Intangible Capital

Intangible Capital, 2010 – 6(2): 272-299 – ISSN: 1697-9818

doi:10.3926/ic.2010.v6n2.p272-299

Distribution and effect of R&D subsidies: A comparative analysis according to firm size

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Received April, 2010

Accepted September, 2010

Abstract:

This study considers the relationship between the size of the firm and innovation policy. The study includes a joint analysis of distribution and the effect of R&D subsidies on inputs and outputs of the innovation process of small and medium enterprises (SMEs) and large firms. Although size has a significant, positive influence on firms' propensity to obtain R&D subsidies, large firms do not always show the strongest effects and in some cases such an effect is not significant. The study likewise concludes that subsidies are effective in increasing the inputs to the innovation process of SMEs and the outputs of large firms. One must consider these differences when evaluating and designing future innovation policies.

Keywords: R&D, R&D subsidies, innovation policy, firm size, propensity score matching.

JEL Codes: O31, O32

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doi:10.3926/ic.2010.v6n2.p272-299

1. Introduction

Central Governments undertake substantial investments in the framework of innovation policies in order to implement programs, strategies and institutions which support and encourage firms' innovation effort. These investments are constantly increasing, given the general awareness that competitiveness and economic achievement are highly dependent on industrial innovation. In the current academic literature, evaluation of the policy's effect is an important research subject matter, even though it has evolved while lacking a comprehensive theoretical framework of technological change and economic development, which includes the role of the Central Government (Nelson & Winter, 1982; Nelson, 1984; Metcalfe & Georghiou, 1998; Teubal, 2002; Verspagen 2005). In spite of theory and policy having jointly evolved, theory is more closely linked to the understanding of the innovation process and to that of technological change, rather than to the management and evaluation of the innovation policy.

Within this context, the empirical evidence is aimed at evaluating the effect of these policies while analyzing the relationship between public and private R&D. At firm level, the empirical evidence is not conclusive; in some studies public R&D *complements* private R&D, while in other analyses private R&D is *substituted* (see David, Hall, and Toole (2000) for a review of this literature). Although different arguments can be formulated to explain these disparities in outcome, some authors sustain the idea that the evaluation of the innovation policies could be improved by means of exercising control over the aid distribution process. The success of innovation policies depends, among other factors, upon the capacity of the Government to distribute the resources and the structural opportunities and the restrictions that are offered by the firms (Lipsey & Carlaw, 1998; Grande, 2001).

Following these premises, recent studies evaluate the effect of innovation policies while taking into account the context in which the aid is granted and the characteristics of the firms that receive public support. In particular, a reduced number of studies have analyzed the relationship between firm size and innovation policy. Since the theory already estimates that when taking into consideration size the firms' innovative activity differs, therefore also the effect of the public aid. In

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this respect, the evaluation literature establishes, on the one hand, that large firms receive aid more frequently compared to SMEs, and on the other hand, that the magnitude and direction of the policy effect changes according to firm size. Although the evaluation literature has advanced with respect to verifying that firm size is an important variable in obtaining consistent estimations of the policy effect, it is still important to obtain a broader knowledge on the influence of firm size to determine, among other things, two key aspects. These aspects are, firstly, whether firms which are most likely to obtain subsidies show the highest effect, and secondly, if the innovation policy boosts different aspects of the innovation activity of large and SMEs.

This article tackles these two aspects while analyzing the joint distribution and effect of the R&D subsidies according to firm size. This analysis includes aspects that the literature on innovation policy fails to consider. These aspects relate to the strategic activity of firms, their difficulty in accessing innovation resources, the state of the market in which they are operating as well as a broad number of indicators of the firms' innovation activity. Thus, an important contribution of this paper is analyzing the effect of R&D subsidies on inputs and outputs of innovation process. This analysis also is performed in two different time periods, that is, the year that the firm receives the R&D subsidies and the year after in order to obtain more precise conclusions with regard to the time period in which the effects of these R&D subsidies become visible.

For the joint analysis of the distribution and effect, this work uses a method of non-parametric pairing called Propensity Score Matching (PSM), which allows for the characteristics of subsidized firms to be taken into consideration while at the same time a robust estimation is performed concerning the R&D subsidized effect on the firm's innovation activity.

This study is structured as follows: section two presents the theoretical arguments to justify the notion that the size of the firm is a basic unit of analysis pertaining to the evaluation of innovation policy and the hypothesis of the study. Section three describes the methodology employed. Section four presents data and variables. Section five discusses the results of the empirical analysis, and finally, section six presents the conclusions.

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2. Firm Size and innovation policy: background and hypothesis

Considering firm sizes the innovative activity differs in terms of its characteristics, sources, actors involved, levels of appropriation, knowledge base, intensity and organization of R&D. This conclusion has been reached thanks to an important body of empirical evidence which has found differences in these aspects (i.e., Cohen & Levin, 1989; Cohen, 1995, Cohen & Kepler, 1996, Camisón-Zornoza, Lapiedra-Alcamí, Segarra-Ciprés & Bonronat-Navarro, 2004; Laforet, 2008). Thanks to these studies, a broader knowledge of the relationship between firm size, innovation and the industrial dynamic is now possible. One of the most important conclusions to be drawn from this literature is that large and small firms are probably good at undertaking different types of innovation and that their roles vary within the industrial cycle in a complementary dynamic (Nooteboom, 1994). As a result, the influence exerted by size becomes a key aspect for maintaining technological diversity and the industrial dynamic (Pavitt, Robson, & Townsend, 1989).

