DOES REGIONAL S&T POLICY AFFECT FIRMS' BEHAVIOUR?

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ABSTRACT

Evaluation has become a key stage in the policy-making process in the last years. In this context, evaluation has to be adapted to new policy rationales that have been progressively introduced in the literature as well as in the policy-making process itself.

Evaluation in Science and Technology Policy has followed the same evolution as policy rationales and it has moved from a neoclassical to a more evolutionary approach. This can be seen following the evolution of the concept of additionality, which has evolved from input and output additionality in a neoclassical framework to behavioural additionality in an evolutionary approach.

This paper aims to analyse behavioural additionality as the result of a regional S&T programme. More exactly, this paper measures the changes produced in firms' behaviour as a result of programme intervention. According to previous literature, these changes include: internationalization of R&D, collaboration alliances in R&D projects, R&D systematization, etc.

The empirical analysis is focused on a regional R&D programme of the Basque Government: the Intek Programme. The methodology used in this analysis to measure behavioural additionality is a matching procedure. The results show that regional subsidized firms have changed their behaviour towards collaboration patterns, internationalization and systematization of their R&D activities. Nevertheless, we found that collaborative projects do not lead to a better performance in R&D.

All these findings have policy implications related to the systemic view of evaluation and its instruments, including the concept of behaviour in the policy-making process.

1. INTRODUCTION

Evaluation has become a key stage in the policy-making process in the last years. In this context, evaluation has to be adapted to new policy rationales that have been progressively introduced in the literature as well as in the policy-making process itself.

As regards Science and Technology Policy, rationales have evolved from a neoclassical to an evolutionary theory. In addition, in the framework of regional S&T policy different rationales can be mentioned (Nauwelaers and Wintjes, 2002, Laranja et al. 2008), including certain regional applied theories as neo-marshallian or systemic approaches. Depending on the rationale employed by policy-makers, different policy objectives and instruments will be implemented. However, theoretical rationales have to be differentiated from policy rationales, as they are usually not well-adapted by policy-makers (Laranja et al. 2008, Mylteka and Smith, 2002).

Evaluation has followed the same evolution as policy rationales and it has moved from a neoclassical to a more systemic approach. This can be seen following the evolution of the concept of additionality. The concept of additionality refers to the complementarity role of the government. It means that a government intervention can be only justified if that intervention originates a complementary effect, which would not have taken place without policy. This concept is explained in the literature by different authors: Georghiou (1994, 2002), Bach and Matt (2002), David et al. (2000), Heijs (2001), Herrera and Heijs (2003, 2007), Ebersberger (2005), Georghiou and Clarysse (2006), Autio et al. (2008), Clarysse et al. (2009).

Within neoclassical theory, the concepts of input and output additionality are the most commonly used in policy evaluation (Clarysse et al. 2009). Input additionality refers to the additional amount of resources subsidized firms invest in the innovation process, whereas output additionality measures the additional outputs achieved as a consequence of policy intervention. These additionalities are therefore responding to market failures.

In the last years, a complementary concept has emerged in the literature: behavioural additionality. Behavioural additionality is linked to a systemic or evolutionary view of the economy and refers to changes in firms' behaviour as a result of policy support (Bach and Matt, 2002). These effects are perceived in a longer term than in the other types of additionalities and according to Geourghiou (2002) they are closer to system failures. More precisely, behavioural additionality includes those behavioural changes that lead firms to

collaborative patterns, to continue with R&D investments after the subsidized project has finalized, to internationalize their R&D activities, and so on. All of them are related to the organizational learning achieved by the firm after public intervention. (Clarysse et al. 2009)

There is little empirical evidence of behavioural additionality of R&D programmes as Clarysse et al. (2009) point out, given that most of the existing studies are mainly focused on input additionality. Therefore there is a gap in the literature that is attended to via this paper.

This paper aims to analyse behavioural additionality as the result of a regional S&T programme. More exactly, this paper measures the changes produced in firms' behaviour as a result of programme intervention. According to previous literature, these changes include: internationalization of R&D, collaboration alliances in R&D projects, R&D systematization, etc.

The main questions undertaken in the paper are the following: Does public funding raise the propensity to collaborate in R&D? Have R&D subsidies resulted in learning effects in the firms that enable them to participate in international R&D programmes? Does public funding lead to systematic R&D behaviour in firms? Would all these effects have occurred in the absence of policy?

In order to achieve the mentioned objectives, a Basque Regional R&D programme will be analysed for the period 2001-2004: the INTEK programme. This programme subsidizes R&D activities to firms located in the Basque Country through the development of two types of projects: individual and cooperation projects. Individual projects are projects in which there is only one beneficiary, usually a company, while cooperation projects are carried out by two or more partners, usually companies and universities or research centres.

The main sources used in the empirical analysis are, firstly, the company subsidies obtained from the Industry, Trade and Tourism Department of the Basque Government; secondly the UDESTE database, which is currently managed by Orkestra, the Basque Institute of Competitiveness, and contains data for individual firms; and thirdly, the participation of Basque firms in the VI and VII European Union Framework Programme, provided by Innobasque, the Basque Innovation Agency.

The empirical analysis applied in this paper is focused on the measurement of behavioural additionality of the Intek Programme. For this purpose, a matching approach is applied. This approach uses a control group to differentiate behaviours between firms receiving subsidies and those that have not received any. The matching method is a quantitative technique frequently employed to measure additionality (Herrera and Heijs, 2003, 2007; Aschoff et al.

