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MATTHEW EFFECTS AND R&D SUBSIDIES IN HIGH-TECH AND LOW-TECH INDUSTRIES

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MATTHEW EFFECTS AND R&D SUBSIDIES IN HIGH-TECH AND LOW-TECH INDUSTRIES[1]

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Abstract

Public policy plays a key role in supporting R&D activities and a variety of policy tools have been applied to contrast the undersupply of technological knowledge including the provision of subsidies to private firms performing R&D activities. A large literature has identified the sources of 'government failures' in discretionary procedures in problems related to asymmetric information and the operation of interest groups. This paper explores the causes and effects of persistence in the discretionary allocation of public subsidies to R&D activities performed by private firms and elaborates a crucial distinction between *vicious* Matthew-effects and *virtuous* Matthew-effects. The latter identifies the role of dynamic increasing returns based upon accumulation of competence stemming from learning, learning to learn and knowledge cumulability. On the contrary *vicious* Matthew-effects lead to substitution of private funds with public ones and represent an additional source of 'government failure' which has not been specifically addressed by previous literature. Virtuous Matthew effects are found in high-tech industries where learning and knowledge cumulability are higher. On the contrary, in traditional industries, perverse Matthew effects prevail. The empirical analysis based upon Transition Probability Matrices, Probit regression and Propensity Score Matching tested the relevance of these arguments on a sample of about 750 Italian firms in the years 1998-2003. We conclude that while the decision to rely on discretionary incentives based on beauty context selection procedures may imply relevant costs, their benefits can be increased by pursuing a 'picking the winner strategy' particularly in high-tech sectors.

KEY-WORDS: R&D SUBSIDIES; PERSISTENCE; GOVERNMENT FAILURES, MATTHEW EFFECTS

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1. Introduction

A large literature has identified the case for a substantial market failure in the identification of the correct amount of resources that markets are able to invest in the generation of technological and scientific knowledge (Nelson, 1959; Arrow, 1962a). The intervention of the state to compensate for such underinvestment has been repeatedly advocated and significant amounts of public funds have been spent on programs to stimulate not only the generation of new scientific knowledge in research institutions, but also to support innovative activities performed by private firms (OECD, 2007).

However, the actual impact of R&D subsidies on firm's innovative activities is not obvious and it is possible that public subsidies crowd-out private investment (David and Hall, 2000; David et al., 2000; Hall and van Reenen, 2000; Bloom et al., 2002). A number of explanations have been provided for the potential ineffectiveness of public R&D incentives. In particular, the following arguments appear to be relevant for understanding the sources of 'government failures' in this context, which might be as large or even larger than the 'market failure' it is supposed to correct (Nelson, 1980). The first is related to the problem of asymmetric information and the consequent difficulty of policymakers and program officials to know which firms to favour (Grossman, 1991; Stiglitz and Wallsten, 2000). Moreover, interest group theories argue that the possibility of receiving some kind of public support gives industries and other interest groups an incentive to invest large resources in unproductive rent-seeking activities such as lobbying (see e.g. Tollison, 1997). Therefore, irrespective of the information problems governments have, politicians try to maximise votes and to allocate subsidies optimally from a political point of view, by responding to the requests of interest groups (see e.g. Peltzman, 1976; Olson, 1982; Mitchell and Munger, 1991; Magee, 1997). In addition to this, the efficiency of public support for R&D activities may be further harmed if bureaucrats seek to maximize their own utility and the distribution scheme is consequently designed to achieve the goal of the bureaucrat himself (Link, 1977).

The allocation of public subsidies takes place either with automatic procedures, typically associated with tax expenditures, or with discretionary beauty context procedures based upon the assessment of the quality of the research programmes. The main theoretical as well as practical difference between subsidizing R&D by tax credits rather than by a direct grant is that the former is neutral with respect to industry or sector and the characteristics of the firm. The most important advantage of tax credit programs relative to direct grants is that they minimize the discretionary decisions involved in project selection for direct government grants (Bozeman and Link, 1984). However, much literature has criticized automatic procedures, mainly based upon tax incentives, and praised the positive effects of discretionary procedures based upon the actual screening of the research projects. The former risk, in fact, to provide support to an array of activities that often do not actually consist in research activities performed by firms that are not actually able to carry out properly research programmes and to make an effective use of the subsidies. The risks of opportunistic behaviour moreover seem to be very high. Firms label some expenses as finalized to research activities while they actually fund other kinds of business activities vaguely related to research: the effective control of public authorities is almost impossible. In parallel, the lobbying activities of firms exert relevant pressure on government authorities in order to obtain changes in the definitions of what counted as R&D as to broadening allowable costs (Alt et al., 2010).

Moreover, according to David et al.(2000), private firms are likely to use any tax credits to first fund projects with the highest private rate of return. For this reason they argue that tax credit users are likely to concentrate their research efforts on projects with short term prospects. These are not necessarily the projects that would most deserve public support, which should concentrate on projects with the largest gap between social and private returns. The availability of tax credits is therefore unlikely to increase the probability that the users will undertake projects with high social and low private rate of return. Hence, even though tax credits represent an agile way of providing public support to R&D and to reduce problems related to 'government failure', they do not appear to be the most efficient tool to correct the 'market failure' (Shane, 2009). On the opposite R&D grants are potentially better suited to fill the gap between the private and social returns to innovation not only for the higher chances to select and hence support better research projects, but also because this allocation procedure of public subsidies can help identifying and supporting potential complementarities among innovative projects (Milgrom and Robets, 1995; Mohnen and Roller, 2005). As a matter of fact many countries do rely on discretionary incentives based on beauty context selection procedures, even though this may come at a cost.

A considerable amount of evidence upon the effectiveness of discretionary grants and on the persistence in their allocation to past recipients has now become available. The identification of such persistency has engendered much perplexity upon the actual reliability of selective procedures and their limitations. In the present paper we claim that it is important to qualify the persistence, whether it is actually and necessarily dysfunctional, or it may be even fruitful from a dynamic efficiency viewpoint and, hence, that it is necessary to enquire about the causes and the effects of persistence in the provision of public subsidies. In doing so we apply to research policy the notion of Matthew effect drawn from the economics of science to assess the causes and effects of the persistence in the assignment of R&D subsidies (Merton, 1968; Arora and Gambardella, 1997; Rigney, 2010). In order to highlight the relevance of this issue, we propose the distinction between *virtuous* and *vicious* Matthew effects. The former consist in the persistence of the provision of subsidies to firms that have been actually able to use previous subsidies to effectively increase their R&D activities. The latter include the cases of persistence in the assignment of public subsidies based on sheer reputation, even to firms that have actually reduced their commitment to research after receiving previous subsidies. The *vicious* case identifies an additional potential source of 'government failure' in the provision of R&D grants, which has not been discussed by previous literature on the subject. On the contrary in the *virtuous* case public authorities can be right in confirming their preferences for firms that have taken advantage of previous grants simply because their projects embody a larger amount of inputs, higher levels of competence and expertise and hence are simply of a higher and better quality. In this context we claim that Matthew effects would be consistent and would complement a strategy of 'picking the winners' in the provision of public subsidies to R&D, by replacing pure arbitrary criteria that might be adopted by selection committees in the absence of such a constraining strategy and, consequently, increasing the efficiency of public support to firms' innovative activities (Cantner and Kösters, 2009).

