R&D subsidies and cluster policy in Catalonia

Agustí Segarra (♣), Mercedes Teruel (♣) and Miquel Angel Bové (♣)

Abstract:

This paper deals with two lines of industrial policy in Catalonia: the public programs to promote R&D and the policies that favor certain clusters within other sectors. During the period 2007-2010, the agency with the line of public funding to promote private R&D investment received 2,263 applications. 1,093 were awarded with an amount equal to 45.2 million euros. This paper pursues three objectives: (i) to analyze the impact of individual, sectoral and territorial factors on a firm's ability to apply for regional R&D calls; (ii) to determine which characteristics of R&D projects, firms and their environment affect the likelihood of being awarded a public R&D subsidy; and (iii) to study whether participation in public calls for R&D subsidies generates spillover effects on firms in the same county. Our results suggest that larger firms which export and belong to the high-tech manufacturing sector are more likely to participate in public calls for R&D subsidies. Furthermore, the previous level of participation by firms enhances current participation in the public call. With respect to the determinants for projects being awarded, those projects presented cooperatively have a better chance of success. Regarding the locational variables, we observe that firms in the densest Catalan metropolitan region are less probable to participate, while those in the second metropolitan region have a higher probability. Finally the territorial spillovers show a positive sign, but this is only significant at intra-industry level.

Palabras Clave: *Evaluation, R&D policies, clusters,*
JEL Classification: L53, L25, O38

Contact: agusti.segarra@urv.cat

(♣) Research Group of Industry and Territory
Department of Economics - CREIP
Universitat Rovira i Virgili
Av. Universitat, 1; 43204 – Reus, Spain
Tel. + 34 977 759 816 – Fax + 34 977 300 661

Acknowledgements

This paper is part of the research done with the financial support of the Consolidated Group of Research 2009-SGR-907. We are very much indebted to ACC1Ó from the Catalan Government. We are grateful to Verònica Gombau, Elisenda Jové and Alba Sánchez for their research support. The usual disclaimer applies.

R&D subsidies and cluster policy in Catalonia

1. Introduction

Since the 1980s, European countries have been promoting R&D among firms, in particular small and medium sized firms. To achieve this, governments may use a variety of tools such as public grants, loans, tax incentives or direct research (in public laboratories or universities). The type of tool is relevant since some may be more precise and efficient[1]. In that sense, public grants are the most selective tool while R&D tax incentives are more horizontal and are less able to prioritize target firms. In general, European governments have preferred grants to promote private R&D investment. However, since the beginning of the global crisis in 2007, the use of tax incentives has increased at national and regional level while R&D subsidies are not so common. This change may have consequences since it reduces the capacity of governments to identify the priority groups of firms.

There is a recent concern related to the ambivalent impact of public policies on firms' innovative activity (Catozzella and Vivarelli, 2012). Some studies have focused on analysing whether public R&D expenditure has a complementary and thus 'additional' impact on private R&D or a substitutive impact and thus tend to 'crowd it out' (David et al., 2000). Other contributions have evaluated the impact of using public R&D tools to promote private R&D and encourage innovation (Antonelli, 1989; Busom, 2000; Holemans and Sleuwaegen, 1988; Levy, 1990; Lichtenberg 1984, 1987; David et al., 2000; Klette et al., 2000). The ambivalent results obtained in the literature may be due to the data and biases of econometric tools. Hence, the economic literature has pointed out the importance of evaluating the public resources devoted to promoting private R&D in order to determine how firms behave.

This paper aims to address some of the gaps in the literature. In line with Huergo and Trenado (2008, 2010) our sample consists not only of those firms participating in the program of the Catalan agency responsible for promoting private innovation (ACC1Ó) during a four-year period but it also includes those firms that did not apply for R&D subsidies. Hence, our sample is the result of merging two databases. On the one hand, the

[1] Recently, Guellec and Pottelsberghe's research (2003) on 17 OECD countries over the period 1981-1996 found that public R&D subsidies have a positive effect on private R&D investment; tax incentives have an immediate and positive effect on private R&D investment; public subsidies as well as tax incentives are more effective when they are stable over time, while firms do not make additional R&D investments if they are uncertain of the durability of government support; public subsidies and R&D tax incentives are alternatives: the increased intensity of one reduces the effect of the other on private R&D investment; and finally the stimulating effect of public subsidies increases up to a certain threshold (about 10% of private R&D investment) and then decreases beyond that point. More recently, Santamaría et al. (2010) analyzed the differences between subsidies and credits for Spanish firms. Their results show that the Spanish public agency uses subsidies and credits as financial tools to address different objectives. On the one hand, some projects close to the market are well supported through credits, while on the other basic research projects receive only selective support in the form of subsidies. In addition, Busom, Corchuelo and Martínez (2012) find that SMEs are less likely to obtain R&D tax credits but more likely to obtain subsidies.

whole sample of Catalan firms will lead us to analyse those factors that affect a firm's decision to apply for a public subsidy. On the other hand, the information from ACC1Ó will help us to determine those factors that affect the agency's selection.

The main results show that larger firms which export or belong to the high-tech manufacturing sector are more likely to participate in public calls for R&D subsidies. Furthermore, previous firms' participation enhances current participation in the public call. On the other hand, we found that those projects presented cooperatively have a better likelihood of obtaining an R&D subsidy. Regarding the locational variables, we observe that firms in the densest Catalan metropolitan region have a lower probability of participating, while those in the second metropolitan region have a higher probability. Finally, the territorial spillovers show a positive sign, but which are only significant at intra-industry level.

Hence, we will be able to analyse individual, sectoral and territorial factors that affect the likelihood that a firm will apply for a public R&D subsidy. The study of the determinants of participation in public R&D support is a first step in evaluating its effect, as it allows us to examine the different characteristics of participants in comparison with non-participants. This is crucial when public agencies have specific target groups in the design of R&D programs. Second, we are able to evaluate those policies to promote clusters, since firms may be classified at sectoral and territorial level. This evaluation may give an overview of the cluster policies that the Catalan government promoted during the nineties. Finally, the access to detailed information about subsidized R&D projects facilitates the analysis of characteristics of R&D projects and the likelihood of obtaining a public R&D subsidy.

This article contributes to the literature on three points. First, our database comprises not only participants but also non-participants. Consequently, it is necessary to tackle the potential problems of endogeneity (Lichtenberg, 1984). Hence we may introduce a control for any selection bias found in other samples. Thus, public funding becomes an endogenous variable with respect to a firm's innovation activity. The literature has tackled the selection problem from two different approaches. First, treatment evaluation offers alternative methodologies to deal with potential endogeneity and selection problems of this nature; however each of them imposes more or less restrictive conditions. Here we apply a Heckman model in line with previous empirical evidence (Huergo and Trenado, 2008, 2010; Santamaría et al., 2012). Second, we adopt a territorial approach since we know the location of the firm. The territorial dimension has usually been ignored in previous analysis, while the territorial spillovers and externalities that may exist in the territory may condition firms to participate and to obtain public R&D subsidies. Third, in general, empirical literature ignores governmental objectives that are achieved through different tools that agencies create. Public agencies may focus on a target number of firms in specific sectoral clusters or territories. Here, we incorporate these dimensions in order to know whether firms located in particular clusters or territories have a higher likelihood of participating or obtaining a subsidy.

Previous empirical literature suffers from different limitations. The majority of studies are based on a cross-section of data at firm level from the CIS for a particular country. For that reason all those studies focus only on innovative firms. In general, the information compiled in public databases only reveals whether or not firms have received a subsidy (Blanes and Busom, 2004).

However, as has been noted previously, the main difficulty that affects policy evaluation is the potential endogeneity of the R&D subsidy. In other words, the estimation of the likelihood of obtaining a public R&D subsidy does not fulfil the property of randomness since those firms that participate in the selection process are not a sample of the whole population of firms. This mismatch may be due to the fact that firms that participate have different characteristics with respect to those firms that do not participate since they may have more experience of R&D programs, better projects, and so on. Therefore, empirical studies regarding impact analysis also include a study of these determinants as a first step of their methodology (Busom 2000; González et al. 2005; Czarnitzki and Licht 2005; Takalo et al. 2008; Huergo and Trenado, 2008, 2010). Consequently, our database comprises all Catalan firms in addition to those that participated in the selection of R&D subsidies.