Though the literature deals extensively with the relationship between size of the firm and innovation, less attention is given to studying the relationship between the size of the firm and innovation policy. Recent studies analyze this relationship by assuming that both large and small firms perform innovation in a different manner and, therefore, their needs for public aid could differ. This literature can be categorized into two groups. The first group engages in analyzing, together with other variables, the influence of firm size on the distribution of public aid. These studies find that large firms have a greater chance of being subsidized compared to SMEs (Wallsten, 2000; Busom, 2000; Acosta & Modrego, 2001, Arvanitis, Hollenstein & Lenz, 2002; Czarnitzki & Fier 2002; Blanes & Busom, 2004; Heijs 2003, 2005). The underlying principles are the information advantages that large firms hold, and also the fact that they very often meet the requirements public agencies stipulate.

This literature does not perform a distribution-effect analysis in order to contrast the hypothesis as to whether those firms with a higher probability of being subsidized also retain a higher effect. This is an important research subject matter, as some authors associate the positive influence of size on distribution to

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distortions regarding the final outcome of the policy. Concretely, large firms could obtain subsidies for projects they would perform even without public support, (Wallsten, 2000; Heijs, 2003) and as a result, could be firms with a greater propensity to substitute public funds for private ones. Thus, Heijs (2003) finds that large firms are more liable to show this “free-rider” behavior. Empirical evidence is necessary to verify these ideas, therefore, this study proposes to test the following hypotheses.

Hypothesis 1: The greater the size of the firm, the more likely it is to obtain R&D subsidies.

Hypothesis 1.1: The greater the size of the firm, the less is the effect of R&D subsidies.

The second group of studies engages in testing the hypothesis that the final effect of the innovation policy changes with firm size. Carmichael (1981) found, for example, that government mission-oriented R&D spending has a greater effect on private spending of large firms compared to small ones. This result is similar to that obtained by Klette and Moen (1998), who found a complementarity effect of public support on the business units of large firms. Recently, Lach (2002) analyzes the effect of subsidies with no significant short-term results, the study detects that a year after obtaining the subsidies, small firms show a significant increase in their R&D spending compared to large firms. On the other hand, in a study of the Spanish case, Gonzalez, Jaumandreu, and Pazó (2005) find a complementarity effect which is higher in small firms compared to large ones. Unlike the previous studies, Gonzalez et al. (2005) work out a bare minimum level of subsidies for the initiation of R&D activities. Their study concludes that this level has to be smaller in large firms and higher in small firms (10 percent and 40 percent of R&D expenditure funding, respectively). Finally, González and Pazó (2008) used a matching approach to estimate the effect of R&D subsidies in Spain. In a sample of innovatory firms the study finds that the effect of R&D subsidies on innovatory effort is greater in firms with fewer than 200 employees. This effect is still positive and significant for a second sample which includes not just innovatory firms but also non-innovating ones. One of the most important conclusions obtained from the

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comparative study of these samples is that for SMEs public funding have an important role in the decision to participate in R&D activities.

As can be seen, the results of these studies are not conclusive for, at least, two reasons. Firstly, the studies do not only differ in their findings, the support programs analyzed, the time period evaluated and the methodological approach used, they also show differences in the class criteria applied to subdivide the sample into several firm sizes. All of the above hinders drawing up a comparative analysis. Secondly, a definite conclusion requires a deeper study of the impact of public aid on the firms' innovation behavior. In general, evaluation studies limit themselves to estimating the effect of subsidies on the R&D expenditure (input effect) and not on other aspects of the innovative activity, such as obtaining innovative results (output effect).

According to the literature on innovation and innovation policy, this analysis could expect –a priori- that innovation policy would have a different effect on the innovation process of SMEs and large firms. Problems such as information asymmetry, having a complicated access to financial markets, and the economic risk of R&D projects, among others, could lead small firms to seek public support and, consequently, to invest more in R&D. On the contrary, large firms could take advantage of public funds to sidestep hitches associated with technical risk, the difficult appropriation of results or other problems not connected to an increase in their R&D investments (Urzay, 2001).

In order to have a broader knowledge of the effect of policy on the innovation process of large firms and SMEs, this study proposes testing two hypotheses:

Hypothesis 2: R&D subsidies have, depending on firm size, a different effect on the inputs of the innovation process.

Hypothesis 3: R&D subsidies have, depending on firm size, a different effect on the outputs of the innovation process.

Testing these hypotheses is of vital importance to policy making, since the differences and complementarities regarding innovation which arise in different sizes of firms suggest that policymakers should combine two different approaches

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in the task of distributing public aid. Firstly, a general approach should be applied which makes aid equally available to large firms and SMEs, an approach that would enable the industry's technological diversity to be maintained. Secondly, a specific approach should be geared to solving the specific problems associated to each of these groups of firms.

