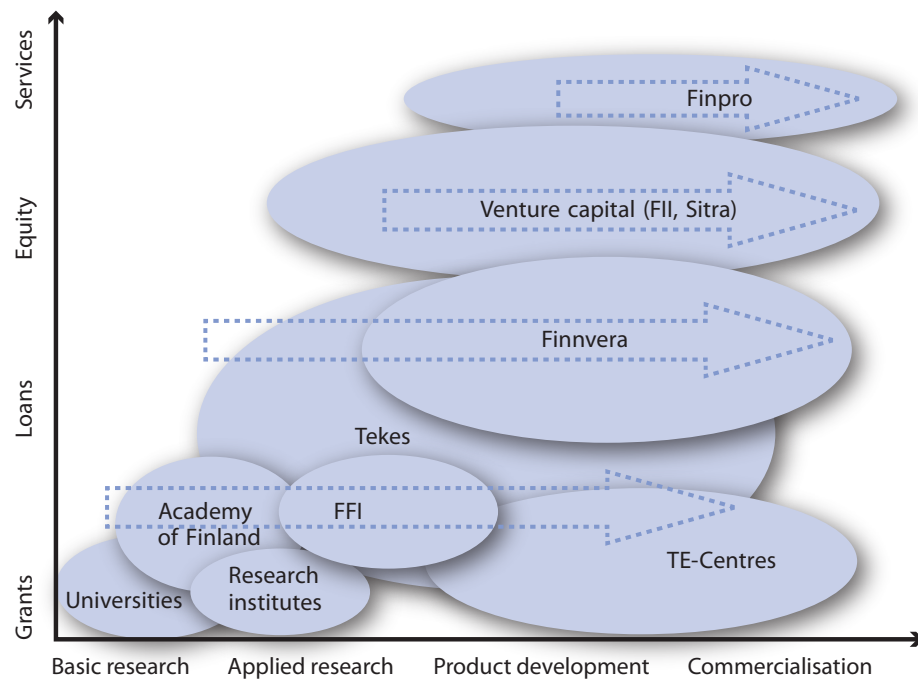
5. R&D subsidies in Finland

5.1 Policy environment

This sub-section briefly reviews the structure of institutions of innovation policy in Finland, i.e., what has been called the 'innovation support system'. The emphasis is on painting the broad picture of how government aims to aid private sector innovative activities.

In a recent evaluation of the Finnish innovation support system, Georghiu *et al.* (2003) provide a description of the system and a short overview of its historical development. The Finnish government – as many other governments – employs several agencies to conduct innovation policy. The most important ones are depicted in Figure 3.

Figure 3. The Finnish innovation support system



Source: Georghiu *et al.* (2003).

In Finland's innovation support system, various institutions get involved at different stages of the innovation process, using different instruments.

As the figure suggests, despite some overlap, various institutions get involved at different stages of the innovation process (horizontal axis), using different instruments (vertical axis). The volume of financial support for R&D splits about equally between applied research, product and process development, and product and process commercialisation, on the one hand, and basic research on the other.⁷

Academy of Finland is the main source of government funding for basic research. However, as the figure suggests, the Academy nowadays also funds applied research. The government also runs a number of research institutes, the most important of which is VTT, the technical research institute.

Foundation for Finnish Inventions (FFI) helps individuals and SMEs to protect their intellectual property. To a limited extent, FFI also participates in marketing innovations.

TE-centres are regional government offices whose task is to provide business support services, consultation and advice, and finance to SMEs.⁸ These centres operate under the joint management of the Ministry of Trade and Industry and the Ministry of Labour.

Finnvera is a state-owned financing company. Its main tasks are to promote and develop SMEs, foster the internationalisation of firms, and contribute to regional policy. Only a small part of the activities of Finnvera fall under innovation policy.

⁷ See <http://www.research.fi>

⁸ TE stands for 'Employment and Economic Development Centre'. In total, there are 15 centres.

