TOWARDS A TAXONOMY OF FIRMS ENGAGED IN INTERNATIONAL R&D COOPERATION PROGRAMS: THE CASE OF SPAIN IN EUREKA

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ABSTRACT

Innovation is increasingly becoming an internationalized process and a strategy that has recently been playing a central role in this scenario is that of R&D collaboration. To assess the outcomes of this strategy we develop an evaluation of Eureka Programme's impact for the case of Spanish companies participating in this initiative and that had projects finished in the period 2000-2005. A total of 77 firms were assessed through statistical association methods and cluster analysis. Company size, Role in the Project, Firm Sector and R&D intensity are significantly associated with the projects' impacts on Spanish participants. A consistent taxonomy is offered in which three clusters are built: (1) *Risky Innovators*; (2) *Inventors*; and (3) *Consistent Innovators*.

Keywords: Innovation Policy; Eureka Programme; Spanish Innovation System; R&D Collaboration.

Introduction

Innovation policies are a matter of great concern worldwide and in the European Union this situation is not different. Much has been said about the "European Paradox", i.e., the difference between scientific capabilities and actual innovation performance (Georghiou, 2001) and, therefore, several measures took place in order to modify this scenario.

Broadly speaking, these programs that stimulate innovative activities take place to correct the market failures associated with R&D investments (Klette, Moen & Griliches, 2000). Nonetheless, unsatisfactory results in this area are mainly attributed to lack of R&D investment and to a low productivity of the resources invested (Benfratello & Sembenelli, 2002) showing a strong need for the analysis, evaluation and measurement of current innovation and technological policies (Edler, 2010). But this cannot be regarded as a simple task depending solely on recognizing the underlying difficulties and designating funds for it. Despite important conceptual and methodological advances in the economics of science and innovation in recent years, there is still little agreement as to what 'good' science, technology and innovation (STI) policy should look like and which instruments should be used (Laranja, Uyarra & Flanagan, 2007), which gives an idea of the complexity involved not only in formulating innovation policies, but also in evaluating their impact.

Embedded in this scenario is the existence not only of firms' strategies to cooperate in R&D, but also its international tendency and a whole set of initiatives that promote this kind of activity. It is well known that not only for firms, but for innovation systems, this sort of integration can be very beneficial for technological growth and evolution, being a key determinant of competitiveness (Archibugi & Iammarino, 1999; Suurna & Katel, 2010). Nonetheless, approaches in this regard are somewhat controversial and there still is an important gap in terms of policymaking implications of R&D cooperation initiatives as well as a stronger framework to foster these activities (European Commission, 2011).

The scope of this paper lies in analyzing through technological and commercial impacts at national level (the case of Spanish firms) one of the most relevant technological programs that take place in the Europe and that has as its main goal fostering innovation through cooperation between organizations from different nations: the Eureka Programme. The objective is to achieve an approximation of companies' profiles when joining such an initiative, generating workable indicators of output determinants in this framework in a context of impact measure, a largely unexplored area of R&D collaboration (Silipo, 2008; Bayona, García-Marco & Huerta, 2001).

The analysis here undertaken is based on a quantitative approach of Eureka's Final Reports of projects completed by Spanish companies during the period 2000-2005. Spain represents an interesting case of study for cooperative R&D for as much as it is one of the most dedicated participants in Eureka, still shows a low level of R&D collaboration between agents and is historically highly dependent on foreign sources of technology (COTEC, 2007; Fernández, Junquera & Vázquez, 1996). These reports are structured in a way that allows the assessment of descriptive information (general features of the companies such as size and status of participation in the project) and general impact of the project (technological achievements, commercial impact, industrial exploitation). Data regarding companies' main characteristics (more detailed data of size and industrial sector) were also combined with the original database. The methodological approach is divided in two parts: analysis of associations (through cross-tabs and chi-square tests) and a proposal of taxonomy of participants.

The paper firstly outlines the literature on cooperative R&D with special focus on international relationships. The main features of Eureka are presented, as well as previous results of evaluations undertaken. Subsequently, the methodology of the research is presented, introducing the main characteristics of the sample and the specific methods applied. Results are presented and discussed and we finish with some concluding remarks and policy implications.

2. International R&D Cooperation

All indicators, such as co-publications, co-inventions, and joint research projects, point in the direction of an increasing relevance of international collaboration in science and technology which is followed by a significant increase and broadening of international and transnational policy initiative and instruments to foster and shape international S&T collaboration – in the case of firms this is mainly driven by the search of more efficient operations (Edler, 2010; Veugelers, 1998; López, 2008).