The structure of the paper is as follows. Section 2 outlines the literature related to design, participation and selection of public R&D subsidies. Section 3 presents the database and some descriptive statistics. Section 4 shows the econometric methodology and variables. The following section reports our results, and the final section presents the concluding remarks.

2. R&D subsidies: public and private decisions

This section presents a brief review of the literature on the evaluation of R&D subsidies and the determinants of participating in calls and being awarded with R&D projects. Furthermore, we present our main hypotheses.

2.1. Promotion of R&D through public policies

From a theoretical approach, the main reason for providing public funding for R&D is the existence of market failures, like additionality, informational asymmetries and spillovers, among others. It is well-known that the knowledge market usually fails to provide enough incentives to private firms to invest in innovation activities. This is due to the fact that innovators face appropriability problems (Nelson, 1959; Arrow, 1962).

Hence, market failures in private R&D justify government intervention. Government support for R&D has been widely accepted, in contrast to public support in other fields such as investment, production or commercial protection (García-Quevedo, 2004; Catozzella and Vivarelli, 2011). Although public policies to promote private R&D and

innovation have increased in recent decades, there is still little consensus regarding their true effectiveness in spurring innovation.

The evaluation of public support for R&D and innovation has mainly focused on the impact of public policies on private incentives to invest in R&D. In particular, these studies have tried to measure if firms increase their effort in R&D and innovation[2]. This line of research neglects both the importance of the allocation process and the possibility that such input-side additionality does not translate into proportionally higher innovative outputs. However, the evaluation process must also tackle other issues. Recent works have focused on the impact on firms' performance measured in terms of sales and productivity (OECD, 2006)[3]. Furthermore, another strand of the literature has focused on the characteristics that determine whether a firm obtains a subsidy or decides to participate.

Hence, the evaluation of public policies is crucial in order to offer information about their effectiveness. In fact, evaluation must be conceived as part of a process and must give useful information to policy-makers. This analysis is particularly crucial in a field where results are ambivalent and affected by different impacts. Aschhoff (2009) points out that R&D subsidies may cause four different impacts on private R&D investment: Full crowding-out; partial crowding-out; null effect; additive effect. Different mechanisms may justify the existence of all these effects. On the one hand, there are two reasons why public subsidies may reduce or counterbalance private R&D investments. First, a selection a bias of public agencies may exist in case they apply a "picking-the-winner" strategy (David et al., 2000; Klette et al., 2000; Wallsten, 2000; Gorg and Strobl, 2007)[4]. Second, the inelastic supply of R&D inputs may result in an increase of R&D inputs which displaces inputs from non-subsidized firms to subsidized firms that have more capacity to pay higher prices (David and Hall, 1999)[5]. Furthermore, inelasticity of R&D inputs may imply a readjustment of a firm's portfolio of R&D projects when they receive a subsidy. This readjustment may cause some projects to be abandoned (Lach, 2002). On the other hand, R&D subsidies may

[2] Klette et al. (2000) and David et al. (2000) offer two surveys of econometric studies. Both authors discuss methodological aspects that may account to some extent for the absence of clear and unambiguous results. David et al. (2000) also offer a survey of the empirical evidence accumulated over 35 years on this topic. They analyze if public R&D investment increases private R&D spending, or if it substitutes and tends to crowd out private R&D spending. Findings are ambivalent according to the database and the biases of the econometric tools.

[3] Catozzella and Vivarelli (2012), with a sample of Italian Community Innovation Survey (CIS-3) of 9,034 manufacturing firms, combined input and output dimensions of innovation and they found that government intervention actually appears to induce higher private R&D spending, while the efficiency associated with such innovative expenditures is affected negatively.

[4] Public agencies may have more incentives to choose those projects belonging to more innovative firms, which have a higher likelihood to succeed and offer a higher return from taxes (Kauko, 1996; Lichtenberg, 1984; Stiglitz and Wallsten, 2000). In this case, public subsidies are given to projects that would be funded with private resources (for a recent survey see Cantner and Kösters (2012)). The "Picking-the-winner" strategy appears because: i) technocrats in charge of policies do not want to give the impression of "wasting public money"; ii) policymakers may prefer to focus on technological sectors with more future potential. However, public subsidies may be more effective in the case of funding R&D projects that would not be continued without this public funding (Lach, 2002).

[5] In particular, this effect has been pointed out for researchers' wages (Goolsbee, 1998; Reinthaler and Wolff, 2004; Üçdoğruk, 2006; Ali-Yrkkö, 2005; Aerts, 2008).

foster private R&D investment. First, R&D subsidies imply a reduction of the private cost, hence it may cause a project to become viable in spite of it not being so initially or it may help to finalize one which is already started. Second, according to Görg and Strobl (2007) additive effects may appear due to: i) improvement in common research equipment; ii) knowledge spillovers due to the learning process and accumulated know-how derived from the subsidized project; iii) a "certification" or "halo" effect, since a public subsidy may be a signal for potential investors (Lerner, 1999; Takalo and Tanayama, 2010)[6]. Hence, these effects may affect the likelihood of the success and profitability of other R&D projects which are not directly related with the subsidy.

2.2. Private decision to participate and selection criteria in public R&D subsidies

Since the empirical evidence shows ambiguous results, Klette et al. (2000) and David et al. (2000) conclude with two recommendations. First, empirical methods that a control for selection and endogeneity bias should be used, arising from the fact that participation in a R&D program is not random. And second, structural models of the decisions of both the public agency and the firm should be developed in order to improve our understanding of R&D subsidy effects. Therefore, we revise the literature of the factors affecting the decision to participate and to obtain a public R&D subsidy.

With respect to the data, this line of research limits the estimation of the impact of R&D subsidies to subsidized firms. Recent empirical literature that uses CIS datasets for an individual country predominates. However, those works only have information relating to projects that have been approved by public agencies and, therefore, they are not able to go deeply into the factors that affect the decision a firm makes to apply for a public subsidy[7]. Furthermore, they do not have access to information related to those firms that apply and do not succeed. An example is Busom, Corchuelo and Ros (2012) for the Spanish CIS. However, other studies have used databases from public agencies which have detailed information about participants and projects. As Clausen (2009) points out, it is important to have information about the amount of the subsidy. Some examples are Santamaría et al. (2010) with the Spanish PROFIT initiative (for subsidies and low-interest credits) and Huergo and Trenado (2008, 2010) with a Spanish CDTI program with low-interest credits.

Furthermore, due to data limitations, previous studies have focused on the determinants that lead to a firm receiving a public subsidy from an agency. However, those studies run into a problem of endogeneity since the determinants for a firm receiving a public subsidy will be rather similar to those determinants that lead a firm to apply for a subsidy. To solve this problem, recent empirical studies (Huergo and Trenado, 2008, 2010; Takalo et al., 2008) propose to analyse a two-step methodology which considers first the determinants

[6] Hence, imperfections of the capital market may diminish due to the effect of "certification" or "halo" (Diamond, 1998; Jaffe, 2002; Lööf and Heshmati, 2004). On a theoretical level, Kleer (2010) presents a model where a financial institution considers the public subsidy as a signal to give funding to a project.

[7] The CIS questionnaire comprises information relating to firms asked to answer the question "*Has your enterprise received any kind of public support for innovation-related activities in the last three years?*".

that lead a firm to apply for a public subsidy and afterwards identifies the determinants that mean the firm obtains the subsidy, controlling for the correlation of the error terms due to non-unobserved characteristics.

Due to data limitations, few works have been able to analyse the participation in public calls to promote private R&D and innovation behaviour. However, we may highlight Czarnitzki and Licht (2005), Takalo et al. (2008) and Huergo and Trenado (2008, 2010). First, Huergo and Trenado (2008, 2010) for a sample of Spanish firms that obtained low-interest credits during the period 2002–2005 identified that young firms, exporters, companies that belong to a high or medium-tech industry and firms with previous experience in similar programs have a higher probability of applying for a credit. Furthermore, for Spain, Santamaría et al. (2010) analyze cooperative R&D project calls during the period 2000-2003. However, their analysis does not consider the analysis of the determinants of participating since their database includes only participants.

