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¿Qué lleva al éxito? Una contribución al debate sobre políticas públicas de cooperación internacional en I+D
Identificación los determinantes de los resultados a través de datos de empresas de Eureka (2000-2008)

What drives to succes? A contribution to the debate on international R&D cooperation policies
Identifying determinants of achievements through Eureka's firm level data (200-2008)

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

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¿QUÉ LLEVA AL ÉXITO? UNA CONTRIBUCIÓN AL DEBATE SOBRE POLÍTICAS PÚBLICAS DE COOPERACIÓN INTERNACIONAL EN I+D

IDENTIFICACIÓN LOS DETERMINANTES DE LOS RESULTADOS A TRAVÉS DE DATOS DE EMPRESAS DE EUREKA (2000 – 2008)

WHAT DRIVES SUCCESS? A CONTRIBUTION TO THE DEBATE ON INTERNATIONAL R&D COOPERATION POLICIES

IDENTIFYING DETERMINANTS OF ACHIEVEMENTS THROUGH EUREKA'S FIRM LEVEL DATA (2000-2008)

Advisor: Prof. José Molero Zayas, PhD.

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FOREWORD

This document brings a final and extended version of a research project which has been taking place since early 2010[1]. The initial goal was to develop an evaluation of the Eureka Program for Spanish participants (only firms), taking into account data from projects' Final Reports for companies with such projects completed between 2000 and 2005 (lately including projects from years 2006 to 2008). The methodology used was somewhat novel in this context: for reasons outlined in the methodological section of this dissertation, I did not resort to counterfactual econometric techniques as the core approach. Fortunately, much literature supported our decision regarding the usefulness of distinct quantitative approaches (and an amazing conversation with Professor Stan Metcalfe at the University of Manchester confirmed that point of view. I cannot thank him enough for these insights).

As a result of these efforts, I had the opportunity to present (and to gather valuable feedback) previous stages of this research at the *DIME Final Conference* in Maastricht, April 2011, *XIII World Economy Meeting* in San Sebastian, May 2011, *EU-SPRI PhD and Early Career Researchers Conference* (where I received important reviews from Prof. Stefan Kuhlmann), in Manchester, September 2011, at the *7th Iberian International Business Conference*, October 2011 and, lastly, at the 2013 IAMOT Conference, April 2013. Also, we had the pleasure of seeing a working paper version of this research to be cited by the Danish Agency for Science, Technology and Innovation in their *Analysis of 25 years of Danish Participation in Eureka Report*. So far, two articles that were originated from this research were published in peer-reviewed journals, namely:

- Fischer, B.B. and Molero, J. (2012). Towards a taxonomy of firms engaged in international R&D networks: an evaluation of the Spanish participation in Eureka. *Journal of Technology Management & Innovation*, v. 7, n. 3, pp. 121-134.
- Fischer, B.B. (2012). Methodological lock-in and the evaluation of R&D policies: a critique to quasi-experimental assessments. *Current Opinion in Creativity, Innovation and Entrepreneurship*. V. 1, n. 1.

Furthermore, I had the great opportunity of spending 3 months at the Manchester Institute of Innovation Research (University of Manchester) under the supervision of Prof. Jakob Edler and supported by a grant from the EU-SPRI Forum. The goal was to further develop this piece of research and I believe this was succesfully achieved – while I also was exposed to one of the most challenging and exciting environments of the academic world when it comes to innovation economics and policy. I would also like to acknowledge valuable contributions from Professors Phillip Shapira and Paul Cunningham.

Lastly, I would like to thank Professor José Molero for his outstanding guidance throughout my doctoral studies, as well as reviews provided by Professors Vitor Corado Simões (ISEG, Lisbon), Manuel García Goñi (Universidad Complutense de Madrid, Spain) and John Rigby (MIoIR, Manchester) which contributed substantially to the quality of this work. The usual disclaimers apply.

[1] During this period (January 2010-December 2011) I was working as a research assistant for the Research Group on Economics and Innovation Policy (www.grinei.es) at the Instituto Complutense de Estudios Internacionales.

ABSTRACT

Innovation is increasingly becoming an internationalized process. A strategy that has recently been playing a central role in this regard is that of R&D collaboration. In the case of firms this is mainly driven by the search of more efficient operations, reduced costs and risks of innovative activities, as well as access to pools of knowledge available outside the traditional organizational boundaries. However, relationships among firms increase complexity of managerial processes, thus evidencing the need for closer coordination between agents, which is expected to be even more complex when these connections happen between companies from different nations, provided that there are additional transaction costs involved, e.g., language, institutional settings, etc. In the European context, efforts have been made towards organizing an integrated Innovation System across the continent, favoring international linkages within the European Union. This situation poses a need for specialized research to focus on the improvement of such initiatives to strengthen the bloc's competitiveness. Moreover, we stress the case of the Spanish Innovation System, one of the largest economies of the European Union with an Innovation System that occupies a relatively laggard position in the EU. The approach undertaken in this dissertation focuses on determining the influential aspects of firms' results, which are expected to lie on three fundamental dimensions: *Microeconomic, Contextual* (project-specific), and *Macroeconomic*. Furthermore, behavioral patterns regarding firms' outcomes are assessed, aiming at providing policymakers with workable information for programs' evaluation and improvement. To cope with these goals we develop logistic regressions to identify determinants of success in terms of: a) technological outcomes; b) market achievements; and c) future expected accomplishments. Data is gathered from Eureka's Final Reports (2000-2005 and 2006-2008) from Spain (research focus), Italy, France, United Kingdom, and Germany (benchmark countries). Results highlight the core importance of the *Contextual Dimension*, whereas the National Innovation System to which a given firm belongs has marginal relevance (*Macroeconomic Dimension*), and firms' characteristics (*Microeconomic Dimension*) do not seem to be related to projects' achievements. This puts special emphasis on the fundamental role played by network coordination. The lack of significance of the *Microeconomic Dimension* as a determinant of achievements poses some implications for the use of *quasi-experimental* methodologies in assessing the effectiveness of innovation policies. Behavioral patterns were identified through log-likelihood clusters. Results confirm trends suggested by Fischer and Molero (2012), where firms fall under three categories: *Inventors, Consistent Innovators*, and *Risky Innovators*. Implications for the specific case of Spain are offered, where international R&D cooperation seems to be a fundamental strategy for sustainable development of firms located in this particular country.

Keywords: *International R&D Cooperation; Eureka Programme; Spain; Innovation Policy; Spanish Innovation System.*

RESUMEN

La innovación presenta características crecientemente internacionales. Una estrategia de fundamental importancia en este escenario es la cooperación internacional en I+D. Para las empresas, esta estrategia representa la oportunidad de alcanzar niveles más altos de eficiencia, reducción de costes y riesgos en actividades innovadoras, además de acceso a conocimientos existentes fuera de la estructura tradicional de las firmas. Sin embargo, las relaciones entre agentes de distintos países añaden complejidad a los procesos gerenciales, lo que pone de manifiesto la necesidad de mejores estructuras de coordinación entre las empresas debido a la presencia de costes de transacción adicionales (idioma, contexto institucional, etc.). En el contexto europeo, esfuerzos son dirigidos a la organización de un Sistema de Innovación integrado en el continente, favoreciendo relaciones internacionales entre miembros de la Unión Europea. Esta situación plantea la necesidad de investigaciones continuadas de las iniciativas existentes con el objetivo de mejorar la capacidad competitiva del bloque. Asimismo, nuestro enfoque dedica especial atención al caso del Sistema Nacional de Innovación español, uno de los más grandes en términos económicos en Europa, pero en una condición rezagada en la UE. La propuesta se define en identificar los factores determinantes de los logros empresariales basados en tres dimensiones: *Microeconómica*, *Contextual* y *Macroeconómica*. Además, hemos creado un abordaje para determinar patrones de conducta de las empresas de acuerdo con sus resultados, proponiendo una estructura de análisis para la evaluación de políticas de innovación. La estrategia metodológica para abordar estos temas está basada en la construcción de modelos regresivos logísticos, buscando verificar los determinantes de éxito en términos tecnológicos y mercadológicos (obtenidos y esperados). Datos para los análisis provienen de los cuestionarios de fin de proyecto del Programa Eureka (2000-2005 y 2006-2008) para España (enfoque principal), Italia, Francia, Reino Unido y Alemania (efectos de comparación). Los resultados indican la importancia fundamental de la *Dimensión Contextual*. El Sistema Nacional de Innovación tiene una relevancia marginal (*Dimensión Macroeconómica*), y las características de las empresas no parecen tener influencia en los resultados de los proyectos de cooperación internacional en I+D. Estos resultados ponen énfasis en los aspectos de coordinación de las redes internacionales de innovación considerando sus impactos sobre los resultados alcanzados. La falta de significación estadística de las variables de la *Dimensión Microeconómica* como un determinante de los logros empresariales tiene implicaciones para el uso de metodologías *cuasi-experimentales* en la evaluación de efectividad de políticas de innovación. Algunos patrones de rendimiento fueron identificados a través de conglomerados agrupados por log-verosimilitud (*log likelihood clusters*). Los resultados confirman los patrones sugeridos por Fischer y Molero (2012): *Inventors, Consistent Innovators* y *Risky Innovators*. Son presentadas implicaciones para el caso español, donde la cooperación internacional en I+D aparece como una estrategia fundamental para un desarrollo sostenido de las empresas que hacen parte del Sistema Nacional de Innovación de España.

Palabras clave: *Cooperación Internacional en I+D; Programa Eureka; España; Políticas de Innovación; Sistema Nacional de Innovación Español.*

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1. Introduction

Innovation is a central feature of the process of economic growth and development (Metcalfe, 1995). Therefore, related policies are a matter of great concern worldwide where the science-technology-innovation system is continuously and rapidly evolving and integrates a context in which business competition is increasingly based on its terms (Freeman & Soete, 2009).

In the European Union this situation is not different. The process of integration leads to incentives for agents to further invest in innovation, since an increase in incentives regarding relative market size arises (Weil, 2006). However, much has been said about the “European Paradox”, i.e., the difference between scientific capabilities and actual innovation performance in the continent (Georghiou, 2001). Several measures took place in order to modify this scenario. Europe needs to be more innovative in order to achieve a higher level of competitiveness – which requires a change in the valuation of innovative activities and a better framework for innovation to develop (European Commission, 2006).