2006, 2009; Czarnitzki et al. 2007; Bussom and Fernandez-Ribas, 2008; Fernandez-Ribas and Shapira, 2009), although few of these analyses have focused on behaviour.

This paper contributes to shed light on a new concept in policy evaluation: behavioural additionality. In addition, the systemic perspective of R&D programmes is evaluated, which constitutes a contribution to policy learning.

2. RATIONALES FOR SCIENCE AND TECHNOLOGY POLICY

According to Laranja et al. (2008), rationales are theories that justify government intervention and therefore, they represent an important input for policy design, implementation and evaluation. There are two main rationales that have been employed for explaining Technology Policy (Bach and Matt ,2002; Metcalfe 1994, 1997; Lipsey and Carlaw 1998; Nelson 2007): the Neoclassical approach and the Evolutionary model. Each one provides justification for government intervention on S&T Policy due to different failures. Within a neoclassical perspective, technology policy is a consequence of market failures whereas following an evolutionary approach, technology policy is responding to evolutionary and system failures.

Furthermore, following the previous literature (Laranja et al. 2008, Heijs 2001, Hauknes and Nordgren 1999), there are different approaches that can be included in the framework of Neoclassical or Evolutionary Theories. Thus, the Endogenous Growth approach is an evolution of the neoclassical theory and it is also based on market failures, whereas the Systemic approach is based on the Evolutionary Theory. Each approach will differ from each other in various characteristics, but under the same theory, S&T policy will respond to the same failures or problems[1].

Following the neoclassical approach, the State will intervene if market failures take place. Taking into consideration that neoclassical theory is based on a perfect market assumption[2], only a market imperfection could justify a political action in order to re-establish the previous equilibrium. One important concept that relies on this approach and that will be explained in detail afterwards is the additionality or incrementality function of public policy. That means that policy has to obtain results that would not have been obtained in the absence of policy. Only in that situation, state intervention is justified.

[1] Edquist (2008) proposes the concept of "policy problems" instead of using the "systemic failures" concept. He argues that the term failure is a neoclassical concept, as (market) failure can only exist when a system is compared to an ideal one. Since it is not possible to define an ideal system in the evolutionary or systemic approach, the concept of failure is not appropriate.

[2] Perfect market implies that there are many buyers and sellers, low entry and exit barriers, perfect information, firms aiming to maximize profits and homogenous products.

Evolutionary theories have emerged by opposition to neoclassical theories. Learning is a central idea of this approach and innovation in this model is considered a collective action that varies among sectors, firms and actors (Bach and Matt, 2002), (Laranja et al. 2008).

The main premises underlying evolutionary theory are firstly, the processes that determinate the variety of innovations, and secondly, the processes that determine the innovations' selection under a competition framework. That implies a behavioural perspective of innovative firms and thus technology policy is a mechanism to enable variety and selection (Meltcafe, 1994).

In Evolutionary Theory there is not an optimum or equilibrium in which benefits are maximised, technology is considered an endogenous part of the economy and institutions play an important role in the innovation process (Lipsey and Carlaw, 1998). In fact, Evolutionary Theory is divided into two main approaches: the evolutionary-structuralist theory, in which cognitive capacities of all actors are the main focus, and the Systemic approach, which gives more importance to institutions as the key element for promoting learning interactions.

There is not a common consensus in the literature about the main policy problems in this framework, but we summarize the most important ones in: networking problems (lack of connection to the network or extremely connected in a wrong direction), lock-in problems (due to systems with no external influence) and organizational or institutional problems (lack of institutions or institutions that are not fulfilling their role).

3. ADDITIONALITY OF SCIENCE AND TECHNOLOGY POLICY

Although rationales are defined as theories that justify government intervention, *additionality* concept is considered the central idea of that justification (Bach and Matt, 2002). Additionality, therefore, is the key element to justify state intervention and in consequence the feature to measure in policy evaluations. Additionality has been explained by some authors as Georghiou (1994), Bach and Matt (2002), David *et al.* (2000), Heijs (2001), Herrera and Heijs (2003, 2007), Ebersberger (2005), among others.

Following the previous literature, additionality concept refers to the complementarily role of the State. It means that a government intervention can be only justified if that intervention originates a complementary effect, which would not have taken place without the policy. In

Georghiou's words additionality involves a comparison with the null hypothesis or what would have happened in absence of government intervention (counterfactual state). Thus, additionality is related to measuring the differences between two different situations.

The authors broadly recognized three types of additionality: input, output and behavioural additionality, although Bach and Matt (2002) also mentioned cognitive capacity as the fourth type of additionality.

Output additionality is related to the results of innovation process, which means that a complementary result is given by the government intervention. Thus, output additionality is a measurement of the outputs obtained from the public intervention (Georghiou, 2002). These outputs must be related to the outputs from the innovation process, which are mainly patents, prototypes, new products and services, etc. Definitely, output additionality captures the effects of the policy intervention in the outputs of the innovation process. These effects would not have happened in absence of the policy in order to give a justification to policy intervention. It is important at this point to differentiate between output and outcome additionality. The former is the one referred to the outputs of the innovation process and the latter refers to the impact of these outputs on business or economic performance (increases in sales, etc.). Outcome additionality is, therefore, an issue more difficult to measure, as it is difficult to really attribute the improvement of the business or economic performance due to the intervention (Georghiou, 2002).