Tekes, i.e., the National Technology Agency of Finland, is the main organisation of Finnish innovation policy. Although it provides smaller financial support than Finnvera, for instance, it fully concentrates on innovation policy related tasks. Tekes provides funding and expert advice and promotes national and international networking. Since the provision of R&D subsidies is the main activity of Tekes (in fact, it is the sole source of R&D subsidies in Finland),⁹ it will be discussed in more detail below.

Finnish Industry Investment (FII) and Sitra are the government's venture capital funds. Finally, Finpro is responsible for providing business support services for the internationalisation of firms.

The way technology policy is organised shows the long tradition of how public policy is organised and conducted in Finland. Interactions between policy makers, policy-making bodies, and interest groups are explicitly organised. This is reflected in the Science and Technology Policy Council of Finland. The Council – which is “responsible for the strategic development and coordination of Finnish science and technology policy as well as of the national innovation system as a whole”¹⁰ – is chaired by the Prime Minister and comprises key ministers and representatives of interest groups, labour unions, and academia. All in all, the role and existence of the Council reflects the importance of innovation policy in Finland.

It is important to note that while Finland's innovation policy during the last few decades can in many ways be deemed a success, it is much harder to pinpoint which parts of the policy have been most crucial. For example, in discussing the supply of engineers and scientists, Georghiu *et al.* (2003) point out that since the early 1970s there has been a steady increase in the number of graduating engineers and scientists. In the interviews conducted for their evaluation, firms often considered the presence of relatively low-cost engineers in Finland a strong point for innovation activities.

While Finland's innovation policy can be deemed a success, it is much harder to pinpoint which parts of the policy have been most crucial.

5.2 Tekes – the National Technology Agency of Finland

It is worth describing in a little more detail how Tekes operates its R&D subsidy policy. This helps to set the stage for an evaluation of studies looking at the effects of R&D subsidies in Finland. Tekes' main objective is to promote the competitiveness of Finnish industry and services by providing funding and advice to both business and public R&D. To this end, it grants about €400 million a year in subsidies. Tekes can provide a subsidy of up to 50 percent of costs incurred (60 percent for SMEs when EU funding is included). Besides supporting specific R&D projects, Tekes funds feasibility studies and university research. The agency receives some 3,000 applications a year. Of this, about half relate to business sector R&D projects, some two-thirds of which are accepted. Tekes takes unsolicited applications, but also runs special programmes. The latter are usually designed in close cooperation with the industry.

Tekes has three funding instruments: grants (i.e., subsidies), low-interest loans, and capital loans. In 2001, the share of each instrument in the funding allocated to business R&D was 69 percent, 18 percent, and 13 percent. Low-interest loans are 'soft' in other respects, too: if the supported firm can demonstrate that its R&D project failed, Tekes may waive the payment – in part or fully. Capital loans are a Finnish speciality: they are granted when the debtor cannot give collateral and they need to be paid off only when unrestricted shareholders' equity is positive.