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 on what “good” science, technology and innovation (STI) policy should look like and which instruments should be used (Laranja, Uyarra & Flanagan, 2007; García, 2010). We can attribute this point of view to the fact that innovation involves systemic interactions between agents and the environment in which they are embedded (Smith, 2000). This gives an idea of the difficulty involved not only in formulating innovation policies, but also in evaluating their impact, and that is why a proper management of innovation is a challenge for many countries, including developed ones (Aghion & Tirole, 1994).

On the other hand, innovation policy in recent years has increasingly paid attention to innovation systems and the underlying linkages between economic agents (Guy, 2009). The idea is to reinforce and foster the existing connections between firms and institutions, thus creating a context in which single firms' projects still have importance in terms of RTD policy, but not as much as network-oriented initiatives. Also, National Innovation Systems have a less "national" orientation than they did a couple of decades ago (Carlsson, 2003), giving room to the discussion of transnational integration of companies' strategies and innovation policies.

Embedded in this situation is the existence not only of firms' strategies to cooperate in R&D, but also its international trend 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, as well as an effective way of transferring knowledge to catching-up regions (Archibugi & Iammarino, 1999; Suurna & Katel, 2010; Coe & Helpman, 1995; Fernández-Ribas & Shapira, 2009; Dyer & Powell, 2002). 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).

Hence, there is a need in Europe to create international networks of collaboration in R&D that work as easily as networks within national borders, which would generate a genuinely unified European Research Area (ERA), creating a critical mass for a stronger global competitiveness of European agents (European Commission, 2010a). Therefore, integrating the existing policies aiming at promoting international R&D collaboration in Europe is a main aspect in this regard (European Commission, 2008). Nonetheless, the bloc still lacks responsiveness in terms of policymaking regarding the challenges and opportunities of an international and integrated framework for research activities (Edler, 2007a; Grutzman, Halme & Reiner, 2009), which is largely based on the Framework Programme and the Eureka Initiative (Georghiou, 1999a), among other more recent initiatives.

Given this context, the scope of this dissertation lies in analyzing the outcomes – or at least the *verifiable* outcomes[2] - from market oriented R&D cooperation in the international arena comprising data from the European Union. This is justified by the current quest for deeper integration between EU's agents (firms, research institutes, universities, etc.) and the systemic consequences of closer R&D cooperation at the international level.

Hence, our goal is ***to assess firm level data in order to identify determinants of performance (technological and commercial) for companies participating in international R&D cooperation initiatives in Europe***. We are trying to look into the development of processes and their respective outcomes instead of resorting to quasi-experimental techniques that evaluate if a given action provided better results than the absence of such initiative. Additionally, we use the gathered information on such outcomes to ***explore firms' patterns and, thus, suggest a workable taxonomy of companies engaged in international R&D cooperation.***

The foundation of such assessment lies on the author's uneasiness with the relative lack of literature focusing on differential impacts of innovation policies on

[2] Issues regarding of time-lags and systemic results of RTD policies are further discussed in the Methodological Discussion section.

companies. While there are extensive studies of policies' effectiveness based on counterfactual methods as well as on impacts on companies' innovative and/or economic performance, we find a gap in terms how these policies affect different companies in heterogeneous ways. What we want to know is ***how companies benefit (or not) from participation in international R&D cooperation activities according to their characteristics, their experience in the venture, and their macroeconomic context***, i.e., what are the main drivers of success of firms engaging in such activities.

Our expectation is to build upon these findings a useful methodology to classify firms participating in international R&D cooperation projects and to extract information regarding patterns of technological and innovative behavior according to companies' outcomes resulting from their participation in a given project. Such analysis should provide policymakers with relevant managerial information regarding processes of international R&D collaboration between agents, as well as a suitable tool for innovation programs' monitoring, not to mention the direct impacts for R&D managers.

Data was gathered from Eureka projects divided in two time-sets: 2000-2005 and 2006-2008[3], thus allowing an assessment of the stability of trends over time (even though data availability does not allow an actual time-series approach). As already presented, Eureka plays a central role in the integration process within the EU in terms of R&D cooperation, also acting as a strategic element of the European Research Area because of its market-oriented approach and its links with the business environment (Eureka, 2003). In addition, Eureka gathers a substantial amount of data from participating companies, offering the possibility of drawing a clearer picture of microeconomic phenomena related to international cooperation in R&D. We must also keep in mind that such data deals with a

[3] This particular timeframe permits the evaluation of results without the direct interference of 2008 crisis' effects, which can potentially distort results when verifying the characteristics of the international R&D cooperation phenomenon *per se*. Archibugi, Filippetti and Frenz (2012), for example, mention the reduced willingness of firms to invest in innovation during periods of uncertain expectations.

fragmented vision of a given nation's tendencies and possibilities. Nonetheless, Eureka's data can be useful in examining the aspects under scrutiny in this research.

Furthermore, we chose data from projects in which Spanish companies participated as the core of the analysis undertaken. This is justified by the interesting position of this country in terms of innovation and international R&D collaboration within the Eureka framework: while Spain occupies a laggard position in comparison to other EU Member States in terms of innovation, it also engages relevantly in international R&D networks, especially in Eureka. Given its situation, Spain might gather substantial benefits from interaction with more advanced nations. We also justify the selection of Spain based on the few empirical works focused on analyzing cooperative R&D in the Spanish context (Bayona, García-Marco & Huerta, 2001)[4].

To cope with this approach we have used a relevant object of analysis considering the central goal of this research: a database of projects' Final Reports from Eureka activities. This allows the achievement of an approximation of companies' *ex ante* and *ex post* profiles when joining such an initiative[5], 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). Determinants of commercial and technological success for these companies were assessed primarily via *binary logistic regressions*. A second stage of the methodological rationale includes a classification according to firms' outcomes, thus further exploring the validity of the abovementioned determinants. For this, we developed log-likelihood cluster structures. These results are compared to those of a set of European countries (*benchmark countries*): Germany, France, United Kingdom and Italy. This will

[4] Even though this picture has changed since 2001, there is still a lack of studies of Spain's cooperation in R&D, especially in the international context.
[5] For this we used clustering algorithms.

provide a framework of comparison for consistencies and inconsistencies across samples, thus allowing a robustness check of this research.

After the introductory aspects, we move to a theoretical and empirical overview of the R&D cooperation process, putting emphasis on the international scope (chapter 2). This chapter involves a thorough conceptual examination of several features regarding the environment of R&D collaboration, main factors determining firms' propensity to cooperate and reported outcomes from R&D collaboration. Chapter 3 brings literature regarding innovation policy evaluation, providing special attention to European Union's case. Given its characteristics of integration, it contains a certain number of specificities that should be taken into account for this research. Furthermore, since data used for this assessment was gathered from Eureka, the empirical outcomes of this study also point in the direction of policy evaluation, i.e., as a contribution for policymaking processes aiming at fostering international R&D cooperation.

Chapter 4 outlines the main features of the Eureka Initiative, as well as a compilation of previously reported evaluations on its impacts and characteristics. Chapter 5 makes a brief description of the Spanish Innovation System, approximating its situation through selected indicators. An introductory comparison to the Innovation Systems of the *benchmark* countries is also presented. Chapter 6 sums up the findings from previous chapters and their implications, thus developing a set of hypotheses to be empirically tested. Chapter 7 depicts the methodological approach and underlying rationale, including operational aspects regarding data and analytical tools. This chapter also debates the methodological reasoning and contributions of this research, as well as its inherent limitations.

In chapter 8, empirical results are presented and discussed in detail. Initially, samples' profiles are observed through descriptive statistics. Estimations of logistic regressions, as well as complementary statistics, are developed following the structure proposed in the methodological section (chapter 7). Results are compared with the expected results as outlined in the hypotheses. Finally, cluster classification procedures are applied, offering additional insights on the process of international R&D cooperation evaluation and on the determinants of firms' outcomes in these alliances. Main outcomes and implications are further explored in chapter 9 (*Policy and Managerial Implications*), aiming at summarizing the impacts and relevance of the research. Chapter 10 concludes with some final remarks.

1.1 Research question and goals

In this section we outline the core propositions of this research: its driving question, the main goal to be achieved and the operational goals involved.

Research question

- *What factors determine firms' performance as a result of their participation in international R&D cooperation projects?*[6]

Main Goal

- To identify drivers of innovative performance for companies participating in international R&D cooperation projects, and develop a workable segmentation of such firms based on the outcomes of their participation in international R&D cooperation.

[6] This implies that the assessments contained in this research concerns a microeconomic perspective.

Operational goals

a) Build a database with relevant and workable data for the case of international R&D cooperation focusing on the relative situation of Spanish firms;
b) Identify patterns – and variations – of performance according to theoretically and empirically relevant variables;
c) Identify associations between variables in order to further explore behavioral patterns;
d) Categorize firms according to their performance in projects.
e) Empirically test the proposed hypotheses.

1.2 Justification and Relevance

The focus of this research lies in the field of international R&D cooperation. Increasingly, companies have been relying on external sources in order to achieve higher degrees of innovative performance. Resorting to knowledge located abroad can be seen as an extension of such collaborations (with several additional aspects influencing the processes involved). In literature, we find a large body of knowledge related to such activities, as well as pertinent policy evaluations.

As this trend further unfolds – especially in developed nations and regions, such as the EU – governments perceive it as an effective way to promote innovation within and across borders, even though results for firms may differ according to the approach undertaken, the nature of agents involved, etc. Provided this brief context, policymakers have been trying to create *behavioral change* in firms in terms of cooperating more in R&D and other innovation related activities. Following this perspective, evaluations have been trying to assess if these initiatives are effective or not.

However, there is a gap in the assessment of these firms' behavior throughout the process of international R&D cooperation. Knowing if the participation in an international consortium had a positive impact or not, and if these impacts were in fact related to the collaboration that took place, are important aspects of economic dynamics, but it is a narrow view of the whole phenomenon. Given the methodological tools available, providing more in-depth knowledge in alternative perspectives can be a very beneficial exercise for managerial and policymaking processes.