In terms of input additionality, policy effects of the inputs of innovation process are measured. According to Bach and Matt (2002), Georghiou (2002), David et al. (2000) input additionality means that the beneficiaries of a policy should add as much as resources to the innovation process that the ones they are receiving, but in any case, they should be beneficiaries for a process that they would not carry on in absence of the policy. That means that input additionality is a measure of the resources invested in order to obtain an output.

Behavioural additionality refers to the policy impacts on the organization behaviour and processes. That means for example, changes into collaborative patterns among firms to innovate or promoting firms to take risks that otherwise they would not have taken (Georghiou, 2002) According to Bach and Matt (2002), behavioural additionality can overlap output additionality in the sense that the changes in routines and processes within an organization or a firm can produce changes into the innovation outputs. Summarizing, behavioural additionality can be considered as the effects produced in routines and processes within a firm as a consequence of policy intervention.

In addition, and from an evolutionary perspective, Bach and Matt (2002) mentioned the cognitive capacity additionality, which expresses the idea of a policy effect on the dimensions of the agent's cognitive capacity. This concept involves a policy impact on the agent or beneficiary's system, in which the action is targeted in. According to these authors, cognitive capacity additionality is a consequence of a system failure from an evolutionary perspective, while output additionality is responding to a market failure in a neoclassical perspective.

Finally, some empirical studies have analysed additionality in the last years, although few of them have focused on behavioural additionalitity. Regarding input additionality, we can mention David et al. (2000), Ebersberger (2005), Aerts and Schmidt (2008), among others. With regards to output additionality we also find some examples as Czarnitzki and Hussinger (2004), Ebersberger (2005) and Czarnitzki and Licht (2006), among others, in which the authors show a positive impact of the programmes on the firms' outputs. Finally, behavioural additionality has been measured in a few studies, as the ones carried out by Autio et al. (2008), Clarisse et al. (2009), who found a positive relation between the public programmes and behavioural additionality. Nevertheless, there are other studies that also analyse a part of behavioural additionality as R&D internationalisation (Fernandez-Ribas and Shapira, 2009), that are also relevant to this analysis.

In the next section we will further analyse the concept of behavioural additionality and the existing empirical analyses in order to define the hypotheses we will contrast afterwards.

4. THEORETICAL FRAMEWORK: MEASURING BEHAVIOURAL ADDITIONALITY

Behavioural additionality is a concept based on evolutionary rationales, as we mentioned before. There is a common view among academics and policy makers that policy intervention in R&D has an effect on firms' behaviour. This effect on firms' behaviour is called behavioural additionality. The concept was firstly introduced by Buisseret et al. (1995) and it refers to the changes in behaviour in firms as a consequence of policy intervention. It appeared as a complementary concept to input and output additionality and not aiming at replacing them (Clarysse et al. 2009). That means that an R&D programme will have effects on the firms' input and output, but at the same time on the firms' behaviour. It is also important to point out that behavioural additionality is a concept reliable to be analysed as it measures the most durable effects on firms (Davenport et al. 1998). Output additionality can be only related to a programme intervention (a patent, a new product) but behavioural changes stay over time.

When considering firms behaviour in programme evaluation we have to take into account organizational learning (Clarysse et al. 2009). Changes in behaviour are a consequence of a learning process that has been promoted in firms by public intervention. Therefore, behavioural additionality can be considered as the changes in behaviour that are appreciated in a firm as a consequence of a learning process. Lundvall (2001) also points out that innovation policy has to support learning processes in individuals, networks and firms, including learning and building competences as an important objective of innovation policy.

With regards to R&D, we can mention several aspects that could be analysed as a consequence of learning processes carried out in firms. Collaboration is one of these aspects. Collaboration in R&D can be considered a change in behaviour as Aschhoff et al. (2006), Busom and Fernandez-Ribas (2008), Autio et al. (2008) and Clarysse et al. (2009) analysed in their respective studies. They found empirical evidence of an effect between R&D funding and collaboration patterns in firms. Following Clarysse et al. (2009) and Autio et al. (2008) firms that collaborate in R&D projects take advantages from interorganizational learning and, in consequence from knowledge spillovers. In addition, cooperative partnerships allow firms to access to resources that they do not have internally as knowledge, capabilities or even financial or technological means to carry out a project (Aschhoff et al. 2006). Therefore, collaborative funding is defined and implemented to overcome to these firms limitations and to enhance the connectivity within the innovation system (between universities, research centres and firms, among others).

Hence, we can establish the following hypotheses:

- Firms funded following a collaborative scheme will continue cooperating after the funding scheme has finished in a higher proportion than those firms individually funded.
- Firms funded following a collaborative scheme will achieve better R&D outputs than those individually funded. (Relation between behavioural and output additionality).

