THE NATIONAL INNOVATION POLICY EFFECT ACCORDING TO FIRM LOCATION

Abstract: The regional nature of innovation and innovation policy was investigated. The aim of this study was to determine whether the specific economic and institutional conditions of a region had an influence on the results of a national policy intended to support entrepreneurial innovation. The analysis compared the effect of the national R&D subsidies on the innovation effort of firms located in central regions which concentrate an important percentage of the national innovation activity, together with those firms located in periphery regions. Significant regional differences were detected with regard to the national R&D subsidies' effect and distribution. The Central regions manifested a higher subsidy effect compared to the periphery regions. The results of this study have allowed us to conclude that the region plays an important differentiating role in connection with the final result of the innovation policy aimed at the entire national territory. Therefore, this study recommends including the geographical location of the firm in future evaluations.

Keywords: R&D Subsidies, Innovation Policy, Propensity Score Matching

1. Introduction

During the last two decades special interest has been drawn to investigate the localisation of the innovation activities as a source of competitive advantage in a global economy. Awareness has risen due to the emergence of industrial clusters, competitive districts and regions, creating the notion that the proximity between firms, economic agents, institutions and resources is a key aspect for the development of the innovative process (Maskell and Malmberg, 1999; Storper, 1997; Asheim, Isaken, Nauwelaers and Tödtling, 2003; Asheim and Gertler, 2005).

Different approaches have been formulated in the literature to shed light on the processes of territorial technological concentration within regions: industrial clusters (Baptista and Swann, 1998; Porter, 1998); innovative milieu (Aydalot and Keeble, 1988; Camagni, 1991, 1995; Kleinknecht and Poot, 1992), technology districts (Saxenian, 1994; Castell and Hall, 1994; Storper, 1995) and regional innovation systems (Cooke, Gómez-Uranga and Etxebarria, 1997; Tödtling and Kaufmann, 1999). These different approaches are based on copious empirical evidence which points out, that the factors identified by the theory as relevant for the technological change to take place, such as, the infrastructures, the nature of the firms' relationship, the learning capacity or the innovation activity, differ significantly among regions (Oughton, Landabaso and Morgan 2002). Consequently, regions are characterised by different preconditions to undertake innovation (Tödtling and Kaufmann, 1999). Thus, the region has developed into an important actor to spur up the innovation activity as well as an important factor for empirical studies. As a matter of fact, some studies have pointed out on one hand, that the degree, in addition to the success, of the innovation activity can be altered by the extent of a regions' knowledge and technology accumulation (Fritsch 2000), on the other hand, this technology accumulation and the proximity increase the knowledge spillovers' effect which contributes to create new technological opportunities that facilitate the emerging of entrepreneurial firms (Kirchhoff and Phillips, 1989; Kassicieh, Kirchhoff, Walsh and McWhorter, 2002; Acs and Armington 2006; Kirchhoff, Newbert, Hasan and Armington, 2007).

Different authors have discussed the impact of these notions on the innovation policies and have entered in a debate to assign different tasks to the national and regional policies (Maillat, 1995, 1998; Landabaso, 1997; Mcdonald, Tsagdis and Huang, 2006). Nevertheless, these authors coincide in stating that given that the economic convergence of regions with different levels of technological development is not easy, a successful national innovation policy should be focussed on the regional dimension as the key aspect in the process of technological change (Storper, 1995; Cooke et al., 1997; Dohse, 2000; Clarysse and Muldur, 2001). Although these concepts have started to be accepted by policy makers, in the majority of industrialised nations the Central Government keeps on devising the innovation policies, and the regional differences regarding innovation activity reveal that the national policy does not affect all regions in equal terms, which poses a serious problem to the process of regional convergence (Holbrook and Salazar, 2003). This poses a new implication for policy makers, that is, to efficiently distribute the public aid between regions with a different concentration level of innovative activity.

Although the literature that has examined the geographical aspect of innovation has provided arguments pointing out to the relevance of considering the regional dimension as an analysis unit, an important gap exists between the former literature and that which studies the effect of the innovation policies. The policy effect has been evaluated taking into account the firm's structural characteristics, such as size or activity sector. Variables that the theory has shown to have some bearing on the innovation activity. Nonetheless, to quantify the effect of the variables related to the geographical or competitive context on the policy outcome is a task pending of the evaluation practice. Obtaining knowledge on the magnitude of the regional differences owing to the effect of these policies results decisive to improve the distribution of the public financing and also to promote a genuine regional convergence. Within this context, this study adopts a central-periphery approach to contrast the hypothesis that the distribution and effect of the national R&D subsidies differ between regions with a dissimilar level of innovation activity concentration. The empirical investigation is based on data of Spanish regions with important disparities concerning technology accumulation.