In general, the determinants of participating in public calls are firm age, firm size, financial constraints, sector and export activity. Among variables related to the project, studies have tried to introduce a control to take into account the previous experience in applying for a public call. However, few empirical results have introduced the territorial dimension as part of their analysis. Nevertheless, it is possible that firms in regions with greater density may have larger knowledge flows or even more competition which implies that they may apply for more subsidies.

Hypothesis 1. Firms in denser territories will be more likely to participate in a public call.

However, public policies have an impact at territorial level not only via firms awarded subsidies but also indirectly to non-awarded firms. On the one hand, subsidies that other firms receive may have a positive effect on the propensity of other firms to apply for subsidies. This situation may be the result of flows of R&D personnel and R&D cooperation agreements. On the other hand, it may be the case that subsidies given to particular firms may discourage access to them for other firms due to the fact that a subsidized project absorbs a large amount of scientific resources. Consequently, competitors will observe a reduction of the profitability of their R&D projects (David et al., 2000). Therefore we may have two different hypotheses.

Hypothesis 2. The awarded projects of firms in a particular sector act as an incentive for the participation of other firms in the same sector but which are territorially close.

Hypothesis 3. The awarded projects of firms in a particular sector act as an incentive for the participation of other firms in other sectors but which are territorially close.

R&D Subsidies and agency selection

In spite of the fact that governments design their public policies to promote private R&D through their public agencies, a scarce number of studies examine the criteria used by governmental evaluators to select projects (Hsu et al., 2003; Lee and Om, 1996, 1997). In the case of Spanish firms, Blanes and Busom (2004), Huergo and Trenado (2008, 2010) and Santamaría et al. (2010) have analysed the agencies' selection criteria. However, it is crucial to go deeper this issue for a number of different reasons. First, the selection process reflects the real objectives of policy makers. Second, they determine the characteristics of those projects that are developed and, consequently, the results obtained. Third, public calls have impacts at sectoral and territorial level.

According to Blanes and Busom (2004), public agencies may use financial support for R&D to achieve two important goals: i) to foster national champions; and ii) to encourage the technological upgrading of firms in declining or traditional industries. In the first case, the idea would be to fund those R&D projects that are most likely to achieve technological and/or commercial success. In the second case, the objective is to increase the chances of a firm's survival. Such reasoning implies that an agency's goals, or combinations of goals, will vary across industries.

The design of public R&D subsidies entails multiple decisions relating to the assignation of public resources with respect to other tools available, the time of applicability, the criteria of the call, the profile of firms that will be prioritized and the sectoral and territorial dimensions, among other questions. In our case, the Catalan public agency must take three decisions during the selection process. First, if the project accomplishes all the requirements of a call it will be accepted for later evaluation; second, an ad-hoc technical commission will be formed to decide to accept or reject a project according to established selection criteria; and third, this technical commission will allocate an amount of funding to an accepted project. Analysis of the three decisions sheds some light on the public agency's behaviour, particularly in relation to decisions about the degree of support given to different projects. The first decision is automatic since it includes or excludes a project from further consideration. The second and third decisions entail some discrimination among the accepted projects in terms of the type and amount of finance provided (Santamaría et al., 2010). Here, governments may include other criteria which are not strictly related to the characteristics of the firm or project in question.

Therefore, different sets of variables may influence the decision to select a firm to receive a subsidy. First, firm characteristics such as age, size, sector and dynamicity. Second, project characteristics such as the project size or the internal quality evaluation of the project. Third, regional variables may also affect the decision (Santamaría et al., 2010, p. 552.). According to Santamaría et al. (2010, p. 552), "it is possible that regional differences in the selection of projects are related to the peculiarities of regional industrial systems (i.e. firm characteristics), which may influence the level of support given to firms from different regions. It is possible also that politics plays a part in regional differences". Those authors

recognize the difficulties of capturing these political criteria and they introduce empirically different dummies to capture the differences between the Spanish regions.

Hence, governments may take into account the existence of clusters as a starting point to formulate policies and strategies. Our hypothesis is that the Catalan government may take sectoral cluster specialization into account. Hence, we may consider that it does not focus on one goal but on a diversity of goals: to promote R&D but also to concentrate on specific sectoral clusters. In fact, any firm may apply for the call. Hence, this disagrees with Afcha (2012) who states that public agencies tend to prioritize high-tech firms. This hypothesis is also emphasized by Klette et al. (2000) who point out that "a significant portion of the support to commercial R&D is targeted towards new, high-tech businesses and emerging technologies, and it seems to be based on infant industry arguments." By considering the cluster policy we may assess not only the published objectives of the public call, but also those "revealed" objectives which were not official.

> Hypothesis 4. The Catalan government prioritizes firms that belong to a particular sectoral cluster.

Furthermore, Afcha (2012) points out that public agencies also tend to prioritize those firms with better opportunities to succeed. Hence, public agencies may apply a "picking-the-winner" strategy that gives subsidies to projects that are already viable. In that case, non-subsidized firms will leave the market[8]. Lerner (2002, p.81-82) points out that "past grants, regardless of project outcomes, help a company gain legitimacy in a particular area of research, as well as acquire the equipment and personnel needed to do future work. There is also a tendency for some government programs to try to 'piggyback' on other government programs, hoping to leverage their grant dollars. In addition, firms gain considerable insight on the grant application process with each proposal they submit. These firms consequentially often have a greater chance of being awarded future government grants than other firms."

> Hypothesis 5. The Catalan government prioritizes firms that had previously obtained an R&D subsidy.

3. Data description and descriptive statistics

Our dataset is a merge of a database from a Catalan public agency that comprises those firms participating in a public R&D call and the SABI database. The SABI database (Sistema de Análisis de Balances Ibéricos) comprises Catalan firms registered in the Mercantile Register and offers information related to balance sheets at a firm level. The SABI database is available from 2004 until 2011. One particularity of our database is that we know the municipality where a firm is located; hence we are able to approach with a

[8] However, if policy-makers are able not only to distinguish viable projects but also those that need additional public resources, then the distortion will be minimized (Shane, 2009).

territorial dimension[9]. Previous scholars (Huergo and Trenado, 2008, 2010) have also merged databases; however those authors do not exploit the territorial dimension.

ACC1Ó is the Catalan public agency that promotes innovation and internationalization of firms, in particular SMEs. It aims to facilitate the competitiveness of Catalan firms. Since 2004, the main policy tool of the Catalan government has been public R&D subsidies and innovation. Although governmental aims are diverse, they mainly focus on reducing the cost of R&D and innovation projects of Catalan firms.

The database from ACC1Ó is associated with four public calls between 2007 and 2010 from the initiative "InnoEmpresa"[10]. The public call consisted of non-refundable R&D subsidies targeted at innovation projects presented by firms. The project needed to develop a new product, a new process, a new methodology of commercialization or a new organizational methodology in order to increase the firms' competitive advantages. Participants could present their project individually or jointly with other firms via intermediate organisms, such as technological centers. At sectorial level, the public call did not have any target sector. Hence, participants are basically SMEs in manufacturing sectors, real estate, tourism, retail and services.

The database from ACC1Ó contains 2,263 innovation projects pertaining to the public calls between 2007 and 2010. 1,093 innovation projects received a total amount equal to 45,204,656 euros. With respect to the available information, there is general data about the firm (location, dimension, etc.) and the characteristics of the innovation projects. Furthermore, the information follows-up on the firm. In other words, we are able to know if the subsidy was finally accepted by the firm and if the project has been finished[11]. Hence, we can study separately which factors determine a firm's decision to apply and which ones affect the agency's selection.

Therefore our database ranges from 2006 to 2010, since some explanatory variables will be lagged by one period. Hence, our database contains information at firm level of three different groups of firms. A first group includes those firms that did not apply for a subsidy. A second group includes those firms that applied for a R&D subsidy but were evaluated negatively. And finally, a third group includes those firms that obtained the R&D subsidy.

The selection of the final database has been based on the following. First, we have excluded firms without a municipality postal code. Second, we have selected firms that

[9] In fact, our territorial dimension will be at county level. Catalonia has 41 counties. Counties are administrative territorial areas between provinces and municipalities.