3. Methodology

This study applies a non-parametric pairing method, called Propensity Score Matching (PSM), so as to analyze the distribution and effect of R&D subsidies according to firm size. This method estimates the effect of a binary treatment (S) on variables denominated potential outcomes (Y). From the work by Rosenbaum and Rubin (1983), the PSM is widely used in the evaluation of policy interventions and recently in the evaluation of innovation policy at a micro level (Czarnitzki & Fier, 2002; Almus & Czarnitzki, 2003; Duguet, 2003; Herrera & Heijs, 2007). As in this study, the PSM is used to discover the effect of participating in programs of subsidies for R&D on the firms' innovation activity Y_i. The method specifically compares the results achieved by the firms that receive R&D subsidies Y_{1i} (factual state) with the results that they would have obtained had they not received aid Y_{0i} (counterfactual state).

Since a firm *i* cannot be simultaneously observed when receiving or not receiving a subsidy, the counterfactual state turns out to be the fundamental evaluation problem and is estimated from the information available on the non-subsidized firms, which form part of a control group. The construction of this group is not easy, since the distribution of R&D subsidies is not random and subsidized firms differ from those which are not subsidized. This produces a problem known in econometric studies as sample selection bias. The PSM reduces the bias by means of a matching method, which compares subsidized firms with the non-subsidized ones which are similar in terms of their observable characteristics X_i. Due to the fact that the matching of firms of many characteristics *n* in an n-dimensional vector is generally unfeasible, the method reduces the characteristics of each firm into a scalar variable or Propensity Score (PS) so as to make a matching more feasible. The PS is defined as the conditional probability of receiving a R&D subsidy given a group of *pre-treatment* characteristics X_i. In this way, the method compares

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subsidized firms with non-subsidized ones having the same likelihood of receiving R&D subsidies. A probit or logit model can be used to estimate the PS. This study uses a probit model as it is the most frequently applied in the literature. This study, does not only estimate the PS for each firm, but also analyzes the variables X_i which have an influence on this likelihood.

Since it is hardly likely that two firms with the same PS value can be found, a matching method is necessary. Becker and Ichino (2002) compare several methods (i.e., Nearest Neighbor Matching, Radius Matching, Kernel Matching and Stratification Matching). This study uses the Nearest Neighbor Matching Method, which is one of the most frequently used in the literature. This method chooses for each unit treated a control group unit which has the closest propensity score.

Once the control group has been obtained, estimating the causal effect requires compliance with a series of assumptions to ensure that the subsidy distribution is random (between subsidized firms and the control group) and that the counterfactual state is estimated on the basis of the control group. Meeting these assumptions requires the researcher to know all the variables which influence on the likelihood of obtaining aid. For these assumptions to be plausible this study chooses a broad set of variables which according to the literature influence the likelihood of obtaining R&D subsidies. The PSM also requires observations with the same PS to have the same distribution of observable characteristics, regardless of the status of the treatment, a balancing property. The algorithm of Becker and Ichino (2002) is used to test the balancing property and to estimate the causal effect. This algorithm tests whether the means of each characteristic differ between the treated and the control units.

Finally, if Y_i represents a firm's innovation activity, S takes the value of 1 when the firm i receives a R&D subsidy and zero in the opposite case, and $P(X_i)$ represents the propensity score, then the effect of subsidies τ can be estimated as the difference between the innovation activity of subsidized firms and the innovation activity of non-subsidized firms, thus:

$$\tau = E\{E\{Y_{1i} \mid S_i = 1, p(X_i)\} - E\{Y_{0i} \mid S_i = 0, p(X_i)\} \mid S_i = 1\} \quad [1]$$

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Dehejia and Wahba (2002) thoroughly review this methodology and Almus and Czarnitzki (2003) describe the use of the PSM applied to the evaluation of innovation policies. The study by Arvanitis and Keilbach (2002) undertakes a comparative analysis between the PSM and other methods used to evaluate innovation policies.

4. Data and variables

Data

The data analyzed in this study arises from the 'Business Strategy Survey' (Encuesta sobre Estrategias Empresariales - ESEE), sampled by the SEPI Foundation. The survey annually records information on the strategic behavior of about 3000 Spanish firms with more than 10 employees. The sample of firms with a complete data set is on average about 2000. Since 1998 the survey collects detailed information on the firms' innovation activity, including information on the degree of formalization of the innovation activity, technological cooperation and R&D funding difficulties. Furthermore, the survey gathers information on the firms´ access to innovation-promoting policies available in Spain. Specifically, R&D subsidies in the form of financial fund transfers from three different sources: the Central Government, the Autonomous regions and other bodies including the European Union.

Data of the period covering the beginning of 1999 to 2001 are used for the analysis. This study estimates the effect of R&D subsidies on the innovation activity of firms in the same year the firms received subsidies (year 2000) and also a year later (year 2001). The treatment variable, that is, whether subsidies were received or not in the year 2000, is determined by lagged explanatory variables (according to the methodology), that is, pre-treatment values in 1999, thereby reducing possible endogeneity problems and improving the quality of matching.