Concretely, the aim of this study has been to assess the effect of the Spanish national innovation policy on the R&D intensity of firms located in the autonomous regions of Catalonia, Madrid and the Basque Country, regions which concentrate 70.5% of the innovative activity carried out by Spanish firms, as well as firms located in the remaining regions. We have focused our analysis on the direct R&D subsidies granted to industrial firms, since they are the most important tool of the Spanish innovation policy.

The analysis of both the distribution and its effect was undertaken by means of a method based on the assessment of non-experimental treatments, Propensity Score Matching (PSM), recently applied to the evaluation of political interventions. The PSM helps to a certain extent to deal with two significant aspects of the evaluation process: the control over the process of aid distribution and the estimation of a counterfactual state. In contrast to other studies carried out so far, this study has included aspects not previously considered in the literature on innovation policy. These aspects are related to the strategic activity of firms, the difficulty of accessing innovation resources, the degree of technological dependence of the firm and the state of the market in which they are operating. The wide range of variables analysed in this study helps to provide a better understanding of the factors that influence the aid distribution.

This study is structured as follows: in section two we present general aspects related to the evaluation of innovation policies and theoretical arguments to justify the notion that the regional dimension is a basic analysis unit pertaining to such evaluation. In the third section we describe the methodology employed, data and variables are presented in section four, the results of an empirical analysis are discussed in section five, and finally, the conclusions are presented in section six.

2. The innovation policy and the regional dimension

The policies that encourage firm innovation are defined as the combined actions directed towards increasing the amount and intensity of the innovation activities, defined the later as the creation, adaptation or adoption of new or improved processes, products or services (Lundvall and Borras, 2005). The literature concerned with the evaluation of these policies has generally contrasted the hypothesis that the R&D subsidies bring about an "additional" growth of the firm's innovation activity, thus denominating the outcomes of the innovation policy as "additionality effects". The definition can be applied to all the possible impacts of a given aid program, in such a manner, that additionality effects have been found in the inputs and outputs of the innovation process (quantitative studies) and also in the behaviour and cognitive capacity of firms (qualitative studies) (Buisseret, Cameron and Georghiou, 1995).

Studies have been carried out at different aggregation levels (country, industry and firm) and they all have presented heterogeneous results. At the firm level, which is the concern of this study, the empirical studies have mainly contrasted a hypothesis regarding the effects of input additionality based on the context of R&D investments. According to David, Hall and Toole (2000), the empirical evidence is not conclusive; in some studies the public R&D *complements* the private R&D, while in other analyses the private R&D is *substituted*. Although different arguments can be formulated to explain these outcome disparities, some authors sustain the idea by which the evaluation of the innovation policies could be improved by means of exerting control over the aid distribution process. The main idea is that the success of the innovation policy depends on, among other things, on the capacity of the Government to distribute the resources, the structural opportunities and the restrictions that are offered by the firms (Lipsey and Carlaw, 1998; Grande, 2001).

Accepting this idea has changed the traditional framing approach associated with policy evaluation, which relied on the analysis of the unidirectional relation of policy innovation *vs*. innovation activity, to bring about the incorporation of a third element into the analysis, that is, the distribution of the public aid. Taking into consideration the distribution, poses interesting questions not only for the policy evaluation, also for the design of aid instruments. For example, what type of firms receive more often subventions?, or is the effect greater in these firms? Different studies have given an answer to these questions taking into account firm size or the sector of activity, variables that the theory as well as the empirical evidence have demonstrated to influence the innovation activity (Cohen 1995; Malerba and Orsenigo, 1997).

In the present study we propose to include the regional dimension as yet another level of analysis. Literature reflects that when the region is taken into account the firms' innovation activity differs in many aspects, as a result, the firms' necessities to receive public aid could also differ. Theory suggests that these regional differences are due to the fact that proximity facilitates the transmission of tacit knowledge and learning (Jaffe, 1989; Jaffe, Trajtenberg and Henderson, 1993; Audrestch, 1998), favours the cooperation between innovation agents (Von Hippel, 1988; Lundvall, 1988), attracts a higher level of human capital (David and Rosenbloom, 1990) and reinforces the capacity to build up relevant institutions (Cooke et al., 1997). In addition, theory points out that regions posses localised capabilities with a path-dependent development (Maskell and Malmberge, 1999). As a result, each region has a different technological reality and it is necessary to take into account the regional dimension to obtain consistent estimates of the innovation policy, specially when the aid instruments are distributed from the national and supranational levels.