History shows that R&D partnerships have been growing since the 1960s with a noticeable acceleration in the 1980s. This is the result of the increasing level of complexity of R&D projects in recent years, higher uncertainty surrounding R&D, increasing costs of R&D projects, stronger competition and shortened innovation cycles that favor collaboration in face of an environment with more specialized organizations in terms of knowledge production (Pavitt, 2002; Hagedoorn, 2002; Narula, 2001; Zeng, Xie & Tam, 2010; Barajas & Huergo, 2006; Katz & Martin, 1997; Jonkers & Castro, 2010). Other benefits of cooperative R&D come from the assumption that it increases the efficiency of R&D efforts, provides more flexibility to adapt to technological changes and eliminates wasteful duplication; also cooperative R&D agreement may serve as a mechanism that internalizes the externalities created by spillovers while continuing the efficient sharing of information (Katz, 1986). Moreover, the process of globalization itself has influenced firms' behavior and technological characteristics of innovations by increasing outsourcing and strategic alliances and also by promoting increasingly multi-technological products (Narula, 2004).

As a consequence of these trends there is an emergence of new forms of interaction between firms, fostering an environment of "open innovation", meaning that many companies across industries externalize several R&D activities, focusing on their core competences and absorbing third parties' capabilities (Wagner & Edelmann, 2002; Herstad *et al*, 2010). This implies that firms use R&D partnerships to access knowledge, expertise or skills and build global R&D networks, being the choice of partners dictated by the complementary resources which the counterpart controls, allowing companies to improve their performance (Miotti & Sachwald, 2003; Georghiou, 1998; Nesta & Mangematin, 2004). One significant outcome of this scenario is that especially large companies are likely to capture results more easily – because of an expected higher absorptive capacity in comparison to SMEs - and to become less self-sufficient in their processes, being able to incur in the division of innovative activities (Pavitt, 2003; Fritsch & Lukas, 2001; Veugelers, 1998; López, 2008; Bayona, García-Marco & Huerta, 2001) which according to economic theory should lead to scale economies[i].

Efforts on R&D cooperation are especially relevant in OECD countries, where the increasing number of R&D strategic alliances stands for a new organization in industrial technological structure focused on network promotion policies instead of direct financial assistance policies (De Jong & Freel, 2010). This interest from governments in promoting international research collaboration comes primarily from expectations of cost savings and other related benefits (Katz & Martin, 1997). Cooperative R&D policies gain even more importance when one considers that the extent to which a country's businesses, institutions and industries are linked with resources and capabilities located outside the country is likely to positively impact the innovation performance of that country (European Commission, 2010), creating local externalities from global relationships.

Also, the idea of international scientific and technological cooperation can be regarded as fundamental for the development of products that demand joint R&D due to specialization patterns in different economies or regions, i.e., the idea of complementarities between firms should also be considered as promoting integration between technically and economically heterogeneous territories. Thus, collaboration fosters knowledge transfer in a context of international economics. Narula and Santangelo (2009) hypothesize that R&D alliances might even act as a substitute for collocation, or as a complementary mechanism for it, embedding the idea of international R&D cooperation in the economic geography framework.

In Europe, the creation of the European Research Area stands for a coordination of closer R&D cooperation between organizations of EU's Member States (Georghiou, 2001). It is interesting to highlight the adaptive role of the policies in this field – R&D cooperation did not follow governmental initiatives but the other way around. Also, An evaluation undertook by the European Technology Assessment Network (ETAN, 1998) concludes that European firms not only have a internationalized S&T profile, but are also increasing its technological alliances and international generation of innovations within Europe and beyond, even though not in the same level as firms in the United States (Foray & Lhuillery, 2010).

However, this growing interest in technological cooperation analysis is followed by a high level of complexity involved in studying it (Barajas & Huergo, 2006). Some models were developed in the past decade trying to cope with non-linear and non-direct relationships between the variables used in the evaluation. Crépon, Duguet and Mairesse (1998) wrote the most influent article in this sense –

they approach this idea of complex interrelations with a model of simultaneous equations that allow the analysis of indirect relationships (a similar approach has been undertook recently by Bogliacino & Pianta, 2010). Their results show that technological cooperation agreements have a positive effect in the achievement of innovations which leads to better economic outcomes, suggesting an indirect relationship between cooperation and economic performance via innovations. Similar results are found by Surroca Aguilar and Santamaría Sánchez (2006).