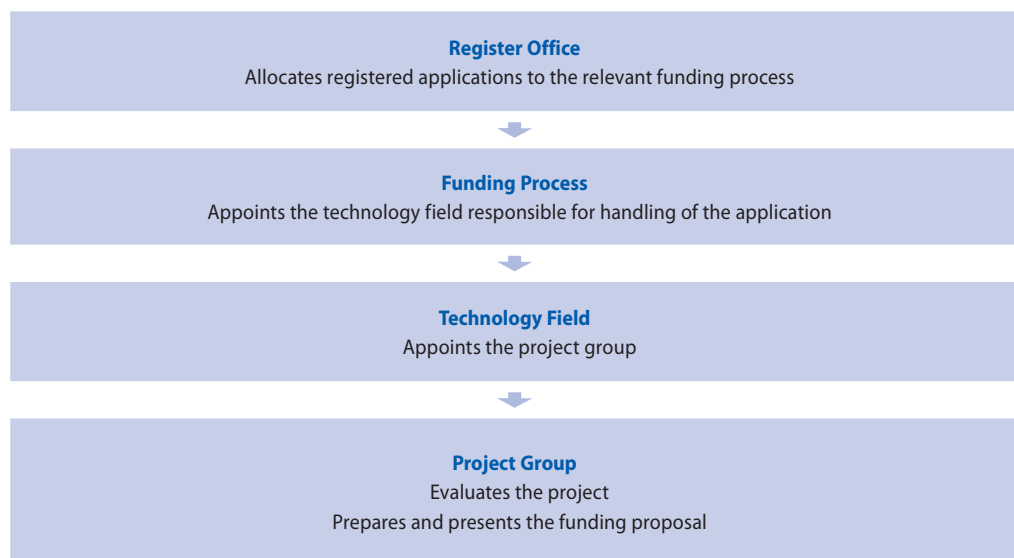
⁹ Other institutions may and do provide other forms of R&D financing. However, their volume is small compared to Tekes' financing.

¹⁰ See http://www.minedu.fi/tiede_ja_teknologianeuvosto/eng/index.html.

The decision making on R&D subsidies in Finland involves four steps: screening of requests, identification of technology field, evaluation of requests, and funding decision.

Tanayama *et al.* (2005) provide a description and a game theoretic model of the application process. In a nutshell, the application process goes as follows: the firm applies for support; Tekes usually does not solicit applications; in the application, the firm describes the objectives and planned execution of the project, and a proposed budget; in practice, firms are in touch with Tekes officials before submitting their application. The decision-making process of Tekes is pictured in Figure 4: after receiving an application, the agency screens it along a variety of dimensions and identifies the technology field and the project group that evaluates the project and prepares the funding proposal. Which level of the Tekes hierarchy (head of the technology field, process leader, director general, or board) takes the decision depends on the size of the subsidy proposed. To illustrate, in 2005, the head of the technology field decided on subsidies below €200,000 and the board on subsidies above €1.7 million.

Figure 4. The Tekes decision-making process



Source: Tanayama *et al.* (2005)

5.3 Empirical evidence on the effectiveness of R&D subsidies in Finland

There are several studies on the effects of R&D subsidies in Finland, although some of them are still at the stage of working papers. This sub-section will briefly review some of these studies before turning to one in more detail.

Ali-Yrkkö and Pajarinen (2003) first replicate Wallsten's (2000) study using data on 117 firms for the year 2000. The authors' cross-section estimates suggest – in line with Wallsten – that subsidies completely crowd out firms' private R&D spending. The authors then use the time-series (panel) dimension of their data and find that Tekes funding, lagged by one year, has a positive impact on private R&D spending.

Ali-Yrkkö (2005) looks at how R&D subsidies affect employment at firms. He separately analyses the effects of R&D subsidies on R&D and other employment, controlling for the endogeneity of subsidies. Also controlling for the effects of lagged R&D employment, he finds that an increase in last year's public support for R&D increases current R&D employment. While he does not control

for current or lagged private R&D spending, this is presumably highly correlated with lagged R&D employment. This result holds for domestic (Finnish) and global R&D personnel.

Piekkola (2005) studies total factor productivity (TFP) growth and how R&D subsidies affect it. Using a large (over 3,000 observations) panel of Finnish manufacturing firms and methods that allow for the endogeneity of subsidies, he finds that R&D subsidies have a nonlinear effect on TFP growth: the coefficient for the linear subsidy variable (subsidy-to-sales ratio) is positive and significant and the one for the squared subsidy variable is negative and significant. Within the sample limits, the positive effect appears to dominate.

Hyytinen and Toivanen (2005) adopt a somewhat different research methodology by adopting the cross-country and industry approach developed by Rajan and Zingales (1998) to a cross-region and firm setting. Their central question can be rephrased as follows: do firms characterised by (i) an industry that is fairly dependent on outside finance and (ii) locating in a region where the supply of government R&D support is fairly good invest more in R&D and/or expect to grow faster than firms not having these characteristics? Using firm-level survey data on about 500 firms, they answer both questions affirmatively and conclude that financial constraints affect firm innovation and growth and that government funding alleviates capital market imperfections.