[10] The public call is available at http://portaldogc.gencat.cat/utilsEADOP/PDF/4912/927264.pdf. This website gives the requirements, procedures, etc.

[11] However, the end date of the project is not available for many of the subsidized projects since many of them are unfinished or because the firm has not yet presented the final report. As a consequence, this information has not been considered in the analysis.

have been observed over a period of 5 or 6 years. Third, we have selected firms that had declared themselves as being "active" in the market in 2010. Finally, we have also selected firms belonging to the OECD's sectoral classification as high-tech manufactures, low-tech manufactures and knowledge-intensive services[12]. Finally, our sample consists of 21,531 firms that did not participate in any call and 608 participants in at least one of the four calls.

Table 1 below reveals that participants represent around 2.2% of all non-participants in this public call. With respect to the number of participants, we observe that the number diminished slightly, with an increase during the last call. Furthermore, the mean value of the expected cost remains quite stable over the different calls. With respect to the amount of subsidy obtained and the final value that firms spent, there is an increase in the mean value between 2007 and 2008, while simultaneously the number of firms has increased. For the last year of observation the average value decreases slightly.

Table 1.
Summary statistics and the characteristics of cost and subsidies (mean).

	2007	2008	2009	2010
Number of firms				
Non-participants	16433	13343	13462	13297
Participants	205	172	149	161
Non-awarded participants	140	84	75	89
Awarded participants	65	88	74	72
Expected cost				
Non-awarded participants	98,379.1	146,172.5	165,155.8	108,976.5
Awarded participants	130,069.8	132,096.4	138,932.9	136,191.3
Subsidy				
Amount of subsidy	16,946.1	24,383.8	33,534.95	29,565.6
Final amount of subsidy	15,837.1	21,021.2	30,747.6	27,609.0

Source: SABI database and ACC1Ó

Table 2 shows descriptive statistics of the main variables of a firm. We classify firms according to our three groups of interest: firms that do not participate, firms that participate and are (or are not) awarded with a subsidy. Our results show that non-participants are smaller and younger. However, on average their average growth rate is much higher which can be closely related with both previous characteristics. Also, the percentage of firms that export is significantly smaller than the percentage of firms that participate in this program. Regarding the financial ratios, non-participants obtain a smaller cash-flow ratio and long-term debt ratio. With respect to location, we observe that the largest percentage of non-participants is located in the metropolitan area of Barcelona, while a smaller percentage of firms are located in the second metropolitan area. However, a smaller percentage of firms do not belong to industries that are considered a priority by the Catalan government. Furthermore, non-participants have less previous experience on average than those that decide to participate. Finally, with respect to spillovers, mean values

[12] Here, we classify firms into one sector in accordance with their main activity. Hence, we do not consider the possibility that a firm may be operating in similar or completely different sectors simultaneously.

are rather similar to firms awarded an R&D subsidy, but significantly smaller in comparison with non-awarded firms.

Table 2.
Descriptive statistics for Catalan firms. Mean and standard deviations (in brackets)

	Non-participants	Non-awarded participants	Awarded participants with a subsidy
Sales (thousands €)	4,477.72 (4868.85)	5,377.26 (7429,98)	6,441.62 (8120,01)
Sales growth rate *	-3.46% (16143.00)	0.07% (172.02)	-0.85% (39.95)
Firm age (years)	15.06 (11.45)	18.42 (13.08)	19.56 (13.10)
Exporting activity (% firms)	24.51% (0.43)	52.97% (0.49)	61.53% (0.48)
Cash-flow ratio	3.95% (0.68)	5.87% (0.16)	7.62% (0.10)
Long- term debt ratio	20.91% (21.45)	89.02% (9.91)	42.08% (4.04)
Location first area (% firms)	56.82% (0.49)	53.74% (0.49)	51.17% (0.50)
Location second area (% firms)	16.88% (0.16)	20.41% (0.40)	24.08% (0.42)
Priority industries (% firms)	17.79% (0.36)	26.35% (0.44)	26.75% (0.44)
Previous public grant (number of times)	0.02 (0.16)	0.21 (0.47)	0.24 (0.51)
Inter spillovers	171,165.2 (172,077.1)	193,693.8 (158,941.0)	197,160.7 (158,774.2)
Intra spillovers	3,516.6 (15,414.0)	7,920.0 (25,148.5)	6,217.5 (18,388.9)

** Median values*
Source: SABI database

Awarded firms are larger and older, but they grow less than non-awarded participants. Furthermore, a larger percentage of awarded firms export. The financial ratios show that awarded firms have a larger cash-flow ratio but a smaller long-term debt ratio. Regarding location, a lower percentage of awarded firms are located in the first metropolitan area, while a higher percentage is located in the second metropolitan area of Barcelona. Furthermore, awarded firms obtain slightly larger mean values compared to the levels of previous public grants. We need to highlight that intra-industry spillovers enjoyed by awarded firms are smaller than those of non-awarded firms. This is a reasonable result since awarded firms will not be affected by their own subsidies. However, awarded firms may benefit from larger inter-industry spillovers.

Table 3 presents those variables most closely related to the project characteristics and determinants of the probability of achieving a public R&D subsidy. Firms are classified between awarded and non-awarded firms. First, the project budget is slightly larger for awarded firms. Second, the percentage of projects which are cooperative is smaller for the awarded projects. Third, the number of times that a firm had previously received the same R&D subsidy is quite similar between both groups. With respect to the quality of the

project and the firm, as is to be expected, the values are larger for awarded firms (non-awarded firms may obtain a positive value should they refuse to accept the subsidy despite it being awarded). Results show that R&D subsidies cover around 35% of the project budget and nearly all of the subsidy ends up being continued (90.16%). Furthermore, it seems that a smaller percentage of awarded firms are SMEs. Finally, a smaller percentage of awarded firms belong to the agricultural cluster, while a larger percentage belong to the metallic and ITCs cluster.

Table 3.
Descriptive statistics for Catalan firms. Mean and standard deviations (in brackets)

	Non-awarded participants	Participants awarded with a subsidy
Project budget	124,385.4 (175,228.6)	134,333.9 (309,239.6)
Cooperation (% projects)	28.68 (45.29)	17.06 (27.68)
Number of awards previously	0.10 (0.34)	0.13 (0.36)
Quality of the project	5.40 (13.22)	35.98 (11.06)
Quality of the firm	0.31 (4.75)	90.16 (17.23)
Small firm (% firms)	56.07% (49.69%)	55.85% (49.74%)
Medium-sized firms (% firms)	17.31% (37.88%)	15.38% (36.14%)
Agricultural cluster (% firms)	9.82% (29.80%)	6.02% (23.82%)
Metallic cluster (% firms)	27.13% (44.52%)	29.76% (45.80%)
ITC cluster (% firms)	8.01% (27.18%)	8.70% (28.22%)

Source: SABI database and ACC1Ó

Finally, we must comment on some shortcomings in our data. First, although we have information about the R&D investment for a project, we lack information relating to a firm's total R&D investment. Hence, we are not able to determine a firm's capacity to carry out R&D activities. However, firm size and sectoral dummies may be good proxies. Second, there is no information on whether a firm applies for other R&D programs (subsidies, taxes…). Hence, we ignore their experience of applying for other programs, even if they have other R&D funds. Third, there is no direct quality ranking given by the evaluators. These three questions may be important, so we must be cautious with our results. However, these problems are also common in previous literature. Finally, we assume that firms are aware of the existence of public support.

4. Econometric methodology and variables

In line with previous scholars (Huergo and Trenado, 2008, 2010), we are able to distinguish between the firm's decision to apply for the subsidy and the probability of receiving an award for an R&D project. As a consequence, our model is the following:

$$\begin{aligned}\Pr(\text{receive an award} = 1) &= \Pr(\text{application} = 1, \text{award} = 1 \mid x) \\ &= \Pr(\text{award} = 1 \mid \text{application} = 1, x) \cdot \Pr(\text{application} = 1, x)\end{aligned}$$

Our first equation considers the probability that a firm decides to apply for a R&D subsidy. We will consider the following equation:

$$y_{1i} = \begin{cases} 1 \text{ if } y_{1i}^{*} - f(x_{1i}\beta_1 + u_{1i}) > 0 \\ 0 \text{ otherwise} \end{cases}, \quad \textbf{(1)}$$

where y_{1i} is a dummy variable which indicates that a firm decides to apply for an R&D subsidy. Furthermore, y^{*}_{1i} is a latent dependent variable, x_{1i} are the determinants of the firm's decision to apply, β_1 corresponds to the vector of coefficients to be estimated and u_{1i} is the error term which follows $N(0, \sigma_1^2)$. Firm "i" applies for the subsidy if y^{*}_{1i} is positive.