Moreover, we argue that the characters of the knowledge generation process play a key role in discriminating among virtuous and perverse Matthew effects. The levels of knowledge cumulability, R&D sunk costs and learning to learn have a direct bearing upon the likelihood that the prior allocation of public subsidies exerts a positive effect upon the actual capability of the recipients to undertake successful research processes. On the contrary, selection committees are more likely to be biased by sheer reputation effects when firms are active in traditional sectors.

The relevance of these arguments is empirically tested by implementing the framework of analysis based on transition probabilities between states and by developing an original model on the determinants of firm's access to R&D grants. The relevance of these arguments is empirically tested by implementing the framework of analysis based on transition probabilities between states and by developing an econometric model of the determinants of firm's access to R&D grants. This issue is further investigated through an evaluation impact analysis based on the Propensity Score Matching method. This allows us to assess the effect of public grants on firm's R&D intensity providing complementary evidence on the nature of the identified persistence.

The empirical analysis is based on the rich information contained in two waves of the Survey on Italian Manufacturing Firms realised by the Unicredit Group. Each wave collects contemporary and retrospective (previous three years) data from samples of more than four thousand firms. In order to obtain a dataset for the study, with two distinct points of observation, it has been necessary to merge the two waves (covering the years from 1998 to 2003). The matched database, containing data for the years 1998-2003, covers around 750 manufacturing firms observed in both the two periods.

2. The Matthew effect in R&D subsidies

The anecdotic evidence about the selective assignment of public subsidies to R&D activities performed by private firms, based upon discretionary procedures aimed at the identification and assessment of the actual quality of the research projects that deserve to be funded with public money, suggests that major 'government failures' may take place. Discretionary procedures to select public subsidies to R&D projects proposed by private firms are based upon the working of Committees of experts appointed by the Ministry and other Intermediary Agencies. The Committees select the projects according to their scientific and technological relevance and to their assessment of the capability of firms to actually perform and finalize the research programmes. It is a typical beauty context characterized by major information asymmetries: the members of the Committees have limited information upon the actual capabilities of the firm to conduct the specific research programmes that are being proposed. Moreover, the work by Committees might be influenced by the pressures exerted by interest groups which invest large resources in unproductive rent-seeking activities.

For these reasons many criticisms have emerged and the basic question concerns the limitations of the procedure and the possible biases in the selection procedures. However, in this context little attention has been devoted to the determinants and the effects of persistence in the provision of public subsidies. Such considerations appear to be relevant in the light of the argument based on the Mertonian 'Matthew effect', according to which the public assessment of the quality of scientific research is related to previous accomplishments. As Merton noted: "…eminent scientists get disproportionately great credit for their contributions to science while unknown scientists tend to get disproportionately little credit for comparable contributions" (Merton, 1968:57). While in the economics of science the 'Matthew effect' hypothesis has received considerable attention (David and Gambardella, 1997; Arora et al., 1998; Medoff, 2006), the relevance of this argument has not been properly elaborated in the economics of innovation policy. Following a typical recombinatory process we believe that the transfer and application of the issues and methodological results of the Matthew effect away from the economics of science into the economics of innovation policy can yield interesting results.

At a first sight it is possible to directly and quite abruptly apply the quote from Merton to the specific context of the provision of public subsidies based upon the assessment of the quality of the research programs and articulate the view that the past ability of firms to receive public support for R&D activities would in fact generate some dysfunctional persistence effects in the probability of gaining access to public funding, even independently from their actual innovative efforts. Along this view, a 41st chair effect risks to take place in the provision of public subsidies and valiant research programmes presented by unknown firms risk to be deprived of the deserved public support with very negative effects in terms of waste of resources, misallocation of public money and losses associated with the delay and the possible decay of relevant research programmes.

Following this line of analysis the criticisms to the selection procedures based upon the perceived quality of the research projects and of the firms performing them, is enriched by the argument that the experts that are members of the selection committees would be too much influenced by the scientific and technological reputation of the candidates, rather than by the sheer quality of the projects. Actually the reputation of the candidates would become a reliable proxy for the quality of the projects. Such reputation would be strongly influenced by previous awards and specifically by the inclusion in precedent assignment tournaments. The claim is that firms that have already received a selective subsidy based upon discretionary procedures censed to screen their quality of the projects in the past have disproportionately higher chances to be selected again, simply because of their acquired reputation, and not because of a correct assessment of their actual efforts. According to these criticisms a *vicious* Matthew effect, i.e. a dysfunctional persistence, would take place in the selective allocation of public subsidies based upon beauty contexts.

However, in order to clarify whether the Matthew effect is exclusively dysfunctional, the careful reading of the original text by Robert Merton is necessary and it reveals that the issue is far from being univocal. As a matter of fact Merton elaborates two distinct arguments. Ex-post we can term the first an information economics argument and a knowledge economics the second, which lead us to propose the distinction between *vicious* and *virtuous* Matthew effects.

The first argument has been already considered and consists in a typical issue elaborated in information economics: search costs and information asymmetries. Authors (members of selection committees) read and cite (praise) better the work of eminent scientists (established firms that were recipients of previous subsidies) because their reputation helps screening the backlog of redundant information (excess number of applicants). Reputation reduces search costs and information asymmetries. Authors (members of selection committees), facing new articles (projects) that are supposed to be original and innovative, and hence such that they cannot command fully, are more ready to trusts established scientists (firms) rather than un-known ones. Once more, and yet for a different reason, they will cite (praise) more the articles (projects) proposed by established scientists (firms that have already won previous tournaments). The second argument stems from the careful reading of Robert Merton's text: "The recognition accorded scientific achievements by the scientist's pier is a reward in the strict sense identified by Parson. As we shall see, such recognition can be converted into an instrumental asset as enlarged facilities are made available to the honoured scientists for further work…the reward system thus influences the 'class structure' of science by providing as stratified distribution of chances, among scientists, for enlarging their role as investigators" (Merton, 1968:57).

This second argument is well supported by the arrovian economics of knowledge (Arrow, 1962a, 1962b, 1969; David, 1994) on two different and yet complementary counts: a) authors (firms) who have been selected in previous tournaments are the persistent recipients of beauty context allocations because they had the opportunity to enlarge their role as investigators in terms of increased access to scarce research resources and the opportunity to concentrate and specialize in conducting their research. In this case past recipients should have performed larger flows of R&D activities, although partly funded by public grants; b) past recipients had the opportunity to learn to learn (Stiglitz, 1987). No surprise hence that in a successive tournament their scientific production, be articles for scientists or research projects for firms, will be actually and intrinsically better. Knowledge exhibits intrinsic cumulability both at the individual, organization and system levels. New knowledge is the result of the recombination of existing bits of knowledge: hence the larger the knowledge base under the command of each firm (author) and the larger the chances to generate new technological (scientific) knowledge (Weitzman, 1996 and 1998). Firms and scientists that received additional resources to conduct research at time t-1, can take advantage of the knowledge generated in the past and climb at times t and t+1, on their own shoulders that will happen to be quite obviously higher and larger than the shoulders of third parties which could not benefit from previous assignment of dedicated resources. This amounts to argue that in the economics of R&D activities a positive relationship between the stock of existing competence and the output in terms of technological knowledge, for a given amount of current efforts, is at work. Consequently, in this second case the persistence effects do not necessarily identify an economic dysfunctionality. On the contrary, in this context a *virtuous* Matthew effect can be justified by the economics of knowledge. Readers and committees members might be perfectly right in confirming their preferences for scientists and firms that have taken advantage of previous awards, simply because their products embody a larger amount of inputs, higher levels of competence and expertise and hence are simply of a higher and better quality.