The total sample contains 1718 firms who replied to the survey in each of the three years. In the sample 208 firms received R&D subsidies. In order to identify these firms, a dichotomous variable was created which has the value of 1 if the firm received a subsidy from one of three sources in the year 2000, and 0 if not. As in most empirical studies, because of the limited number of subsidized firms, it is not

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possible to undertake a comparative analysis of the subsidy source or the influence the amount of aid given. Only the overall effect of the R&D subsidies available to Spanish firms is calculated.

Although the ESEE survey records unpublished information on innovation activity and innovation policies, this survey has the limitation of only indicating where the subsidies came from, and does not record any information on the characteristics and aims of the support programs. Central Government subsidies may stem from programs with different aims; such as to foster technological research in firms (The Aid Program to Develop Technological Research), giving financial support to perform R&D projects (The Aid Centre for Industrial Technological Development), stimulating innovation and technology transfer (National Technology Transfer Program), financing scientific-technical teams and strengthening human resources training (*Programa Torres Quevedo*). Moreover, the Autonomous Regions have developed plans for promoting research, technological development and innovation. In this case, the support measures for firms are manifold, varying between regions. Finally, among the subsidies included in other bodies the survey covers European Funds. These funds are mainly geared to supporting technological research of an industrial nature.

In addition to the main model, firms are classified according to size into SME's (10–249 employees) and large firms (over 250 employees). The classification by size was made following European Commission recommendations.

Variables used to estimate the causal effect of the R&D subsidies

This study uses different indicators of inputs and outputs of the innovation process to discover the effect of R&D subsidies. Table 1 shows the definition of variables. Firms´ total R&D intensity is an indicator of the innovation effort and input innovation process. Although this variable does not cover the entire range of a firm's innovation activities, the empirical evidence indicates that the subsidy effect is reflected mainly on the R&D expenditures (David et al., 2000). Unlike other studies, this work subdivides the total R&D expenditure into external and internal to discover whether the innovation policy encouraged internal R&D production activity as against acquiring technology from outside the firm. The amount of R&D

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expenditure used to generate these indicators does not include the quantity corresponding to the R&D subsidies.

The effect of R&D subsidies on the output innovation process is less evaluated in the literature. Some authors use patents as an indicator of technology creation (e.g., Branstetter & Sakakibara, 1998, 2002; Czarnitzki & Licht 2006). This analysis includes the firms' propensity to patent. According to Czarnitzki and Licht (2006), despite the limitations that this indicator comprises, the patenting propensity is a closer measure in time to the undertaking of R&D projects, compared to either the sales of new products or to the cost reduction achieved by applying new processes.

Variables used to estimate the propensity score

In order to estimate the propensity score, in other words, the conditional probability of receiving R&D subsidies, the variables are selected in this study according to the empirical evidence that analyses this probability (Busom, 2000; Wallsten, 2000; Acosta & Modrego, 2001; Arvanitis et al., 2002; Czarnitzki & Fier, 2002; Almus & Czarnitzki, 2003; Duguet, 2003). A definition of these variables is given in Table 1.

Size and *age* of firms are included as indicators reflecting management capacity and ability to obtain resources, together with experience. Following the typology introduced by Pavitt (1984), five *industries* are considered in order to control sector differences. An indicator of *region* is introduced in order to verify whether the proximity to a large concentration of infrastructures supporting innovation influenced the propensity to obtain grants. This study differentiates between firms located in central regions of the Spanish innovation system and firms located in peripheral regions following the study by Herrera and Nieto (2008). The *firm's ownership* is incorporated to confirm the influence of the participation of foreign capital.

One variable is included to detect possible aid distribution deviations: *innovation funding difficulty.* Firms with a high capacity for investment could presumably perform R&D projects without an evident need to be subsidized. On the contrary, it

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is hoped that tools such as subsidies are directed towards firms for whom funding is a barrier to innovation.

In order to determine the influence of competitive environment in which the firms operate three variables are analyzed. The first to indicate whether the *firm's main market is growing*. The second to indicate if the firm reports that its *main market consists of fewer than 10 competitors* and the third *export propensity* is considered as a measure of foreign competitiveness.

Finally, *previous R&D expenditures* are included in order to discover whether subsidies were targeted at R&D-performing firms.