Conceptually, cooperative R&D consists of an arrangement among firms aiming at sharing costs and results of an R&D project and can be achieved through R&D contracts, consortia or Research Joint Ventures - The kind of cooperative agreement in which firms engage is largely determined by technological characteristics and sectors of industry (Sakakibara, 1997; Hagedoorn & Narula, 1996). The idea of open innovation formalizes the importance of these networking initiatives and absorptive capacity while reducing the focus on internalization of R&D activities (De Jong & Freel, 2010). As a matter of fact, external sources of knowledge and skills play an increasingly important role in innovation and the capacity of accessing and exploring this knowledge is fundamental for companies' competitiveness in the described context (Cohen & Levinthal, 1990). Also, an important prerequisite to manage the permanently changing dynamic market requirements and to secure the competitiveness is the linking and cooperation of companies (Wagner & Edelmann, 2002).

In an environment of constant technological change and high levels of R&D complexity, the best way to minimize risks and achieve sustainable competitiveness seems to be through specialization. It is impossible to imagine that this trend leads to economic growth if firms and agents do not interact with themselves (since they are all deeply specialized) or do not even have the capacity to do so. R&D cooperation practices have a twofold impact in this arena: on the one hand they create the possibility of firms addressing complexity in a multi-capability and multidisciplinary manner, promoting valuable innovations; on the other hand, R&D cooperation increases absorptive capacity and learning capabilities in the company, generating better prospects for future collaboration. This latter aspect is also pointed out by Barañano (1995). Therefore, promoting the strengthening of companies' technological skills through collaboration and therefore providing them with absorptive capacities is a fundamental focus that technological policies must consider (Molero, 2001; Luukkonen, 1998; Silipo, 2008).

But it is important to highlight that despite the increasing relevance of R&D cooperation and the growing literature about it in both the fields of management and industrial economics, there is little evidence on the performance effect coming from R&D collaboration (Belderbos, Carree & Lokshin, 2004). However, available analyses at the firm level show positive results: Zeng, Xie & Tam (2010) report that interfirm cooperation shows a significant positive impact on the innovation performance of SMEs in the Chinese environment. International R&D collaboration also seems to be positively associated with higher innovation expenditures (De Jong & Freel, 2010) and to provide firms with strategic flexibility to undertake short-term innovation projects with a variety of partners (Hagedoorn, 2002).

Cooperative R&D structures can be seen as innovative *per se* as it creates a new institutional framework for companies cooperate in the generation of technological change. Policies fostering cooperation also show adaptive characteristics since they cannot be regarded as linear: they promote a more complex and holistic approach to innovative processes in opposition of direct funding initiatives. But one has to be very careful when analyzing collaborative R&D and its related policies. For many sectors, cooperation regarding innovation may be too dangerous for companies' appropriability strategies – as it is the case of the pharmaceutical sector which relies deeply on the launching of new products and in the intellectual property rights of these new drugs – sharing valuable information with competitors or even with agents from industries not directly related to the pharmaceutical sector might be too big of a threat for this organizations (which explains why this market is controlled by huge corporations with high degrees of internalization).

Also, cooperation may happen in different stages of R&D. Some projects are related to basic R&D, others to pre-competitive activities and lastly (as it is the case of the Eureka Initiative), close-to-market cooperation (the one which poses the biggest risks for companies). Conceptually, R&D alliances can be distinguished from production-based alliances in terms of its fixed-term horizon and the fact that it covers only a small part of the value-adding activities of companies (Narula, 1999). So as it can be noticed, collaboration in the area of innovation can not only take different shapes in the interorganizational relationship (contracts, research joint ventures, etc.) but can also apply to R&D activities with different purposes. When dealing with evaluation of technological policies one cannot neglect these aspects.

3. The Eureka Programme: an overview

The Eureka Programme emerged as part of a concerted effort to bridge the widening technological gap observed since the 1960s between Europe and its global competitors: notably the USA and Japan (Eureka Secretariat, 2005). It was created in 1985 by a French initiative as a complementary structure for the Framework Programmes aiming at enhancing collaboration between companies in a market oriented, non-bureaucratic, bottom-up approach promoting cooperative projects for national funding (León, 2006; Stubbs, 2001; Georghiou, 2001; Marín.& Siotis, 2008).

It became a Europe-wide network that aims at increasing its participants' competitiveness through the promotion of cross-border ``market-driven'' R&D projects in which firms may seek entry for any projects that meet the broad criterion of developing advanced technology with a market orientation (Georghiou & Roessner, 2000; Bayona-Sáez & García-Marco, 2010; Trabada, 2000; Molero & Fonfría, 2008; Marín.& Siotis, 2008). It is also important to highlight the relevance of the bottom-up approach of this initiative: unlike programs that have clearly defined areas of interest for R&D projects, in Eureka, the nature and scope of proposals is defined by the proponents themselves.