Thus, by focusing our analysis on workable indicators - at the firm level - that allow the construction of company's profiles regarding their inherent characteristics, their experience as part of a R&D consortium, as well as their perceived outputs, we believe that we can provide a deeper understanding of firms' engagement in international R&D networks. A throughput of this contribution lies in setting a practical framework of analysis that can be replicated elsewhere.

In this regard, following the main goal of our research, identifying determinants of innovative performance considering both *ex ante* and *ex post* aspects and categorizing these firms can be seen as an effective way to reformulate existing initiatives that promote international R&D cooperation, driving it towards an orientation based on segments and their evolution over time. The usefulness of this methodology relies on the consistency of groups, as well as on the theoretical background upon which our assumptions are based upon.

2. Notes on International R&D Cooperation

All indicators, such as co-publications, co-inventions, and joint research projects (through networks, alliances and other forms of international cooperation) point in the direction of an increasing relevance of international collaboration in science and technology, followed by a significant increase and broadening of international and transnational policy initiative and instruments to foster and shape international S&T collaboration (Edler, 2010; Edler, 2008; Edler, 2007a; Edler & Polt, 2008; Carlsson, 2003; Kuhlman & Edler, 2003; Archibugi & Iammarino, 1999). In the case of firms, this is mainly driven by the search of more efficient operations (López, 2008; De Prato & Nepelski, 2012), but these linkages also extend to relationships between firms and universities and/or research institutes (Hall *et al*, 2000).

In the case of organizational cooperation with international partners, strategic partnerships in R&D represent also a subject of increasing interest for companies, researchers and policymakers (Hagedoorn & Schakenraad, 1994; Edler & Polt, 2008; Bayona, García-Marco & Huerta, 2001). Along with this trend, national governments increasingly perceive international research collaboration as a positive and desirable phenomenon (Jonkers & Castro, 2010; Quintas & Guy, 1995).

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 decades, higher uncertainty surrounding R&D, increasing costs of R&D projects, stronger competition and shortened innovation cycles. Hence, collaboration is understood as an effective strategy to deal with an environment composed by 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; Pellegrin *et al*, 2010; Motta, 1992)[7].

This increased interest in technological cooperation analysis is followed by a higher level of complexity involved in studying it, including technical and economic idiosyncrasies that make R&D networks of difficult comparability (Barajas & Huergo, 2006; Archibugi & Iammarino, 2002). To cope with this, R&D cooperation has usually been assessed via two main theoretical perspectives: the Industrial Organization approach which is concerned with the dynamics of collaboration regarding R&D investment and spillovers (incoming and outgoing; also using Game Theory settings); and the Management literature which focuses on the interaction between firms (transaction costs and Resource-Based View of the firm) (Belderbos, 2004; Veugelers, 1998).

This situation leads to a situation in which many companies cannot handle the shortened innovation cycles and complexity of new technologies individually (Saxenian, 1991). This promotes a business sector which has been involved in global strategic technological alliances with firms maintaining distinct ownership structures, but agreeing to exchange and/or generate information and knowledge (Archibugi & Iammarino, 1999). Consequently, firms must take into account the opportunities offered by other agents within/between innovation systems and must develop their abilities to absorb this existing knowledge in order to access these "available" resources and stocks of knowledge (Edler, 2007a; European Commission, 2008).

These inter-firm relationships often occur in a quasi-cooperative manner (Smith, 2000), which should be attributed to current innovative practices that require a bigger role of specialization and, thus, collaboration between agents (Molero, 2010). Consistent with this view, R&D cooperation between rival firms

[7] A practical implication of this context is that cooperative settings are likely to produce more radical levels of innovative products and processes, whereas "new to the firm" innovations remain under the concept of internal development (Tether, 2002).

from different countries has become an increasingly common phenomenon (Song & Vannetelbosch, 2007; Petit & Tolwinski, 1999). This situation supports the hypothesis that, even in competitive environments, firms find it helpful to cooperate with rivals in certain aspects.

Efforts towards stronger R&D cooperation are especially relevant in OECD countries, where the growing number of R&D strategic alliances stands for a new organization in industrial technological structure where focus lies on network promotion policies instead of direct financial assistance policies (De Jong & Freel, 2010). Cooperative R&D policies gain more importance when one considers that the extent to which a country's businesses, institutions and industries are linked with resources and capabilities located abroad is likely to positively impact the innovation performance of that country (European Commission, 2010; Filippeti, Frenz & Ietto-Gillies, 2009) creating local externalities from global relationships. In order to cope with these dynamics and underlying challenges of modern innovation systems, cooperation for innovation became a main issue in RTD policymaking (European Commission, 2002), even though it should be mentioned that it was not until recently that policymakers started paying attention to the internationalization of R&D activities (Edler & Flanagan, 2011).

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, working as a fundamental tool to achieve a more competitive dynamic in the bloc (Georghiou, 2001; Álvarez, 2004). One of the pillars of the ERA lies on the Framework Programme, which has enhanced EU's quality and quantity of international R&D collaboration agreements across the continent (European Commission, 2008). Additionally, we can mention Eureka/Eurostars, the ERA-NETs and the Joint Technological Initiatives as highly relevant policies tackling the goal of fostering closer interactions between agents within the Union in the process of technological change.

Complementing this regional perspective of international R&D collaboration, it cannot go unnoticed that innovative regions tend to cluster together in a situation of spatial dependence which has increased over time, influenced also by the availability of human capital and R&D expenditure (Freeman & Soete, 2009). Therefore we can expect an impact on the need of peripheral regions to adopt open innovation strategies and use R&D collaboration in order to have access to the pool of knowledge available at more developed regions. This underlying idea of geographical integration in R&D – such as the European Research Area – provides a framework for increased specialization, provided there are no barriers for the exchange of knowledge (European Commission, 2009).

2.1 Conceptual Aspects

The underlying challenge of R&D networking is related to the systemic aspects of innovation (Imai & Baba, 1989) and by the process of globalization itself, that 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). Cooperative R&D consists of an arrangement among firms (two or more) aiming at pursuing common objectives, sharing costs and results of an R&D project and can be achieved through R&D contracts, consortia, Research Joint Ventures, licensing contracts or other forms of interaction, including informal ones (Sakakibara, 1997; Archibugi & Iammarino, 1999; 2002; Huggins, 2001; Imai & Baba, 1989).

The kind of cooperative agreement in which firms engage is largely determined by technological characteristics and sectors of industry, as well transaction costs and information asymmetry between agents (Hagedoorn & Narula, 1996; Zander, 1999; Silipo, 2008; Oxley, 1997; 1999). For example, in industries with a rapid rate of technological change, the dynamics favor "softer" forms of collaboration instead of "harder" ones[8], where the former can be understood as informal agreements (such as a "memorandum of understanding", as Goyal & Moraga-González, 2001 exemplify), while the latter refers to contractual relationships with strong equity ties, e.g., Research Joint Ventures (Fernández-Ribas & Shapira, 2009; Pyka, 2000; Goyal & Moraga-González, 2001).

But why do these cooperative agreements take place in an environment of tough competition, being the internalization of knowledge an alleged form of competitive advantage? This can be explained by the fact that firms might be extremely competent in one specific area, but this competence has limits and these firms will frequently find technological problems that are outside the range of their existing capabilities, thus providing them with benefits they believe will be larger than if the company would act on its own (Smith, 2000; Silipo, 2008).

This brings to light the fact that individual firms are usually dependent on external sources of knowledge in order to develop innovations, leading to a growing importance of R&D cooperation between agents (Dyer & Powell, 2002). As a result, there is a maximization of the added value of a firm through the combination of complementary resources and knowledge between partners (Das & Teng, 2000; Hagedoorn *et al*, 2000; Sakakibara, 1997a; Roller, Tombak & Siebert, 1997; Srholec, 2011a; Siebert, 1996; Mowery, 1989; Motta, 1992; Czarnitzki and Hottenrott, 2012). This is especially relevant for SMEs, since they are less likely than large firms to have inside its facilities all of the tangible and intangible assets required for R&D projects, making them more dependent on external sources of knowledge (Teece, 1986).

[8] Kreiner and Schultz (1993), based on a sample of biotech firms in Denmark, identify that R&D collaboration often happens through informal and personalized networks of individuals. That is an interesting perspective on what "Marshallian" industrial districts represented, even though decreasing costs of communications (as a result of efficient IT platforms) reduce the importance of geographical distances in these relationships. On the other hand, for as dynamic as these informal collaborations can be, they imply a significant amount of risks in sharing valuable knowledge without properly establishing managerial boundaries. We will address these issues in section 2.3.4 Knowledge Spillovers, Transaction Costs and IPR.

Another potential feature of R&D cooperation is that of internal "reviewing" of results before they reach markets. Rigby and Edler (2005) find that in academic research, intra-network peer review leads to less variability in research outcomes. If we think of R&D performing networks, the process of interaction between agents can resemble what peer review does in basic science, thus one can expect a similar trend for the case of R&D collaboration, leading to less variability in innovative outcomes[9]. Such perspective is empirically supported by Hottenrot and Lopes-Bento (2012).

Other explanatory aspects relate to rising scientific complexity and development costs, with (international) R&D collaboration providing firms with reductions on projects' risks and expenditures, and also helping them to develop more business opportunities domestically and abroad (Álvarez, 2004; Grutzman, Halme & Reiner, 2009; Archibugi & Michie, 1997; Roller, Tombak & Siebert, 1997; Goyal & Moraga-González, 2001; Zu et al, 2011). Veugelers (1998) summarizes this by pointing out that R&D cooperation allows access to new markets, absorption of new skills and technologies, achievement of scale economies and sharing costs and risks of innovation projects. Roller, Tombak and Siebert (1997), Silipo (2008), and Katz (1986) also put emphasis on the importance of spillovers' internalization as a core driver of collaboration in R&D, where D'Aspremont and Jacquemin (1988) propose that (precompetitive) R&D cooperation results in higher levels of overall R&D efforts, output and welfare, provided that spillovers are above a certain threshold.

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 others (since they are all deeply specialized) or do not even have the capacity to do so.

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[9] Such appreciation of Rigby and Edler's (2005) work was discussed in detail with Prof. John Rigby, where the analogy presented herewith was consented by the author.

R&D cooperation practices have a twofold impact in this dimension. 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). 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 (Katz, 1986). Hence, promoting companies' technological skills through collaboration and providing them with higher levels of absorptive capacity should be the focus of technological policies (Molero, 2001; Luukkonen, 1998; Silipo, 2008).

