Public support to innovative firms – a quantitative assessment of potential effects

Lars Bager-Sjögren[*] and Hans Lööf[**]**

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Abstract.

The theoretical literature on economic benefits of innovative activities is vast. There is also a steadily growing empirical econometric literature as well as in case studies verifying the importance of R&D and innovation at various level of aggregation. Due to assumptions on market failures and underinvestment in these activities all OECD countries are spending significant amounts of public money on program intended to stimulate R&D and innovation activities. Since several years many countries are targeting especially on so-called new technology based firms (NTBF). However quantitative evaluations of the effects of such support are hitherto limited. This paper is a first step in estimating such effects using the control group approach. The paper discusses the link from support to a probable innovative effect, in our case a latent variable, and a final effect on the firms' economic status.

Our method takes the departure in identifying the different kinds of selection processes inhered in this kind of estimation. They are including the probability to be a successful innovator, to be a innovator who apply for public support and finally an innovator selected by public officials as a probable successful innovator. We use several sources of data. First, the database from the agencies distributing public support, e.g. in the form of beneficial loans. Second, data from registers gives us information about the economic performance of the whole population of firms in the relevant size group (up to 250 employed which means that we focus on what is considered as small and medium sized firms). Finally we are utilizing the Community Innovation Survey data in the construction of the relevant control group.

The effect estimates are based on the economic development between 1995 to 2001. The methodology we use may in a further studies be utilized as a selection tool for in depth analyses (case studies) of innovation effects and barriers to innovations between "twins" of innovators/non-innovators.

Keywords: Public innovation subsidies. Nonparametric matching. New technology based firms.

[*] Swedish Institute for Growth Policy Studies –ITPS www.itps.se

[**] Swedish Institutes for Studies in Education and Research.

1. Introduction

In Sweden like in all other modern economies there are policies supporting innovativeness.[1] The core of innovation policy lies mainly in the interface between academic research, and R&D taken place in business. Science parks, incubators and R&D tax allowances are among utilized instruments. The emergence of fast commercialisation of especially ICT-technologies and the so called research-boutiques in the biotech-area lay ground for special interest in policies directed to so-called new technology based firms (NTBF) as an additional tool in the public innovation policy spectra.

This paper focus on the seed financing program at NUTEK directed to NTBFs with a size less than 250 employees taken place in Sweden since 1995. The paper aims to discuss some methodological considerations regarding how to evaluate the impact of public programs easing the financial constraint for NTBF and empirical illustration follows the presented methods.

We start in Section 2 by considering the existing literature on public support to innovation and microeconometric evaluation studies. Section 3 discusses some methodological problem of evaluation. In Section 4 the data used are presented and the hypothesis of the study are stated. The last section concludes the discussion on methodological issues and suggests an approach for further empirical research.

2. Assessment of previous contributions

The present study is in the cross-road between three branches of research literature. First, theoretical literature on market failures associated with R&D, technological innovations and investments in intangible assets, and knowledge spillover from these activities. Second, empirical evaluation studies on public R&D subsidies. Third, recent advances in microeconomic techniques for evaluation studies. This section will give a brief review of the recent contribution on issue 1 and issue 2 while the evaluation problems are discussed in section 3.

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[1] The share of government funding of R&D was 30% in the OECD, 31% in the U.S., 36% in Europe and 19% in Japan. See Guellec and Pottelsberge 2000.

The economic-theoretic support for governmental intervention in research and development activities starts with Schumpeter (1942), Nelson (1959) and Arrow (1962) and is revolvering the conceptual aspect of knowledge as a nonrival good. Therefore the returns to investments cannot be appropriated by the firm undertaking the investments, leading to the underprovision of R&D investment in the economy. In an attempt to estimate the order of magnitude of optimal public support to commercial firms to correct for this market failure Gullec and Pottelsberghe (2000) suggest a tresholdvalue about 13 per cent on average for 17 OECD countries. Interestingly this is only slightly above the reported average rate of subvention for the OECD as a whole (10 per cent in 1998).

The main tools of public support to individual firms are tax incentives, direct government funding, corporation arrangement including both firms, research institutes and universities, and conditional loans. Although there are several advantages evaluating these direct or indirect R&D subsidies at the macroeconomic level (for example capturing the spillover effects) in line with Gullec and Pottelsberghe (2000) and others, an important drawback is the difficulties finding meaningful control groups. Since individual firms are a main receiver of public support one crucial issue is how much would the subsidy receiving firms have invested had they not participated in the public policy scheme.