Eureka is present in 38 countries and acts not through financial support but providing projects with a seal of approval that facilitates access to governmental funds in the national level as well as support in finding funding opportunities which makes it a fairly decentralized program (Molero, 2001; Stubbs, 2001; Georghiou & Roessner, 2000). Even though Eureka does not entitle firms to EU subsidies (it should be noted that Eureka is not an EU program), obtaining the Eureka "seal of approval" enhances firms' ability to receive support from their respective national authorities (Marín & Siotis, 2008). By conferring an objective seal of quality on a project, EUREKA labeling greatly aids the process of negotiation with public sources of finance[ii]. Many member countries accord preferential treatment to labeled proposals by giving access to specifically reserved funding (Eureka Secretariat, 2005).

Eureka's focus is on improving European competitiveness and productivity through an enhanced cooperation between companies and research centers in high-tech areas (Molero, 2001). Under Eureka, cooperation often consists of occasional meetings between firms at which information is shared (Fölster, 1995), but more formal ways of cooperation also take place.

Eureka carries out its own evaluation system through periodic reviews. In its first decade of existence, evaluations of projects were responsibility of the Member State holding the Chair for that year and in 1992-1993 Eureka had its first major evaluation, involving teams from 14 countries working together and carrying out a survey with all of the participants (Georghiou & Roessner, 2000).

However, besides its internal evaluations, Eureka is the focus of several academic analyses. Some examples:

a) Bayona-Sáez and García-Marco (2010) demonstrate that participation in a Eureka Programme has a positive effect on firm's performance both in manufacturing and non-manufacturing sectors with a 1 year lag between project completion and performance improvements (which is in accordance with Benfratello & Sembenelli, 2002 results – they also highlight an increase in labor productivity and price-cost margins for participants);
b) Barañano (1995) suggests that Spanish Eureka participants see the improvement of the organization's public image as one of the most important features of the program;
c) Marín and Siotis (2008) result's tell that it seems that Eureka serves the purpose for which it was designed, namely to correct the market failures associated with the generation of economically valuable knowledge;
d) Fölster (1995) hypothesizes that, given that Eureka projects require cooperation but do not require result-sharing agreements, the likelihood of cooperation is not increased while do promote incentives to conduct R&D to the same extent as subsidies that do not require cooperation;

e) Georghiou (2001) points that Eureka started with major projects but a decline since then took part driven by its divergence with national innovation policies.

So as it can be noticed, Eureka is a relevant target of innovation policy evaluation. But it is important to take into account that even though the results presented are mainly positive, continuous assessments and even different research foci might not only identify weaknesses of the program, but also provide information necessary for adaptations and changes in the initiative's characteristics.

4. The Sample

The sample consists in a subset of Eureka's database of Spanish participants in the initiative for the period 2000-2005. However, some adjustments had to be made for this database (consisting originally of 330 observations). The first stage consisted in two steps:

1. Eliminating participants that did not respond the Final Report since information regarding their participation in the Eureka project was not available.
2. Selecting those participants which were either Large Companies or Small and Medium Size Enterprises (SMEs) given the scope of the analysis. Research Centers, Universities and other institutions were then dropped from the database as we expect that these participants will not have market-driven behaviors necessarily.

After these adjustments the 2000-2005 database was left with 77 firms. A last effort was made to categorize companies according to their sector (NACE 2 digit Rev. 2) using the Amadeus database and to identify actual number of employees: 2 companies from the 2000-2005 subset could not be classified in this regard.

A general description of the sample used is depicted in Table 1 where the most relevant features of Spanish companies participating in Eureka with projects finished in the period 2000-2005 are compared in relative terms with the global average of Eureka's participants for the same period.