Nonetheless, special emphasis must be put on the micro-level of analysis. R&D collaboration poses serious complexity issues when putting together agents of different sizes, types and competences (Georghiou, 1999a), thus requiring intense coordination and information flows for firms engaging in R&D cooperation (Teece, 1986). This means that the way in which a network or partnership develops can be highly associated with the quality of outcomes, as well as with the duration of the linkage. We can regard this aspect as an intuitive argument, since the status of a given cooperative R&D project's functioning will at least partially determine firms' willingness to *actually* cooperate with each other.

We can add to this viewpoint another factor influencing these processes and which represents opportunities, as well as additional complexity, to the analysis: 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 (Archibugi & Michie, 1997), 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. Moreover, firms cooperate with international partners aiming at assessing this knowledge available elsewhere, which results from the lack of certain capabilities in a given region/country, as well as an underdeveloped innovation system (Fernández-Ribas & Shapira, 2009; Bottazzi & Peri, 2007). In a similar vein, Mitsos et al (2012), use the case of the European Research Area to propose that further integration between domestic economies leads to higher degrees of specialization, thus demanding stronger collaboration between agents in order to tackle the existing challenges in innovation dynamics. Nonetheless, they point out that a core-periphery structure may arise if such hypothesis holds.

But it is important to highlight that for firms, the decision between domestic *or* international R&D cooperation is often a fallacy. Firms that develop this kind of behavior tend to establish partnerships at both national and international levels (Srholec, 2011a). Nonetheless, diffusion of knowledge in an international context occurs less perfectly than within national borders (Bottazzi & Peri, 2007). We can relate this latter aspect to many variables, including language, geographical distance, cultural background, legislation, etc.

Also, policymakers that envisage international collaboration in R&D as a desirable phenomenon must put into perspective how to assess the specific policies in terms of the existing "barriers" related to it. For example, the main factors hindering international R&D partnerships are related to market and coordination aspects of the relationship between agents (Fernández-Ribas & Shapira, 2009). These issues were previously stated for cooperation in general, but at the international level one must expect a higher level of difficulty involved in the management of such joint projects, since additional transaction costs arise.

Governmental policies aiming at promoting global R&D collaboration for firms within a national territory should focus on upgrading the national STI competences, since higher levels of technical and scientific potential are likely to turn a given National Innovation System into a more attractive partner (Archibugi & Iammarino, 1999). Fostering country-level collaboration can enhance the capacity and attractiveness of companies within a nation by both "training" them to cooperate and turning them into more competitive and knowledgeable agents. 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 why would R&D cooperation be desirable for economic policy? As a first explanation we find that firms that engage in R&D cooperation often spend more on internal R&D (Veugeleres, 1997; Sakakibara, 1997a). This situation poses a virtuous circle, in which a company – by investing in R&D – becomes more attractive for potential partners and also absorbs more knowledge, thus becoming even more attractive for collaborative projects and so on.

Nonetheless, for many sectors, cooperation regarding innovation may be too dangerous for companies' appropriability strategies. Sharing valuable information with competitors or "potential competitors" might be too big of a threat for some firms. In a collaborative R&D project there is the risk of the partner imitating the innovator's technology and competing with him (Teece, 1986), which would represent a case of *free riding*. The same can hold true for the case of entire regions or countries, taking advantage from knowledge generated elsewhere (Rodríguez-Pose, 2001). This is due to the fact that R&D collaboration implies a certain level of potential opportunism because of asymmetric information which might lead to insufficient investments from the parts involved (Socorro, 2007; Rodríguez-Pose, 2001).

When collaborating in R&D, firms may not be able to monitor the level of R&D effort undertaken by its partner(s), thus creating a *moral hazard problem* (Silipo, 2008). This whole situation highlights the importance of project functioning in a collaborative setting. But even if properly managed, R&D cooperation carries with it a wide array of *transaction costs* involving *information asymmetry, opportunistic behavior and moral hazard* (Veugelers, 1998). Nevertheless, there is a perspective that firms should be focused on accessing new technologies that might be crucial for upcoming generations of products and processes *in spite of* the risks associated in sharing valuable knowledge (Larédo, 1998). This view might be of governmental or policymaking interest, but will probably find scarce supporting evidence on micro-level data: the potential costs and benefits are still likely to be core drivers of cooperation between agents. Notwithstanding these risks, firms see R&D cooperation with rivals, suppliers and customers as more relevant than cooperation with universities and research institutions (De Backer, López-Bassols & Martinez, 2008).

But not all R&D collaborations can be considered socially desirable at both national and international levels. Policies aiming at fostering the creation of interfirm networks do so because there is a belief that these activities might enhance economic productivity, particularly through the generation of technological spillovers (Petit & Tolwinski, 1999). However, firms have their own agenda when cooperating and sometimes these objectives might be considered perverse for the economic system. Governmental agencies must consider the possibility of cooperation between firms leading to collusive outcomes – which is especially relevant for cooperation between rivals (Tao & Wu, 1997; Silipo, 2008; Grutzman, Halme & Reiner, 2009).

Regarding the structure of networks, cooperation may happen in different stages of R&D. Some projects are related to basic R&D, others to pre-competitive activities and, lastly, close-to-market cooperation (the one which poses the biggest risks for companies, and also for society, given the possibility of collusion amongst agents)[10]. Greenlee and Cassiman (1999) suggest that a case-by-case analysis of

[10] Collusive outcomes are often found in market-driven networks (D'Aspremont & Jacquemin, 1988; Hennart, 1988), such as the case of Eureka's individual projects (which represent the sample of analysis in this research). Kamien, Muller and Zang (1992) identify reduced levels of technological improvements in such collusive structures.

R&D Joint Ventures is the only feasible way of attaining efficient (and socially desirable) levels of R&D cooperation, thus avoiding the generation of such market collusions.

But we must remind that 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). Nonetheless, depending on the market impacts, R&D networks might change aspects in different levels of the production chain, i.e., even though it covers only part of the value-adding process, it might also *alter* this same process.

In tables 1 and 2 we illustrate the main findings of these introductory sections by offering a summary that highlights the main aspects, theoretical features and the most relevant authors cited so far.

2.2 The Open Innovation and Absorptive Capacity Perspectives

As a theoretical complement to the analysis being developed, it is interesting to assess some related concepts to those of R&D cooperation. As previously stated, innovation and R&D in firms are processes facing an increasing level of *openness*, where knowledge and ideas are often sourced outside the organizational boundaries (Grutzman, Halme & Reiner, 2009)[11]. On the other hand, agents must be able to *absorb* knowledge generated elsewhere in order to benefit from these relationships, thus *openness* must be followed by an *absorptive capacity* so the former can increase productivity more efficiently (Veugelers, 1997; Belderbos *et al*, 2004; Parisi, Schiantarelli & Sembenelli, 2006; Caloghirou, Hondroyiannis and Vonortas, 2003). Edler, (2008) even concludes that costs and benefits from internationalization of R&D lie on firms' absorptive capacities.

[11] Open innovation has been boosted by increasing levels of virtual communication (cloud, mobile and collaborative computing) (European Commission, 2010a).

Aspect	Main Theoretical Findings	Main sources
Broad Definition	Firms (tw o or more) pursuing together common or complementary R&D objectives, sharing costs and result	*Sakakibara, 1997; Archibugi & Iammarino, 1999; 2002; Huggins, 2001; Imai & Baba, 1989*
Main Theoretical Approaches	- Industrial Organization approach - Game theory - Management Approach	*Belderbos, 2004; Veugelers, 1998*
Main Modes	- R&D contracts - Consortia - Research Joint Ventures (RJVs) - Licensing contracts	*Hagedoorn & Narula, 1996; Zander, 1999; Silipo, 2008; Fernández-Ribas & Shapira, 2009; Sakakibara, 1997; Archibugi & Iammarino, 1999; 2002; Huggins, 2001; Imai & Baba, 1989*
Motives	- Limited competence of individual agents - Rising scientific complexity of projects - Risk sharing - Cost sharing - Internalization of technological spillovers	*Smith, 2000; Silipo, 2008; Dyer & Powell, 2002; Das & Teng, 2000; Hagedoorn et al, 2000; Sakakibara, 1997a; Roller, Tombak & Siebert, 1997; Srholec, 2011a; Siebert, 1996; Mowery, 1989; Teece, 1986; Álvarez, 2004; Grutzman, Halme & Reiner, 2009; Archibugi & Michie, 1997; Roller, Tombak & Siebert, 1997; Katz, 1986; Veugelers, 1998*
International scope	- Increased complexity for management and transfer of results - Different political, economic and social background - Integration of National Innovation Systems - Access to foreign capabilities	*Archibugi & Michie, 1997; Narula & Santangelo, 2009; Fernández-Ribas & Shapira, 2009; Bottazzi & Peri, 2007; Srholec, 2011a; Archibugi & Iammarino, 1999*

Table 1. Summary of findings on R&D cooperation between firms (concepts)

Aspect	Main Theoretical Findings	Main sources
Risks for Firms	- Free riders - Moral hazard - Opportunism - Information asymmetry	*Teece, 1986; Socorro, 2007; Rodríguez-Pose, 2001; Silipo, 2008; Veugelers, 1998*
Risk for Society	- Collusions	*Tao & Wu, 1997; Silipo, 2008*
European Scenario	- European Research Area - ERA - Framework Programmes - Eureka/Eurostars - Joint Technological Initiatives	*Georghiou, 2001; Álvarez, 2004; ETAN, 1998; Foray & Lhuillery, 2010; Aguiar & Gagnepain, 2011*
Justifications for Policy Action	- Flexibility - Avoids wasteful duplication of R&D efforts - Productivity - Competitiveness - Absorptive capacity	*Barañano, 1995; Molero, 2001; Luukkonen, 1998; Silipo, 2008; Veugeleres, 1997; Sakakibara, 1997a; Petit & Tolwinski, 1999*

Table 2. (cont.) Summary of findings on R&D cooperation between firms (concepts)

The concept of absorptive capacity was initially developed by Cohen and Levinthal (1989; 1990), where they assessed firms' abilities to exploit external knowledge as a core feature of their innovative potential. The authors build upon criticisms to the idea of costless transmission that underlies assumptions behind the exploitation of publicly available technology, since the absorption of such knowledge would have to rely on existing capacities of internalizing it to the intramural environment of the firm, thus representing substantial costs in the long run.