This study has adopted a simple regional central-periphery scheme to analyse the impact of the regional conditions on the innovation activities. Central regions benefit from a higher development and a greater concentration of innovation resources and results. On the contrary, periphery regions would have a scarce development, a meagre orientation towards change of its traditional sectors, a scant innovation culture together with structural problems, as for instance, the firms' difficulty to identify its innovation necessities (Buesa, Martínez, Heijs and Baumert, 2002a). According to Fritsch (2000), three hypothesis have been contrasted in the literature. The first hypothesis suggests that new processes are developed first in the central and then in the periphery regions. The second hypothesis regards that the decision to undertake R&D and the intensity of the R&D activities is greater in the Central regions compared to those in the periphery. The third hypothesis proposes that the Central regions are more favourable environments to carry out product innovations. According to the author, the empirical research that contrasts these hypotheses is still not conclusive. Nevertheless, the regional differences related to the innovation activity remain and are a source of preoccupation for policy makers, who must be acquainted with the magnitude of these differences in order to promote the real convergence across regions and to improve the design of the different public aid instruments (Oughton et al., 2002).

In spite of the different standpoints favourable to include the regional dimension in innovation studies, the literature concerning innovation policy evaluation has hardly contrasted the hypothesis that the regional conditions impinge on the final outcome of the policy. In studies at the firm level, like the present, the literature concludes that the innovative firms in Central regions show a higher tendency to receive R&D subsidies, however, the studies did not assess if the effect was greater in these regions (Czarnitzki and Fier, 2002; González, Jaumandreu and Pazó, 2005). In a study concerning firm participation in European Technology Programmes, Vence, Gutín and Rodil (2000 p. 37) found that the partaking depended mainly on the accumulated technological capability of firms or R&D effort. Concretely, these authors have called attention to the possibility of creating in Europe "a 'vicious circle' for peripheral and less developed regions, falling into a low R&D trap: low R&D implies low participation in European programmes, and vice versa, low participation increases the gap with regard to core regions".

Recently, in the study carried out by Czarnitzki and Licht (2006), the regional dimension was included to shed light on the innovation policy effect. The study analysed the distribution and effect of the R&D subsidies in firms located in the German former East and West regions. The study established that not only the beneficiary firm profile differed between the regions, in addition also the magnitude of the subsidy effect varied. Although the study determined that the effect of the same policy differed between regions, it was not established if this also occurs when the region's innovative activity level of agglomeration is taken into consideration. This concentration level is important, as recent studies have shown that different firm necessities exist in innovative activity accumulating and non-accumulating regions (Erken and Gilsing, 2005; Hu, Lin and Chang, 2005).

In agreement with the theoretical viewpoints in support of the region's importance as an analysis factor pertaining to the investigation on innovation activity, as well as the empirical evidence that the regional conditions have an effect on the innovation policy result, we have formulated the following hypothesis:

Hypothesis: *the innovation policy effect varies between regions with a different level of innovation activity concentration.*

We have contrasted this hypothesis adopting for the case of Spanish regions a central-periphery framework. The majority of the studies that have analysed the relationship between innovation and the Spanish regional dimension have concluded that the innovation activity is concentrated in a few regions and the regional disparities are very marked (Castillo and Jimeno, 1998; Coronado and Acosta, 1999; Calvo, 2000, 2002; Buesa et al., 2002b). The geographical distribution of the innovation activity in Spain has lead some authors to distinguish between two groups of regions in the peninsula. *Central* regions holding first order innovation systems, which retain a greater development of resources and innovation results. Within this group are the autonomous communities of Madrid, Catalonia and the Basque country, which concentrate seventy percent of the Spanish entrepreneurial innovation activity. The rest of the autonomous communities belong to the second group and are denominated *periphery* regions (Buesa et al. 2002a). Table 1 depicts different indicators that reflect the Spanish level of innovation activity accumulation; these indicators have shown almost no variation over the last decade.

(Table 1 here)

Studies have concluded that the innovation effort of Spanish regions depends largely on the industrial sector (Buesa et al., 2002b) and that the regions are orientating their local R&D budgets towards academia and not the industry (Sanz-Menéndez and Cruz-Castro, 2005). As a result, the firms' innovation activity incentive weighs strongly on the national policy. Accordingly, the worth to evaluate for the Spanish case the policy's relevance in the regions.

In this study, the effect of the national R&D subsidies was estimated in the three Central regions and in a sample that pooled the rest of the regions. In this manner, this study also presents evidence that determines if the effect of the innovation policies can differ among the Central regions. Even though in this study a central-periphery approach was adopted to analyse regional differences, we do not enter in the debate concerning the convenience of more public R&D investment in central or periphery regions as have done other authors (Landabaso, 1997; Ougthon et al., 2002; Rodriguez-Pose, 2001, Buesa et al., 2002ab). Nevertheless, we coincide completely with the different authors in affirming that it results crucial to know the magnitude of these differences at the moment of designing new innovation policies.