The proposed distinction between the two types of Matthew effects appears to be relevant in the light of recent advancements in the literature on public subsidies to firm's innovative activities. These studies showed that a possible way to reduce 'government failures' in the allocation of subsidies and to increase the efficiency of public support to private companies is to follow a 'picking-the-winner strategy' (Shane, 2009; Cantner and Kösters, 2009). In so doing program agencies choose firms that are more experienced and capable or firms which are already on a high level of technological competence or on a promising strategic and technological path. Evidence for a policy focus on high potential and best-equipped firms has been recently found for example in the German case (Aschhoff, 2010; Hussinger, 2008; Cantner and Kösters, 2009), highlighting the advantages of adopting such a strategy.

In this context the observation of persistence in the access to R&D grants could be associated with a *virtuous* Matthew effect instead of a *vicious* one. The repeated and sequential selection of firms that were recipients of previous subsidies is in fact fully justified when and if they are able to implement and propose projects of a intrinsic higher quality because of the higher content in terms of R&D activities. These firms are currently able to perform more R&D and to support higher levels of talents of the scientific personnel at work within the firm. In this case in fact, the higher quality is made possible by the current levels of R&D activities augmented by the previous allocation of subsidies and hence the accumulation of knowledge and competence based upon learning processes activated at an earlier stage by previous subsidies. Here the different characteristics of industrial sectors may play a role and the distinction between reputation persistence and competence persistence can be useful to interpret differentiated effects of subsidies across different types of industrial sectors.

In the high-tech science based industries the generation of technological knowledge is indeed characterized by high levels of cumulativity with actual persistence in the introduction of innovations at the firm level (Ortega-Argiles, Piva, Potters, Vivarelli, 2010; Antonelli, Crespi, Scellato, 2010). In these industries the experts of the selection committees have much more opportunities to assess the actual quality of

the research projects: the proximity to scientific knowledge helps the screening process and favours the inclusion of high quality projects and the exclusion of phoney innovators. The allocation of public subsidies in prior discretionary rounds is likely to affect positively the actual enlargement of the knowledge base of the firm, to increase its opportunity to learn to learn and to take advantage of economies of density stemming from the sunk costs (Lee, 2011). Hence following Merton we can believe that prior subsidies have actually been instrumental "for enlarging their role as investigators". In sum, the allocation of public subsidies by means of discretionary procedures in high-tech sectors is likely to activate virtuous Matthew effects (Gonzalez, Jaumandreu, Pazo, 2005 and 2008) and to complement internal funds for R&D activities (García-Quevedo, 2004).
On the opposite, in traditional sectors where the cumulativity of technological knowledge is much lower, process innovations purchased from upstream suppliers prevail and the introduction of product innovation is occasional, there is a stronger possibility that the allocation of public subsidies based on discretionary procedures is more influenced by reputation effects (Almus, Czarnitzki, 2003; Busom, 2000). The members of the selection committees can rely less of the scientific content of the project to assess their quality. The reputation based upon previous inclusions may have stronger effects, because of higher levels of subjectivity in the assessment. The probabilities of inclusion of phones innovators and exclusion of true innovators are higher. The allocation of previous subsidies may have engendered typical crowding out effects with the substitution of private funds with public ones and hence no increase in the actual levels of research intensity (Kauko, 1996; Klette, Moen, Griliches, 2000).

Following these arguments our hypotheses can be synthesized as it follows:

H1: Matthew effects are relevant. We expect that significant persistence is at work in the allocation of public subsidies by means of beauty context discretionary allocation procedures aimed at the identification of higher quality research projects.

H2: Matthew effects can be of two types. If a pure reputation *vicious* effect is at work we expect that in the allocation of R&D subsidies only the achievement of past grant is relevant in explaining the current access to public funds. On the contrary we expect that in the *virtuous* case the allocation of R&D subsidies can identify firms that are actually better able to persist and succeed in the pursuit of innovation strategies. Such persistence can be explained by their higher commitment to innovative activities and by the accumulation of expertise, tacit and codified knowledge by firms that had access to larger resources for a longer stretch of time to conduct research in the past, also because of the previous allocation of public subsidies. In this context Matthew effects would be consistent with a 'picking the winners' strategy, with potential benefits in the effectiveness of the adopted policy instrument.

H3: Competence Matthew effects matter with path dependent dynamics in high-tech industries where knowledge cumulativity is higher. In this context innovation persistence is expected to be most relevant and to exert a major role in explaining firms' innovation performance only when and if current R&D activities of firms reflect higher levels of competence.

H4: Reputation Matthew Effects are expected to apply to Low-Tech industries with past dependent dynamics. Reputation Matthew effects take place when selection committees, unable to assess the true content of the research proposal, because of its low scientific content, are mainly influenced by information externalities.

3. Descriptive analysis and empirical strategy

3.1 Empirical strategy

Consistently with the theoretical discussion, in our empirical analysis we follow three different but complementary approaches. The first aims at the identification of firm-level persistence in the access to R&D subsidies by means of Transition Probability Matrixes (TPM). The second explores the determinants of firm-level persistence in gaining public support by means of a probit model and qualify the allocation strategy pursued by public authorities in granting subsidies. Finally, the third applies a propensity score matching method to evaluate the impact of public subsidies on firms' innovative investments. While the initial TPM approach is expected to provide only summary evidence on the persistence of firms' access to R&D subsidies along time, the probit analysis aims at identifying the actual role of past subsidy history in determining the admission to subsequent support programs when relevant contingent factors are taken into account. In this way it will be possible to test the relevance of the Matthew effect and to obtain a first indication on the nature of the identified persistence, by verifying if it is consistent with a 'picking the winner strategy' adopted by granting committees. Moreover, the probit model will offer the statistical basis for an evaluation impact exercise which will allow us to obtain complementary insights on whether it is possible to identify a *virtuous effect*, that is past grants increase the innovative performance of benefited firms and consequently the probability to access further funding, or a pure *reputational effect* so that the past success in receiving public support increases the probability of gaining access to public funding independently from firms' innovative results.