Klette, Moen and Griliches (2000) argue that most microeconometric evaluation studies on governmental are based on the assumption that R&D subsidies to a large extent are allocated randomly to firms and project. If the randomness are large in the allocation process the challenging issue is to get access to enough data for firm receiving R&D subsidies as well as for similar non supported firms. The differences in performance between the two groups of firms can then be estimated with public funds as a determinant.

However, there are overwhelming evidence that firms do not randomly participate governmental R&D programs or not. On the contrary many studies (See for example Irwin and Klenow 1996 Lerner 1998) document that public R&D policy to a large extent tries to "pick winners" in programs such as SEMATECH and SBIR in the US and ALMI/NUTEK programs in Sweden.

The difficulty of this kind of analysis are potential selection biases coming from the public institutions that decide the recipients of the public funding solely. This makes public funding an endogenous variable, and its inclusion in a linear regression will cause inconsistent estimates. To estimate the net effect of public subsidies, it is necessary to address the core evaluation question: How much would the subsidy receiving firm have invested had they not participated in the public policy scheme?

If the performance of the supported and non supported firms ex ante differ systematically the difficulty of this kind of analysis are potential selection biases. This makes public funding an endogenous variable, and its inclusion in a linear regression will cause inconsistent estimates.

Recent years has shows a growing literature of empirical evaluation studies using microeconomic methodlogy conducted in many OECD countries. To these belongs Lichtenberg 1988, Irwin and Klenow 1996, Lerner 1998, Griliches and Regev 1998 and Wallsten 1999 for the U.S. Branstetter and Sakakibara 1998, (Japan) Toivanen and Niinen 1998 and Hyytinen 2002, (Finland), Busom 1999 (Spain), Klette and Möen 1999, (Norway). Summarize the findings from firm level studies David, Hall and Toole (1999) concludes that there is no clear evidence similar to what Gullec and Pottelberhe report from the macro level. On the contrary, 9 out of 19 studies indicate substitutional effects meaning that public fund crowd out private investment, partially or even completely. 10 out of the 19 studies suggest partly or completely complemnetary effect leading to increased R&D investments in the total economy.

One conclusion to draw from these studies is that R&D programs not easily are hitting their target. An alternative or complementary interpretation is that the data used and research metodology can play an important role for the estimated results. Finding relevant and valid control groups are the perhaps one of the most challenging task in the research metodology.

3. The problem of evaluation

An evaluation of a public support program cant exclude a quantitative impact assessment which is the conclusion drawn by Storey (1999) and Jarmin & Jensen (1997) which explicitly surveyed pro and cons of different approaches from case studies and client follow ups to econometrical models addressing the problem of self-selection. The quantitative expression of the evaluation problem is usually stated as follows (Heckman, Lalonde & Smith 1999, Smith 2000).

(1) $$\Delta = Y_{it}^{1} - Y_{it}^{0}$$

Where Y is an outcome variable measured in time *t* and the subscript denotes two different states for the agent *i*. The evaluation problem or the general problem in causal analysis (Holland 1989) is the fact that at any given time individuals or firms may only be in either one of two states, on our case participating or not participating in a publicly financed program.

For each individual or firm only one of these outcomes are observed. This is a genuine missing data problem and the only way to handle it, is to reformulate the problem to estimate not individual effects but mean effects (or other parameter of interest).

The following set-up is common (Heckman, Lalonde&Smith 1999).[2] Let D=1 be an indicator if a firm is participating in the program otherwise D=0. In expression 2) the dilemma above is expressed as the difference of two expected means conditioned on a matrix **X** of cofactors.

(2) $E[Y_1|\mathbf{X}, D=1] - E[Y_0|\mathbf{X}, D=1]$.

Allowing some randomness due to among other things measurement errors and formulating the problem in a switching regression mode with a set of covariates in a common **X** matrix one get:

(3) $E[Y]= E[Y_0|\boldsymbol{X}] + D(E[Y_1|\boldsymbol{X}] - E[Y_0|\boldsymbol{X}] + u_1 - u_0) + u_0$

The second term in (3) consists of the program effect for the participators the average treatment on the treated (ATET). This is composed by two parts. First the difference between the two expected conditionals. The second part amounts to the difference of individual specific values observed by the outside researcher but known by the individual firm. This difference might consist of comparative advantages the firm expects from participating. Putting more structure on the expressions th program effect can be re-expressed as follows:

X is a matrix of covariates and β_1 and β_0 are vectors with the parameters. We assume that these parameters are equal. Assuming also $E[u_1|\boldsymbol{X}]=E[u_0|\boldsymbol{X}] = 0$:

(4) $Y = X'\beta_0 + D(X'(\beta_1 - \beta_0) + u_1 - u_0) + u_0$

[2] Individual index i, and time index *t,* is suppressed.