3. Methodology

The methodologies applied to the innovation policy evaluation have been recently revised and it has been concluded that the new approaches must control two key aspects. In first place, the incorporation in the evaluation models of the public aid distribution problem. For instance, R&D subsidy distribution is non-random, firms request these subsidies and often compete for them. Consequently, a distribution process exists which results in differences between firms that were granted a subvention and those that were not bestowed (sample selection bias). In second place, there exists the problem of how to estimate the casual effect of the policy, it has been argued that the estimation of the "additionality" effect requires knowledge of the events in absence of the policies, so as to determine if the effect was in reality "additional"; Klette, Moen and Griliches (2000) offer a detailed discussion about the subject. In other words, the analysis requires a comparison of the potential outcome of the dependent variable (Y) when receiving public support – or *factual state* – with its value in the absence of policies – or *counterfactual state*. Due to the fact that both states are for a firm simultaneously unobservable, it is crucial to calculate approximately the counterfactual value in order to obtain a correct estimation of the policy effect.

We have applied in this study a non-parametric pairing method, called Propensity Score Matching (PSM), in order to produce a situation as close as possible to solving these problems. Following the work of Rosenbaum and Rubin (1983), the PSM method has been widely used in the evaluation of policy interventions, especially those concerning the labour market and recently also in the evaluation of innovation policy at a micro level (Czarnitzki and Fier, 2002; Almus and Czarnitzki, 2003; Duguet, 2003;

Czarnitzki, 2006; Czarnitzki and Licht, 2006; Herrera and Heijs, 2007). As in the above studies, the PSM has been used in this study to establish the effect of participating in R&D subsidy programs on the firms' innovation effort (Y_i). Specifically, the method compares the results achieved by those firms taking part of the program Y_{1i} (factual state) with the results that they would have obtained if they had not taken part Y_{0i} (counterfactual state).

Since a firm (*i*) cannot be simultaneously observed receiving and not receiving a subsidy, the counterfactual state becomes the fundamental evaluation problem, it is estimated from the information available on non-subsidised firms which form part of a control group. The construction of this group is not an easy task, since the distribution of R&D subsidies is non-random and subsidised firms differ from those which are not supported. This produces a problem known in econometric studies as sample selection bias. The PSM reduces this bias by means of a matching method, which compares the subsidised firms with the non-subsidised which are similar in terms of their observable characteristics (X_i). Due to the fact that the matching of firms with 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), in order to make matching more feasible. The PS is defined as the conditional probability of receiving a R&D subsidy given a group of individual characteristics (X_i). In this way, the method compares subsidised firms with non-subsidised ones having the same likelihood of receiving R&D subsidies. A probit or logit model can be used to estimate the PS. We have used a logit model since it one of the most-frequently used in the literature. In this study we not only estimate the PS for each firm, but we also analyse the variables (X_i) which have an influence on this likelihood (See section 5.1).

Since it is hardly likely to find two firms with the same PS value, it is necessary to use a matching method. Becker and Ichino (2002) compare several methods (i.e. Nearest Neighbor Matching, Radius Matching, Kernel Matching and Stratification Matching). Though all the methods are assumed to arrive at the same result, in accordance with Heckman, Ichimura and Tood (1997), the choice between one method or another is only important in the case of small samples. In this study, the Nearest Neighbour Matching Method, one of the most widely used in the literature, was chosen. This method selects for each treated unit a unit belonging to the control group which has the closest propensity score.

Once the control group has been obtained, estimating the causal effect requires the compliance with a series of assumptions to ensure that the subsidy distribution is random 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 influencing on the likelihood of obtaining aid. For these assumptions to be plausible, in this study we have chosen a broad set of variables which according to the literature influence the likelihood of obtaining R&D subsidies (See Section 4.3). 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. We have used the algorithm of Becker and Ichino (2002) to test the balancing property and to estimate the causal effect. This algorithm tests that the means of each characteristic do not differ between treated and control units.

Finally, if Y_i represents the firms' innovation effort, S takes the value of 1 when firms receive R&D subsidies 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 effort of subsidised firms and the innovation effort of non-subsidised firms, thus:

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

Dehejia and Wahba (2002) thoroughly review this methodology and Almus and Czarnitzki (2003) describe the use of the PSM applied to the case of the innovation policy evaluation. The study of Arvanitis and Keilbach (2002) undertakes a comparative analysis between the PSM and other methods utilised to evaluate innovation policies. A review of the selectivity problem and a comparative study of different methods to solve it can be found in Heckman, Ichimura and Tood (1998).