This so-called absorptive capacity, they argue, is a function of prior knowledge existing within the firm, where learning skills are increased as a function of information that has been previously learned, thus developing the fundamental characteristic of absorptive capacity: it is a self-reinforcing process, given that learning is cumulative (therefore, it is highly path dependent). In the organizational context, this would involve not only individuals' competences, but firms' experience in managing knowledge flows with the external environment and within its own boundaries.

In this context, R&D investment serves two purposes: to generate new knowledge and to provide firms with a higher capacity of absorbing knowledge generated outside the organization (Cohen & Levinthal, 1990; 1989). We can thus relate the concepts of R&D investment and absorptive capacity to the presence of firms in innovation-driven networks. In order to fully cooperate with partners, i.e., to take full advantage of a network, agents must be capable of properly interacting with each other (basically because of knowledge transfers and technological spillovers), which requires a body of knowledge that is above a certain threshold (which depends on the technological dynamics of industries). Furthermore, such R&D investment will provide companies not only with the desired levels of absorptive capacity, but also make them more attractive partners in these inter-organizational relationships.

It is also important to notice that there is a strong emphasis in the commercial aspect of this absorption process, thus implying that the absorptive capacity concept is not primarily technique-oriented, but rather business-oriented, involving interdisciplinary bodies of knowledge that ultimately contribute to the organizational innovative potential. For example, Bogers and Lhuillery (2011) approach absorptive capacity through a multifaceted perspective, where R&D investment is only one side of it. They also consider investments in manufacturing plants and in marketing as sources of improvements in absorbing knowledge from external sources, finding that the former is especially relevant for capturing knowledge from suppliers and competitors, while the latter is key for understanding customers' knowledge.

In the assessment of the necessity of external interactions between firms, a complementary perspective to that of absorptive capacity relates to the idea of open innovation, which formalizes the importance of networking initiatives and absorptive capacity while reducing the focus on internalization of R&D activities (De Jong & Freel, 2010). Consequently, external sources of knowledge and skills play an important role in innovation and the capacity of accessing and exploring this knowledge is fundamental for companies' competitiveness (Cohen & Levinthal, 1990; Lin et al, 2012).

Chesbrough (2003) coined the concept of *open innovation* as opposed to *closed innovation.* He identified the growing number of firms engaging in collaborative projects regarding innovation related activities. This, he argues, is an important mechanism to generate inflows of knowledge, thus accelerating innovation inside the firm. Firms are more prone to share core strategic knowledge than it is generally expected (Archibugi & Iammarino, 1999), which makes open innovation a subject that has received increasing attention in the business management literature and also in the policymaking debate, building mainly upon the ideas of networking and collaboration (De Backer, López-Bassols & Martinez, 2008; Grutzman, Halme & Reiner, 2009).

An environment of "open innovation" means 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; Savitskaya, Salmi & Torkkeli, 2010). This implies that firms use R&D partnerships to access knowledge, expertise or skills and build global R&D networks, where the choice of partners is 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 context is that especially large companies are likely to capture results more easily – because of an expected higher absorptive capacity (Cohen & Levinthal, 1990) in comparison to SMEs – as well as to become less self-sufficient in their processes, being able to incur in the division of innovative activities (Pavitt, 2003; Fritsch & Lukas, 2001; López, 2008; Bayona, García-Marco & Huerta, 2001). According to economic theory (deeper specialization, steeper learning curves) this should lead to scale economies[12]. Furthermore, firms that increase their absorptive capacity and learn to exchange knowledge become active agents of innovation systems' internationalization (Carlsson, 2003), which has in international R&D cooperation one of its main vehicles.

But, as previously stated, in order to achieve higher levels of absorptive capacity – and thus achieve full benefit of open innovation strategies – firms cannot neglect internal R&D expenditures. Hence, in an environment of deeply specialized players, the firm must take an active position, instead of simply relying on knowledge generated elsewhere. We can attribute this aspect to an incapacity of properly interacting with partners in the innovative process and, also, being unattractive as a partner for R&D and innovation networks. If this proposition holds in empirical cases, it would pose a natural economic barrier for purely opportunistic

[12] 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.

behavior through free riding, since a minimal threshold of absorptive capacity would have to be achieved in order to provide companies with the capacities of developing proper innovation-driven interactions.

Chesbrough (2003) also highlights that even though the external availability of knowledge might discourage firms to invest internally in its own R&D activities, there is a high level of *complementarity* between the two (external and internal R&D) because of the capacities required to make full use of existing knowledge. In sum, an open innovation strategy does not reduce the importance of internal R&D efforts (Grutzman, Halme & Reiner, 2009) given the absorptive capacity required to engage in such initiatives. A major consequence of an increasing use of open innovation strategies and the impacts they have in economic systems shall lead to the institutional evolution required for an optimal functioning of collaborative R&D (Dreyfuss, 2011).

2.3 The Collaborative Context

In this section we explore the main determinants for firms to engage in R&D collaboration ventures/projects, as well as the contextual environment in which these interorganizational arrangements take place. Special emphasis on cooperation at the international level is given. Even though there is no agreement in literature regarding the influence of firms´ characteristics – such as firm size, R&D intensity, technological spillovers and sector of activity - on their propensity to cooperate in innovative activities (Barge-Gil, 2010; 2010a), a series of insights and patterns can be drawn from it.

Besides micro-level aspects, firms' propensity to engage in international R&D cooperation should be regarded as largely nation-specific, which is mainly a function of: a) national STI capabilities; b) perceived advantages of international cooperation; and c) foreign partners' characteristics (Fernández-Ribas & Shapira, 2009). Next we will briefly develop on these main aspects that influence firms' propensity to commit to cooperative agreements aiming at developing innovative activities.

2.3.1 Firm Size

There is a general perception (but not an agreement) that large companies are better positioned to capture benefits from R&D cooperation. But the kind of partners they search for give room to some discussion. While some authors suggest that they usually prefer networks with smaller companies in order not to expose critical knowledge to potential competitors (Sinha & Cusumano, 1991; Barnard & Chaminade, 2011; Grutzman, Halme & Reiner, 2009), others propose that large firms are not prone to establish cooperative projects with smaller firms since this action will not provide the former with greater market power, thus networks would tend to be constituted by firms of similar sizes (Roller, Tombak & Siebert, 1997).

The former assumption puts large firms as being the backbone of R&D networks, with SMEs also playing an important role as partners in these interorganizational structures, whereas the latter suggests the existence of networks of large firms and networks of SMEs co-existing “separately”. In this sense, firm size as a propensity determinant regarding international R&D collaboration remains as a blurry spot in theoretical arguments. Larger firms have a better structure to engage in international cooperation, since they have the capacity to internalize knowledge-intensive activities and the opposite is true for SMEs (Fernández-Ribas & Shapira, 2009; Rammer, Czarnitzki and Spielkamp, 2009). While large corporations have a greater capacity to engage in such cooperative settings, SMEs might have a greater *necessity* to do so. Hence, R&D collaboration can be regarded as especially relevant for SMEs, since it increases their opportunities to obtain knowledge that is not available within organizational boundaries (Rese & Baier, 2011). Consequently, SMEs are bound to benefit more than large companies in terms of knowledge spillovers (Nishimura & Okamuro, 2013), provided they have the capabilities required to *internalize* intellectual inputs.

This last comment leads to a widespread empirical perspective: there is a higher propensity of larger firms to engage in international R&D cooperation – which is mainly attributed to firms' absorptive capacity (this view is also supported by Faems *et al*, 2010; Veugelers & Cassiman, 2005; López, 2008; Anderson, 1995; Cusmano, 2001; Barge-Gil, 2010a; Silipo, 2008). But it must be kept in mind that this higher absorptive capacity will be largely dependent on a company's R&D intensity and prior innovative behavior (López, 2008; Ebersberger & Herstad, 2013). Additionally, a firm can increase its investments in R&D *through* R&D cooperation (Bayona, Corredor & Santamaría, 2006). This generates an endogenous relationship between these variables, where a firm which is intensive in R&D will achieve higher levels of absorptive capacity, thus allowing a firm to better capture results from R&D networks, increasing its absorptive capacity and so on.

Complementarily, we must mention the role played by company past behavior (Hernán, Marín & Siotis, 2003), i.e., the positive influence that networking strategies from the past have on current and future conduct. This can be attributed to successful results, encouraging further engagement in cooperative settings, but we should also point out the possibility of an endogenous relationship between variables, as already debated.

Large corporations can also benefit more from networking because of their capacity of participating simultaneously in various different networks (Anderson, 1995). But Veugelers and Cassiman (2005) emphasize a conditioning aspect for this: large firms are more prone to engage in industry-science links whenever risks of disclosing critical assets are low, thus allowing them to better capture the benefits of collaboration.

On the other hand, large companies or firms that are part of conglomerates may have additional financial resources for innovation activities and to cope with risky innovation projects – which can make them less prone to engage in R&D alliances (Belderbos *et al*, 2004; Smith, 2000). In this case the reasoning of "cost sharing" behind the motivation for establishing R&D networks would be weaker.

Nonetheless, data from innovation surveys show a trend that suggests that larger firms innovate more openly than SMEs, which is mainly attributed to the lack of resources from the latter firms to engage in these relationships, especially at the international level (De Backer, López-Bassols & Martinez, 2008; Hageedorn & Schakenraad, 1990). This highlights the importance of having enough financial and technological capacity to participate and to manage the participation in such networks (costs that will most likely rise whenever firms from different territories are involved).

This pattern reveals that governmental intervention regarding R&D cooperation should not be restricted to large firms, since SMEs may not have the same level of formal R&D investment as large firms, but they account for a large share of innovative products (Sakakibara, 1997a; Audretsch, 2003). One fruitful example in this regard is provided by the US, which has started to focus on SMEs innovative capabilities since the early eighties – via the Small Business Innovation Research Program - as a response to its loss of international competitiveness (Audretsch, 2003). Therefore, SMEs must attain increasing levels of performance in order to maintain overall economic growth, which can be achieved mainly through novel and strategic management of R&D and innovation (Raymond & St. Pierre, 2010).