3.2 Database description

The analysis is based on a dataset derived from the questionnaire surveys developed originally by the investment bank Mediocredito Centrale (MCC, now Unicredit), regarding a representative sample of Italian manufacturing firms with more than 11 employees. The original MCC database comes from two different questionnaire waves, each of them collecting contemporary and retrospective (previous three years) data from samples of more than 4000 firms. In order to obtain a dataset for our study, we merged two waves (covering years from 1998 to 2003). For the purposes of our analysis we restricted the sample to firms which invest in R&D activities and which have been observed in both the two waves of the survey. We finally cleaned the dataset by eliminating outliers and cases of M&As, ending up with a balanced dataset of 752 manufacturing firms observed two times over a 6-year period. The questionnaire survey collects information about firm structure and behaviour, including investment and innovation activities, internationalization strategies, financial characteristics and public grants and fiscal incentives. As the paper will discuss in detail, the richness of the information contained in the database and the possibility to observe both supported and non supported firms for two times in the considered period offers a high satisfactory information base to account for the role of firm's past subsidy history in the analysis of the determinants of R&D subsidies and in the evaluation of their effectiveness.

Table 1 exhibits the sectoral composition of the sample, while Table 2 provides the basic descriptive statistics of the sample. The share of firms that accessed R&D subsidies were respectively 13.56% in the period 1998-2000 and 22.61% in the period 2001-2003. In the period 2001-2003, the companies included in the sample had an average number of employees equal to 139. Firms not receiving R&D subsidies are smaller than those that are granted a subsidy (115 employees vs. 222). This evidence is confirmed when turnover is taken into account, with an average turnover for subsidized firms of about 59 Millions of Euros and of about 33 Millions of Euros for non subsidized companies.

Subsidized firms are also more capital intensive, with a capital labour ratio value of about €5582 per worker against €5262 for non-subsidized ones. The same pattern holds for R&D investments and human resources devoted to R&D activities. Firms receiving grants are, on average, more R&D intensive than non benefiting ones (5242 Euros per worker invested in R&D vs. 2744 Euros), and employ a higher percentage of total workers in R&D activities (11.06% vs. 8.46%). However, as it will be subsequently clarified, such difference cannot be considered as an effect of R&D subsidies since it may simply reflect the selective nature of the group of funded firms.

[Insert Table 1 here]

[Insert Table 2 here]

3.3 Descriptive analysis based on Transition Probability Matrixes

In this section we provide descriptive evidence on the extent of firm-level persistence in the access to R&D subsidies, using transition probability matrixes. This statistical tool allows to modelling the sequence of subsidized and non-subsidized states as a stochastic process approximated by a two-state Markov chain with transition probabilities:

$$P[X_t = i \mid X_{t-1} = j] = \begin{bmatrix} p, (1-p) \\ (1-q), q \end{bmatrix}$$

Each term of the (2X2) TPM will be the conditional probability $p_{ij} = P(I_t = j \mid I_{t-1} = i)$, or the probability of moving from state j to state i[2].

The analysis of the diagonal terms, based on estimated transition probabilities (Roper and Dundas, 2008), allows the identification of specific patterns of persistence. In the case of a 2-dimensional matrix there is evidence of persistence if the sum of the main diagonal terms is more than 1.

[Insert Table 3 here]

This applies to our data representing a first indication of the presence of some form of inter-temporal stability in the access to R&D subsidies that has to be qualified by looking in more details at our empirical findings (see Table 3). In particular, for the whole sample, while the probability of accessing public funding at time t for non-subsidized companies at t-1 is only 0.19, the probability of obtaining R&D subsidies in period t for subsidized firms in period t-1 is 0.45, that is more than the double. Symmetrically, the "negative" state dependence appears to be very strong in our sample, with 81% of non-subsidized companies in t-1 still not gaining access to public subsidies at time t.
The distinction between two (equally sized) groups of companies classified by dimension (Table 4) offers further insights to the analysis, highlighting that an higher level of state dependence in accessing public funds for R&D investments concerns companies with the largest number of employees. In this latter case, while the probability of accessing public funding at time t for non-subsidized companies at t-1 is 0.22, the probability of obtaining R&D subsidies in period t for subsidized

[2] Let P_{ij} and $\hat{P}_{ij}$ denote the population and sample probabilities of a transition of a company from the status i to the status j. This transition process can also be seen as the outcome of a binomial distribution. Hence, standard errors of the estimated transition probabilities can be calculated as a binomial standard deviation: $\sqrt{P_{ij} * (1-P_{ij})/N}$ where N equals the number of companies in status i. As N increases $\hat{P}_{ij}$ tends to P_{ij} . In the matrixes that will be presented in our analysis the binomial process has just two possible outcomes, hence the estimated standard error is the same for the elements of each row in the 2X2 matrix.

firms in period t-1 is 0.48. The same probability is 0.40 for companies belonging to the group of smallest firms.

[Insert Table 4 here]

Finally, Table 5 presents the analysis of the TPMs based on two (equally sized) subsamples ordered in terms of firms' R&D personnel intensity, which shows that the overall degree of state dependence in accessing R&D subsidies increases with the percentage of R&D personnel over total employees. In the case of companies belonging to the top 50% in terms of R&D personnel intensity strong "positive" state dependence is found, with a probability of obtaining grants in period t for subsidized firms in period t-1 equal to 0.5. Conversely, the "negative" state dependence decreases with the percentage of R&D personnel, with the share of non-subsidized companies in t-1 still not gaining access to public subsidies at time t falling from 0.85 (Low group) to 0.76 (High group).

[Insert Table 5 here]

The analysis conducted so far provides strong preliminary indications for state dependence in firm's access to public funds for R&D investments, with differentiated patterns of persistence across crucial dimensions such as size or the intensity of R&D capabilities. It should be clear that such findings provide only a preliminary support about the relevance of persistence in the access to public R&D subsidies by firms. In fact they suggest the presence of some form of inter-temporal stability in getting public funds for firms' innovative activities. However, they do not provide, yet, a sound indication on how much the observed persistence can be identified as a true state persistence, which would represent a more solid indication of the presence of operating mechanisms related to Matthew effects in the access to public support for R&D. The observed persistence can clearly be influenced by other factors, and the evidence provided in Tables 4 and 5 offers precise hints in this direction. The econometric analysis in the next section aims specifically at controlling for those factors in order to test the robustness of this result and eventually isolate true state persistence effects.

4. Econometric analysis

4.1 The probit model

In this section we present the econometric model that tests the determinants of the access to R&D public support with special attention to firm's past subsidy history. The analysis is based on a probit model in which the dependent variable is affected by a set of exogenous control variables and by the lagged realization of the dependent variable. The presence of the lagged outcome variable allows us to test

the hypothesis of true state dependence. In this way we aim at capturing the effect on firms' current subsidy status of the event of being subsidized or not at time t-1.
In our econometric analysis we estimate a probit model of the event (Y=1) of receiving a public R&D subsidy that can be represented as follows:

$$\Pr(Y_{it} = 1 \mid X_{it-1}, Y_{it-1}) \quad (1)$$

where $X_{i,t-1}$ is a vector of observable firm i's characteristics at t-1 and Y_{it-1} the event of being subsidized or not at time t-1[3].

Control variables beside firms' past R&D subsidy history have been selected in this study according to the empirical evidence that analysed this probability (Busom, 2000; Wallsten, 2000; Arvanitis et al., 2002; Almus and Czarnitzki, 2003; Duguet, 2004; Blanes and Busom, 2004; Görg, H. and E. Strobl, 2007; Hussinger, 2008). The theoretical and empirical literature points to a number of factors that are correlated to the probability of receiving a subsidy for R&D. Previous research has found that several firm characteristics, such as group membership, size, age, financial structure, past R&D and innovation efforts or export activity are correlated with public funding of R&D. Although the studies widely differ in the support programs under analysis, in almost all the studies large firms who planned their innovation activity and had previous R&D experience were the main beneficiaries of subsidies.