Another aspect that can be related to behavioural changes in firms and learning processes within an R&D framework is R&D internationalisation. Fernandez-Ribas and Shapira (2009) suggest three types of factors[3] that connect national or regional collaboration in R&D

[3] These three types of factors are reallocation of resources, which means that firms have an overall R&D strategy for not to concentrate their efforts in only one programme (national or subnational), learning opportunities developed by firms in regional or national programmes and adaptation mechanisms for participating in international funding programmes that have been developed through the participation in national or regional partnerships.

programmes to international collaboration. Among them, we can highlight the factors referred to the learning capabilities developed in firms during the regional or national partnerships that encourage them to participate in international programmes. As Clarysse et al. (2009) mentioned, experimental learning or learning by doing processes can be related to behavioural changes in firms. That means that firms learn from experience and therefore their experience in regional and national funded projects will lead them to participate in international funded projects. Fernandez-Ribas and Shapira (2009) empirically found that innovation policy encourages internationalization of firm's innovation activities. Therefore, we can define the following hypothesis:

- Firms funded by regional funded programmes will develop a higher participation in international funded programmes than those firms that have not participated.

Finally, a third behavioural change that can be considered as behavioural additionality is the one referred to R&D systematization. Following the same learning theory than in the case of internationalization, firms develop innovation managerial capabilities through the participation in funded R&D programmes (Malik et al., 2005). Learning-by-doing processes allow firms to develop managerial and administrational capabilities related to the process of applying for a grant or a funded project. That means that they develop a learning experience curve with R&D funding projects. The experience leads to a change in behaviour and encourage a systematization of R&D activities. The hypothesis related to this can be stated as follows:

- Firms subsidized in regional programmes will have developed a higher systematization of their R&D activities than those that have not participated in R&D regional-funded projects.

Summarizing, learning processes and behavioural changes are closely related to firms' behaviour in R&D. Policy programmes in the field of R&D includes instruments to encourage those changes, as R&D collaborative projects. Therefore, it is important to measure behavioural additionality of R&D programmes to evaluate their complementary role to other additionalities and their contribution to firms R&D activities.

5. METHODOLOGY AND DATA

5.1. Matching Method

Following the previous empirical studies, we will apply to this research a propensity score matching method (Rosenbaum and Rubin, 1983) that has some advantages with respect to other methods used to measure additionalities. Concretely, the main advantages for using this matching approach instead of other quantitative methods are the followings:

- First of all, the matching procedure avoids selection bias by the establishment of a control group with similar characteristics of the treatment group (quasi-experimental design).
- Secondly, no particular form of equation has to be established.
- Finally, all non matched observations (discarded observations) are not included in estimating the treatment impact.

This method has also limitations. The most important one is the fact that some of the characteristics of both the treatment and the control group are unobservable and therefore, they cannot be included in the model. This limitation is important when referring to innovation policy, in which managerial capabilities of the firm's managers have an influence on innovative behaviour. Nevertheless, given the mentioned advantages and the use in many empirical studies regarding additionality (Ebersberger, 2005; Aerts and Schmidt 2008; Herrera and Heijs, 2003 and 2007; Aschhoff et al. 2006; Fernandez-Ribas and Shapira, 2009; among others) we will apply this method.

Propensity score matching is a non parametric method that imitates natural experiments in order to apply it to social sciences. The basic idea of these quasi-experiments is to randomly match units from two groups (the treatment and the control group) with similar characteristics in order to compare them and therefore identify the effects of the policy in the treated group. The matching protocol can be summarized as follows (Rosenbaum and Rubin, 1983; Dehejia and Wahba, 2002; Herrera and Heijs 2003 and 2007; Hujer and Radic 2005; Ebersberger 2005; Schibany 2004, among others):

The first step in the matching approach is to select a control group with similar characteristics of the treated group, which is composed of the firms that have received any subsidy within the studied programme. Propensity Score Matching (PSM) is used for calculating the probability of being treated within the units in the control group, according to a set of characteristics. Therefore, it is useful for identifying non-participants with the same probability of participating

than the treated group (participants in the programme). In a second step, this method compares the average rates in both groups in order to identify the effects of the policy intervention. We explain this method in detail in the following paragraphs:

Through the PSM we can identify the causal effect (τ) of the binary treatment (T), comparing the result of the treated units (Y_1) with the units in the control group (Y_0). The causal effect (τ) can be defined as follows:

$$E(\tau) = E(Y_{1i} \mid T_i = 1) - E(Y_{0i} \mid T_i = 1)$$

As one unit (i) cannot be observed in both treated and not treated situations in the same period (being and not being subsidized) the situation of not being treated is analyzed through the mentioned control group. The PSM method calculates the *Average Effect of Treatment on the Treated* (ATT) and reduces the comparison bias between the treated and the control group through the matching of units in both groups with similar characteristics. This method finds similar firms in the control group, which allows defining a counterfactual situation (in absence of subsidies) for the participating firms. The first step of this method is to calculate the probability of being subsidized as matching criteria (*Propensity Score*). The criteria used for calculating the propensity score is composed of a set of individual firm's characteristics. Therefore, *propensity score* can be defined as the probability of being subsidized according to a set of individual characteristics (X):

$$p(X) \equiv P\{D = 1 \mid X\} = E\{D \mid X\}$$

where(X) is the vector of individual characteristics and D= {0, 1} is the participating situation of the firm, being 0 when the firm has not being subsidized and 1 when the firm has received a subsidy.