Equation (1) will depend on the following set of explanatory variables (x_{1i}):

Firm characteristics:

1. **Firm size**: Empirical evidence shows a positive relationship between firm size and the likelihood of engaging in R&D activities. Large firms have more capacity to cope with sunk costs and fixed costs, control financial barriers and increase the appropriability of R&D outputs. Hence, we expect a positive relationship between firm size and the likelihood to participate. We consider that large firms are in a better position to ask for R&D subsidies. This variable is measured by the value of ln(sales) and it is lagged by one period.
2. **Firm age**: On the one hand, R&D and innovation are dynamic processes where temporal persistence is relevant, so we expect that firm age will be positively related to the capacity of a firm to engage in R&D activities. Hence, we expect a positive relationship between firm age and the likelihood of applying for an R&D subsidy. On the other hand, young firms suffer more financial constraints, so they may need to have access to R&D subsidies. Hence, we have an unexpected result. This variable is measured as ln(age) and it is lagged by one period.
3. **Cash-flow ratio**: R&D projects are subject to a higher risk and high financial barriers. Empirical literature shows the existence of a negative correlation between financial barriers and R&D performance and a positive correlation between cash-flow and the probability of doing R&D. Hence, we expect a positive correlation between cash-flow and the probability of doing R&D and hence of applying for a subsidy. This variable is measured as the ratio of cash-flow over total assets and it is lagged by one period.

4. **Long-term debt ratio**: Firms with long-term debt contracts may have less financial constraints in order to invest in long-term projects such as innovation projects. Hence, conversely, we expect a negative relation between long debt ratio and the probability of applying for an R&D subsidy. This variable is the ratio of long-term debt over total assets and it is lagged by one period.
5. **Export:** Export activity is used as a proxy for a firm's internationalization strategy, suggesting the presence of enlarged market opportunities as well as intensive interactions with foreign partners that may allow for (technological) learning effects in R&D (Keller, 2010).
6. **Priority**: A dummy variable that indicates if a firms belongs to a sector that the Catalan agency considers as a priority. These sectors are: automotive and motorcycle (cnae93: 2911), biotechnology (cnae93: 3310), consumer electronics (cnae93: 30 & 31), renewable energy (cnae93: 4011), pharmaceutical industry (cnae93: 24), chemical industry (cnae93: 24), advanced alimentary products (cnae93: 73) and ICT (cnae93: 6420 – telecommunications & cnae93: 72 computer activities)
7. **Low-tech manufactures** and **KIS:** Sectorial particularities may have significant differences. In that sense, according to Blanes and Busom (2004), firms in the same industry may face different hurdles to participate in different agencies' programs and patterns differ across high-tech and low-tech industries. Furthermore, Capron and Van Pottelsberghe (1997b) show that the public R&D subsidy may have a different impact on the private R&D investment depending on the sector. Hence, we include two dummy variables indicating whether the firm belongs to a low-tech manufacturing industry or to a knowledge-intensive service.
8. **Previous application:** Applying for a public subsidy requires experience of dealing with all the administrative burdens. As a consequence, we may expect that those firms with previous experience of applying for a public call will have a greater propensity to participate. This variable is the number of previous times that a firm has applied for a public subsidy.
9. **Metrop Area 1**: The densest metropolitan area of Catalonia is found in the counties of *Barcelonès, Vallès Occidental, Vallès Oriental* and *Baix Llobregat* (with a population equivalent to 63.4% of Catalonia's inhabitants and to 58% of the firms located in Catalonia). We may expect that large metropolitan areas create positive externalities due to the diversity and flow of knowledge. This is a dummy variable that takes a value equal to 1 if the firm is located in this region.
10. **Metrop Area 2**: The second crown that surrounds the densest metropolitan region has traditionally been an industrial region. The counties included are: *Bages, Osona, Maresme* and *Anoia*. This is a dummy variable with a value equal to 1 if the firm is located in this region (with a population equivalent to 11.8% of Catalonia's inhabitants and 10.5% of all firms located in Catalonia).
11. **InterSpillovers:** Inter-industry spillover is defined as the stock of knowledge available to firms located in a region that originates in sectors different to the

ones in which the firms operate. This stock varies according to firms and regions. Inter-industry spillovers are an approximation of R&D linkages between firms that operate in different industries and do not trade with each other, but 'borrow' each other's knowledge (Bernstein and Nadiri, 1989). We estimate these externalities as:

$$INTERspill_{i,t} = \ln(SUBSIDIEScounty_{i,t} - SUBSIDIEScounty\_sector_{i,t})$$

Where *interSpillovers*$_i$ are the spillovers of firm "i" due to the fact that other firms, in sectors different to the one in which the firm operates, receive a public subsidy but are located in the same county. On the one hand, a positive sign implies a firm receives a positive influence through the fact that the firm may capture positive externalities from nearby firms that invest in R&D. On the other hand, a negative impact may imply difficulties in applying knowledge generated by other sectors.

12. **IntraSpillovers:** Intra-industry spillover refers to the stock of accessible know-how from firms in the same sector. The estimation is the following:

$$INTRAspillovers_{i,t} = \ln(SUBSIDIEScounty\_sector_{i,t} - SUBSIDYfirm_{i,t})$$

where *intraSpillovers* makes reference to the percentage of the total amount of subsidies received by other firms in the same sector and county of a particular firm "i". On the one hand, a positive sign exists when knowledge spreads to other firms in the same sector. On the other hand, a negative sign exists if firms protect the knowledge they generate and/or compete for the same R&D resources.

The second equation is the probability that a firm is awarded a subsidy through agency selection. The dependent variable y_{2i} is a dummy variable that takes a value equal to 1 when the project is awarded. This second equation will have the following form:

$$y_{2t} = \begin{cases} 1 \text{ if } y_{2t}^{*} = f(x_{2t}\beta_2 + u_{2t}) > 0 \\ 0 \text{ otherwise} \end{cases} , \quad (2)$$

where y^*_{2i} is the latent dependent variable, x_{2i} are the determinants of the agency's selection, β_2 corresponds to the vector of coefficients to be estimated and u_{2i} is the error term which follows $N(0, \sigma_2^2)$. The proposal is approved if y^*_{2i} is positive. Equation (2) will depend on the following set of explanatory variables (x_{2i}):

1. **Project size**: Across the agency selection process we would expect project size to be significant in the selection process (Heijs, 2005b, Acosta and Modrego, 2001). This variable is measured as the natural log total budget of the R&D project.
2. **Cooperation**: Presenting a project jointly with other projects may be a characteristic that evaluators consider as relevant. This is a dummy variable with a value equal to 1 in the case of presenting a cooperative project.