All in all, the studies reviewed here do not corroborate the hypothesis that public support for private R&D crowds out private spending and has no effect on firm productivity. The next subsection, which draws on a paper by Takalo, Tanayama and Toivanen (2005, TTT hereafter), turns to a deeper analysis of firms' decision to apply for R&D subsidies, Tekes' decision to grant them (and how much), and firms' subsequent R&D spending.

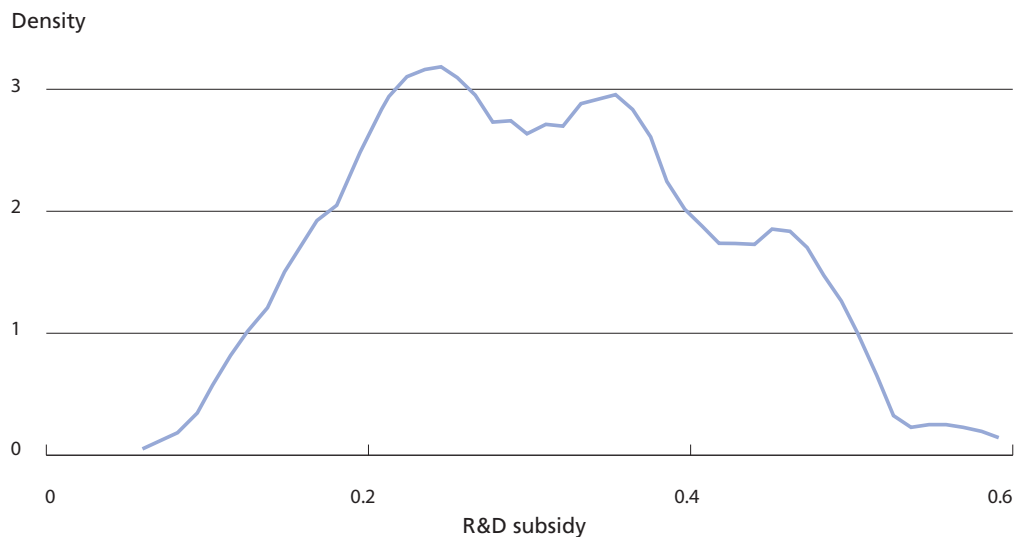
5.4 Modelling the R&D subsidy process

TTT build a game theoretic model where, first, firms have an R&D idea. They then decide whether to apply for funding. This stage is important because Tekes (and comparable organisations in other countries) sometimes voices concerns about the low propensity of some firms to apply for subsidies and because it is crucial from society's viewpoint that the 'right' firms apply for subsidies. Firms are assumed to make the application decision knowing the general rules by which Tekes grants subsidies, but not knowing exactly how it will treat their application. If firms apply, they need to describe their project and state a proposed budget. To make the model meaningful, it is important to assume that there is a cost for applying and that this may be firm specific. In the next stage of the game, Tekes screens the application and decides whether to grant a subsidy. In the final stage, firms implement their R&D projects. This simple model seems to capture the essence of firms' and Tekes' decision-making process.

TTT show that in equilibrium some firms apply and get funded, some apply and get turned down, and others do not apply. The existence of such an equilibrium is crucial given that the outcome described is indeed observed in practice. Considering the period 2000 to mid-2003, Tekes data show that of roughly 11,000 firms (potential applicants), some 1,000 firms applied. Around 30 percent of these applications were rejected. The remaining firms received a subsidy, varying across firms, however. Figure 5 shows a nonparametric (kernel) estimate of the frequency distribution of subsidies. It turns out that subsidies vary greatly in size, the smallest being close to zero, and the highest equivalent to 60 percent of R&D costs incurred, i.e., the maximum possible in the period considered here.