Treatment variable	
R&D Subsidies	1 indicates that the firms obtained R&D subsidies from the Central Government, the Autonomous Communities and other Bodies including the European Union in the year 2000
Variables used to estimate the causal effect	
Internal R&D Intensity	Rate between the internal R&D expenditures and sales in the year 2000
External R&D Intensity	Rate between the external R&D expenditures and sales in the year 2000
Total R&D Intensity	Rate between the total R&D expenditures and sales in the year 2000
Patent Propensity	Rate between the patents and the employees in the year 2000
Variables used to estimate the propensity score	
Size	Log of employees in the year 1999
Age	Log of age of the firm in the year 1999
Producers of traditional consumer goods	1 indicates that the firm belonged to this sector in the year 1999 (NACE: 15-22, 26, 36, 37)
Suppliers of traditional intermediate goods	1 indicates that the firm belongs to this sector in the year 1999 (NACE: 27, 28)
Specialized suppliers of intermediate goods and equipment	1 indicates that the firm belonged to this sector in the year 1999 (NACE: 25, 29 33)
Mass production assemblers (reference sector)	1 indicates that the firm belonged to this sector in the year 1999 (NACE: 30-32, 34, 35 Including 35.3)
R&D based sector	1 indicates that the firm belonged to this sector in the year 1999 (NACE: 24)
Region	1 indicates that the firm was located in a central region (Catalonia, Madrid, Basque Country) in the year 1999
% of Foreign Capital	Percentage of foreign capital participation in the year 1999
Difficulties to finance R&D	1 if the firm had difficulties to finance R&D in the year 1999
Growing markets	1 if the firm considered its main market as growing in the year 1999
Market concentration	1 if the firm reported that its main market consisted of fewer that 10 competitors in the year 1999
Export propensity	Rate between exports and sales in the year 1999
R&D expenditures	1 if the firm had R&D expenditures in the year 1999

Table 1. Description of the Study's Variables

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5. Results of the empirical analysis and discussion

Variables that influence the propensity to obtain R&D subsidies

Table 2 shows the results of the estimations of the probit model and the marginal effects obtained. In the general model the findings indicate that large national firms, active in growing markets with difficulties in financing R&D and previous R&D experience are the main receivers of subsidies. On the contrary, firms in traditional sectors and firms with foreign capital are less likely to be subsidized. These findings are similar to those obtained in other studies on the distribution of public support (Busom, 2000; Czarnitzki & Fier, 2002; Heijs, 2003, 2005; Almus & Czarnitzki, 2003; Blanes & Busom 2004). This approach in distribution reveals that public agencies select firms which could guarantee the technical viability of the subsidized projects and which, presumably, could be successful in the market. The results obtained in the estimates by sizes are not very different from the general profile. This is due to the fact that the three determining variables to access public aid are size, the domestic capital and previous R&D experience.

Of the previous findings, it is important to highlight three. In the first place, this study finds that the size exerted a positive and significant influence, not only in the general model, but also in the sub-samples by size (Hypothesis 1 is true). The literature argues that with an increasing firm size the information advantage grows, the capacity to finish R&D activities enhances and the ability to apply for public funds is developed (Almus & Czarnitzki 2003). As a result, public agencies prefer to select large firms. This finding could be explained by the requirements implicit of the support programs. A broad range of public financial support schemes for innovation –theoretically accessible to all firms- is focused on clearly designed R&D projects, which hinder the entrance of small firms with other types of innovation activities. At the same time, the limited capacity of innovation management in smaller firms could have hindered the conversion of their innovation activities in well-organized projects with clear objectives. This problem generated the self-exclusion of smaller firms, due to the very strict concept of the R&D activities which are the object of the majority of the support schemes. Previous studies reveal that the firms reached by the instruments of innovation policy are those which already perform innovation activities, only a very small number of the

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supported firms undertook R&D in an occasional fashion and hardly any of them started R&D activities for the first time due to the public aid.

Secondly, in line with what is previously stated, this analysis finds that previous R&D experience is the most important variable in all models when accessing public funding. In the general model, a change in this variable, ceteris paribus, could increase the probability of obtaining subsidies by 15 percentage points. By firm size, this percentage is greater in the case of large firms (27 percentage points) and remains above 10 points in the case of SMEs.

Thirdly, a special mention is worthwhile to the findings obtained with regard to the variables indicating the sector to which the firm belongs. These findings fit into the reality of the Spanish productive system. The R&D based sector provided 77 percent of the R&D expenditure for the whole of the industry in the period analyzed, and accounted for an important number of innovating firms (cf., INE, 2003). Due to the fact that the agencies more often support firms with previous R&D experience, the firms in traditional sectors have a lesser likelihood of access to public aid, as is shown in the findings in Table 2. The analysis shows that the barrier in obtaining aid for firms in less innovatory sectors is higher in the subsample of large firms. In this case, traditional suppliers of intermediate goods and specialized suppliers of intermediate goods and equipment have less possibility of obtaining R&D subsidies, ceteris paribus, in 25 percentage points and 18 percentage points, respectively.

Finally, the results show significant differences in the case of large firms. Unlike the SMEs, large firms in growing markets are more likely to obtain R&D subsidies. A change in this variable, ceteris paribus, could increase this likelihood by 9 percentage points. This is not an atypical finding. Normally, large firms are chosen on the basis of their experience and likelihood of success in the markets. In the literature this approach is called ‘picking the winners’ (Wallsten, 2000; Czarnitzki & Fier 2002; Blanes & Busom, 2004). The argument against this distribution approach is that successful firms could finance projects even without public aid. Consequently, the policy effect could be less as a result of giving aid to firms which do not have an obvious need for a subsidy.

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According to these ideas, this study expects to find lesser input effects in large firms but not a substitution effect. In general, the results show that the subsidy policy benefits firms with problems in financing R&D activities. Consequently, it could be expected that firms do not substitute private funding for public aid, with a consequential positive result of the policy.