	Aspect	TOTAL	SPAIN
Composition	SMEs	63%	62%
	Large Companies	37%	38%
Overall Technological Achievements	***Excellent***	***19%***	***24,7%***
	Good	***62%***	***67,5%***
	Weak	9%	7,8%
	Bad	2%	-
	No answer	8%	-
Technological Achievements - total participants	***New Products***	***36%***	***47%***
	Improved Products	***32%***	***47%***
	New Processes	34%	38%
	Improved Processes	***27%***	***42%***
	Prototype/demonstrator	43%	44%
	New services	***11%***	***18%***
	New strategic alliances	***19%***	***12%***
	New licenses	3%	4%
	New Patents	10%	8%
Technological Achievements - expected within 3 years - total participants	New Products	24%	20%
	Improved Products	10%	7%
	New Processes	13%	13%
	Improved Processes	8%	10%
	Prototype/demonstrator	5%	4%
	New services	10%	9%
	New strategic alliances	10%	12%
	New licenses	4%	5%
	New Patents	7%	5%
Industrial Exploitation	No industrial exploitation	22%	18%
Already on market	***Results already on market***	***31%***	***46%***
Actual Commercial Impact	***Excellent***	***6%***	***11,7%***
	Good	42%	41,6%
	Weak	20%	19,5%
	Bad	4%	2,6%
	Nil	17%	15,6%
	No answers	10%	9,1%
Employment Impact	***Increase***	***34%***	***44%***

Table 1. Comparison between Spanish Firms and Total of Participants in Eureka

5. Towards a Taxonomy: Methodological Approach

Given the central purpose of this evaluation, the applied methodology consists basically in quantitative techniques that allow the construction of relatively homogeneous groups out of a sample and based on a set of predefined variables. Hence, the approach of this study consists in evaluating through statistical methods how variables are associated with themselves and how companies behave according to their characteristics and outcomes from their participation in the project. In a first moment, cross-tabs (chi-square) analyses are performed in an attempt to identify how descriptive variables of firms relate to their projects' outcomes. The second step undertaken is a cluster analysis that aims at verifying latent groups of companies with similar profiles either regarding their structure (size for example) or the impact of their participation in Eureka. This approach aims at generating in-depth knowledge on aspects that might contribute for the policy-making process at the Eureka (and maybe other similar initiatives) level.

The cross-tabs (chi-square) method represents a step ahead in the identification of associations, allowing for some inferential propositions. The approach described in this section is developed according to the following structure: descriptive variables are analyzed according to impact variables. The objective of this approach is to generate some knowledge on how variables such as company's size and its role in the project interact with the results achieved. It is worth noticing that these statistical interactions obey logical and theoretical propositions. When analyzing impact variables, it is relevant for the study of innovation aspects to relate it to variables representing companies' size and their role in the technological project, as well as how technological achievements may influence commercial results, for example. Working with this set of Spanish companies we can, through this specific methodology be able to identify some valuable trends in the sample.

The cluster analysis developed in this paper has a rather exploratory character – instead of a confirmatory one. The objective is to provide some insights on a preliminary typology of Spanish participants in the Eureka Initiative based on a set of descriptive and impact variables. For this approach, the TwoStep Cluster (SPSS) method was used – this method is an exploratory tool designed to reveal natural clusters in the dataset according to the parameters indicated. As auxiliary tests showed, the TwoStep Cluster method performs better than the K-means method – the Hierarchical method was also tested but its results did not seem to be analyzable. The Ratio of Schwarz's Bayesian Criterion (BIC) Changes was the test used for establishing the optimal number of clusters for the sample. Chi-square tests for the classification relevance of variables were also performed.

The specific variables included in the settings of the cluster are: *Companies' Size, Role in the Project* (as Main player or Partner and as Producer, End user, Supplier, Research, Other or Multiple), *Functioning of the Project, Overall Technological Achievements, Industrial Exploitation by the Respondent's Company, Product Already on the Market and Commercial Achievements*.

6. Identification of Associations

Our empirical analysis starts with the results presented in table 2, which bring a summary of the cross-tabs (chi-square) results for significant associations between descriptive (columns) and impact (rows) variables. First of all, descriptive variables that did not show any significant relationship with impact variables were omitted from this table: a) Total Cost of Project; b) Total Duration of Project; and c) Role in the Project as Main Player or Partner.

First results report the relationship between companies' size and the group of selected impact variables. Results show that the size of the companies (SMEs or Large Companies) has an association with *Commercial Achievements*. SMEs seem to show a greater commercial impact as a result of their participation in the project than Large Companies. This result is somewhat expected since the commercial impact of one single project should be perceived as having a larger importance in smaller firms than it would be the case in larger corporations.

The analysis of companies' Role in the Project (as Producer, End User, Supplier, Research, Other or Multiple Roles) suggests that Technological Achievements appear to be related to companies' characteristics – Excellent achievements are obtained by firms playing the role of Producer; Good achievements are related to both Producers and companies that have Multiple roles in the project; and the poorest results can be associated with those companies that report having Other roles in the project (which might be an indication of smaller participation in Eureka). Also, it was found a significant relationship for firms that participate as End Users associated to Industrial Exploitation by Another Company.