2.3.2 The Resource Based View and Inter-Organizational Arrangements

The Resource-Based View (RBV) provides a framework for analyzing economic units according to their capabilities and endowments, thus characterizing companies according to their competences and existing possibilities, where technological skills and knowledge pool can be regarded as core resources in terms of innovative potential (Wernerfelt, 1984). The RBV perspective over firm competitiveness is dependent upon inimitable, non-substitutable and imperfectly mobile resources and capabilities (Peteraf, 1993). In other words, strategic positioning is related to companies' unique competences.

In a multidisciplinary context, where several of dynamic features of innovation apply (as previously outlined in section 2.1), such "uniqueness" becomes harder to achieve independently. Inter-firm collaboration, then, plays an important role in directing independent companies in a joint effort of combining their most relevant resources towards the common goal of generating value, where collaborative arrangements will exist if, and only if, firms foresee a synergistic combination in the combination of individual capabilities (Lorenzoni & Lipparini, 1999; Madhok & Tallman, 1998). Hence, emphasis is increasingly put on competence-sharing and competence-combining among economic agents (both horizontally and vertically)[13].

Even though addressing the case of mergers and acquisitions only, Wernerfelt (1984) offers the concept of non-marketable resources and its relationship with firms' necessity of absorbing relevant bodies of knowledge that exist outside its organizational boundaries as a requisite for increased competitiveness. Such perspective can be easily adapted to the environment of

[13] RBV literature often refers to the use of external sources of competences as a "make-or-buy" decision. Collaborative agreements provide an example that shows that such decision is of a more complex nature, as Ahuja (2000) pinpoints. Such complexity is a function of non-tradable assets, such as knowledge itself.

inter-firm collaboration involving knowledge flows (as suggested by Ireland, Hitt and Vaidyanath, 2002). Literature usually defines these strategic resources as:

a) Supplementary – deepening of firms' existing capabilities.
b) Complementary – extension of competences that can be combined with those which firms already possess.

While geographical proximity and prior relationships among agents are important determinants of the establishment of international R&D networks in Europe, knowledge and technological overlaps seem to be the core drivers of such activities, highlighting that these alliances have a strong orientation towards linkages based on supplementary capabilities (Paier & Scherngell, 2011; Scherngell & Barber, 2008, both works based on FP evidence). Nonetheless, when these overlaps are too strong, limitations to learning are expected to arise (Keil et al., 2008), thus providing networks with potentially low levels of knowledge to be absorbed.

Another conclusion drawn from the RBV literature is that the choice of partners in the formation of alliances is highly related to external resources firms need in order to improve their competitive position (Mowery, Oxley & Silverman, 1998). On the other hand, firms' attractiveness as partners is defined by their existing (valuable) resources, especially technological and commercial ones (Ahuja, 2000). Consequently, R&D networks can function as mechanisms not only for value creation, but also for resource generation for partners, thus increasing, improving and expanding their pool of intra-organizational competences and resources[14] (Ireland, Hitt & Vaidyanath, 2002; Lorenzoni & Lipparini, 1999). Moreover, this combination of firms' internal resources in collaborative R&D agreements is also likely to generate some kind of convergence in partners'

[14] We can highlight two main resources related to R&D networks: knowledge *per se* (embodied and/or disembodied) and, additionally, managerial/relational capabilities, as they are likely to be improved through inter-firm interactions. The latter aspect can become extremely valuable in further collaborative relationships the firm might be involved with (Lorenzoni & Lipparini, 1999).

technological portfolios, pointing towards an effective distribution of knowledge across networks (Mowery, Oxley & Silverman, 1998).

A central feature of the RBV in a context of redefined organizational boundaries, therefore, is that firms' critical resources are often part of inter-organizational settings, where complementary assets, knowledge-sharing mechanisms and relational governance highly define the competitive position of alliance partners (Dyer & Singh, 1998)[15]. This conclusion offers an important addition to traditional RBV approaches (such as that of Teece, Pisano and Shuen, 1997), which often neglect the dynamics of inter-firm relationships in building a joint set of valuable competences.

2.3.3 Industry

Regarding sectoral background as a propensity determinant for engagement in R&D networks, firms in industries with higher rates of technological change have also more incentives to participate in cooperative R&D projects (Belderbos *et al*, 2004). Another influential aspect is that of divergent technological trajectories and the fact that they shall influence in firms propensity to cooperate in R&D (as shown in works of Pavitt, 1984 and Leiponen, 2001). These propositions generate a positive association between firm-size and innovative intensity in sectors that offer more technological opportunities (Archibugi & Evangelista, 1995)[16].

[15] In empirical terms, R&D networks that are formed with the sole goal of cost reduction represent relevant microeconomic risks in the long run[15], while synergy-oriented alliances represent a stronger case for successful cooperation (Lee et al., 2010), thus indicating that a RBV approach to strategic reasoning is expected to be more economically sustainable over time in comparison to a "labor division" perspective.

[16] Nonetheless, Edwards-Schachter et al (2012) estimate that technological intensity does not perform well as an explanatory variable on the propensity of firms in engaging in technological cooperation at the international level.

Furthermore, Sakakibara (2002) identifies two industrial features that are highly related to drive cooperation: oligopolistic concentration and knowledge appropriability conditions of knowledge. Regarding the former, oligopolistic industries show higher levels of R&D cooperation than those found in competitive industries, since potential for joint benefits are larger. On the latter aspect, industries with poor conditions for knowledge appropriability drive firms towards the formation of R&D networks, as a consequence of the fact that individual efforts are likely to be easily available for imitation elsewhere, increasing risks related technological and knowledge spillovers.

Also, other industrial settings play an important role in this approach. Firms send signals to the market by disclosing knowledge and this strategy (conduct) gives them a reputation that makes them more prone to engage in R&D networks – and to play a central position in these partnerships (Muller & Pénin, 2006). Authors conclude that, even though this behavior can be risky in the short run, it enables firms to access a wider pool of knowledge than its non-disclosing peers, which provides them with advantages in the longer run. Hageedorn and Schakenraad (1990) also put emphasis on market positioning as a determinant for R&D collaboration, while Hernán, Marín and Siotis (2003) mention the importance of industrial concentration.

In this regard, the conduct (strategy) of a company should be understood as a function of the industrial structure, thus determining performance. If we assume the idea of R&D networking as a desirable signal, we must perceive it as more relevant in sectors with higher degrees of competition and with more potential for *external* rivalry (substitutes). Industries that are highly concentrated and with low *current* risks of substitutes would behave differently, as a result of their environment (and the lower pressure for differentiation signals it would exert on companies).

2.3.4 Knowledge Spillovers, Transaction Costs and IPR

Economic relationships are bound to face what theory describes generically as transaction costs. In cooperative agreements, risks of opportunistic behaviors, if high enough, bring with them the need for stronger coordination (governance) between partners, thus shaping the contractual context and defining whether or not the collaboration will take place (Katila & Mang, 2003). The most basic rationale behind innovation-driven economic incentives lies in the capacity of firms exploiting results of their efforts in the market (Leiponen & Byma, 2009). If these incentives are distorted by existing risks, levels of R&D efforts are expected to be lower than their optimal level, thus affecting the dynamics of networks.

The role played by technological spillovers in R&D cooperation is of great relevance for companies in their strategic decisions regarding these activities (Hernán, Marín & Siotis, 2003). When choosing to participate in R&D agreements, a company must consider the levels of spillovers involved, in and out of the organization. While external technological adoption is a key ingredient of innovation (Bogliacino and Pianta, 2010), having competitors accessing a given firm's pool of knowledge might represent an undesirable risk in the medium/long term (Arranz & Arroyabe, 2008a). As Oxley (1999, p. 284) puts it: "*how can we* [firms engaged in R&D alliances] *promote technology transfer and learning, without losing control of valuable intellectual property?*". This question pinpoints an intrinsic and central feature of transaction costs when collaboration involves R&D interactions[17]: sharing critical knowledge with external agents (as suggested by Teece, 1986; Kreiner & Schulz, 1993; Hennart, 1988)[18]. Ultimately, appropriability hazard issues are likely to affect the success of such collaborative agreements

[17] This issue is so critical in the formation of R&D networks that the European Commission launched a guide for IPR management in projects related to the 7th Framework Programme. This document, "*Guide to Intellectual Property Rules for FP7 projects*" clearly states that IPR conditions are strongly connected with projects' coordination and exploitation of results.

[18] We may assume a certain level of cultural/institutional influence in this regard: Sakakibara (1997a), e.g., finds that opportunistic behavior and spillovers of critical knowledge are not perceived as important problems in R&D cooperation in the case of Japanese firms.

(Frenz & Ietto-Gillies, 2009)[19], as well as to determine aggregate propensity of firms to engage in R&D cooperation (Tripsas, Schrader & Sobrero, 1995). Inter-firm R&D alliances face appropriability hazard issues when relevant activities are hard to be incorporated in contracts, or when these are contain elements that are hard to monitor and enforce (Oxley, 1997). Moreover, the complexity involved in a contract which addresses the development of new technologies represents additional uncertainty, given the unpredictable nature of innovation.

Alternatively, incoming spillovers in R&D cooperation increase a firm's profitability once it reaches a certain minimum level, but if this level is high enough, it may foster free riding issues, thus posing a duality for these "leakages" of knowledge – higher levels of *incoming* spillovers promote cooperation, but high levels of *outgoing* spillovers may hinder firms from engaging in such an activity (De Bondt & Veugelers, 1991; Kesteloot & Veugelers, 1995; Eaton & Eswaran, 1997).

These risks depend largely on the structure of the R&D network that is established. They will be more representative the more the partners are capable of competing with each other in their specific core markets. This situation occurs as value appropriation takes place in an environment of rivalry, causing opportunism concerns that erode the potential of joint knowledge creation (Ritala & Humerlina-Laukkanen, 2009; Helm & Kloyer, 2004). Intellectual Property Rights function as a catalyst in this process, allowing a stronger coordination of appropriability of innovative outcomes that arise from R&D networks. On the other hand, Ritala and Humerlinna-Laukkanen (2009) propose through a game-theoretic approach that collaboration between rivals is likely to provide firms with better technological results, provided that common knowledge of markets and technologies is larger.