Variables†	Full Sample		SMEs		Large Firms	
	Coef.	M.E.	Coef.	M.E.	Coef.	M.E.
Size (log)	0.28**	0.02**	0.38**	0.01**	0.26**	0.08**
Age (log)	-0.01	-0.00	-0.06	-0.00	0.02	0.01
Producers of traditional consumer goods	-0.81**	-0.07**	-0.86**	-0.04*	-0.84**	-0.25**
Suppliers of traditional intermediate goods	-0.37 ˙	-0.02*	-0.86**	-0.02**	-0.01	-0.00
Specialized suppliers of intermediate goods and equipment	-0.64**	-0.04**	-0.65*	-0.01*	-0.71**	-0.18**
Mass production assemblers	-0.15	-0.01	-0.10	-0.00	-0.28	-0.08
Region	-0.11	-0.01	-0.14	-0.00	-0.11	-0.03
% of Foreign Capital	-0.01**	-0.00**	-0.01**	-0.00**	-0.00 ˙	-0.00 ˙
Difficulties to finance R&D	0.29*	0.03	0.39	0.02	0.21	0.07
Market concentration	0.06	0.01	0.05	0.02	0.10	0.03
Growing markets	0.17 ˙	0.01 ˙	0.04	0.01	0.29*	0.09*
Export Propensity	0.01	0.00	0.00	0.00	0.00	0.00
R&D expenditures	1.29**	0.15**	1.43**	0.114**	1.09**	0.27**
Specification of the models						
N	1718		1232		486	
Number of supported firms	208		75		133	
Number of non-supported firms	1510		1157		353	
Log Likelihood	-415.88		-180.07		-225.15	
Pseudo R^2	0.34		0.36		0.17	
Correctly classified	88.11%		93.51%		73.98%	

† All variables are lagged one year

M.E.= Marginal Effects

** p<0.01; * p<0.05; ˙ p<0.1

Table 2. Results of the Probit Model Estimations and Marginal Effects

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Impact of R&D subsidies on the innovation activity.

Table 3a, 3b, 3c show the findings for a test of means of the pre-treatment variables and the propensity score before and after matching. As expected, before matching the analysis shows significant differences. After matching, these differences disappear between the subsidized and the selected control firms. This not only provides evidence on the matching quality, but also demonstrates that the balancing property is satisfied.

Once these methodology assumptions are satisfied, the average effect of the subsidies on the firms´ innovation activity is established, results are given in Table 4. In order to estimate this effect, an area of common support is used which allowed the firms showing poor levels of matching to be excluded.

In the general model, the results show a positive and significant effect of R&D subsidies on the firm's input innovation process. This finding coincides with that of recent evaluation studies of innovation policy in Spain (e.g., Busom, 2000; González, Jaumandreu, & Pazó, 2005; Callejón & García-Quevedo, 2005; González & Pazó, 2008). The intensity of the firms' total R&D is an average of 2 percentage points higher than that of firms not receiving subsidies in the year 2000. Unlike other studies, the present study divides the total R&D expenditure into internal and external. The results show that subsidies, in all cases, have a positive and significant stimulus on production and technology purchase.

The findings also show a positive, significant effect on firms' propensity to patent. These results coincide with those found in other studies at the firm level (e.g., Branstetter & Sakakibara, 1998, 2002; Czarnitzki & Licht, 2006). Nevertheless, in the Spanish case, the above causal effects should be interpreted with caution for three reasons. First, Spanish firms patent very little because of their low innovation propensity and also due to the firm's not tending to protect the findings of their research. Second, these results need to be understood in view of the type of firms that receive aid. In this analysis, subsidized firms are mainly large with previous R&D experience and do not belong to traditional sectors. These firms generally fit into the chemical and pharmaceutical sectors (according to the R&D based sector classification of Pavitt, 1984). The firms in these sectors are more dynamic and

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have a higher R&D intensity. As a result, their patenting propensity is even higher in the short run.

A year after receiving aid the result is the same in the general model. Nevertheless, in the case of the effect on inputs, though the effect on R&D intensity is reduced, the effect was not significantly lower than that obtained for the year 2000. Only the propensity to patent of firms receiving subsidy show a significant increase a year after receiving aid.

The analysis by firm size finds the following results. Firstly, in the year in which the subsidies are received the effect on inputs of the innovating process is the same in SMEs and large firms. R&D subsidies stimulated effort in R&D, as well as both in-house and outsourced technology generation. This study uses a Student's t-test of means to ascertain whether the effect was significantly greater in any one group of firms when compared with others, no significant findings are obtained. However, a year after the firms receive their subsidies, the findings reveal significant differences between SMEs and large firms. The subsidies act as a positive and significant spur with regard to all degrees of R&D intensity in SMEs, however, only in-house R&D intensity of large firms (Hypothesis 2 is true). In this latter case it can be seen that, although large firms are more likely to receive aid, the effect of subsidies on their in-house R&D intensity is noticeably less than that obtained by SMEs. (Hypothesis 1.1 is true). Specifically, 1.44 and 0.99 percentage points, respectively. An apparently lesser effect of the innovation policy in large firms could be associated with the distribution approach. Public bodies choose large firms with previous R&D experience and a high probability of market success. According to some authors, these firms may be more inclined to undertake projects even without public aid and in consequence could reduce their R&D investment or substitute private funds for public ones (Heijs, 2003).