Given that the PS is a continuous variable, the probability of finding two firms with the same characteristics is near zero. Therefore, in the literature we can find some estimators to effectively match firms in the two groups. The most used one is the NNM (*Nearest Neighbour*

Matching), which matches each treated unit with the most similar unit in the control group according to their propensity score:

$$\tau^{NNM} = \frac{1}{N^T}\sum_{i\in T} Y_i^T - \frac{1}{N^T}\sum_{j\in T} w_j Y_J^C$$

where T is the treated group, C is the control group, Y_i^T and Y_J^C, the dependent variables in both groups, N_i^T shows the number of control units matched with treated units $i \in T$, and the weightings are defined by $w_{ij} = \frac{1}{N_i^C}$ if $j \in C_{(i)}$ and $w_{ij} = 0$ on the contrary.

Once the matching is carried out, we calculate the *Average Effect of Treatment on the Treated* (ATT) through the difference between the average of the dependent variable in the treated group and the average of this variable in the control group. Summarizing, the average effect of an intervention or programme is calculated by the average of the differences in both groups[4].

5.2. Data and variables

This research uses data from a regional R&D programme to contrast the defined hypotheses. Data comes from the Intek Programme, which is a regional R&D programme of the Basque Government, Spain. This programme aims at promoting R&D activities within firms in the Basque Region through two different types of projects: individual and collaborative projects. Individual projects are projects carried out by only one firm, which receives the whole subsidy. Collaborative projects are projects carried out in cooperation by two o more firms or by firms and universities or research centres. All the beneficiaries have to be located in the Basque Region in order to receive a subsidy. This programme has been running since 1997 and it is still running. In this research we will analyse the effect of the programme in the framework of the Basque Science, Technology and Innovation Plan 2001-2004. Therefore, our treated group will be all the firms that have received any subsidy during this period (2001-2004) and the control group will be established within the firms that carried out R&D activities in that period but have not received any subsidy from the Intek programme. This information has been obtained for the Basque R&D Statistic, carried out annually by the Basque Statistic Institut (EUSTAT).

[4] Dehejia and Wahba (2002) give a detailed description of this method.

In order to compare both groups (the treated and the control group) we will match the firms according to some external characteristics that have been used in similar studies (Almus and Czarnitzki, 2003, Aschhoff et al. 2006, Aschhoff 2009, Busom and Fernández-Ribas, 2008, Czarnitzki et al., 2007, Fernández-Ribas and Shapira, 2009, Herrera and Heijs, 2007, among others) and they are relevant in the literature for the determination of the firm's R&D behaviour. These are the following:

- Firm size: Although there is not a common agreement in the literature (Malerba et al., 1995, Acs and Audretsch, 1998), we expect that biggest firms have a higher probability to develop R&D activities than SMEs. For this study employment has been used to determine company size: micro SMEs (less than 10 workers), between 10 and 49 workers, between 50 and 249 workers, between 250 and 499 workers and more than 500 workers.
- Industry: Literature shows that innovative behaviour differs across industries (Pavitt, 1984; Acs and Audretsch, 1998; Malerba and Orsenigo, 1995; Breschi and Malerba 1997; and Asheim et al., 2007). The classification of industries that has been used is the one defined by Eurostat and OECD, which define industries into seven technology groups. These technology groups are the following: High technology manufacturing, high-medium technology manufacturing, medium-low technology manufacturing, Low technology manufacturing, high technology and knowledge intensive services and other knowledge intensive services, less knowledge intensive services.
- Ownership: We distinguish between national firms and firms with foreign capital. As Love et al. (1996) stated, much of the literature suggests that it is expected to be a negative relation between foreign ownership and innovation behaviour in a firm, taking into account its size and industry. This occurs as a consequence of the concentration of strategic activities, skills and know-how, including R&D, in the parent companies. However, both the literature (Narula and Zanfei, 2005; Carlsson, 2006) and some current indicators referred to R&D internationalisation (share of world trade represented by R&D intensive sectors, internationalisation of patenting …) suggest that the R&D internationalisation is growing. For that reason, we expect that firms with foreign ownership will carry out more R&D activities than national firms. For foreign ownership, owners' country of origin participation has been used to determine the foreign ownership factor.

These independent variables have been obtained from the UDEste database, which contains data for individual firms and for all the firms located in the Basque Country.

In the next table (table 1) we show a brief description of these characteristics in the different groups of firms we will use for the study:

		Size		Industry			Ownership		
	Total	Of which		Of which			Of which		
		Less than 50 workers	More than 50 workers	High or medium tech	Low tech	Non available data	National ownership	Foreign ownership	Non available data
Treated firms: Firms subsidized in the period 2001-2004	644	351	293	373	242	29	129	37	478
	100%	54,50%	45,50%	57,92%	37,58%	4,50%	20,03%	5,75%	74,22%
Non-treated firms	584	332	252	329	232	23	85	28	471
	100%	56,85%	43,15%	56,34%	39,73%	3,94%	14,55%	4,79%	80,65%
Firms with R&D activities	1228	683	545	702	474	52	214	65	949
	100%	55,62%	44,38%	57,17%	38,60%	4,23%	17,43%	5,29%	77,28%

Table 1: Descriptive analysis of firms' characteristics

From the above data we can observe that firms that have been subsidized by the Intek Programme during the period 2002-2004 (treated firms) and firms that carry out R&D activities, have similar characteristics. More than half of them are small firms with less than 50 workers. In addition, almost 60% of subsidized firms belong to high-tech or medium-tech industries (including services). Finally, it is remarkable that 20% of subsided firms are national companies, although we do not have all the required information due to lack of data. Taking into account these variables, and after accomplishing the matching between the units in two groups, we will analyse differences in some dependent variables, which will contrast the research hypotheses. Concretely, the dependent variables we have defined are:

- Internationalisation of R&D activities: For measuring behavioural additionality in terms of participation of R&D international projects we use the participation in European projects (Framework Programme from 2005-onwards) as a dependent variable. We will analyse the participation of those previously subsidized firms by a regional

programme in international projects in comparison to those that have not been subsidized. Data from the different Framework Programmes was given by Innobasque, the Basque Innovation Agency. Previous analyses about this issue can be found in Fernández-Ribas and Shapira (2009), among others.