In more detail the control variables used in our model specifications are the following:

Firm size (lagged): Evaluation studies suggest that larger firms are more likely to be subsidized than smaller firms. This is in part due to the positive relationship between firm size and innovation activities which has been extensively debated in the literature (Cohen and Klepper, 1996). In the probit model, firm size is measured as the log of total number of employees.

Firm age: The experience in the application process for public funding can be a relevant determinant. Moreover, from an interest-group perspective, one would also expect that supports should be biased towards older firms. Older firms may have had better opportunities new and young firms to establish contacts with and influence the support-granting authorities.

Past Innovative Behaviour Indicators: If policymakers follow a "picking the winner" strategy in allocating the public R&D funds, the probability of the receipt of public R&D funding is affected by the existing R&D staff and equipment and the innovative history of the firm. Research has shown that previous innovation activities, proxied by patents or by the presence of R&D departments, are positively related to the probability of being subsidized (Wallsten, 2000; Hussinger, 2008). Previous research activities influences the granting of subsidies because the firms

[3] Given the structure of our data for *t* has to be intended the years 2001-2003 and for *t-1* the years 1998-2000.

that do the more R&D are the ones that are the most likely to apply for subsidies. It is in fact to be expected that those firms with previous R&D experience which systematically plan their activities, detailing them in a plan, will find making the request for subsidies easier. In the model the innovative background is approximated by the percentage of R&D personnel over total employee and by a dummy variable indicating whether the firm introduced any innovation at time t-1 or not.

Export activity (lagged): Firms that export their products are usually exposed to strong international competition, and are likely to strengthen their competitiveness through innovation. Furthermore, one of the goals of R&D funding schemes may be to strengthen the competitiveness of firms in international markets. Thus, export activities can represent a signal for the allocation decision of the public R&D funds if policymakers are believed to be inclined to subsidize R&D projects with potentially high international market success (Blanes and Busom, 2004).

Other characteristics of the firm: We have considered other variables that might have an important discriminatory power between subsidised and non-subsidised firms. The relationship of these variables with innovation activities has been widely documented in the literature. In particular, the econometric specifications account for **group membership**, since firm belonging to a group may be better equipped to apply for a subsidy because resources at the corporate level, such as information, expertise and funds, are made available to the applicant; **credit rationing** (proxied by the percentage of firms declaring of having asked for additional funds being denied at t-1); the intensity of fixed capital investments measured as the log of fixed capital investments per employee at t-1 as well as ICT investments. All models will be tested on the whole sample and on the two sub-samples concerning companies operating in Low-Tech and High-Tech industries.
In the following Table 8 we report the definition of the variables that will be used in the different specifications of the model on the persistence of R&D subsidies.

[Insert Table 6 here]

4.2 The impact evaluation analysis

Building on the results obtained from the probit model previously described it is possible to carry out an impact evaluation analysis on public R&D subsidies. In order to test the effect of public grants (treatment) on the targeted subjects (treated), it has to be taken into account that the receipt of a subsidy is not random, but rather is subject to different selection processes. Among the different methods developed to perform impact evaluation analysis, the approach based on matching techniques has been widely used in recent years (Heckman et al., 1999, Blundell and Costa Dias, 2000; Almus and Czarnitzki, 2003; Hussinger, 2008). In our analysis we follow this approach, which appears to be appropriate with respect to the objectives of the research and the statistical information available. Regarding this latter aspect, four important characteristics of the database used for the empirical analysis appear to be relevant for the effectiveness of the evaluation method adopted (Heckman, Ichimura and Todd, 1998). First, the information on both supported and not-supported firms derives from the same survey; second, the data contains a rich set of variables on firms' structure and behaviour relevant to modelling the participating decision; third, the goodness of matching is facilitated by the presence of a large number of non-treated companies in the sample; finally, the use of two survey waves allowed us to use lagged variables as controls in the selection equation so that we could reduce problems due to endogeneity.

The crucial research issue in this type of analyses is to measure the effect of public R&D support on firms' innovation performances in the absence of counterfactual evidence, so that it is not possible to forecast the result of firms' innovation performances in the absence of subsidies. The solution that can be adopted in such circumstances is to use the results of non-treated firms, with similar characteristics, to estimate the possible effect on treated companies had they not participated in public funded R&D programmes. The basic idea of matching is then to balance the sample of subsidy recipients and comparable non-recipients by selecting the best twin from the control group for each subsidized firm, so that the means of the outcome are comparable between the two groups. In this way, the differences in the means of the outcome variable between the treated and the selected control groups (Average Treatment Effect on the Treated – ATT) can be then attributed to the treatment (Rosenbaum and Rubin, 1983; Heckman et al. 1998).

In the ideal case, the best twin for a subsidized firm is the firm which is identical in all relevant characteristics. However, when the number of matching criteria is large, it would be very difficult to find any such observation. A solution to this problem is represented by the "propensity score" matching (PSM) method, proposed by Rosenbaum and Rubin (1983) who demonstrated that it is possible to reduce the multi-dimensionality of the matching procedure through the use of a synthetic mono-dimensional propensity score. The procedure consists in estimating the propensity score which is the probability of accessing R&D subsidies for the whole sample and find pairs of treated and non-treated that have the same probability value of participation. Usually, a 'nearest neighbour' (NN) matching is performed, so that the control observation with the estimated probability value closest to the participant is selected.

The Average Treatment Effect on the Treated (ATT) is only defined in the region of common support, since a major source of evaluation bias arises if the common support assumption is violated (Heckman et al., 1997). Hence, an important step is to check the overlap and the region of common support between treatment and comparison group. We therefore have to impose the restriction that the region of common support lies between the minimum and the maximum of the propensity score of the comparison group and consequently drop in the estimates the treatment observations whose propensity score lies outside this region.

Since we do not condition on all covariates but on the propensity score it is important to check if the matching procedure is able to balance the differences of the relevant variables in both the control and treatment group. In order to assess the quality of the matching we will compare the situation before and after the NN matching and we will check, with two-sample t-tests, if differences after conditioning on the propensity score have been eliminated. Finally, as a further test we will check the robustness of our results by using different matching estimators.

5. Empirical results

Table 7 shows the results for different specifications of the probit model regarding the determinants of firms' access to public R&D subsidies. Globally, the predictions of the probit models are good with about 80% of concordant predictions and levels of the likelihood ratio chi-square always suggesting that our models, as a whole, are statistically significant. Results in general show that, even after controlling for a number of firm and industry level characteristics, the probability of observing a subsidized company in period t is still positively and significantly affected by its R&D subsidy history. Hence, the estimated models confirm the picture emerged from the analysis on TPMs highlighting the presence of state dependence in the access of public R&D grants by firms, which, however, turns out to be shaped by specific firms' idiosyncratic characteristics.