Secondly, significant differences are found when analyzing the effect of R&D subsidies on the innovation process outputs (Hypothesis 3 is true). R&D subsidies only have a significant effect on the large firms' propensity for patenting in the year when they receive the subsidies and in the following year. These findings are related to those obtained in previous studies in the Spanish case. These findings disclose that the decision to engage in R&D activities and also the obtaining of

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innovatory results are positively related to firm size (e.g., Busom, 1993). SMEs may need more time for the effect of the subsidy to be noticed.

An important conclusion to be drawn from the studies is that the input and output effects are sensitive to firm size and this should be taken into consideration in future evaluation studies. What is more, the differences could encourage policy makers to design support instruments better suited to the reality of firms.

	Full Sample		
	Subsidized	Non-Subsidized	Control Group
Variables	Mean	Mean	Mean
Size (log)	5.8	4.1**[a]	5.7
Age (log)	5.0	4.2**	5.1
Percent of Foreign Capital	30.9	17.4**	34.8
Export Propensity	35.4	16.7**	33.9
Region	0.5	0.5	0.5
Producers of traditional consumer goods	0.2	0.5**	0.3
Suppliers of traditional intermediate goods	0.1	0.1	0.1
Specialized suppliers of intermediate goods and equipment	0.1	0.1	0.1
Mass production assemblers	0.3	0.1**	0.3
R&D based sector (reference sector)	0.2	0.0**	0.1
Market concentration	0.7	0.5**	0.7
Growing markets	0.5	0.7**	0.5
Difficulties to finance R&D	0.1	0.0**	0.1
R&D expenditures	0.9	0.3**	0.9
Propensity Score	0.3	0.1**	0.3
N	208	1510	146

a Significances ** p<0.01; * p<0.05; . p<0.1) indicate that the means compared differ according to the two tailed t-test for continuous variables and Fisher exact test dichotomic variables.

Table 3a. Means Comparisons between Subsidized Firms and Non-subsidized Firms (before matching) and between Subsidized firms and Control Group (after matching)

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	SMES		
	Subsidized	Non-Subsidized	Control Group
Variables	Mean	Mean	Mean
Size (log)	4.4	3.6**	4.4
Age (log)	4.1	3.9	4.2
Percent of Foreign Capital	9.9	10.3	11.7
Export Propensity	27.4	13.3**	20.9
Region	0.5	0.5	0.5
Producers of traditional consumer goods	0.3	0.6**	0.3
Suppliers of traditional intermediate goods	0.1	0.1	0.1
Specialized suppliers of intermediate goods and equipment	0.1	0.1	0.1
Mass production assemblers	0.3	0.1**	0.4
R&D based sector (reference sector)	0.1	0.0**	0.2
Market concentration	0.6	0.4**	0.6
Growing markets	0.4	0.4	0.4
Difficulties to finance R&D	0.1	0.0**	0.1
R&D expenditures	0.9	0.2**	0.8
Propensity Score	0.2	0.1**	0.2
N	75	1127	58

[a] Significances (** p<0.01; * p<0.05; · p<0.1) indicate that the means compared differ according to the two tailed t-test for continuous variables and Fisher exact test dichotomic variables.

Table 3b. Means Comparisons between Subsidized Firms and Non-subsidized Firms (before matching) and between Subsidized firms and Control Group (after matching)

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	Large Firms		
	Subsidized	Non-Subsidized	Control Group
Variables	Mean	Mean	Mean
Size (log)	6.5	6.2***	6.5
Age (log)	5.5	5.4	5.8
Percent of Foreign Capital	42.8	46.5	41.7
Export Propensity	39.9	32.0***	37.1
Region	0.5	0.5	0.5
Producers of traditional consumer goods	0.2	0.5***	0.3
Suppliers of traditional intermediate goods	0.2	0.1**	0.2
Specialized suppliers of intermediate goods and equipment	0.1	0.1	0.1
Mass production assemblers	0.3	0.2**	0.2
R&D based sector (reference sector)	0.1	0.0**	0.1
Market concentration	0.7	0.7	0.7
Growing markets	0.5	0.4**	0.5
Difficulties to finance R&D	0.1	0.0*	0.1
R&D expenditures	0.9	0.7***	0.9
Propensity Score	0.4	0.2***	0.4
N	133	311	82

[a] Significances (** p<0.01; * p<0.05; · p<0.1) indicate that the means compared differ according to the two tailed t-test for continuous variables and Fisher exact test dichotomic variables.