- Systematization of R&D activities: We will use as a proxy for this variable the continuous participation in regional projects after the analysed period. The systematization of R&D activities configure a response of an organizational learning in R&D and also a consequence of some acquired resources that the firm has reached through the previous participation in R&D funded projects (Malik et al., 2005).
- Collaboration in regional R&D funding: We will use the collaborative projects in the Intek programme as a measure of collaboration within this R&D programme. We will compare initial collaboration (collaboration and number of collaborative projects) between two periods (2001-2004 and 2005-onwards). For this specific case the subsidized firms will be divided into two groups: those subsidized firms that have participated through a collaborative scheme (treated group) and those subsidized firms that have not participated in collaborative projects (control group). Previous studies concerning additionality and collaboration can be found in Busom and Fernández-Ribas (2008), Ashsoff et al. (2006), Autio et al. (2008) and Clarysse et al. (2009), among others. Additionally, we will measure the interorganizational learning or the impact of collaboration on R&D performance. For that issue, we will consider as an important output of the innovation process the patents registered by the firms. Several studies (Czarnitzki and Hussinger 2004, Ebersberger 2005 and Czarnitzki and Licht 2006, among others) have found a positive impact of the programmes on the patenting behaviour of firms. However, this analysis goes beyond and studies the relationship between collaboration in R&D and R&D performance as the one carried out by Czarnitzki et al. (2007).

A brief descriptive analysis of the mentioned dependent variables is now presented:

		Collaboration		Internationalization		Systematization	
	Total	Of which		Of which		Of which	
		Participation in collaborative projects	Non-participation in collaborative projects	Participation in FP	Non-participation	R&D Systematization	Non-systematization
Treated firms: Firms subsidized in the period 2001-2004	644 100%	476 73,91%	168 26,09%	42 6,52%	602 93,48%	260 40,37%	384 59,63%
Non-treated firms	584			8 1,37%	576 98,63%	57 9,76%	527 90,24%
Firms with R&D activities	1228 100%			50 4,07%	1178 95,93%	317 25,81%	911 74,19%

Table 2: Descriptive analysis of the dependent variables

As the above table shows, most of the subsidized firms have participated in collaborative projects (near 75% of firms). We will contrast if these firms have continued their collaboration in the same programme afterwards. With regards to their participation in European projects, figures show that regionally subsidized firms have internationalized their acitivities in a greater amount than non-subsidized firms. Finally, data shows that almost half of subsidized firms have also systematized their R&D activities through their systematic participation in this regional programme.

We will contrast this data with the explained Matching procedure in the next section. This model has been run by using the software R, which is a free software provided by GNU Foundation. Concretely, the packages MatchIt and Zelig have been employed.

6. RESULTS

We have previously defined three set of hypotheses:

a. Hypotheses related to R&D internationalization
b. Hypotheses related to R&D systematization
c. Hypotheses related to R&D collaboration

In order to contrast these hypotheses we have applied a Matching protocol, which have been previously described. In the following paragraphs we present the obtained results for each hypothesis.

Before it, we have run a correlation analysis in order to firstly evaluate the relationships between funded firms and the rest of the explicative variables, while size, industry and ownership are the controlled variables. In the next figure, we can appreciate the partial correlations among the different variables. With regards to funded firms, we can appreciate a positive correlation with the rest of variables, thus indicating a positive relation between the R&D programme and R&D internationalization, systematization and collaboration. These relationships will be further explored with the Matching method:

Table 3: Correlations analysis

Control variables			Funded	Systematization	Internationalization	Collaboration	International projects	Collaborative projects	Patents
Industry & Ownership & Size	Funded	Correlation	1,000	,350	,131	,592	,101	,310	,140
		Significant (bilateral)	.	,000	,000	,000	,000	,000	,000
		Gl	0	1222	1222	1222	1222	1222	1222
	Systematization	Correlation	,350	1,000	,194	,538	,172	,447	,174
		Significant (bilateral)	,000	.	,000	,000	,000	,000	,000
		Gl	1222	0	1222	1222	1222	1222	1222
	Internationalization	Correlación	,131	,194	1,000	,192	,818	,208	,012
		Significant (bilateral)	,000	,000	.	,000	,000	,000	,664
		Gl	1222	1222	0	1222	1222	1222	1222
	Collaboration	Correlation	,592	,538	,192	1,000	,153	,513	,183
		Significant (bilateral)	,000	,000	,000	.	,000	,000	,000
		Gl	1222	1222	1222	0	1222	1222	1222
	International projects	Correlation	,101	,172	,818	,153	1,000	,174	,019
		Significant (bilateral)	,000	,000	,000	,000	.	,000	,506
		Gl	1222	1222	1222	1222	0	1222	1222
	Collaborative projects	Correlation	,310	,447	,208	,513	,174	1,000	,249
		Significant (bilateral)	,000	,000	,000	,000	,000	.	,000
		Gl	1222	1222	1222	1222	1222	0	1222
	Patents	Correlation	,140	,174	,012	,183	,019	,249	1,000
		Significant (bilateral)	,000	,000	,664	,000	,506	,000	.
		Gl	1222	1222	1222	1222	1222	1222	0

6.1. Hypotheses related to R&D internationalization

We have contrasted two hypotheses:

a) Firms funded by regional programmes (Intek programme) will have a higher probability of participating in international funded programmes (European Framework Programme) than those firms that have not been regionally funded.
b) Firms funded by regional programmes (Intek programme) will develop a higher number of international funded projects (European Framework Programme) than those firms that have not been regionally funded.