When analyzing the association of results of the participation in the initiative with companies' sectors, it can be noticed that only *commercial achievements* show a statistically significant relationship. Regarding this result, Manufacturing and Services firms achieve better performances in comparison to firms from the Primary and Construction sectors. For this case, a more disaggregated level of sectoral analysis would be ideal, but the number of observations does not allow us to capture that picture.

R&D intensity is a variable that shows significant correspondence only with the launching of a new product on the market by the end of the project. This would be a hint that firms with higher levels of relative investment on R&D have a smaller time-to-market period, which can be a useful information for Eureka when analyzing projects to be accepted and the specific goals of the initiative.

	Company Size	Role in the Project	Sector (Broad)	R&D Intensity
Functioning	-	-	-	-
Technological Achievements	-	Excellent Technological Achievements are associated with Producers; Good Technological results are associated with either Producers and participants with Multiple Roles. Poorest results are related to Other roles. *	-	-
Industrial Exploitation by the respondent's company	-	-	-	-
Industrial Exploitation by another company	-	Positive exploitation by other companies is associated mainly with the role End user. **	-	-
Product Already on Market	-	-	-	Companies with higher R&D intensity (as a % of total turnover) are more prone to have products on the market by the end of the project.*
Commercial Achievements	Good and Excellent results are related to SMEs; Poorer results are related to Large Companies. *	-	Good and Excellent resulta are assoaciated with Manufacturing and Services firms. Poorer results are related to Water, Energy and Construction sector.**	-

* Difference is significant at a 0.10 level.
**Difference is significant at a 0.05 level.

Table 2. Summary of significant associations between descriptive and impact variables.

7. Taxonomy of Participants

In this part of this empirical assessment of Spanish companies' participation in the Eureka initiative for projects completed in the period 2000-2005, an attempt of developing an exploratory typology of firms included in the sample is performed. As it has been already mentioned in the methodological section, the set of variables used to define the characteristics of the clusters are *Companies' Size* (Large company or SME), *Role* (as Main player or Partner), *Role in the Project* (Producer, End User, Supplier, Research, Other or Multiple Roles), *Overall Technological Achievements, Functioning of the Project, Industrial Exploitation by the Company, Product Already on the Market* and *Commercial Achievements*.

Table 4 brings a summary of the structure of the clusters built based on a TwoStep Cluster approach. One first aspect that has to be commented is that the outcome of the analysis suggested the division of cases in 3 clusters with rather similar sizes. Nonetheless, it is evident that some of the variables used in the classification do not necessarily perform a considerable separation between clusters as it can be seen in the composition of clusters and also through chi-square results for the variables. Results were kept in the original structure since this assessment has exploratory interests (and the cluster analysis itself is not an exact science).

As results show, the size of companies does not correspond to a good separation variable between clusters – Cluster 1 and 3 both have a similar structure and no particular cluster correspond to the set of Large Companies – which are divided in small groups within clusters. A very comparable situation is provided by the Role as Main player or Partner – in this case, both clusters 1 and 3 are predominantly composed by Main players, while cluster 2 shows no defined characteristic in this aspect. These observations are supported by chi-square tests that do not provide either variable with a significant classification power.

The cluster analysis starts taking shape when considering Role in the Project as a separation variable. In this case each cluster has a clear predominance of each one of the three most common roles played by Spanish companies participating in Eureka for the period analyzed. Cluster 1 is mainly composed by Producers; Cluster 2 by End Users; and Cluster 3 by companies playing multiple roles. Nonetheless, chi-square results do not allow for an inferential confirmation of these patterns so Role in the Project performs as a rather suggestive variable instead of a confirmatory one.

Following this variable, Technological Achievements seem to provide some interesting level of discrimination between clusters: while Cluster 1 is mainly made of companies with excellent results, both Clusters 2 and 3 show companies with good technological results – this should be no surprise since 92,2% of the sample classified their technological achievements as either excellent (24,7%) or good (67,5%), but cluster 2 also shows the presence of weak technological results, which does not happen for either of the two other clusters. In this regard, the chi-square coefficient indicates that this variable represents a good classification aspect between groups. Functioning of the project, a variable that deals with internal aspects of management of the project, does well in separating cluster 1 from 2 and 3 in a similar manner to that generated by Technological Achievements (even though chi-square results show a good fit for this variable only for clusters 1 and 3).