Moreover, the significance of other variables entered in the models is most important as it confirms the path dependent character of the non-ergodic persistence. Among the relevant factors, the size of observed companies, their age and the level of R&D capabilities, as measured by the share of internal R&D personnel over total employee, significantly enhance the probability of subsequent access to public R&D subsidies.

With respect to our research hypotheses these results have important implications. First, the stable significance of the coefficient associated with past R&D subsidies confirms that in analysing the issues related to the allocation of public R&D grants and in assessing their effectiveness it is important to look at the effects of persistence in the provision of public subsidies. Second, since this result is robust to the introduction of a number of relevant control variables we can claim that the access to R&D subsidies is characterised by state dependence, suggesting that some mechanism related to Matthew effects is at work. Third, the joint significance of the variable associated with the intensity of R&D capabilities previously accumulated, along with that related to past grants can be interpreted as a first indication that the identified Matthew effect is not necessarily *vicious*. The strength of firms' technological capabilities would not be significant if the persistence was purely reputational because the past conditions related to grant's assignment would play an exhaustive causal role. On the contrary, the detected persistence could be also explained by the accumulation of expertise, tacit and codified knowledge by firms that had access to larger resources to conduct research in the past, also because of the previous allocation of public subsidies.

These results can be qualified further by looking at differentiated patterns that can be observed for different groups of industries as shown in Table 8. Here a clear distinction emerges between companies operating in the two different groups of industries. In the case of low-tech industries, the past access to R&D subsidies is the only variable that appears to matter in every model specifications considered. On the contrary, for the group of firms in high-tech sectors, R&D subsidy history is statistically relevant but with a lower magnitude and other characteristics of companies appear to be important in shaping the probability of accessing subsidies. In particular firms' research capabilities come out as a crucial determinant in the allocation of public resources in this field.
These results are consistent with our research hypotheses and have relevant implications. In both cases Matthew effects apply, but they appear to have a distinct nature. In particular, in low-tech sectors, the dynamics of the process is purely past dependent where cumulative and self-reinforcing reputational effects dominate whatever firms do along the process. On the contrary, in the case of high-tech sectors the process is path dependent: the past allocation of a public subsidy matters but does not guarantee that the firm will receive a subsidy in subsequent rounds of allocation. When competence-virtuous Matthew effects apply, firms' specific behaviours and characteristics are relevant in shaping committee members perception of the actual technological competence accumulated by applicant companies also as a consequence of previous grants. In particular, our results show that larger, experienced and R&D intensive firms are perceived as more promising to be successful with their R&D projects and are, consequently, more likely to receive public R&D funding. We interpret this result as evidence that in these sectors the distribution policy of public agencies favoured firms guaranteeing the technical viability of the subsidised projects. This suggests that public authorities followed a "picking the winner" strategy by encouraging firms with the best chances to successfully conduct the proposed R&D projects. As already stated, the adoption of such a strategy does not assure that the selected projects are necessarily the best, however, it may represent a practical way to reduce the 'government failure' costs associated with the selective assignment of public subsidies.

Since this distinction is supposed to produce effects in terms of differentiated success of the policy instrument we can test further the result with the impact evaluation analysis based on the Propensity Score Matching method described in the previous section. Table 9 reports the non-parametric estimation results of average treatment effect obtained throw nearest neighbour matching for all the considered models. Results for the whole sample show that after controlling for selection bias the average subsidised firm has significantly greater R&D expenditure per employee compared to a twin-firm not supported by this type of public intervention. This evidence suggests that our data in general support the hypothesis of additionality of R&D subsidies, which do not substitute private R&D investments. Moreover, regarding complementarity effects, the empirical evidence shows that grants do not induce firms to further increase private R&D investment as a response to public funding. As reported in Table 9, firms receiving subsidies are characterised by

higher private R&D investments. However, the result is in general not statistically significant, suggesting that differences between granted and non granted firms are ambiguous.
In order to test if differentiated effects of subsidies across groups of sectors operate, we performed the impact evaluation analysis on the two subsamples of companies in high-tech and low-tech industries.
Our results are clear cut and coherent with our hypotheses. All the tested models confirm that in the former group marked signs of additionality emerge from the analysis. Such evidence represents a further indication on the type of Matthew effect here in action, suggesting the prevalence of a virtuous-competence Matthew effect, where cumulability is at work and the persistence of the provision of subsidies is associated with firms that have been actually able to use previous subsidies to effectively increase their overall R&D activities. Conversely, in Low-Tech industries, additionality in R&D investments is not supported by data suggesting that some substitution mechanism has taken place and that the nature of the identified persistence is mainly perverse.

Different tests have been carried out in order to check for the reliability and robustness of our results. Firstly, we verified that after the matching procedures tests show that all considered variables are balanced in both groups, with the matching strongly reducing the bias of the matched groups with respect to the unmatched groups[4]. We further test the robustness of our results by using different matching estimators (See Table 10). First, we implemented a *Caliper* matching, which avoids the risk of bad matches if the closest neighbour is distant. Finally, since the NN matching is a one-to-one technique and discards data that are potentially valuable, we performed a *Kernel* estimator, which makes it possible to match each treated with more than one comparable non-treated. In this last case we also used bootstrapped standard errors, so that the estimated variance of the treatment effect include the variance due to the derivation of the propensity score, the determination of common support and the order in which treated individuals are matched. The bootstrapping is based on 50 replications of the original sample. As shown in Table 10 our results are robust to different model specifications and different matching techniques adopted.

6. Conclusions and policy implications

Public policy plays a key role in supporting R&D activities. Because of limited appropriability firms are likely to underinvest in the performance of R&D activities with substantial social losses in terms of inadequate supply of technological knowledge. A variety of policy tools have been applied to contrast the undersupply of technological knowledge ranging from the direct involvement of public authorities in the generation of technological and scientific knowledge within

[4] We have omitted the table for reasons of space. Results of the tests are available from the authors on request.

Universities and other public research centers, the procurement of technology intensive products, to the provision of subsidies to private firms performing R&D activities. A sharp debate contrasts the advocates of the merits of the provision of such public subsidies by means of automatic procedures, typically associated with tax expenditures directed to firms able to exhibit their undertaking in R&D activities with the supporters of the advantages of discretionary allocation of grants based upon beauty context procedures.
The sources of 'government failures' in the case of discretionary procedures have been widely discussed in the literature, which mainly focused on the problems related to asymmetric information and interest group arguments. In this paper we propose a further potential critique to discretionary allocation of R&D subsidies, by recognising the possibility that a pathological persistence in the selective discrimination process may take place because past recipients have disproportionate access to public support with respect to other firms that never received such a grant. However, this critique deserved a careful assessment. In particular, the detailed analysis of the theoretical basis of the mertonian Matthew effect has enabled us to elaborate and substantiate analytically the distinction between *virtuous* and *vicious* Matthew effects. This distinction is quite important and deserves further investigation. Careful reading of Merton seminal contribution reveals that persistence in science and hence in research is not necessarily associated with perversion and sub-optimality.
Vicious Matthew effects are clearly at work when the recipients of public subsidies reduce the amount of private funding and actually substitute their internal funds with the public subsidies. *Vicious* Matthew effects concern the cases of persistence in the assignment of public subsidies based on sheer reputation, even to firms that have actually reduced their commitment to research after receiving previous subsidies. *Virtuous* Matthew effects consist in the persistence of the provision of grants to firms that have been actually able to use previous subsidies to effectively increase their competence, their internal stock of technological knowledge and the flows of current R&D activities. Indeed persistence is at work: current behaviour is influenced by past awards, but such persistence reflects dynamic increasing returns in the generation of technological knowledge that can be particularly relevant in high-tech sectors of economic activity.
The relevance of these arguments has been tested by implementing a rich strategy of empirical analysis based on the exam of transition probabilities between states, the development of an original model on the determinants of firm's access to R&D grants and on an evaluation impact analysis adopting the Propensity Score Matching method. Both the descriptive and econometric evidences show that past grants increase the probability to access further funding and suggest that the access to public subsidies for R&D activities is indeed characterised by significant persistence. However a differentiated pattern across sectors emerged from our analysis.
Our results reject the claim that discretionary procedures of allocation engender automatically perverse effects of persistence and exclusion in high-tech sectors. On the opposite the empirical analysis provides evidence on the working of a positive persistence, i.e. *virtuous* Matthew effects in high-tech industries, which turns out to