3. **Previous concession**: Evaluators may apply a "picking-the-winner" strategy by considering more preferable firms that have been awarded previously. The variable measures the number of times that a firm has obtained an R&D subsidy in the same call.
4. **Quality project**: The best considered projects have more chances of obtaining a subsidy. This variable corresponds to the percentage of the amount of subsidy that the firm has obtained compared to the total amount of money requested by the firm.
5. **Quality firm**: This index measures the capacity of the firm to plan and carry out the research project during the period of time. This variable corresponds to the ratio of the amount that the firm finally uses of the total amount of subsidy.
6. **Small firm** and **Medium-sized firm**: We consider that large firms are in a better position to ask for R&D subsidies and to present better R&D projects. However, public agencies may prioritize SMEs. Hence, the impact is unforeseeable. This variable is a dummy variable with a value equal to 1 in the case that a firm is smaller than 50 employees (small firm) and equal to 1 in the case that a firm is between 50 and 250 employees (medium-sized firm).
7. **Firm age**: Young firms may be more innovatively dynamic or they may suffer more financial constraints. As a consequence they may need to have access to these public R&D subsidies. However, public agencies may also prioritize old firms which need a transformation. This variable is equal to ln(age) and it is lagged by one period.
8. **Firm growth:** Firm growth may be an indicator for evaluators that a firm is in a dynamic sector. We expect a positive correlation between sales growth and the probability of obtaining an R&D subsidy. This variable is measured by the annual growth of sales (%).
9. **Low-tech manufactures** and **KIS:** Evaluators may prioritize firms in some sectors. Hence, they may show different probabilities to obtain an R&D subsidy. We include two dummy variables indicating whether they belong to a low-tech manufacturing industry or to a knowledge-intensive sector.
10. **Cluster_agro, cluster_metal, cluster_itc**: Projects of firms located in a strategic cluster may be preferable to evaluators in the case that they want to promote these clusters. Four dummy variables indicate whether a firm belongs to the Catalan agroindustrial cluster (cluster_agro), metal cluster (cluster_metal) or ITC cluster (cluster_itc).

Both equations include time dummies since, during an expansion, there are better facilities to gain access to financial resources, while during a financial crisis resources decrease. The error terms in Eqs. (1) and (2) might contain some commonly omitted variables, and therefore the correlation term ϱ between u_1 and u_2 might be unequal to zero. There are different channels through which this bias may appear. First, some firms apply for support because they have discovered particularly promising R&D projects. Second, screening of projects in the government agencies will also tend to create selection bias, since those firms

that obtained a subsidy may attract more external funds due to the certifying role of public subsidies. Thus, as a consequence, those firms may perform better and may be in a better position for future calls.
Consequently, there may be a sample selection bias, and the estimation of coefficients $\beta_{2,}$ only for proposals, yields inconsistent estimates. Following Huergo and Trenado (2008, 2010), we estimate both equations as a probit model with sample selection by maximum likelihood.

5. Empirical results

Table 4 contains the results for the estimation of the probit model with sample selection. The strategy for the estimations is the following: estimation (1) includes firm characteristics and some characteristics of the project (project size and cooperative project), estimation (2) includes the project characteristics and some variables related to the firm's past behaviour, estimation (3) includes variables related to the territorial location in one metropolitan area, estimation (4) includes the cluster variables if the firm does or does not belong to one of the prioritized sectors of Catalan industrial policy, and estimation (5) includes spillover variables, both intra-industry and inter-industry spillover effects. To begin with, we comment on the likelihood that a firm applies for a R&D subsidy.

First, firm size shows a significant positive impact while firm age shows a negative but non-significant impact (except for the first estimation). Consequently, larger firms will be more likely to apply for an R&D subsidy. Our evidence may confirm the fact that large firms are more likely to have the required financial and non-financial resources to carry out R&D activities that involve sunk costs and high uncertainty. Our results are in line with Czarnitzki and Licht (2005), González et al. (2005), Takalo et al. (2008), Bannò and Sgobbi (2010).

Second, with respect to the financial ratios, we do not find any significant impact although the cash-flow ratio has a significant positive impact in estimation (1) and (2), while the long-term debt ratio shows a non-significant negative impact.

Third, firms that compete in international markets present a greater probability of participating in public calls for R&D subsidies in Catalonia. This result may indicate that participation in international markets generates knowledge flows through improvements in the firms' knowledge due to their exposure to a wider range of technologies, better international practice, and tougher competition in international markets. Similar results are obtained in Czarnitzki and Licht (2005), González et al. (2005), Barajas and Huergo (2010), Bannò and Sgobbi (2010) and Huergo and Trenado (2010).

Table 4.
Heckprobit estimation of the probability of obtaining an R&D subsidy for Catalan firms.

	(1)	(2)	(3)	(4)	(5)
Probability of applying for a subsidy					
Firm size (t-1)	0.131 (0.009)*	0.122 (0.009)*	0.124 (0.009)*	0.124 (0.009)*	0.125 (0.009)*
Firm age (t-1)	-0.0004 (0.012)	-0.002 (0.012)	-0.001 (0.012)	-0.001 (0.012)	-0.001 (0.012)
Cash-flow ratio (t-1)	0.034 (0.017)***	0.030 (0.018)***	0.028 (0.018)	0.028 (0.018)	0.029 (0.018)
Long-term debt ratio (t-1)	-0.00004 (0.00003)	-0.00003 (0.00003)	-0.00004 (0.00003)	-0.00004 (0.00003)	-0.00004 (0.00003)
Export	0.334 (0.039)*	0.312 (0.039)*	0.313 (0.039)*	0.313 (0.039)*	0.310 (0.039)*
Priority	-0.045 (0.051)	-0.013 (0.054)	-0.006 (0.054)	-0.006 (0.054)	0.001 (0.055)
Low-tech manufactures	-0.308 (0.057)*	-0.279 (0.059)*	-0.299 (0.059)*	-0.299 (0.059)*	-0.243 (0.061)*
KIS	-0.449 (0.064)*	-0.396 (0.067)*	-0.427 (0.067)*	-0.427 (0.067)*	-0.372 (0.070)*
Previous application (t)		0.872 (0.048)*	0.865 (0.048)*	0.865 (0.048)*	0.860 (0.048)*
Metrop Area 1			-0.074 (0.038)*	-0.074 (0.038)***	-0.123 (0.055)**
Metrop Area 2			0.427 (0.046)*	0.130 (0.046)*	0.094 (0.057)***
INTERspillovers (t)					0.004 (0.006)
INTRAspillovers (t)					0.014 (0.005)*
cons (t)	-8.246 (-)	-9.739 (-)	-9.469 (0.098)	-9.495 (0.613)*	-9.613 (-)
Probability of obtaining a subsidy					
Project size (t)	-0.004 (0.030)	0.117 (0.178)	0.127 (0.180)	0.111 (0.190)	0.114 (0.192)
Cooperation (t)	-0.141 (0.112)	1.207 (0.416)*	1.230 (0.391)*	1.192 (0.350)*	1.190 (0.335)*
Previous concession (t)		-1.620 (0.596)*	-1.536 (0.599)*	-1.557 (0.589)*	-1.494 (0.584)**
Quality project (t)		0.026 (0.006)*	0.025 (0.006)*	0.025 (0.006)*	0.025 (0.007)*
Quality firm (t)		0.092 (0.024)*	0.094 (0.021)*	0.093 (0.019)*	0.093 (0.017)*
Small firm (t)	0.115 (0.092)	0.732 (0.396)***	0.721 (0.405)***	0.746 (0.390)***	0.726 (0.392)***
Medium-sized firm (t)	0.253 (0.140)***	0.861 (0.466)***	0.835 (0.488)***	0.821 (0.460)***	0.792 (0.464)***
Firm age (t-1)	-0.047 (0.027)***	0.141 (0.145)	0.141 (0.142)	0.195 (0.098)**	0.196 (0.096)**
Firm growth (t)	-0.0004 (0.0002)	-0.005 (0.005)	-0.006 (0.005)	-0.006 (0.005)	-0.006 (0.005)
Low-tech manufactures	0.087 (0.125)	-0.343 (0.397)	-0.360 (0.414)	-0.649 (0.482)	-0.663 (0.483)
KIS	0.145 (0.123)	-1.288 (0.664)***	-1.347 (0.656)**	-1.667 (0.691)**	-1.685 (0.682)**
cluster_agro				-0.935 (0.701)	-0.937 (0.684)
cluster_metal				-0.034 (0.275)	-0.023 (0.270)
cluster_itc				-1.380 (0.630)**	-1.381 (0.625)**
cons (t)	1.605 (0.455)*	-4.800 (2.467)***	-5.236 (2.348)**	-4.938 (2.295)**	-4.815 (2.030)**
Rho	-0.876 (0.210)*	-0.188 (0.505)	-0.052 (0.508)	0.010 (0.497)	0.097 (0.465)
Uncensored obs.	73709				
Censored obs.	686				
Wald χ^2	30.24	86.64	103.58	185.07	199.03
Prob > χ^2	0.001	0.000	0.000	0.000	0.000

Time dummies included.
*, ** and *** correspond at significance levels at 1%, 5% and 10%

Therefore, belonging to one of the sectors prioritized by the Catalan government does not seem to exert a significant impact on the probability of participating. However, it seems that firms in high-tech manufacturing apply more often for R&D subsidies than low-tech manufacturers and knowledge-intensive services.