The Finnish experience does not corroborate the view that public support for private R&D crowds out private spending and fails to raise firm productivity.

Figure 5. Frequency distribution (in %) of size of R&D subsidies granted by Tekes



Source: Takalo *et al.* (2005) and author's own calculations.

Note: The subsidy amount (horizontal axis) is expressed as a ratio of the underlying R&D spending.

The key equations estimated in the TTT model concern (i) Tekes' decision rule, (ii) firms' R&D spending, and (iii) the application decision of firms. The authors estimate their model both using standard assumptions (the error terms are normally distributed and homogeneous, etc.) and allowing the error terms to be freely distributed.

Except for firm size, firm characteristics do not seem to significantly affect Tekes' R&D subsidies, but project characteristics do.

To start with the equation concerning Tekes' decisions rule, the TTT estimates reveal how firm characteristics affect the subsidy a firm gets – if it applies. An interesting finding is that the subsidy a firm gets is largely independent of the industry the firm is in. That said, firms in the food industry get higher subsidies, mainly because during the observation period Tekes actively solicited applications from that industry. The only other industry systematically receiving different subsidies is data processing – firms in that industry get lower subsidies than firms in other industries. SMEs get some eight percentage points higher subsidies – this reflects the explicit Tekes rules by which firms meeting the SME criteria of the European Commission are entitled to the maximum subsidy of 60 percent. Large firms, measured by (the log of) employment get higher subsidies. If one believes in Tekes acting like a benevolent social planner, the interpretation is that, for the same R&D project, big firms generate larger spillovers than small firms. However, other interpretations are possible depending on one's stand on what it is that Tekes maximises. Other firm characteristics do not affect the subsidies, but project characteristics do. For instance, projects facing (in Tekes' evaluation) considerable technical challenges benefit from relatively large subsidies. There is some but less conclusive evidence suggesting that projects facing large commercial risks (again by Tekes' evaluation) get lower subsidies.

Whatever interpretation one wants to give to these results, they suggest that subsidies are in practice decided on in a horizontal manner. Note however that nothing in Tekes rules or the economic reasoning for optimal subsidies (Box1) suggests that this should necessarily be the case. Indeed, if anything, one would not expect the same consumer surplus in all industries; likewise, one would expect greater variation in knowledge spillovers between firms in different industries

than within a particular industry. To illustrate, think of an industry/product with a major domestic impact, such as snow tires, and another where the market largely lies outside Finland, such as a cure for bird flu or hepatitis B. Having said this, it is important to keep in mind that subsidies vary greatly, as shown in Figure 5. Depending on what view one takes on Tekes' decision-making and objectives, one might see this variation either as a strength (Tekes being able to tailor its support to the socially optimal level) or a weakness (Tekes being able to tailor the subsidy to whatever level it finds convenient for the firm in question).

Turning to firm's R&D spending equation, it is important to note that determinants of R&D are notoriously difficult to identify. Loosely speaking, a good deal of what determines R&D spending is not reflected in the variables usually observed, but is embedded in things researchers cannot observe. Examples already elaborated on above include the quality of management and of R&D engineers. Despite these difficulties, estimating R&D spending equations furthers our understanding of firm characteristics related to R&D. The benefit of TTT's structural model is that the parameters of their R&D spending equation can be interpreted as effects of the variable in question on the marginal profitability of (log) R&D. They find that the profitability of R&D is higher, all other things being equal, for large firms and firms with a higher value added of production and a chief executive officer (CEO) who is not chairman of the board. The robustness of the CEO result is weaker than that of the two others, however. Other firm characteristics did not affect R&D profitability, but there were differences over industries and regions: firms in the food industry have low R&D profitability, whereas firms in the radio, TV, and telecoms industries have high R&D profitability; firms in eastern Finland have lower profitability than firms in southern Finland – the geographical core of economic activity in Finland.