be coherent with the adoption of a 'picking the winner strategy' by public authorities.
Subsidies give to benefiting firms an artificial competitive edge and, consequently, have the potential to keep inefficient recipients alive and inducing a crowding out of non-subsidized firms. In order to minimize these distortions, subsidies should therefore be targeted at truly "good" firms. Moreover, while the evaluation of the potential outcome of a specific project might be particularly difficult to assess for public agencies, the general assessment of firms' quality seems to be a task that can be performed more easily. It is a matter of looking at their performance in the past. Thus, the observation of persistent flows of R&D or patenting activities and the high level of human capital might represent crucial, objective indicators that public agencies may consider in taking their decisions. Within this context, firms that exhibit both a record of innovative investments and innovative performances above the average in the past might be more likely to be successful in the new innovative venture and hence should be selected in the program. Obviously, the adoption of a 'picking-the-winner strategy' cannot assure an optimal allocation of public resources so that the selected projects are necessarily the best. However particularly in high-tech sectors, such a strategy may represent a viable way through which public authorities can reduce the 'government failure' costs associated with the selective assignment of public subsidies to R&D activities performed by private firms. When the decisions of selection committees are at least partially constrained by the adoption of objective criteria based on firm's past performance, the tendency of assuming totally arbitrary choices, that might be affected by the lobbying activities of interest groups and by the maximising behaviour of policy makers or bureaucrats, could be reduced.
In this respect, the implications of our results are most important as they provide the foundation to support the implementation of discretionary procedures for the allocation of selective subsidies to research projects only in high tech industries. Automatic public subsidies might apply in the rest of the economic system.

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TABLES

Table 1 Sectoral composition of the sample

NACE Rev. 1 Sectors	Number of firms	%
FOOD PRODUCTS AND BEVERAGES	48	6.38
TEXTILES	50	6.65
WEARING APPAREL, DRESSING AND DYING OF FUR	29	3.86
LEATHER, LEATHER PRODUCTS AND FOOTWEAR	29	3.86
WOOD AND PRODUCTS OF WOOD AND CORK	18	2.39
PULP, PAPER AND PAPER PRODUCTS	10	1.33
PRINTING AND PUBLISHING	7	0.93
COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	1	0.13
CHEMICALS AND CHEMICAL PRODUCTS	51	6.78
RUBBER AND PLASTICS PRODUCTS	42	5.59
OTHER NON-METALLIC MINERAL PRODUCTS	32	4.26
BASIC METALS	10	1.33
FABRICATED METAL PRODUCTS, except machinery and equipment	74	9.84
MACHINERY AND EQUIPMENT, N.E.C.	177	23.54
OFFICE, ACCOUNTING AND COMPUTING MACHINERY	6	0.8
ELECTRICAL MACHINERY AND APPARATUS, NEC	42	5.59
RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	30	3.99
MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	29	3.86
MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	13	1.73
OTHER TRANSPORT EQUIPMENT	9	1.2
MANUFACTURING NEC	45	5.98
TOTAL	752	100

Table 2 Summary statistics for the sample (years 2001-2003).

	Total Sample		Access to R&D Subsidies			
			Yes		No	
	Mean	**st dev**	**Mean**	**St. dev.**	**Mean**	**St. dev.**
Number of employees	139.69	520.35	222.06	948.21	115.63	293.08
R&D per employee (Euro)	3308.51	4896.34	5241.93	6396.20	2743.76	4204.22
Share of employees in R&D (%)	8.46	8.96	11.06	9.72	7.71	8.59
Turnover (MEuro)	39.04	271.85	59.08	344.61	33.19	246.64
Fixed capital investments/Emp. (Euro)	5334.325	6506.06	5582.54	6369.79	5261.82	5648.95
Export	83.00%		85.12%		82.38%	
Access to R&D Subsidies (1998-2000)	13.56%					
Access to R&D Subsidies (2001-2003)	22.61%					

Table 3 Transition probabilities between period T and T-1 along years 1998-2003. Full sample.

T-1 \ T	Yes	No
Yes	0.451 (0.0493)	0.549 (0.0493)
No	0.191 (0.0154)	0.809 (0.0154)

Standard Errors in parentheses

Table 4 Transition probabilities between period T and T-1 along years 1998-2003 by size classes.

	T-1 \ T	Yes	No
Group of smallest companies	Yes	0.400 (0.0828)	0.600 (0.0828)
	No	0.165 (0.0202)	0.835 (0.0202)
	T-1 \ T	Yes	No
Group of largest companies	Yes	0.478 (0.0610)	0.522 (0.0610)
	No	0.219 (0.0234)	0.781 (0.0234)

Standard Errors in parentheses

Table 5 Transition probabilities between period T and T-1 along years 1998-2003 by class of R&D personnel intensity

	T-1 \ T	Yes	No
Lowest 50%	Yes	0.361 (0.0801)	0.639 (0.0801)
	No	0.150 (0.0194)	0.850 (0.0194)
	T-1 \ T	Yes	No
Highest 50%	Yes	0.500 (0.0615)	0.500 (0.0615)
	No	0.235 (0.0240)	0.765 (0.0240)

Standard Errors in parentheses

Table 6 Definition of variables.