With respect to past experience, a firm that has applied previously increases significantly the propensity to participate in subsequent calls. Our results are in line with previous evidence such Barajas and Huergo (2010) and Huergo and Trenado (2010), while Takalo et al. (2008) find non-linear effects for Finland. Two explanations may explain this behaviour. First, firms learn from previous experience in applying for public subsidies. Second, there is a persistent behaviour between firms that have a larger propensity to innovate and also to apply for R&D subsidies.

Regarding location, operating in the first crown of the metropolitan area of Barcelona significantly decreases the probability of applying for a subsidy. Although the first crown agglomerates Catalonia's largest percentage of firms and population, the typology of firms is also rather diverse, while the second crown has traditionally been more industrialized.

Finally, we observe that both types of spillover show a positive impact but only significant for intraindustrial spillovers. Hence, our results seem to shed light on the existence of some kind of externalities of R&D resources and knowledge flows. Hence, our results would appear to confirm the hypothesis that the concession of R&D subsidies to a firm will positively affect competitors' efforts and other firms in the same sector.

With respect to the likelihood of being awarded an R&D subsidy, we obtain the following results. First, the project size seems not to be a significant variable, although in general it shows a positive sign. Second, and more interestingly, those projects that are jointly presented by a group of firms through an intermediate agent, demonstrate a higher probability of obtaining an R&D subsidy (with the exception of estimation (1)). This result shows evidence that joint projects are preferred by evaluators for several reasons. First, collective projects may cover a larger number of private agents under the same umbrella. Second, a positive attitude towards cooperation increases the likelihood of cooperating with new partners and further spreading the externalities. This result is in line with Santamaría et al. (2010, p.559) where the probability of obtaining a subsidy increases with the participation of a university or a technology institute.

Third, in the case where a firm obtains an R&D subsidy and decides to participate in a future call, it will be less probable that the firm obtains an R&D subsidy. Hence, being a successful firm in the past does not determine that evaluators are going to choose these past winners in the future. This result may be a signal of a direct rejection of the "picking-the-winner" strategy since evaluators do not prioritize past successful firms.

Fourth, regarding the variables related to the quality of the project and the firm, our results show a positive impact on the probability of obtaining an R&D subsidy. Hence, the better the evaluation of a firm's quality, the better the chances of increasing the probability of obtaining a public subsidy.

Fifth, our results show that while large firms seem to participate more, small and medium firms have a higher probability of obtaining a public subsidy than larger firms. This result is closely related to the Catalan government's aims, since it is trying to promote R&D and innovation among SMEs. However, firm age shows a significant and positive sign once we control for the characteristics of the projects and the persistence in participating and achieving public R&D subsidies. Hence, old firms have a better likelihood of obtaining an R&D subsidy once we control quality and past experience and locational variables.

Sixth, being a more dynamic firm shows a non-significant impact, while firms in KIS services have significantly less probability of obtaining and R&D subsidy. Hence, concerning our evidence, we might say that the Catalan public agency seems to prioritize firms involved in high-tech manufacturing in order to encourage the technological upgrading of firms with higher opportunities to grow. This result is partially in line with Huergo and Trenado (2010) who find that high tech and medium-high tech manufacturers have less probability of securing low-interest credit. However, their result may be specific to the type of policy tool.

With respect to cluster policy, belonging to the agroindustry or metal clusters does not show a significant impact, while those belonging to the ITC are negatively affected in terms of the probability of being awarded a subsidy. This result may highlight the misalignment between calls for R&D subsidies and a clusters policy.

Finally, similarly to Huergo and Trenado (2010), in the case of omitting project-level variables, we may omit relevant variables that are good proxies of unobserved factors. As a consequence, the correlation term rho might be unequal. This would be the case in estimation (1).

6. Conclusions

This paper explores the determinants of Catalan firms for participating in a public call for R&D subsidies and the factors that explain the possibility of obtaining them. Our strategy therefore has two different stages. Following previous empirical literature we apply a probit model that controls for a sample selection.

For the first stage, the results suggest that larger firms which export and belong to the high-tech manufacturing sector are the most regular participants in public calls. Furthermore, previous firms' participation enhances current participation in the public call. These results are fairly robust with different specifications. Regarding the locational

variables, we observe that firms located in the Barcelona metropolitan area have a lower probability of participating, while those in the second metropolitan region – in the manufacturing belt of Catalonia- have a higher probability. Finally, locational spillovers show a positive sign but are only significant at an intraindustry level.

With respect to the determinants of being awarded a subsidy, those projects presented cooperatively have a better likelihood of succeeding. In addition, our results do not suggest the existence of a "picking-the-winner" strategy, since firms that have received previous R&D subsidies do not demonstrate a higher probability. Our quality proxies of the firm and quality seem to be significant and positive. Once we control for locational variables, firm age shows a positive sign on the likelihood of obtaining a subsidy. In general, firms operating in KIS services have fewer probabilities of obtaining an R&D subsidy. With respect to the interaction between a targeted policy such as the R&D subsidy and the cluster policy, we observe that only firms belonging to the ITC sector show a significant but negative impact.

The main policy implications are the following. The joint dynamics of project characteristics, location, sector and firm characteristics must be taken into account. Hence, policymakers should design and implement R&D promotion policies that take into consideration that not all firms have the same propensity to participate in calls for public R&D subsidies. And therefore, they will have to have in mind which their target group of firms is and whether they have enough tools to participate. This requires combining initiatives in order to both reduce administrative costs to be able to participate and also to enhance and facilitate the communication of experiences of local firms in the same sector where a firm is located. These policy implications may be particularly relevant for SMEs given their lack of financial assets and the absence of economies of scale and scope that place them at a disadvantage.

However, the selection of R&D projects is difficult due to expected externalities, a variety of objectives and multiple actors with different goals and preferences (Schilder, 2000; Corbett and Lennon, 2002; Bannò and Sgobbi, 2010). The interaction between all those factors determines the total budget allocated to R&D programs, its distribution across industries, the ranking criteria and screening rules applied in the selection of projects and firms, and the funding awarded to individual firms (Blanes and Busom, 2004, p. 1465).

Finally, the introduction of the territorial dimension into the analysis of the determinants of the probability of obtaining an R&D subsidy shed light on the fact that R&D subsidies have focused basically in promoting R&D investment, while they have not included clusters policies. In that sense, we consider that is it is essential to design public calls for R&D subsidies specific to the geographical areas of Catalonia that show low levels of innovative activity.

References

Aerts, K. (2008): "Who writes the pay slip? Do R&D subsidies merely increase researcher wages?. Department of Managerial Economics, Strategy and Innovation. Katholieke Universiteit Leuven. OR 0806.

Afcha, S. (2012): "Analyzing the interaction between R&D subsidies and firm's innovation strategy". *Journal of Technology Management & Innovation*, 7 (3): 57-70.

Ali-Yrkkö, J. (2005): "Impact of public R&D financing on employment". ENEPRI Working Paper No. 39/August 2005.

Antonelli, C. (1989): "A failure-inducement model of research and development expenditure". Journal of Economic Behaviour and Organization, 12: 159-180.

Arrow, K.J. (1962): "Economic welfare and the allocation of resources for innovation". In R. Nelson (Ed.), *The rate and direction of inventive activity*. Princeton University Press, Princeton.

Aschhoff, B. (2009): "The effect of subsidies on R&D investment and success: Do subsidy history and size matter?". ZEW Discussion Papers, No. 09-032.

Bannò, M. and Sgobbi, F. (2010): "Firm participation in financial incentive programmes: The case of subsidies for outward internationalisation". *Journal of Policy Modeling*, 32(6): 792-803.

Barajas, a. and Huergo, E. (2010): "International R&D cooperation within the EU framework programme: Empirical evidence for Spanish firms". *Economics of Innovation and New Technologies*, 19(1): 87-111.