4. Data and Variables

4.1 Data

The data used in this study proceed from the survey on Business Strategies (Encuesta sobre Estrategias Empresariales / ESEE) prepared by the SEPI Foundation. The survey annually compiles data from approximately 3000 Spanish manufacturing firms[1]. We have used data of industrial firms during the period spanning 1998 to 2000. The sample

[1] Farinas and Jaumandreu (1999) undertook a descriptive study of the survey which includes the mechanisms applied to gather the data.

was limited to the innovative firms which answered the questionnaire during the three consecutive years, and in addition, invested in R&D during that period. The sample includes firms that received national R&D subsidies in the form of financial transfers of funds, excluding regional or European grants. The sample contains a total of 1517 Spanish firms distributed as follows: 343 in Catalonia, 300 in Madrid, 109 in the Basque Country and 765 in other regions. In order to identify the group of subsidised firms, a dichotomous variable was created which had the value of 1 if the firm received a subsidy, and 0 if not.

4.2 Estimator of the casual innovation policy effect

The potential outcome (Y), from which the innovation policy effect was estimated, was the R&D intensity of firms, defined as the average R&D expenditure over sales during the period, multiplied by one hundred. Although the 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 expenditure (David et al., 2000). Estimating the effect on other elements of innovation activity is a task awaiting the evaluation practice. In this study an initial estimation of the policy effect on R&D intensity was carried out, with the objective of comparing the results of the Spanish case with studies undertaken in other countries and which have applied the same methodology.

4.3 Estimators of the propensity score

As explained above in the methodology, the estimation of the propensity score or the conditional probability of receiving national R&D subsidies is a preliminary step necessary to estimate the causal effect. The researcher's lack of information regarding unobserved aspects, as for instance, the criteria applied by the agency that distributes the support, the characteristics of the firms that participate and are rejected, as well as the non-identification of the programme, have all hindered arriving at an approximation of a model that explains the distribution of the grants. Consequently, econometric studies as in the present case, have resolved the problem by means of an equation that explains the probability of obtaining R&D subsidies. Up to the present time, the selection of variables which explain this probability has been approached in the absence of a theoretical framework, and has only responded to the necessity to include equations in the models in order to reduce the bias derived from a non-random aid distribution.

Variables have been selected in this study according to the empirical evidence that analyses this probability (Busom, 2000; Wallsten, 2000; Acosta and Modrego, 2001; Arvanitis, Hollenstein and Lenz, 2002; Czarnitzki and Fier, 2002; Almus and Czarnitzki, 2003; Duguet, 2003). Additionally, variables which had not been previously analysed in the literature have been included in this study to offer information about the innovation policy approach and direction. These variables are related to: the ability to obtain resources, the possibility of a privileged relationship with agencies, the innovation strategy and the degree of technological dependence of the firm. In this context, three groups of variables were identified, namely, variables associated with the firm's characteristics, the firm's market and its innovative behaviour.

Variables associated with the firms' characteristics. *Size* was included (log of the number of employees) and *age* (average age during the period) as indicators of experience, management capabilities and ability to obtain resources. In order to control for industrial differences, the firms were classified as belonging to *high, medium* or *low tech industries*[2]. *Ownership of the firm* (percentage of capital participation) was included with the purpose of testing whether the aid was mainly addressed to firms with foreign or public capital participation[3]. The subsidiaries of foreign companies usually see their R&D strategy influenced and could take advantage of the technological developments in other countries (Blanes and Busom, 2004). Due to the aforementioned reason, agencies are expected to discriminate against these kinds of firms. The public share is included in order to test for a possible privileged relationship with Government agencies. Following the study of Lichtenberg (1987), we have included for the same reason, a dichotomised variable that indicates whether the *Government is a customer* of the subsidised firm. Finally, we have included a variable which aims to detect possible deviations in the distribution of subsidies: the *difficulty in funding innovation activity*. Instruments such as subsidies are expected to be directed towards firms for whom financing is a barrier to innovation (Arvanitis et al., 2002). The variable acquires a value of 1 if the company had difficulties in obtaining external funding for innovation, and 0 in the opposite case.

Market related variables. The choice of this group of variables responds to the necessity to consider in models regarding innovation policy evaluation the competitive environment in which the firms operate (Papaconstantinou and Polt, 1997). The main reason for this argument is that the agencies generally demand that firms hand in a description of the potential market towards which the subsidised projects are directed. A

[2] The high tech industry was maintained as a reference.
[3] The general tendency of these studies is a stricter selection of firms with public capital and a smaller share of companies with foreign capital.

dichotomised variable was included to reveal whether the firm was operating within an expanding market during the period of analysis. Similar to other studies, we have included the export propensity [(average of exports/average of sales) * 100] within this group of variables, as a measure of foreign competitiveness.