Cluster Distribution		
	Cluster 1 – *Risky Innovators*	28 observations (36.4%)
	Cluster 2 – *Inventors*	26 observations (33.8%)
	Cluster 3 – *Consistent Innovators*	23 observations (29.9%)
	Missing	0 observations

Cluster Profile	**Cluster 1**	**Cluster 2**	**Cluster 3**
Size (Large or SME)	Predominance of SMEs (70% of cases)	No predominance (50% of cases are SMEs and 50% are Large Companies)	Moderate Predominance of SMEs (70% of cases)
Role (Main or Partner)	Predominance of Main players (80% of cases)	No predominance (50% of cases are Main Players and 50% are Partners)	Moderate Predominance of Main players (65% of cases)
Role in the Project	Predominance of Producers (40%) and End Users (30%)	Predominance of End Users (35% of cases) and firms with Multiple Roles (30%).	Predominance of companies with Multiple roles (50%) and Producers (40%).
Technological Achievements	Excellent Technological Results (65% of cases)*	Good Technological Results (80%) and Weak Technological Results (20%)*	Good Technological Results (100%)*
Functioning of the Project	Functioning of the project rated as Excellent (60% of cases) or Good (nearly 40%).*	Functioning of the project rated as Good (60% of cases) or Weak (25% of cases).	Functioning of the project rated as Good (100%). *
Industrial Exploitation by the Company	Yes (95%)	No (55%)*	Yes (95%)
Product Already on the Market	Yes (70%)*	No (100%)*	Yes (65%)
Commercial Achievements	Excellent Commercial Results (30%), Good Commercial Results (20%), Weak Commercial Results (20%), Nil Commercial results (5%)*	Nil Commercial Results (40% of cases), Weak results (35%)*	Good Commercial Results (100%)*

*Clusterwise Importance (chi-quare at 95% confid.)

Table 3. Results of the TwoStep Cluster analysis

Regarding Industrial Exploitation of results, Clusters 1 and 3 represent groups of companies that do have some level of exploitation, and Cluster 2 seems to be composed by both companies that exploit their project outcomes and those firms that do not (chi-square tests show a significance only for the latter case). A clearer division is provided by the variable Product Already on the Market: both Clusters 1 and 3 have the characteristic of having commercial activities already by the end of the project which does not happen with Cluster 2 (chi-square significant for groups 1 and 2). Lastly, the variable Commercial Achievements shows that

Cluster 1 represents companies with a myriad of different results: while it is the only group containing firms with excellent results, it also comprehends companies with good commercial results, weak commercial results and even nil commercial outcomes. This structure is rather complicated to analyze as there is no clearly defined pattern (Excellent and Good results only account for 50% of cases). Cluster 2 is composed mainly by those firms with weak and nil commercial outcomes and Cluster 3 is related to those with good commercial achievements.

Focusing in those aspects that successfully divide clusters, the results indicate a general structure according to the following cluster profile:

1. ***Risky Innovators -*** SMEs which participate in the project as Main Players, playing the role of Producers or End Users, that achieve excellent technological results through an excellent functioning of the project, exploit their results in the industry, have products being commercialized by the end of the project and this generates excellent commercial achievements for a group of companies comprehended in this cluster. The name of this cluster makes reference to the fact that companies comprehended in it have the best technical outcomes out of the three clusters, but only partially they can obtain satisfactory market results.
2. ***Inventors -*** Large Companies and SMEs that play Multiple roles or the role of End Users in the project, that achieve good technological results through a good or weak functioning of the project, that do not necessarily perform industrial exploitation of results, that are not commercializing the outcomes of the project by the time of its completion, thus having nil and weak commercial achievements. These companies are classified as inventors for showing fair technical results without taking advantage of it in the market – which does not allow us to define them as innovators *per se* – at least by the time the Eureka project is completed.
3. ***Consistent Innovators -*** SMEs which participate in the project as Main Players, playing Multiple roles or the role of producer in the project, that achieve good technological results through a good functioning of the project, exploit their results in the industry, have products being commercialized by the end of the project and this generates good commercial achievements. These companies have poorer technical results than the *risky innovators*, but truth of the matter is that they consistently achieve good commercial results.

One last aspect of this analysis concerns a quite obvious result according to theory, but that deserves some attention. Spanish companies participating in Eureka for the period 2000-2005 are mostly well satisfied with their technological attainments, which is an important aspect of the evaluation of any technological initiative. However, this is only part of the story: the companies' capacity of introducing their results in the market and exploiting the technical outcomes of the project clearly influence the point of view towards commercial achievements – and when dealing with an innovation-driven approach (and not invention-driven), this latter part of the analysis is the one that matters the most.