(5) $Y = X'\beta_0 + D\alpha + D(u_1 - u_0) + u_0$

Bias in estimation in the assessment of a program impact might occur because the that in spite of the assumption E[u_1|**X**]= E[u_0|**X**] = 0 is valid the difference $E[u_1$-u_0|**X**,D = 1], might not. If this last difference is not equal to zero the estimate of program impact i.e. the expression within the parenthesis will be biased. This biased is called selectivity bias. The are reasons to believe that in programs the participants is not a random sample of the population eligible to participate. It for example reasonable to assume that firms are forward-looking and expects benefits from joining the program.We assume that $E\left[D(u_1 - u_0) + u_0\right] \neq 0$, which is the case if $(u_1 - u_0)$ "determines" in a sense or is correlated with, the probability to participate in the program i.e. $E\left[D(u_1 - u_0)\middle|D = 1\right] \neq 0$. We thus come up with following set up:

(6) $Y_0 = X'\beta_0 + u_0$

(7) $Y_1 = X'\beta_1 + u_1$

(8) $D^* = Z_i'\gamma + \varepsilon_i$

D^* is a latent, non-observable, index on the propensity to participate in public programs. This is measured by an indicator D where

(9) $\mathrm{D} = \begin{cases} 1 & iff\ D' > 0 \\ 0 & iff\ D^* > 0 \end{cases}$

The random terms for each equation have a joint distribution assumed as:

$$\begin{bmatrix} u_0 \\ u_1 \\ \varepsilon \end{bmatrix} \sim N \left[\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \delta_{00} & \delta_{01} & \delta_{0\varepsilon} \\ * & \delta_{11} & \delta_{1\varepsilon} \\ * & * & 1 \end{bmatrix} \right]$$

With the expectations:

(10) $E\left[Y_j\middle|D = 1, X, Z\right] = X'\beta_j + \delta_{1\varepsilon}\lambda(Z'\gamma)$, j= 1,0

(11) $E\left[Y_j\middle|D = 0, X, Z\right] = X'\beta_j + \delta_{0\varepsilon}\widetilde{\lambda}(Z'\gamma)$, j= 1,0

The index j is introduced in order to indicate a unit participating. The two new expressions are the so-called hazard-rates which differ depending if D=0 or D=1. In the first case

$\lambda(Z'\gamma) = \phi(Z'\gamma)/(1-\Phi(Z'\gamma)$ and in the second case $\widetilde{\lambda}(Z'\gamma) = \phi(Z'\gamma)/\Phi(Z'\gamma)$, where ϕ denotes normal density distribution and Φ the cumulative normal distribution

This leads to a final expression for an outcome variable considering the potential bias stemming from self-selection:

(18) $E[Y_i | D=1, X, Z] = X'\beta_0 + D\alpha + (\delta_{1\varepsilon} - \delta_{0\varepsilon})\lambda(Z'\gamma)$

The estimated difference between program participators and non-participators will thus estimated by the following difference:

(19) $E[Y_{1i} | D=1, X, Z] - E[Y_{0i} | D=1, X, Z]$

(20) $= \alpha + (\delta_{1\varepsilon} - \delta_{0\varepsilon})\lambda(Z'\gamma)$

The second term is the part due to self-selectivity and other miss-specification correlated with participation not explicitly taken care of in the model. The coefficient α, is the alleged program effect.[3]

The definition of the treatment group and an analogous control group representing the counterfactual state, Y_0, is the main issue in cooping with the evaluation dilemma, (see e.g. Heckman, Ichimura, Smith and Todd(1997) or Heckman, Lalonde & Smith (1999)). This directs the interest of constructing relevant comparison groups of participants versus non-participants. Early literature on evaluation recognized selection bias as a main problem estimating the parameters of interest consistently but the development of evaluation methods in Heckman, Ichimura and Todd (1997) concluded that selectivity bias is one of several factors. Their list of factors implying bias in the parameters of interest consists of whether:

1) Participants and controls have the same distributions of unobserved attributes
2) Participants and controls have the same distributions of observed attributes
3) The same method of measurement (e.g. questionnaire) is administered to both groups
4) Participants and controls are placed in the same economic environment

The focus on self-selection-bias, i.e. the process of selection into the program falls under the first of the above listed factors. The ultimate remedy of this has been the

[3] The parameters should at best be estimated simultaneously but two-step methods yields also consistent estimates but to the expense of less efficiency. The STATA treatreg module is an example of commercial product.

suggestion of conducting so called social experiments, where a fraction of individuals eligible to a program is randomised out and used as a control group thus eliminating potential differences in the distribution of un-observables.[4] Items 2-4 can also be achieved in non-experimental evaluations. Resampling methods like bootstrapping can make non-experimental data having the properties under item 2). In fact, Heckman, Ichimura & Todd (1997) concludes that the factors 2)-4) in the above list are far more important for a successful impact assessment than the potential bias item 1) might produce.