The level of opportunistic behavior risks largely defines the structure of networks. The contractual architecture in R&D collaboration is a way of building up

[19] This issue implies that governments and institutions that promote R&D cooperation have a role to play in reducing transaction costs of such agreements through administrative mechanisms[19] (Tripsas, Schrader & Sobrero, 1995).

trust among partners (Blomqvist, Hurmelinna & Seppänen, 2005). Kim and Song (2007) find that more stable networks are more productive in terms of joint patenting than newly formed alliances. The authors relate this finding to higher managerial quality in the presence of *lower* transaction costs (as previous relationships increase *trust* between partners, as well as create the settings for better coordination of activities[20]), since firms are averse to share critical knowledge when appropriability risks are high.

However, other factors can be understood as influential in determining the IPR framework in R&D alliances. Strategic flexibility influences the decision over the coordination of networks (softer agreements *vs.* equity-based alliances), since long-term interdependence can play a costly role for network members (as demonstrated by Roijakkers and Hagedoorn, 2006 in an assessment of R&D cooperation in the pharmaceutical biotechnology industry). An alternative perspective is provided by Mowery, Oxley and Silverman (1996), Lucena (2011) and Sampson (2007), who find that equity arrangements are more effective in the process of knowledge flows within networks, since these forms of cooperative arrangement provide firms with the abovementioned concept of *network stability*, reducing incentives for opportunistic behavior, thus increasing overall managerial quality of knowledge flows[21].

The use of patents and trade secrets as protection mechanisms against opportunistic behavior deserves some additional comments, since they can be regarded as managerial tools in a context of (undesirable) knowledge spillovers arising from collaboration. Katila and Mang (2003) find that the use of patents is significantly related to firms' propensity of engaging in collaborative agreements, whereas Pénin (2005) highlights that patents can be used for firms as a strategy to protect knowledge from opportunistic behavior, not only as a way to achieve

[20] The findings of Gulati (1995) also support the concept of increased trust when repeated interactions take place among partners in an alliance, thus modifying the contractual relationship.
[21] Nonetheless, Mitsuhashi (2003) finds that stable networks, while having higher levels of managerial quality, are bound to exchange redundant knowledge over time, making them less adaptable to new technologies and cutting-edge knowledge.

temporary monopoly. Emphasis would, hence, rest on patents' coordination role, rather than on the rents they shall provide.

However, other firm-level characteristics must be taken into account in this process. SMEs IPR strategies, for example, are significantly different from those of larger firms. Smaller firms are more likely to use time-to-market as a tactical form of appropriating the results from a collaborative project (Leiponen & Byma, 2009)[22]. Even though patents represent a more robust mechanism for knowledge protection/appropriation (Leiponen & Byma, 2009; Arundel, 2001), they represent an additional (and highly relevant) cost. As SMEs lack resources for registering and, more importantly, for enforcing their patents, stronger forms of coordination among members become infeasible. This is particularly relevant for the fragmented European framework for patents (European Commission, 2010a).

Additional uncertainty can be attributed to networks that involve partners from multiple countries (Lhuillery & Pfister, 2009). As previously addressed, Intellectual Property Rights shape the governance structure of inter-firm alliances, where more hierarchical relationships (i.e., equity joint ventures instead of contract-based alliances) take place when protection of knowledge is weak (Oxley, 1997; 1999)[23]. This situation is influenced by both the transaction characteristics, and the institutional environment to which partners belong. Furthermore, international linkages face constraints related to distance, language and other cultural factors (Mowery, Oxley & Silverman, 1996), which hamper the optimization of inter-firm interactions.

Regarding R&D alliances within the European Union, the stable institutional environment in terms of IPR protection across different Member States provides

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[22] SMEs lack, for example, resources for registering and, more importantly, for enforcing their patents. This is particularly relevant for the fragmented European framework for patents (European Commission, 2010a). On the other hand, trade secrets are hard to keep in a collaborative setting, making patents a stronger mechanism for knowledge protection/appropriation (Leiponen & Byma, 2009; Arundel, 2001).

[23] This situation can be conceptually described as risks of *opportunistic behavior*, as well as an issue of *moral hazard* (*or appropriability hazard*). These are particularly relevant in international R&D networks, since monitoring behavior becomes extremely costly and difficult (Oxley, 1997).

firms with increased trust in inter-organizational structures. For instance, the European Patent Office sets the basic rules for patenting activities across Europe, providing countries with linear expectations concerning the protection of incorporated knowledge. An illustrative example of the opposite situation (distinct institutional settings) would be networks that involve locations with high degrees of variability in terms of such protection, posing a context in which additional transaction costs are present.

In conclusion, transaction costs related to IPR management in (international) R&D alliances represent a critical issue in the managerial processes of these networks and, hence, they are expected to be linked with firms' outcomes and their initial propensity to develop cooperative agreements in R&D. This complexity is enhanced by the fact that stronger coordination can be desired in many sectors, but if agents actively engage in knowledge-protection strategies, they can be seen by markets as less attractive partners for collaborative projects (Muller & Pénin, 2006), since networking with them can becomes too costly. A proper administration of the abovementioned aspects should take into account not only short-run risks, but also long-run orientation.

2.3.5 National Innovation Systems

The last aspect to be assessed as a propensity determinant for engagement in R&D networks (especially at international level) makes reference to the geographic and institutional environment in which agents are embedded: National Innovation Systems – NIS. Adding this variable into our analysis provides a macro-oriented perspective of the phenomenon under scrutiny.

First of all, country size, as well as degree of openness to globalization, is a relevant driver for agents to engage in international R&D cooperation, where smaller and more open countries are more prone to develop these activities in relative terms (Srholec, 2011a; Hernán, Marín & Siotis, 2003). This proposition is related to the idea of complexity involved in R&D, leading to multi-technological, interdisciplinary, outcomes. Small countries usually have a relatively small width in terms of industrial capacity, thus requiring partnerships with agents from other countries in order to participate in more multifaceted technological developments.

Srholec (2011a) also states that firms from less advanced nations seem to be more prone to engage in international cooperative projects aiming at the generation of innovations. Complementing the former idea, firms from these nations are less likely to have the necessary knowledge in complex technologies, thus resorting to networks with foreign agents. De Prato and Nepelski (2012) find that this situation has led to a "core-periphery" structure in international collaboration, where countries with stronger innovation systems (called "hubs") work as strong nodes in most networks. In this sense, Edwards-Schachter et al (2012) suggest that firms from countries with less-developed innovation systems are also less likely to achieve successful results from the interaction.

In terms of national policymaking, Fernández-Ribas and Shapira (2009) show that participation in national innovative initiatives positively influence the probability of firms to engage in international innovative networks. This approach emphasizes the importance of internal institutions promoting *indirectly* the international association of companies through local R&D partnerships. In this regard, we cannot neglect the role played by the NIS in terms of R&D expenditures by public sources, the education system, specific industrial policies, etc., which influence the macroeconomic landscape for firms, thus affecting their capabilities.

For the general case of Europe, 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).

Next (table 3), we offer a summary of the findings related to the collaborative context of firms and their interaction within R&D networks with focus on the international level of such relationships. After, we move to an analysis of empirical findings on the outcomes of the subject under analysis.

2.4 A Literature Survey on Empirical Outcomes

As a starting point in the subject of outcomes from (international) R&D networks, we should point out that there is no consensus on how cooperative performance can be measured. Evaluation so far focuses on subjective (interviews, questionnaires) or objective sources (published financial data) (Veugelers, 1998). Moreover, collaborative R&D is more difficult to evaluate than individual R&D projects, since there are multiple perspectives involved in the former situation (Dyer & Powell, 2002), and, also, benefits of cooperative pre-competitive R&D can be only seen in the long-term and they are usually systemic rather than discrete (Quintas & Guy, 1995).

The abovementioned context gives room to different kinds of assessments (and different dimensions) aiming at providing partial answers to the phenomenon. In this regard, none is capable of answering all of the questions involved, but a combination of such results might provide some robust hints on the microeconomic effects of these initiatives. We shall analyze the following findings under three constructs: Innovative Intensity & Performance; Corporate Performance; and Network Structure & Management. The first two give emphasis to outputs *per se*, while the third one is process-oriented.

Aspect	Main Theoretical Findings	Main sources
Firm Size	a) Large firms are better in a better position to capture benefits from R&D cooperation b) SMEs play a relevant role in netw orks, but a secondary one compared to large companies c) Large firms have a higher capacity (higher absorptive capacity and more financial resources) to engage in international R&D netw orks. Nonetheless, absorptive capacity should be proxied by a given firm's R&D intensity d) SMEs have a greater necessity to engage in international R&D netw orks in order to become competitive in innovative activities e) Large firms are more concerned w ith disclosing critical assets via R&D netw orks than SMEs	*Sinha & Cusumano, 1991; Barnard & Chaminade, 2011; Grutzman, Halme & Reiner, 2009; Fernández-Ribas & Shapira, 2009; Faems et al, 2010; Veugelers & Cassiman, 2005; López, 2008; Anderson, 1995; Cusmano, 2001; Barge-Gil, 2010a; Silipo, 2008; De Backer, López-Bassols & Martinez, 2008; Hageedorn & Schakenraad, 1990*
Resource Based View	a) Firms cooperate w hen they foresee synergies arising from the alliance b) Netw orking can provide firms w ith 2 sorts of strategic resources: complementary and supplementary c) The choice of partners is related to resources that are scarce w ithin the firm	*Wernerfelt, 1984; Peteraf, 1993; Lorenzoni & Lipparini, 1999; Madhok & Tallman, 1998; Ireland, Hitt and Vaidyanath, 2002; Ahuja, 2000; Dyer & Singh, 1998*
Industry	a) Firms in industries w ith higher rates of technological change have more incentives to participate in cooperative R&D projects b) R&D cooperation - especially at international level - gives firms a reputation that favors further engagement in netw orks c) Industrial structure plays a central role in determining firm conduct (strategy) concerning R&D cooperation	*Belderbos et al, 2004; Muller & Pénin, 2006; Hernán, Marín & Siotis, 2003; Hageedorn & Schakenraad, 1990*
Transaction Costs, Know ledge Spillovers and IPR	a) High levels of incoming spillovers promote cooperation b) High levels of outgoing spillovers may hinder firms from engaging in R&D cooperation c) Transaction costs and netw ork structure	*De Bondt & Veugelers, 1991; Kesteloot & Veugelers, 1995; Eaton & Eswaran, 1997; Hernán, Marín & Siotis, 2003; Mowery, Oxley & Silverman, 1996; Oxley, 1997; 1999*
National Innovation Systems	a) Firms from smaller countries are more prone to engage in international R&D cooperation b) The farther a country is from technological frontier, more benefits its firms can gather from participating in international R&D netw orks, but firms from less-developed innovation systems are less prone to be successful in such relationships c) National R&D cooperation policies foster international R&D cooperation in the future d) European firms have an internationalized S&T profile and are becoming more oriented tow ards international R&D	*Srholec, 2011a; Hernán, Marín & Siotis, 2003; Fernández-Ribas & Shapira, 2009; ETAN, 1998; Foray & Lhuillery, 2010; Edwards-Schachter et al, 2012*

Table 3. Summary of findings on the contextual environment of R&D cooperation

2.4.1 Innovative Intensity & Performance

One of the most relevant outcomes from cooperative R&D in companies is the expectation it creates in providing greater innovative capacity, which can be attributed to external knowledge absorption as well as to a higher level of innovative intensity in collaborating firms. Nonetheless, there is no consensus on the effects of R&D cooperation and innovative intensity and/or performance.