Innovative behaviour variable. Different indicators were introduced in order to verify whether those firms with an articulated and formal innovation activity are also those which are the main recipients of subsidies. Two dichotomised variables indicate respectively, if a firm carried out innovation planning and management activities, and if it underwrote technological cooperation agreements. With regard to the first variable, firms that plan their operations systematically and detail them in a proposal, should be expected to find it easier to file aid applications (Heijs, 2005). This variable, to a certain extent, is also a representative of the absorption capacity, and therefore, it is interesting to find out whether it increases the probability of obtaining subsidies. The technological cooperation indicator was included in order to examine whether companies with a certain potential for technology transfer find it easier to access support programmes. For the same reason, we have also included the variable *technological exports*[4]. Differing from other studies, it seems important to include the variable *technological imports* as an indicator of technical dependence, as it is possible to deem that one of the targets of the policy is to reduce dependence while favouring the internal production of innovations.

[4] The variables related to the export and import of technology take a value of 1 if the firm made or received payments for foreign technical assistance.

In a great majority of policy evaluation studies, the previous R&D experience proved to be one of the main explanatory variables of the firms' participation in aid programmes. In general terms, studies usually consider data regarding R&D expenditures of the previous year in which aid was granted or the number of employees involved in R&D. These variables are included in order to test whether agencies select firms that have a certain innovation experience and could, presumably, ensure the success of the subsidy projects. This study includes the number of patents recorded during the preceding year in which the aid was granted.

5. Results of the empirical analysis and discussion

In our presentation of the empirical results we make a distinction between two types of analysis. First, we identify the variables that influence on the probability of obtaining R&D subsidies. And second, we analyse the causal effect of those subsidies on the firms' R&D intensity.

5.1 Factors that influence on the propensity to obtain R&D subsidies.

We have applied a Logit model to estimate the propensity (PS) to obtain public subsidies for each one of the firms in the sample. The Logit model was applied to the whole sample, as well as to four subsamples of firms classified by regions (Table 2). At the national level, the main beneficiaries of the subsidies were: large firms with national capital and exporters present in expanding markets and having formal and articulated innovation activities. These results are in accordance with some obtained previously by the related empirical evidence (Fernández, Junquera and Vázquez, 1996; Heijs, 2003, 2005; Busom, 2000; Wallsten, 2000; Acosta and Modrego, 2001; Czarnitzki and Fier, 2002; Almus and Czarnitzki, 2003; Blanes and Busom, 2004).

Regarding the models of sub-samples by regions we have concluded, in general terms, that notwithstanding the autonomous region involved, the Spanish firms in the manufacturing industry which had the highest probabilities of obtaining innovation aid were: large firms that managed and planned their R&D activities. According to Heijs (2003, 2005) and Czarnitzki and Fier (2002), one reason for the exclusion of the SMEs from the innovation policies could have been the implicit requirements of the programmes. A broad range of public financial support schemes for innovation – theoretically accessible to all firms – was focused on clearly designed R&D projects, which hindered the entry of small firms with other types of innovation activities. In addition, large firms more often had R&D departments and laboratories which achieved a critical mass of R&D activities and staff. Therefore, those firms more frequently met the explicit and implicit requirements of the public support programmes. At the same time, the limited capacity of innovation management in smaller firms could have hindered the conversion of their innovation activities into well-organised 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 were the object of the majority of support schemes. With respect to the innovative behaviour variables, we have concluded that those variables were one of the key aspects to explain the access to public support measures. Previous studies have already revealed that the firms reached by the instruments of the innovation policy were those who already carried out innovative activities (Busom, 2000; Czarnitzki and Fier, 2002; Heijs, 2003, 2005; Almus and Czarnitzki, 2003; Blanes and Busom, 2004). Some of these studies have shown that only a very small number of the supported firms undertook R&D in an irregular way and hardly any of them started R&D activities for the first time as a result of the public aid. However, it should also be stressed that it is probably not the public agencies which discriminated against the less innovative firms, instead, these enterprises claimed support less often (Heijs, 2005).

This study has found profile differences among subsidised firms located in the Central regions. For instance, in the case of the autonomous regions of Catalonia and Madrid, subsidised firms had more complex characteristics than firms located in other regions. In the case of the autonomous region of Madrid, firms that had the Central Government as a client and had innovative experience, obtained national R&D subsidies more frequently, while in the case of Catalonia, firms with technological cooperation agreements also obtained aid more notably. Stated in another way, we could say that in the autonomous regions of Catalonia and Madrid the subsidies were granted to firms that could guarantee the technical and financial feasibility of the subsidised projects. On the contrary, the opposite case was found in the Basque Country where previous R&D experience and the technological cooperation indicators did not appear to have a significant influence.

The firms that obtained the subventions and were located in less innovative regions, namely, the "periphery regions" fitted the general profile. In this case, the Central Government supported big firms that planned their R&D activities and exported technology. This shows that the subsidies were not focused on increasing the number of innovative firms nor were they directed towards supporting those firms with hitches to finance their innovation activities. Two of the most important problems of periphery regions, therefore, we conclude that the policy could increase the technological gap.