The relevant outcomes, data and hypotheses

The definition of the treatment group and an analogous control group representing the counterfactual state, Y_0, is the main issue in cooping with the evaluation dilemma.

The purpose of NTBFs support schemes is to realize projects with a technical content and with a prospective commercial outcomes (innovations) otherwise not developed in the same time-period. The main issue here is that the public support is given with respect of an expected income stream from the results of the project (partially) financed by the loan. The conclusion is that there is a commercial applicability in not a too distant future. The relevant outcome variable on a firm level is accordingly, sales. The notion "otherwise not developed" imply that there is a belief from the public authorities that the amount of risk capital on the market is not sufficient financing all interesting projects or by some reason disregard the projects the public supply financial support to. The public support thus acts in a manner to complement this insufficient capital market. If we accept the premise that the public act like commercial seed financer (venture capitalist) it seems plausible to evaluate the outcomes like such institutions demand ie quantifiable performance indicators like sales and rate of returns on capital. The only difference is that the public might allow less rate of return than the market do.

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[4] See Smith (2000) for a discussion on limitations and problems social experiments are facing.

This brings us to a discussion of the definition of a relevant control group. Optimally this group should consist of characteristics equal or of close resemblance to the firm selected into the seed financing program with the only difference that they did not participate. Which characteristics are most important? The control group must be defined using data before the participators enters the program. While we will not collect new data our information limits to the data in Swedish registers. These consists of on the one hand a population of seed financing receivers in the register the governmental agencies of NUTEK and ALMI and the public foundation of Industrifonden. From registers of the annual reports we can deduce the economic development of all firms in Sweden between 1990 to 1995 which is the year of program start. Thus we have information regarding the profit and loss account and the balance sheet regarding debt and liabilities for all firms in Sweden. Our empirical analysis accordingly not be based on sample survey data. The Size group and sector code are first important matching variables. We only include firms up to the eligible applicant size of 249 employees. The control group must also equal the industries which the participators (treatment group) work in and eventually the age of firm will be a relevant structural variable. These according to the register (preliminary data) are manufacturing focusing on machine and instrument construction, business services as constructing consultancy and wholesale trade. Looking at the economic side the debt structure before the date of entering the program is qualifying variable especially the ratio between the sum of long term debt and owner capital. This matching variable eventually indicate the need to gather resources necessary for developing new applications or investments. The design of the support scheme we focus on here was in the form of beneficial loan. Beneficial in the respects that on the one hand firms have not being successful in finding other sources of financing and on the other hand beneficial in the way firms could alter the conditions of the loan. The latter aspect amounted to three possible loan construction, one regular loan with interest payment due at the time of receiving the loan, second a loan with capitalized interest ie. the firm could postpone paying interest until a certain time with annually interest compounding the loan. Finally the loan could be changed to a royalty arrangement where the firm had to pay a proportion of the sales to the public agency giving the loan. In our data we have data how large the loan was. In principle our matching variable regarding long term loans for the control group much equal the amount of this resources.

Finally development of sales before date of entering the seed financing program will be important to match upon. This variable controls for how large market penetration the firm have before entering the programme. As underlined by Lindström & Olofsson (1998) the client or customers often are the most important factors for development for NTBFs. In our preliminary data we have approximately 400 participators. From the population data base on over 90 000 firms we will pick as close match as possible.

A public seed financing program directed to NTBFs must not necessarily exceed the results of the defined control group but it surely must exhibit an average positive rate of return in order to finance the public costs. A further problem is the relevant time span to evaluate. The six years between 1995 and 2001 which we have accessible data on economic outcomes might be not enough. A first test is to use the common expectancy in venture capitalist market.

Concluding discussion

Public programs supporting new technology based firms can be assessed under following two preconditions. First that the programs acts like private market financiers implying similar outcome variables is relevant and second if elaborated control groups are defined. The latter presumably demands the access of population data like census data.

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