Table 3 shows the matching results between firms that have been subsidized by the Intek Programme during the period 2001-2004 and those innovative firms that have not been subsidized, according to the previously defined characteristics (ownership, size and industrial technology group). As the units of the control group were fewer than in the treated group, only 584 units were matched.

	Control	Treated
All	584	644
Matched	584	584
Unmatched	0	60
Discarded	0	0

Table 4: Matched units

Next table shows the Average Treatment for the Treated (Y-EV) after running the whole procedure for the two dependent variables defined in these hypotheses. That is to say that next table shows the differences in the dependent variables between the treated and the control group, illustrating the effect of the Intek programme in the firms' participation in the European Framework Programme.

	Average Treatment Effect for the Treated			
	mean	standard desviation	2,50%	97,50%
Participation in FP in the period 2005-2007	0,052375	0,004923	0,042912	0,062246
Number of projects in FP in the period 2005-2007	0,07083	0,0092	0,05246	0,08756

Table 5: Effect of the Intek Programme in the international participation of firms.

In the above table, we observe that the firms of the treated group have on average 5,2375% more probability of participating in the European Framework programme than those of the

control group during the period 2005-2007. Furthermore, with a confidence of 95% we can state that the effect of the programme is included in the interval of 0,042912 (4,2912%) to 0,062246 (6,2246) on the dependent variable.

With regards to the number of international projects, we observe that the treated group have develop in the period 2005-2007 on average 0,07083 projects more than those firms that have not been previously funded by the Intek Programme. In addition, with a confidence of 95% we can state that the effect of the programme is included in the interval of 0,05246 to 0,08756 on the dependent variable.

Summarizing, data shows a positive effect of the Intek Programme on the firms by encouraging them to participate in international partnerships as the European Framework Programme.

6.2. Hypotheses related to R&D systematization

Regarding R&D systematization we have defined the following hypothesis:

a) Firms subsidized in regional programmes (Intek programme) will have developed a higher systematization of their R&D activities than those that have not participated in R&D regional-funded projects. Concretely, we have measure the R&D systematization as the systematic participation in the Intek Programme in the following three years to the subsidized period. That is to say, firms subsidized in the years 2005, 2006, 2007.

Following the same procedure than in the above set of hypotheses the matched units have been reduced to 584 (see table 3).

The results of this model are presented in table 5. Concretely, table 5 shows the results for the Average Treatment Effect for the Treated, which means the differences in R&D systematization between the treated and the control group.

	Average Treatment Effect for the Treated			
	mean	standard desviation	2,50%	97,50%
R&D systematization in 2005-2007	0.31156	0.01273	0.28666	0.33558

Table 6: Effect of the Intek Programme in the R&D systematization of firms.

In the above table, we observe that the firms of the treated group have on average 31,156% more probability of systematizing their R&D activities through the participation in the Intek

Programme than those of the control group during the period 2005-2007. Furthermore, with a confidence of 95% we can state that the effect of the programme is included in the interval of 0.28666 (28.66%) to 0.33558 (33.56%) on the dependent variable.

According to these results we can state that the Intek Programme has positive effects on the systematization of the firms' R&D activities.

6.3. Hypotheses related to collaboration

In this case we have defined two different hypotheses, one related to changes in firms' behaviour (behavioural additionality) and the other one related to the relationship between collaboration and patenting (relation between behavioural and output additionality). Concretely, the hypotheses are defined as follows:

a) Firms funded following a collaborative scheme will continue cooperating after the funding scheme has finished in a higher proportion that those firms individually funded. That is to say, firms funded following a collaborative scheme in the Intek Programme in the period 2001-2004 will continue collaborating through this scheme in the period 2005-2007 in a higher proportion than those firms individually funded.
b) In addition, firms funded following a collaborative scheme in the Intek Programme in the period 2001-2004 will collaborate in more projects through this scheme in the period 2005-2007 than those firms individually funded.
c) Firms funded following a collaborative scheme will achieve better R&D outputs that those individually funded. Concretely, firms funded by a collaborative Intek project will register more patents in the period 2005-2007 than the firms individually funded.

For this specific case, as we are comparing two groups from the treated group (firms funded by a collaborative scheme and firms individually funding) we will divide this group into the treated and control groups. Therefore the matching procedure differs from the previous ones. As table 6 shows, only 168 firms have been matched.