(Table 2 here)

5.2. Effect of innovation policy on firms' R&D intensity.

The average effect of the subsidies on the R&D intensity of the firms was established, results are summarized in Table 3. In order to estimate the average effect, an area of common support was used which allowed the firms showing poor levels of matching to be eliminated. According to the general model, the total R&D intensity of the Spanish subsidised firms was on average 1.84 percentage points higher than that of firms not receiving subsidies. The effect of the support instruments granted by the Central Government was significant and positive in all cases. Nevertheless, in comparison to other studies that have applied the same methodology, the magnitude of the subsidies' effect on the firms' R&D intensity has been light. For instance, in the German case, the studies of Czarnitzki and Fier (2002) and Almus and Czarnitzki (2003) established roughly speaking a 4% effect, hence duplicating the Spanish result. Although it is not convenient to draw conclusions about who makes a better use of the public resources, the existence of these differences invites to the reflection recently expressed in the literature, as to the need for firms to develop a certain capacity to absorb public resources, together with the requirement to take into account this aspect in the future design of support instruments. Despite the fact that aid on average did not significantly increase the innovative effort, it is important to stress the absence of a "crowding out effect" of public funding with regard to private funding. In other words, firms were not generally substituting their private efforts by public effort.

This study has found regional differences as far as the effect of the national innovation policy is concerned. This effect was greater in the central than periphery regions. In addition, the study found significant differences between the Central regions. Concretely, the autonomous regions of Catalonia and the Basque Country showed the highest effect regarding the national R&D subsidies (2.50% and 2.31%, respectively), exceeding the Spanish average or general model (1.84%). On the other hand, the autonomous region of Madrid (1.77%) achieved an effect below the Spanish average, a result similar to the regions located in the periphery (1.39%). All of the above allows us to conclude that the region causes a differentiating effect concerning the final outcome of the national innovation policy, and therefore, when policy effects are estimated it will be necessary to keep in mind the firm's localisation.

From an initial distribution-effect analysis, it is possible to conclude that there are two significant elements which characterised the regions with a higher policy effect (Catalonia and the Basque Country compared to the other regions): firms operating in expanding markets and firms exporting technology. Nevertheless, we cannot conclude in this study, that these variables were responsible for an increased effect of the subsidies to innovation. For instance, the variable technological exports also had a positive and significant influence on the probability of firms located in the rest of the regions of obtaining subsidies, regions as a whole which reported the lowest effect. In regions where the effect was minor, such as in the case of Madrid, firms with the highest probability of being subsidised were those that had the Government as a client and proved to have previous R&D experience, only in this case did these two variables have a significant effect. With respect to firms located in the “periphery” regions which possessed less innovative activity, the innovation policy continued to support large firms which planed and managed their R&D activities and exported technology.

From the above it is clear that the firms that received subventions, independently of their regional location, were innovative firms. Therefore, this does not explain the differences found in the policy effect, future research could be guided to explain these differences with variables representing the geographic and competitive milieu, as for instance: the proximity to infrastructures, the industry concentration level or the innovative culture.

(Table 3 here)

6. Conclusions and Policy Implications

The purpose of this study has been to analyse whether regional differences exist in relation to the factors that bear an influence on the firms’ chances of obtaining national innovation subsidies, as well as, on the effect of such a policy. The study adopted a central-periphery focus to contrast the hypothesis that the effect of the subsidy policy changes according to the region’s accumulation level of innovative activity. The study undertook a comparative analysis between the autonomous regions of Madrid, Catalonia and the Basque Country, denominated in this study Central regions given that they accumulate almost seventy percent of the Spanish innovative activity, together with the rest of regions in Spain which were in this study referred to as the regions of the periphery. The statistical analysis was undertaken using the non-parametric approach of Propensity Score Matching (PSM). This method allows two key aspects related to the evaluation of innovation policies to be taken into account, explicitly, the process of aid distribution and the estimation of the counterfactual state.

The first part of the present analysis, aimed at investigating and controlling the process of aid distribution, allowed us to conclude that, in general terms, regardless of the autonomous region involved, the large Spanish firms which planned and managed their R&D activities were the main beneficiaries of the subsidies. Public aid was mainly granted to firms that were able to ensure the technical and financial feasibility of their projects. Technological indicators were determinant in almost all of the regions. This points out, that these indicators do not solely explain the policy effect's regional differences that were detected, hence, future investigations should include aspects of the geographic and competitive milieu.

Regarding the policy effect, significant regional differences were identified in the case of the Central regions. The autonomous regions of Catalonia and the Basque Country achieved an average effect well above the Spanish average. This study has recognised two significant variables that characterised these regions (compared with the other regions): firms operating in expanding markets and firms exporting technology. Nevertheless, we cannot conclude from the present analysis that these two characteristics induced a major policy effect.