TTT identify the cost of applying for a subsidy as a major determinant of firms' application decisions. These costs comprise much more than the cost of filling in and submitting an application. In fact, a major cost element is the opportunity costs of management time of potential applicants. In the TTT data set, the median firm has only five employees, suggesting that the managing director has a large role also in R&D and, thus, would be heavily involved in writing an application were the firm to decide to submit one. The cost of applying is then largely what the firm would achieve if management spent its time on R&D and related tasks instead of optimising the application. A key finding of TTT is that the costs of applying for subsidies rise with the quality of the underlying R&D idea, meaning that ideas promising large profits come with large application cost. TTT find application costs substantial.

TTT are able to calculate the social return to subsidies, a key assumption being that Tekes acts as a benevolent social planner. Although there are several caveats, their estimate is 9 percent. This, if correct, is a relatively high return on public investment, but objectively ought to be compared to the shadow cost of public funds, the estimates of which are usually higher. It is however clearly higher than what the Finnish government pays as interest on its bonds.

Estimates suggest a social return on R&D subsidies in Finland of 9 percent.

All in all, by modelling the R&D subsidy process using modern structural methods, the TTT study shows that it is possible to answer a host of interesting questions. However, one should probably view their empirical results as suggestive given that they are based on the first empirical implementation of the model. The main findings are that Tekes decides on subsidies in a horizontal manner and application costs are a significant determinant of firm behaviour, which should be taken into account when evaluating R&D subsidies; the return on Tekes subsidies is estimated at 9 percent.

6. R&D subsidies in Norway

As discussed in Section 4, Norway spends less on R&D and has a lower R&D output than Finland in relation to population. This is not for lack of trying: in the 1980s and 1990s, Norway implemented a rather aggressive innovation policy, largely focussing on the (then-perceived) strength of the Norwegian IT sector. Indeed, during the early 1980s, Norsk Data was one of the leading minicomputer manufacturers in the world. That said, Norwegian policy makers were concerned about the fragmentation of public funds for R&D, too many small and independent firms, and little long-term planning and originality in product development (see Klette and Møen 1999).

The motivation for R&D subsidies in Norway explicitly recognised the goal of fostering general purpose technologies, with a heavy concentration on IT manufacturing.

Norway is an interesting case in that the motivation for R&D subsidies explicitly recognised the goal of fostering general-purpose technologies (see Klette and Møen 1999). Two consequences of the concerns mentioned above and the GPT orientation of Norway's R&D policy are worth mentioning. For one thing, R&D funding of the programme was substantial, reaching some 40 percent of the total funding for research carried out by universities and government laboratories. To initiate the kind of 'positive feedback' loop envisioned by the GPT theory, large-scale initial investments might be necessary. Second, there was a heavy concentration on IT manufacturing, and within this sector large firms where the main beneficiaries. To illustrate, the industry leader, Norsk Data, received some 12 percent of all funds available to firms. Such concentration of effort not only between but also within a sector might also be justified by returns to scale in R&D and the goal to create a positive feedback loop. Despite this and other large-scale public support (see Møen 2004), Norsk Data went bankrupt in 1993.

In what follows, I briefly review three studies on Norwegian R&D subsidy programme. To start with Klette and Møen (1999), they examine the effects of R&D subsidies on firm conduct and performance, measured by growth in employment and sales, return on assets, profit margins, labour productivity, total factor productivity, investment, and the level of R&D spending financed without subsidies. Their approach involves three parts: first, they compare the short-run performance of targeted firms to other firms in the same industry; second, they compare the long(er)-run performance of these firms; finally, they compare the development of the IT industry in Norway with that of other OECD countries in 1983-92.