R&D_SUB	Dummy variable that equals one if the company has access to public R&D subsidies
SIZE	Log of the number of employees
INNOV	Dummy variable that equals one if the company performs any innovation activity
R&D_EMP	Share of R&D personnel over total employee (%)
EXPORT	Dummy variable that equals one if the company exports
INV_EMP	Log of the fixed investments per employee performed by the company
GROUP	Dummy variable that equals one if the company belongs to a group
CRED_RAT	Dummy variable that equals one if the company declared having asked for credit being denied
DEG_EMP	Share of personnel with university degree over total employee (%)
PAVITT	Dummy variables for industry Pavitt classes

Table 7 Probit model. Dependent variable: Access to public R&D subsidies (R&D_SUB)

	(1) Model I	(2) Model II	(3) Model III
R&D_SUB (t-1)	0.63***	0.63***	0.64***
	(0.144)	(0.144)	(0.145)
AGE	0.01*	0.01*	0.01*
	(0.003)	(0.003)	(0.003)
SIZE (t-1)	0.09*	0.09*	0.09
	(0.053)	(0.055)	(0.055)
R&D_EMP (t-1)	0.01***	0.01**	0.01***
	(0.006)	(0.006)	(0.006)
CRED_RAT (t-1)	-0.07	-0.07	-0.07
	(0.140)	(0.140)	(0.141)
GROUP (t-1)	-0.05	-0.05	-0.04
	(0.130)	(0.130)	(0.130)
INV_EMP (t-1)	0.00	0.00	0.00
	(0.016)	(0.016)	(0.016)
EXPORT (t-1)		-0.01	-0.00
		(0.146)	(0.146)
INNOV (t-1)		0.01	0.02
		(0.123)	(0.123)
ICT_EMP (t-1)			-0.01
			(0.006)
Constant	-1.44***	-1.44***	-1.43***
	(0.220)	(0.235)	(0.235)
N. of firms	752	752	752
LR Chi-sq.	42.66	42.67	44.46

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10

Table 8 Probit model. Dependent variable: Access to public R&D subsidies (R&D_SUB)

	LOW-TECH INDUSTRIES			HIGH-TECH INDUSTRIES		
	(1)	(2)	(3)	(5)	(6)	(7)
VARIABLES	Model I	Model II	Model III	Model I	Model II	Model III
R&D_SUB (t-1)	0.99***	0.96***	0.97***	0.36*	0.36*	0.37**
	(0.227)	(0.228)	(0.228)	(0.191)	(0.191)	(0.192)
AGE	0.00	0.00	0.00	0.01*	0.01*	0.01*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
SIZE (t-1)	0.05	0.05	0.05	0.15**	0.13*	0.13*
	(0.079)	(0.083)	(0.083)	(0.075)	(0.077)	(0.077)
R&D_EMP (t-1)	0.01	0.01	0.01	0.02**	0.02***	0.02***
	(0.010)	(0.010)	(0.010)	(0.008)	(0.008)	(0.008)
CRED_RAT (t-1)	-0.29	-0.33	-0.32	0.17	0.18	0.18
	(0.205)	(0.207)	(0.207)	(0.202)	(0.203)	(0.203)
GROUP (t-1)	-0.14	-0.13	-0.13	-0.03	-0.01	0.01
	(0.192)	(0.193)	(0.193)	(0.182)	(0.183)	(0.184)
INV_EMP (t-1)	0.01	0.01	0.01	-0.01	-0.00	0.00
	(0.021)	(0.022)	(0.022)	(0.024)	(0.025)	(0.026)
EXPORT (t-1)		-0.20	-0.19		0.28	0.29
		(0.189)	(0.190)		(0.244)	(0.244)
INNOV (t-1)		0.11	0.11		-0.17	-0.16
		(0.169)	(0.170)		(0.188)	(0.188)
ICT_EMP (t-1)			-0.00			-0.01
			(0.011)			(0.008)
Constant	-1.26***	-1.19***	-1.18***	-1.63***	-1.78***	-1.76***
	(0.309)	(0.320)	(0.320)	(0.331)	(0.377)	(0.378)
N. of firms	398	398	398	354	354	354
LR Chi-sq.	25.30	26.69	26.74	21.55	23.48	25.15

Table 9 Estimation of the ATT with the Nearest Neighbour Matching method.

All Industries	Model	Mean		Difference	t-test
		Treated	Control		
Outcome Variable					
R&D /EMPLOYEE	I	5241.9	3404.8	1837.2	2.75
PRIVATE R&D /EMPLOYEE	I	3751.8	3294.6	457.2	0.73
R&D /EMPLOYEE	II	5241.9	2949.0	2292.9	3.42
PRIVATE R&D /EMPLOYEE	II	3751.8	2846.9	904.9	1.45
R&D /EMPLOYEE	III	5241.9	2385.5	2856.4	4.51
PRIVATE R&D /EMPLOYEE	III	3751.8	2315.7	1436.0	2.43
Low-Tech Industries					
R&D /EMPLOYEE	I	3754.3	3100.3	654.0	0.66
PRIVATE R&D /EMPLOYEE	I	2414.0	2911.0	-497.1	-0.52
R&D /EMPLOYEE	II	3754.3	2927.0	827.3	0.86
PRIVATE R&D /EMPLOYEE	II	2414.0	2759.5	-345.5	-0.38
R&D /EMPLOYEE	III	3754.3	3304.0	450.2	0.52
PRIVATE R&D /EMPLOYEE	III	2414.0	3192.6	-778.5	-0.83
High-Tech Industries					
R&D /EMPLOYEE	I	6416.4	3791.7	2624.7	2.57
PRIVATE R&D /EMPLOYEE	I	4808.0	3654.1	1153.9	1.22
R&D /EMPLOYEE	II	6416.4	3843.4	2573.0	2.63
PRIVATE R&D /EMPLOYEE	II	4808.0	3793.2	1014.7	1.11
R&D /EMPLOYEE	III	6416.4	3718.7	2697.7	2.87
PRIVATE R&D /EMPLOYEE	III	4808.0	3503.8	1304.7	1.48

Table 10 Robustness Checks: Estimation of the ATT with the Nearest Neighbour Matching with Caliper and with Kernel method (Bootstrapped S.E.)

Matching Method		Nearest Neighbour with Caliper		Kernel with Bootstrapped S.E	
All Industries	**Model**	**ATT**	**t-test**	**ATT**	**z-test**
Outcome Variable					
R&D /EMPLOYEE	I	1733.9	2.60	1879.6	3.80
PRIVATE R&D /EMPLOYEE	I	374.7	0.60	538.7	0.97
R&D /EMPLOYEE	II	2195.1	3.29	1878.9	3.18
PRIVATE R&D /EMPLOYEE	II	827.8	1.32	537.9	1.21
R&D /EMPLOYEE	III	2765.3	4.39	2081.5	3.55
PRIVATE R&D /EMPLOYEE	III	1365.2	2.31	720.1	1.32
Low-Tech Industries					
R&D /EMPLOYEE	I	738.9	0.76	809.4	0.96
PRIVATE R&D /EMPLOYEE	I	-466.7	-0.50	-434.4	-0.59
R&D /EMPLOYEE	II	735.8	0.80	1066.1	1.58
PRIVATE R&D /EMPLOYEE	II	-412.4	-0.47	-245.7	-0.41
R&D /EMPLOYEE	III	384.0	0.43	998.2	1.23
PRIVATE R&D /EMPLOYEE	III	-972.0	-1.15	-313.6	-0.48
High-Tech Industries					
R&D /EMPLOYEE	I	2659.7	2.65	2205.3	2.57
PRIVATE R&D /EMPLOYEE	I	1187.8	1.28	805.9	1.13
R&D /EMPLOYEE	II	2298.8	2.31	2455.7	2.87
PRIVATE R&D /EMPLOYEE	II	821.4	0.88	1096.3	1.47
R&D /EMPLOYEE	III	2568.5	2.71	2514.3	2.83
PRIVATE R&D /EMPLOYEE	III	1110.6	1.24	1151.3	1.45