In the case of the regions with a minor effect like Madrid and the "periphery" regions, the analysis shed interesting results. In the case of Madrid, one of the Spanish regions with the most intensive innovation activity, the firms with a higher probability of obtaining aid were those that had the Government as a client and had proven R&D experience. On the other hand, in the "periphery" regions with a low innovation activity, the Spanish Government supported large firms that planned and managed their R&D activities and exported technology. The aid distribution policy in these regions clearly favoured some of the most dynamic and fast growing innovative firms, widening or accelerating their innovative activities. However, it did not generate an improved industrial dynamic by increasing the number of innovative firms. As a result, the subsidies could increase the technological gap between the different regions.

The findings of this study have allowed us to conclude that the region accounts for different results with regard to the distribution and effect of the national innovation policy. The current analysis clearly states that it is necessary to consider the location of firms in order to eventually assess correctly the effect of the innovation policy. In addition, future research should be undertaken to inquire which elements are responsible for these distribution and effect differences.

The existing regional differences regarding the distribution and effect have strong implications with regard to the design of the national innovation policy. The Central Government will have to make future efforts to identify the firms' problems and needs within a regional context. In addition, it will also have to contribute to developing the firms' capacity to absorb public funds.

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Vitae

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Table 1. Technological indicators of Spanish regions in the year 2005

Indicator	Catalonia	Madrid	Basque Country	Rest of Regions	Spain
R&D expense as percentage of the regional GDP	1.36	1.81	1.44	0.76	1.13
Firms' R&D expense as percentage of the regional GDP	0.86	1.05	1.16	0.35	0.61
Regions' R&D expense as percentage of the national total	22.6	28.6	8.1	40.7	100
Firms' R&D expense as percentage of the national total	26.6	30.5	11.7	31.2	100

Source: Statistics concerning scientific investigation activity and technological R&D development. Basic indicators 2005. (INE, 2006).

Table 2. Results of the Logit estimations

Variables	Spain		Catalonia		Madrid		Basque Country		Rest of Regions	
	Coef.		**Coef.**		**Coef.**		**Coef.**		**Coef.**	
Size	0.571	***	0.573	***	0.676	**	1.143	**	0.539	***
Medium technology industry	-0.558	**	-0.638		-0.674		-1.054		-0.796	*
Low technology industry	-0.469	**	0.206		-1.452	*	-2.099	*	-0.625	
Age	-0.206	*	0.083		-0.469		-0.689		-0.208	
Foreign capital %	-0.080	***	-0.009	*	0.000		-0.005		-0.007	*
Government capital %	0.016	**	NA		0.207		0.051		0.013	
Government is a firm’s client	0.188		-0.373		1.262	**	2.097		-0.179	
Export propensity	0.007	**	0.003		0.015		0.020		0.006	
Expanding market	0.587	***	0.811	**	0.331		0.873		0.634	
Plans and manages R&D	2.376	***	1.620	***	3.584	***	4.410	**	2.422	***
Technological cooperation	0.716	***	1.316	**	-0.203		-0.663		0.611	
Difficulty in financing innovation	0.007		0.541		-0.616		1.379		-0.186	
Patents t-1	-0.001		0.133		1.453	***	0.107		-0.016	
Exports technology	1.457	***	2.392	***	-1.257		2.992	*	1.745	*
Imports technology	-0.129		0.159		0.868		0.811		-0.639	
N	1517		343		300		109		765	
Number of subsidised firms	250		55		44		34		117	
Number of non-subsidised firms	1267		288		256		75		648	
Log likelihood	-401.6		-95.144		-47.966		-27.954		-195.95	
Pseudo R^2	0.391		0.353		0.610		0.555		0.381	
Prob. > chi^2	0.000		0.000		0.000		0.000		0.000	
Correctly classified (%)	86.99		87.65		93.62		86.67		87.93	

NA: Not available, public capital predicts success perfectly.
* P < 0.10; ** P< 0.05; *** P<0.01.

Table 3. Average effect of national R&D subsidies on firms' R&D intensity

Regions	Mean R&D Intensity		ATT-Causal Effect	Test statistic t-value	Number of matchings
	Subsidised firms	Non-subsidised firms	Percentage points	(Bootstrap t-value)	
Spain	2.828	0.982	1.846	5.874*** (6.346)***	240
Catalonia	3.352	0.845	2.507	3.915*** (4.582)***	53
Madrid	3.994	2.223	1.771	1.685* (1.413)	43
Basque Country	2.922	0.610	2.312	2.143** (2.261)**	30
Rest of Regions	2.147	0.769	1.378	3.921*** (3.985)***	112

* P < 0.10; ** P < 0.05; *** P < 0.01.