For the first part, the paper does not find positive effects of R&D subsidies - even when not controlling for firm-specific unobservable variables.¹¹ When Klette and Møen control for these effects, they find that small subsidies (less than 5 percent of R&D spending) have negative effects on sales growth, labour productivity, and total factor productivity. Because they do not attempt to control for contemporaneous endogeneity, it is not clear whether one can give these results a causal interpretation, but the results do suggest the possibility that (small) R&D subsidies provide a cushion to lean on in the sense that firms do not have to improve their productivity as fast as they would have to without the subsidies. Regarding the R&D spending of targeted firms compared to other firms in the same industry, the paper finds that although subsidised firms were more R&D intensive to start with, their R&D spending (measured in monetary units, not intensity) grew less than the spending of non-subsidised firms. The authors also find evidence that subsidised firms perform relatively poorly when measured by productivity growth and profitability.

As to the second part, Klette and Møen (1999) compare the behaviour and performance of subsidised firms to non-subsidised ones in 1985, and look at the changes between 1985 and 1995. They find that subsidised firms invested more heavily in R&D in 1985, suggesting possible selection bias. However, looking at changes over time they find non-subsidised firms increased their R&D

¹¹ As argued in Section 3.1, unobservable variables could be of substantial importance in studies of this kind.

intensity on average by 15 percent (from 4.1 to 4.8 percent) whereas subsidised firms' R&D intensity decreased by 17 percent. They also find that non-subsidised firms grew faster, but had the same labour productivity growth and exit rates as subsidised firms. Finally, while subsidised firms' profits grew faster than the profits of non-subsidised firms, by 1995, the former had not reached the latter's 1985 profit levels. Overall, the long-run comparison thus does not suggest that subsidies had any major positive effects on firm performance.

Empirical evidence for Norway does not suggest that R&D subsidies had any major positive effect on the performance of firms.

Turning then to the comparison of Norway with other OECD countries, Klette and Møen (1999) note that the Norwegian IT industry was exceptionally R&D intensive. In the period considered (i.e., 1983-92), subsidies to the Norwegian IT industry were substantial and its R&D intensity increased considerably. Yet, Norway was the only OECD country experiencing a fall in IT production.

The second study is that of Klette and Møen (1998). It uses the same data as their later study, but takes a closer look at the mechanisms that might induce effects of R&D subsidies on privately financed R&D. Their initial analysis of some 700 business units from three high-tech industries (ISIC 382, 383, and 385) shows that R&D subsidies have no effect on privately financed R&D spending. They find that cashflow has a significant positive effect, indicating capital market imperfections. They then allow small and large firms to differ in their response to subsidies. The results show that there is neither additionality nor crowding out for small firms, crowding out to the tune of 50 percent for medium-sized firms, and additionality of around 25 percent for large firms.

Klette and Møen (1998) then allow for dynamics by including lagged R&D subsidies in their estimated equations. It turns out that subsidised firms continue to spend more (relative to sales) on R&D after the subsidy period than they otherwise would have. In other words, the positive effects of R&D subsidies come through 'elevating' the firm's level of investment in R&D, rather than through a contemporaneous increase in privately financed R&D spending. In particular, they propose a model of learning-by-doing to account for their finding that R&D subsidies have positive long-run effects.

The third study on the effects of Norway's R&D subsidy programme challenges the claim made by the Norwegian Research Council that despite the bankruptcy of Norsk Data the programme had positive effects by boosting human capital that later diffused through the Norwegian industry. Møen (2004) looks at the productivity effects of workers who worked in subsidised firms and at the performance of firms that are spin-offs from formerly subsidised firms. He finds no support for the suggestion that work experience in the subsidised firms has been valued more than any other experience. Thus, having worked in a subsidised firm did not hurt an employee, but did not produce gains either. What is of course lacking from this analysis is the answer to the counterfactual question of what wages (employment, etc.) would have been without the subsidy programme.

Møen's firm-level analysis echoes the findings of Klette and Møen (1999) on R&D subsidy-receiving firms: he finds that spin-offs from these firms are performing on par with other, similar firms, but are less profitable by both measures used (return on equity, return on assets).