8. Concluding Remarks

Technological policy evaluation is a process of utmost importance in any economic context that aims at fostering economic growth through technological progress and innovation. This is an exercise of constructive criticism with the ultimate goal of providing information and feedback that allow the continuous improvement of any kind of initiative – private, governmental or even supranational.

The work developed and presented in this paper represents an effort in this sense. A quantitative appreciation of a database composed by Spanish companies participating in the Eureka Initiative with projects finished in the period 2000-2005 made possible some interesting exploratory insights.

The methodology used in our analysis had a quantitative character aiming at taking the step beyond purely descriptive assessments – even though we recognize the risks of it. We have seen that the overall rate of technological achievements is impressively high and even the commercial achievements can be considered outstanding in a context of innovation where R&D outcomes can be considered as uncertain by its own nature (Silipo, 2008). While this might indicate that Eureka is doing a really good job in selecting potentially successful projects, it might also suggest that companies may not be taking the level of risk necessary for introducing major relevant innovations in the market, which corresponds to Georghiou's (2001) criticism that the quality of Eureka's innovation projects seem to be diminishing over time. Or it could also mean that the questionnaires are failing in capturing the real complexity involved in the process (Georghiou, 1997) or are simply influenced by too optimistic respondents (Huggins, 2001).

A fairly robust cluster structure was presented for the sample, dividing participants in 3 groups. This step also allowed the confirmation of the idea that commercial achievements are strongly affected by the insertion of results in the market before or by the end of the project. Cluster 1 was classified as *risky innovators*. One interesting aspect of this group in particular is that it seems to perform better than the other clusters except for the case of commercial results, which shows a very heterogeneous pattern. Cluster 2 represents companies with poor market performance by the end of the project but with satisfactory technical results, therefore *Inventors*, and Cluster 3 is composed by moderately successful companies or *consistent innovators*. Cluster results also showed that both technological (marginally) and commercial (significantly) achievements are quite strong separation variables for groups of firms within the sample. Crossing this analysis with other Eureka samples (from different periods and territories) can be an interesting exercise for future validation of a Eureka-wide typology of participants, since we dealt with a relatively small sample of companies for a limited timeframe.

The results of the cross-tabs (chi-square) approach aimed at generating some insights on the relationship of descriptive variables of companies, i.e., those that are not related to their participation in the project, and impact variables that gather information of firms' outcomes from the Eureka project they have undertaken. These results basically support the outcomes of the clustering process while also providing valuable and workable information in the shape of indicators for the management of Eureka for both the selection of applicants and for the monitoring of ongoing projects.

Main policy implications of our research point towards the relevance of Spanish firms' characteristics on the resulting impacts from their participation in a Eureka project. Clearly, the analysis of a given project *per se* does not provide nearly enough information for the decision makers to decide if whether this project should receive a seal of approval or not: characteristics such as the sector, the size, the R&D intensity and the specific role a company will be carrying out in the project are significant in defining to which group (according to our proposal of clusters) a company will belong to when the project ends. If the goal is to achieve ever increasing results, the outcomes of our research suggest rich information on what to consider in a firm before it participates in a European project.

Thus, practical and useful results of our research suggest that the use of operational indicators should be taken into account together with the existent evaluation methodologies – which in the case of Eureka mainly derive from case studies and descriptive tables. Also, developing and updating taxonomies built on these indicators, for as imperfect as they can be, shall contribute to a better management of processes within initiatives, at least suggesting relevant information for interventions and control.

Hence, efforts in the sense of continuously evaluating the Spanish participation in Eureka have to be performed in order to complement and even provide a different perspective than the one presented in this paper. Nonetheless, achieved results are quite insightful and do well in offering an assessment of Spain's participation in Eureka. Future research should aim at combining data contained in both Eureka's reports and objective economic data available at the micro level. Also, comparing innovation impacts between different technological initiatives would result in even more relevant knowledge regarding policy evaluation.

Endnotes

[i] This does not mean at all that R&D cooperation has no effect on SMEs. The point to be noticed here is that smaller firms are not likely to proceed to internalization of processes in the first place, making them more prone to outsourcing by their own organizational definition.

[ii] Edler (2007) points the importance of signaling policies regarding innovations and there are several other authors that analyze signaling strategies and adverse selection risks in the context of R&D and innovation funding. For examples see Beatty, Berger & Magliolo, 1995; Takalo & Tanayama, 2010; Plehn-Dujowich, 2009; Janney & Folta, 2003; Bagella & Becchetti, 1998.

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