Table3c. Means Comparisons between Subsidized Firms and Non-subsidized Firms (before matching) and between Subsidized firms and Control Group (after matching)

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	Mean Subsidized Firms	Mean Non-Subsidized Firms	Causal Effect	Bootstrap standard errors	t- value	n
Full sample						
External R&D Intensity						
2000	1,224	0,386	0,838**	0,194	4,309	334
2001	0,983	0,261	0,722**	0,257	2,808	334
Internal R&D Intensity						
2000	2,051	0,89	1,161**	0,317	3,665	333
2001	1,553	0,437	1,116**	0,198	5,625	334
Total R&D Intensity						
2000	3,275	1,272	2,003**	0,422	4,742	334
2001	2,536	0,698	1,838**	0,348	4,555	334
Patent Propensity						
2000	0,005	0,002	0,003*	0,002	1,998	333
2001	0,212	0,016	0,196**	0,053	3,703	332
SMEs						
External R&D Intensity						
2000	1,19	0,277	0,913**	0,234	3,903	137
2001	1,018	0,162	0,856**	0,19	4,51	137
Internal R&D Intensity						
2000	2,51	1,052	1,458**	0,458	3,183	136
2001	2,082	0,641	1,441**	0,475	3,031	137
Total R&D Intensity						
2000	3,7	1,315	2,385**	0,55	4,34	137
2001	3,1	0,803	2,297**	0,617	3,726	137
Patent Propensity						
2000	0,005	0,002	0,003	0,003	1,106	135
2001	0,142	0,046	0,096	0,072	1,335	135
Large firms						
External R&D Intensity						
2000	1,244	0,432	0,812**	0,288	2,822	217
2001	0,963	0,704	0,259	0,435	0,499	218
Internal R&D Intensity						
2000	1,785	0,702	1,083**	0,29	3,728	217
2001	1,247	0,468	0,779**	0,222	3,504	218
Total R&D Intensity						
2000	3,029	1,126	1,903**	0,469	4,059	218
2001	2,21	1,172	1,038	0,639	1,626	218
Patent Propensity						
2000	0,004	0,001	0,003**	0,001	3,172	215
2001	0,298	0,011	0,287**	0,104	2,745	167

(** p<0.01; * p<0.05; · p<0.1).

Table 4. Average Effect of the R&D Subsidies on the Firm's Innovation Activity in the years 2000 and 2001

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6. Final remarks and conclusions

The aim of this research is to delve more deeply into the study of the relationship between the size of the firm and innovation policy. With this aim this study analyzes the distribution and effect of subsidies for R&D on inputs and outputs in firms' innovation process. The analyses are made on the general model and on two subsamples by size of firms (SMEs and large firms).

The study of the distribution finds that large firms are more likely to obtain subsidies for R&D and that this finding could be explained by the fact that they are more able to meet the requirements laid down by the bodies distributing public aid. The study also shows that between SMEs and large firms the most important variable in gaining access to this type of aid is previous R&D experience. The aid distribution policy clearly favours some of the most dynamic and fast-growing innovative firms. However, this policy does not generate an improved industrial dynamic by increasing the number of innovative firms.

The results also show a differentiating element between SMEs and large firms. Unlike SMEs, large firms in growing markets are more likely to receive R&D subsidies. In the literature the argument against this distribution approach is that firms likely to be successful in the market could finance their R&D projects without public aid and consequently could register a lesser effect from innovation policies on their R&D investments, due to a tendency to replace private funds by public ones. This study finds that in the case of large firms this effect is not only slighter; it is also non-significant on some variables.

In the study of the effect this article concludes that in order to be able to observe significant differences between SMEs and large firms a certain time margin must be borne in mind before such differences become visible. In the study of the effect of R&D subsidies on inputs of the innovation process, the analyses show that in the year when firms receive subsidies the effect is the same for SMEs and large firms. Nonetheless, a year after the subsidies are received, significant differences are found. R&D subsidies have a positive influence on the total innovative effort of SMEs and there is a complementary nature between in-house and outsourced strategies for generating technology. Though large firms are more likely to receive subsidies, they only show a positive and significant effect on in-house technology

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generation, the size of this effect is significantly less than that obtained by the SMEs. This confirms that firms which are less likely to obtain public aid showed the greatest effect.

With regard to outputs of the innovation process, the analysis shows that R&D subsidies have a positive, significant effect only on the tendency to patent in the case of large firms and that this propensity shows a significant rise a year after receiving this aid. As a consequence, the present report concludes that the effects of innovation policy on the inputs and outputs of the innovation process are variable depending on the size of the firm. From the findings obtained in this study two recommendations are formulated for future innovation policy evaluations. Firstly, it is important to make a joint evaluation of the aid distribution and its effect. Firms more likely to obtain public backing do not always gain the greatest effect from the policy. Consequently, the conclusions stemming from this analysis could improve the access to the different support instruments. Secondly, input and output effects are sensitive to firm size. This could encourage policy makers to previously define the type of effect they wish to attain in relation to each firm size.

Finally, it is necessary to make reference to one of the limitations of the study which could become a possible future research line. Having performed this study using a cross-sectional analysis, this study cannot draw conclusions nor shed light on the subsidy effect in relation to the future performance of firms. Estimating the future impact of the subsidies is a task pending in the innovation policy evaluation practice. If the task is not completed, the policy effect on technological progress and on the transformation of the productive sectors will not be able to established. In consequence, future research lines should determine the minimum time period necessary to make the R&D subsidy effects visible, particularly making an allowance for broader aspects of the firms' innovation activities. In addition, it should also be verified that this time period is the same for large and SMEs.

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