7. Conclusions

Innovation policy in general and R&D subsidies in particular are believed to be important in fostering economic growth. These beliefs are held by politicians and backed by economic research. The consensus seems to be that while economic theory gives ample justification for innovation

policy, the problems lie either in the actual execution of those policies or a government's general ability to conduct anything resembling an optimal policy due to various constraints.

It is standard for researchers (e.g., Klette and Møen 1999) to voice concerns over political economy issues that may divert actual policies from optimal ones. Government failure is the rubric under which one generally collects such and other potential problems in government's ability to deliver. A potentially more fundamental problem is that even when government officials base their arguments for policies on market failure (this is the case at least in Finland), the standard against which they gauge them is the improbable full information Pareto optimal state of affairs. A more reasonable, yet still challenging, yardstick would be to take the informational constraints of the government seriously into account when analysing the need for existing or new policies.

A further important problem that falls under the rubric of government failure is that civil servants – no matter how qualified and competent – are at a disadvantage when it comes to active forms of financing, such as venture capital. This is because they face entirely different incentives than private sector financiers, and realigning their incentives with those of private financiers is most likely not possible nor would it be wise.

An important insight derived even from the simplest model of R&D subsidies is that optimal subsidies are heterogenous, i.e., they ought to vary from firm to firm and from project to project, and that the informational demands for designing optimal policies are potentially prohibitive. Especially the first conclusion should be borne in mind when judging the supposedly horizontal nature of R&D subsidies.

Finland is generally viewed as successful in terms of innovation performance and innovation policies while Norway clearly lags behind.

In the last three sections of this paper I have presented academic research on the effectiveness of R&D subsidies in two rather similar countries, Norway and Finland. While in many ways similar, both in general circumstances and in terms of the R&D subsidy policies, important differences emerge. First, Finland is generally viewed as (comparatively) successful in terms of innovation performance and innovation policies while Norway clearly lags behind. Second, there are important differences in the way R&D subsidy programmes were administered in the two countries. Norway chose to back a 'national champion' and firms operating in fields related to this champion. Finland has followed a more horizontal R&D subsidy policy, although one should acknowledge that Tekes also runs special programmes in parallel to its general R&D subsidy scheme.

The bulk of academic research suggests that in Finland, R&D subsidies work relatively well. There is evidence that they spur private R&D investment, firm productivity, and R&D employment but have no effect on general employment of firms. An analysis of Tekes' subsidy decisions shows that few firm-level variables affect these decisions. The most notable one is firm size: for similar R&D projects, large firms get larger subsidies (measured in percent of R&D spending) than small firms. However, there is little evidence that firms in different industries are treated differently.

The Norwegian evidence suggests that R&D subsidies had few positive effects. Most of the evidence suggests that subsidies were either granted to firms with sub-par profitability and productivity, or even worse, that subsidies lead to sub-par performance. Evidence from spin-off firms suggests that firms spun off from subsidised firms have consistently lower profitability than other firms. The only positive finding is that subsidised firms continue to invest more in R&D than they would have otherwise.

The difference in performance between Finnish and Norwegian R&D subsidy policies naturally raises the question of why the results are so different. Three potential answers emerge.

First, Norway chose to target a national champion and, in general, to heavily concentrate its support whereas Finland chose a more horizontal policy. Targeting might work but relies critically on the ability of the government to pick the 'right' target. Questions can and should be raised about the governments' ability to make such choices. Second, the Norwegian IT industry (Norsk Data in particular) concentrated on minicomputers, and was very possibly a victim of a discontinuous innovation where minicomputers as a technology were superseded by developments in computing. According to this interpretation, the industry would have failed with or without support. Third, one could also take the view that Norway quite clearly understood the winner-takes-it-all nature of innovation deriving from the skewed distribution of payoffs from innovation, but – as it very often happens in such an environment – ended up backing the wrong technology. Thus, while *ex post* a failure, it may be hard to conclude that this could have been known *ex ante*.

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