Bernstein, J. I. and Nadiri, M.I. (1989): "Research and development and intra-industry spillovers: An empirical application of dynamic duality". *Review of Economic Studies*, 56(2): 249-269.

Blanes, J. V. and Busom, I. (2004): "Who participates in R&D Subsidy Programs? The Case of Spanish Manufacturing Firms". *Research Policy,* 33: 1459–1476.

Busom, I. (2000): "An empirical evaluation of the effects of R&D subsidies". *Economics of Innovation and New Technology*, 9(2): 111-148.

Busom, I.; Corchuelo, B. and Martínez, E. (2012): "Tax incentives or subsidies for R&D?". *United Nations University Working Paper Series*, 2012-056.

Cantner, U. and Kösters, S. (2012): Picking winners? – empirical evidence on the targeting of R&D subsidies to start-ups". *Small Business Economics*, 39(4): 921-936.

Catozzella, A. and Vivarelli, M. (2011): "Beyond Additionality: Are Innovation Subsidies Counterproductive?". *IZA Discussion Paper* No. 5746.

Catozzella, A. and Vivarelli, M. (2012): "The possible adverse Impact of Innovation Subsidies: Some evidence from a bivariate switching model". *Economics Bulletin*, 32(1): 648-661.

Clausen, T.H. (2009): "Do Subsidies have positive impacts on R&D and innovation activities at the firm level?". Structural Change and Economic Dynamics, 20(4): 239-253.

Czarnitzki, D. and Licht, G. (2005): "Additionality of public R&D grants in a transition economy: The case of Eastern Germany". *The Economics of Transition*, 14(1): 101-131.

David, P. A.and Hall, B.H. (2000): "Heart of darkness: modelling public-private funding interactions inside the R&D black box". *Research Policy*, 29(9): 1165-1183.

David, P. A.; Hall, B.H. and Toole, A.A. (2000): "Is public R&D a complement or substitute for private R&D? A review of the econometric evidence". *Research Policy*, 29(4-5): 497-529

Diamond, D. W. (1989): "Reputation acquisition in debt markets". *The Journal of Political Economy*, 97: 828-862.

Capron, H. and B. van Pottelsberghe de la Potterie (1997): " Issues in Measuring the Relationship Between Government and Private R&D". Mimeo, Université Libre de Bruxelles.

Corbett, T., and Lennon, M. C. (2002): *Implementation analysis: An evaluation approach whose time has come*. The Urban Institute Press. Washington, DC.

García-Quevedo, J. (2004): "Do public subsidies complement business R&D? A meta-analysis of the econometric evidence". *Kyklos*, 57(1): 87-102.

Goolsbee, a. (1998): "Does government R&D policy mainly benefit scientist and engineers?" National Bureau of Economic Research Working Paper No. 6532.

González, X.; Jaumeandreu, J. and Pazó, C. (2005): "Barriers to innovation and subsidy effectiveness". *The Rand Journal of Economics*, 36(4): 930-949.

Görg, H. and Strobl, E. (2007): "Money for Nothing? Do R&D Subsidies Add to or Crowd Out Private R&D?". *Economica*, 74: 215-243.

Guellec, D. and Van Pottelsberghe de la Potterie, B. (2003): "The impact of public R&D expenditure on business R&D". *Economics of Innovation and New Technology*, 12(3): 225-243.

Heckman, J.J. (1979): "Sample selection bias as a specific error". *Econometrica*, 47:153-162.

Holemans, B. and Sleuwaegen, L. (1988): "Innovation expenditures and the role of government in Belgium". *Research Policy*, 17: 375-379.

Huergo, E. and Trenado, M. (2008): " Determinantes de la solicitud y concesión de créditos blandos. La empresa española y el apoyo del CDTI a la I+D+i". *Documentos de trabajo 06* del *Centro para el Desarrollo Tecnológico Industrial* .

Huergo, E. and Trenado, M. (2010): " The Application for and the Awarding of Low-Interest Credits to Finance R&D Projects". *Review of Industrial Organization*, 37: 237-259.

Hsu, Y.G.; Tzeng, G.H. and Shyu, J.Z. (2003): "Fuzzy multiple criteria selection of government-sponsored frontier technology R& projects". *R&D Management*, 33(5): 539-551.

Jaffe, A. (2002): "Building program evaluation into design of public research-support programs". *Oxford Review of Economic Policy*, 18: 23-33.

Kauko, K. (1996): "Effectiviness of R&D subsidies – a sceptical note on the empirical literature". *Research policy*, 25: 321-323.

Kleer, R. (2010): "Government R&D subsidies as a signal for private investors". *Research Policy*, 29: 1361-1374.

Klette, T.J.; Moen, J. and Griliches, Z. (2000): "Do subsidies to commercial R&D reduce market failures? Microeconometric evaluation studies". *Research Policy, 29*: 471-495.

Lach, S. (2002): "Do R&D subsidies stimulate or displace private R&D? Evidence from Israel". *The Journal of Industrial Economics*, 4: 369-390.

Lee, M. and Om, K. (1996): "Different factor considered in project selection at public and private R&D institutes". *Technovation*, 16(6): 271-275.

Lee, M. and Om, K. (1997): "The concept of effectiveness in R&D project selection". *International Journal of Technology Management*, 13 (5-6): 511-524.

Lerner, J. (1999): "The government as a venture capitalist: The long-run impac of the SIBR program". *The Journal of Business*, 72: 285-318.

Lerner, J. (2002): "When bureaucrats meet entrepreneurs: The design of effective public venture capital programs". *The Economic Journal*, 112 (February): 73-84.

Levy, D.M. (1990): "Estimating the impact of government R&D". Economic Letters, 32: 169-173.

Lichtenberg, F.R. (1984): The relationship between federal contract R&D and company R&D". *American Economic Review Papers and Proceedings*, 74: 73-78.

Lichtenberg, F.R. (1987): "The effect of government funding on private industrial research and development: a re-assessment". *The Journal of Industrial Economics*, 36: 97-104.

Lööf, H. and Heshmati, A. (2005): "The impact of public funding on private R&D investment. New evidence from a firm level innovation study". CESIS Working Paper 06, Sweden.

Nelson, R.R. (1959): "The simple economics of basic scientific research". *The Journal of Political Economy*, 67: 297-306.

OECD (2006): "Empirical analysis of the effects of R&D on productivity: Implications for productivity measurement?". OECD Workshop on Productivity Measurement and Analysis, OECD.

Rinthaler, V. and Wolff, G.B. (2004): "The effectiveness of subsidies revisited: accounting for wage and employment effects in business R&D", ZEI Working Paper B21-04.

Santamaria, L.; Barge-Gil, A. and Modrego, A. (2010): "Public selection and financing of R&D cooperative projects: Credit versus subsidy funding". *Research Policy*, 39: 549-563.

Santamaria, L.; Nieto, M.J. and Miles, I. (2012): "Service innovation in manufacturing firms: evidence from Spain". *Technovation*, 32: 144-155.

Schilder, A. (2000): "Government failures and institutions in public policy evaluation: The case of Dutch technology policy". Assen: Van Gorcum & Comp. B.V.

Shane, S.A. (2009): "Why encouraging more people to become entrepreneurs is bad public policy". *Small Business Economics*, 33(2): 141.149.

Stiglitz, J.E. and Wallsten, S.J. (2000): "Public-private technologly partnerships – promises and pitfall", in: Vaillancourt Rosenau, P. (ed.), P*ublic-Private Policy Partnerships*. The MIT Press, Cambridge, Mass.

Takalo, T. and Tanayama, T. (2010): "Adverse selection and financing of innovation: Is there a need for R&D subsidies?". *The Journal of Technology Transfer*, 35 (1): 16-41.

Takalo, T.; Tanayama, T. and Toivanen, O. (2008): Evaluating innovation policy: A structural treatment effect model of R&D subsidies". Bank of Finland Research, Discussion Papers, 7/2008.

Üçdoğruk, Y. (2004): "Do researchers benefit from R&D suport programs in Turkey?". Paper presented at the 10th SMYE Conference, Geneva, Switzerland.

Wallsten, S. (2000): "The effects of government – industry R&D programs on private R&D: The case of the SBIR Program". *RAND Journal of Economics*, 31:82-100.