	Control	Treated
All	168	476
Matched	168	168
Unmatched	0	308
Discarded	0	0

Table 7: Matched Units

According to the stated hypotheses the next table shows the differences on average between the treated and the control group in the three dependent variables:

	Average Treatment Effect for the Treated			
	mean	standard desviation	2,50%	97,50%
Probability of Collaboration in 2005-2007	0.24092	0.04242	0.15954	0.32478
Number of collaborative projects in 2005-2007	2.942	0.314	2.335	3.572
Patents registered in 2005-2007	0.05548	0.05625	-0.05028	0.16610

Table 8: Effect of the Intek Programme in the collaboration patterns of firms.

In the above table, we observe that the firms of the treated group have on average 24,092% more probability of collaboration after the subsidized period than those of the control group. Furthermore, with a confidence of 95% we can state that the effect of the programme is included in the interval of 0.15954 (15.95%) to 0.32478 (32.47%) on the dependent variable.

Additionally, the results show that the treated group has developed on average 2.942 more projects in collaboration than the control group during the period 2005-2007. With a confidence of 95% we can state that the effect of the programme is included in the interval of 2.335 to 3.572 on the dependent variable.

According to these results we can state that the Intek Programme has positive effects on the establishment of collaborative patterns between firms and other agents in the Innovation System.

Nevertheless, the results do not statistically give evidence about the effect of the collaborative projects into the R&D performance of the firms (measuring by patents). Although on average, the treated group have registered 0.05548 more patents than the control group as the standard deviation is very high, we cannot conclude that the collaborative projects in the Intek Programme have lead to a higher patenting activity.

7. CONCLUSIONS AND POLICY IMPLICATIONS

Regional R&D policy, following an evolutionary theory, is defined to overcome policy problems beyond market failures. These problems are related to the lack of networking, lock-in of firms in a regional system of innovation, among others. Regional policy aims at changing firms' behaviour in order to overcome these problems and enhance the regional innovation system and its innovation performance. For that reason, policy evaluation has to evolve from measuring input and output additionality (measures of R&D policy following a neoclassical perspective) to measuring behavioural additionality (from an evolutionary point of view).

Behavioural additionality aims at measuring changes in firms' behaviour as a result of a policy intervention. In this case, we aim at measuring changes in firms' behaviour as a consequence of a regional R&D programme. We also have related changes in behaviour with organizational learning (interorganizational learning and learning by doing) as it facilitates behavioural changes (Clarysse et al. 2009). According to this framework, we have analysed the policy effects on certain firms' decisions as R&D collaboration, R&D systematization and R&D internationalization through firms' participation in international projects.

The analysis carried out through this research has found that regional R&D programmes lead firms to participate in international projects, supporting Fernandez-Ribas and Shapira (2009). In addition, we have contrasted that firms regionally subsidized change their behaviour in carrying out R&D activities into a systematic behaviour, due to the resources and learning acquired in the participation of funded projects (Malik et al. 2005).

The role of regional policy in stimulating networking or collaboration schemes has been widely studied by Busom and Fernández-Ribas (2008), Ashsoff et al. (2006), Autio et al. (2008) and Clarysse et al. (2009), among others. We also support these studies as we found that regional programmes support the establishment of continuous cooperation in R&D activities. In addition, several studies find a positive effect on regional R&D programmes on the firms' patenting performance (Czarnitzki and Hussinger 2004, Ebersberger 2005 and Czarnitzki and Licht 2006, among others). Nevertheless, we cannot conclude that collaborative projects lead to a highly patenting performance than individual projects, in opposition to the positive effects that Czarnitzki et al. (2007) found in their study.

These findings have policy implications. First of all, regional R&D policy helps to overcome to policy problems derived for an evolutionary perspective of systems. Therefore, regional R&D

policy supports the organizational learning and some behavioural changes. Nevertheless, policy-makers have to realize that some regional schemes (as collaborative ones) might not accomplish a twofold objective as enhancing systemic interconnectivity and R&D performance at the same time. For that reason, they should clarify policy objectives within a programme and link them to the best scheme in order to reach the policy's goals.

In addition, there would be better instruments than subsidies to promote behavioural changes through learning as the systemic instruments proposed by Smits and Kulhmann (2004). These instruments are conceived to cope with the challenges of the systemic view of the innovation processes, where learning processes take place at three levels: policy makers, researchers and firms.

In this analysis we found a positive effect of R&D programmes on firms collaboration, which is an objective also shared by other policy arenas as cluster policy. Given this situation, it would be necessary to adopt a new governance of the innovation policy, keeping in mind the interrelation of different policy arenas and, therefore, avoiding institutional fragmentation (Edler et al. 2003).

Finally, and as a tool for better adequate regional policy to targets and beneficiaries, it is necessary to include behavioural additionality in policy evaluation.

8. LIMITATIONS AND FURTHER RESEARCH

This study has been limited by data availability. Due to lack of data for all the firms, we could not include as control variables in the model some important variables that might be affecting firms' behaviour, as firms' participation in national R&D programmes. We will include this variable in a further research. In addition, the model does not allow the inclusion of some intangible variables that might be also affecting firms' behaviour as the managerial capabilities of the general manager, for instance. The best solution for including this and other variables in the research is to triangulate methods and combine quantitative approaches with qualitative ones. For that reason, we will complement this research with some case studies, in order to better evaluate the impact of the programme in some strategic decisions, as collaboration or internationalization. In addition, further research might include an analysis of the different partnerships established through the funded scheme and their continuation, following the analysis carried out by Aschhsoff et al. (2006).

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