As a positive body of evidence regarding the relationship between innovative performance and R&D cooperation we find the works of Faems et al (2010), Zeng, Xie and Tam (2010), Cusmano, (2001), Chang (2003) and Beaudry (2011). To properly define the concept of innovative performance in each context, Faems et al (2010) and Zeng, Xie and Tam (2010) use the proportion of turnover attributed to new or strongly improved products, Cusmano (2001) and Beaudry (2011) use patenting activity, while Chang (2003) analyzes market introduction of technological innovations. Even though we acknowledge that these analyses provide a limited view of the complex definition of innovation, they are representative in defining a trend: R&D collaboration positively affects innovative performance. Nonetheless, we recognize that several variables influence this process, as addressed in several sections throughout this literature review.

R&D collaboration – especially at the international level - also seems to be positively associated with higher innovation expenditures according to De Jong and Freel (2010), Beaudry (2011), Siebert (1996) and Czarnitzki, Ebersberger and Fier (2007). However, these aspects are representative of an innovation *input*, thus not being able to estimate actual innovation *output*, though they can contribute to a good assessment of innovative performance. Even if innovation cannot be regarded as a linear process, substantial differences in input indicators are usually relevant indicators of distinct innovative performance (which is less likely to hold when there are only marginal differences in inputs).

Franco, Marzucchi and Montresor (2011) find evidence that firms' reliance on external knowledge tends to increase its absorptive capacity. Building upon an opposite direction of causality, Lin et al (2012) find that innovation performance (measured via patent indicators) arising from firms' participation in R&D networks is highly dependent on existing levels of absorptive capacity, which highlights the driving potential that this construct is likely to have on the economic outcomes of such interorganizational arrangements.

Additionally, Bogliacino and Pianta's (2010) 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). These results support an idea of R&D networks working rather successfully in providing firms with better corporate results *through* better innovative outcomes. We shall turn to these corporate aspects in the upcoming section.

On the other hand, Fritsch and Franke, (2004) find that R&D cooperation plays a minor role in generating actual knowledge spillovers that can add efficiency to innovation activities, while Stenbacka and Tombak (1998) claim that R&D networks are highly dependent on external subsidies if the goal is to achieve higher rates of R&D intensity amongst partners, i.e., they do not represent an advantageous initiative in terms of its cost-efficiency.

2.4.2 Corporate Performance

While innovative intensity and performance can be considered as a highly desirable output from R&D partnerships - along with higher levels of absorptive capacity and increased awareness of technological and *non*-technological capabilities existing outside the boundaries of the firm – they only represent a source of competitiveness when they translate into better corporate performance (financial indicators, increased productivity, etc.).

In this sense, as already pointed out, the work of Bogliacino and Pianta (2010) reaches a favorable conclusion regarding the role that R&D networks play in improving corporate performance via better innovative results. Nonetheless, most empirical works approach this phenomenon in a direct, *non*-endogenous, manner, aiming at establishing a relationship between collaboration and firms' outcomes. As examples of R&D cooperation's positive impacts on corporate performance we can mention the works of Hageddorn and Schakenraad (1994) and Sakakibara (1997a), which conclude that R&D cooperation improves corporate performance and industry competitiveness.

Another aspect to be pointed out is that international R&D collaboration also seems to provide firms with strategic flexibility to undertake short-term innovation projects with a variety of partners (Hagedoorn, 2002). Also, financial markets perceive international and cross-sectoral alliances (between two partners) as positive (drawing evidence from stock prices) (Bayona, Corredor & Santamaría, 2006), indicating a market perception of R&D networks as signals of future improvements in corporate performance (as an expectation of stockholders and buyers).

In opposition, Siebert (1996) reports the achievement of lower profit margins for firms that collaborate in R&D – even though the same author found for the analyzed firms a larger rate of innovative returns. Similar results were proposed by Aguiar and Gagnepain (2011) for the case of small networks. Egbetokun (2012) finds positive technological results arising from innovation networks, whereas he does not find support for the hypothesis that such firms achieve better market outcomes in comparison to those firms that do not participate in R&D networks.

But it must be kept in mind that a core aspect to be taken under consideration concerning this situation is the timing of the assessment. Sakakibara (1997a) highlights the fact that the commercialization of a given project involving R&D collaboration drives the project's positive or negative evaluation by participants. If further results arise after the evaluation takes place, there is a potential risk of misrepresenting companies' outcomes if returns are not yet being commercialized. The same perspective holds for objective indicators of corporate performance. Besides, benefits from R&D cooperation seem to be largely intangible, related mainly to researcher training and increased awareness of R&D in general (Sakakibara, 1997a).

2.4.3 Network Structure & Management

In section 2.3.4 Knowledge Spillovers, Transaction Costs and IPR, it was streamlined that the innovation linkages among companies face an environment of complex interactions, where issues of knowledge sharing are at the core of the analysis, shaping governance modes of networks. However, even considering the risks involved in this context, firms are increasingly resorting to inter-organizational arrangements. Managerial capabilities become key to define outcomes from alliances, where proper coordination among agents seems to be fundamental for the achievement of efficient R&D activities.

The "Network Structure & Management" dimension analyzed in this section refers to the impacts of R&D networks' organizational impacts on firms' outcomes. Provided that there is no standard way of cooperating in R&D – networks' characteristics vary in structure, geography, level of rivalry, etc. – it is of significant relevance to verify what hints literature can give in this regard.

Despite all the benefits that encourage co-production of knowledge between different organizations, its nature is highly complex and carries with it the challenge of inter-firm coordination (Husted & Michailova, 2010). As a result, managerial processes of R&D networks represent core drivers of ultimate achievements, provided that they take place in an environment of complex transaction costs (as suggested by the works of Sampson, 2005; Sakakibara, 2002). For example, Granero and Vega-Jurado (2012), analyzing the case of the Spanish Ceramic Tile Industry, find strong support for the role of managerial practices (network coordination concerning knowledge sharing activities and formalization based mechanisms[24]) in determining market results of R&D-oriented alliances.

The proposition that the quality of coordination is a main determinant of success in R&D networks is also supported by several other authors (e.g. Dyer & Powell, 2002; Caloghirou, Hondroyiannis and Vonortas, 2003; Husted & Michailova, 2010). Some have even stated that network coordination (intensity and quality), organization and cohesion are of *similar importance for successful results as technological capabilities and market potential of products*, provided that the former condition the process of enabling external knowledge to become a marketable output (Rese & Baier, 2011; Husted & Michailova, 2010; Granero & Vega-Jurado, 2012).

Since innovation has become a more “open” process, where R&D interactions take place both horizontally and vertically, the development of the necessary capabilities to manage innovation strategically and across organizational boundaries represents a crucial aspect for companies’ achievements (Blomqvist et al., 2004). This happens because inter-firm collaboration faces several difficulties regarding its management and coordination, thus leading to a high rate of failures, abandonments and delays in these relationships (Dyer & Powell, 2002; Lhuillery & Pfister, 2009).

Key aspects related to management processes of R&D networks are related to: i) planning of resources; ii) partners’ contributions; and iii) timing of contributions (Arranz & Arroyabe, 2008). As innovation needs to be integrated strategically with

[24] Understood as formal explicit rules of conduct.

financing functions, marketing and sales, human resources and so on, good coordination becomes harder to achieve when R&D processes involve suppliers, customers, competitors, etc. (Blomqvist et al., 2004). Furthermore, the process of network management regarding R&D-related activities is one of controlling inflows and outflows of knowledge[25], where the firm must contribute to the network while also benefitting from it and protecting critical intangible assets (Husted & Michailova, 2010).

The challenge, then, to achieve an efficiently managed cooperative R&D project, lies upon defining clear objectives, which coordinate tasks, solve conflicts, distribute results and hinder opportunistic behavior from alliance members (Arranz & Arroyabe, 2008). Firms that share similarities in their organizational structures and cultures are likely to achieve better results in inter-company relationships (Keil et al., 2008), as interactions are expected to be of higher quality. Hence, firms' learning processes regarding partner selection (as an *ex ante* managerial task) represent a fundamental step towards establishing functional R&D networks (Chang, 2003; Hagedoorn, Roijakkers & Kranenburg, 2006; Arranz & Arroyabe, 2008; 2008a). However, preliminary cost-benefit assessments are imperfect, since the market for knowledge-based assets is surrounded by uncertainty (Husted & Michailova, 2010).

Besides aspects of managerial complexity that are common to networks in general[26], we must remind the risks involved in R&D cooperation, which are mainly related to – undesired - knowledge flows, or technological spillovers. This implies that vertical networks are easier to manage than horizontal (among competitors) ones (Dyer & Powell, 2002; Tao & Wu, 1997; Badillo & Moreno, 2012; Lhuillery & Pfister, 2009), hence potentially leading to better outcomes[27]. That is to say,

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[25] For individual firms' results, absorptive capacity and innovation appropriability are core features of the managerial processes involved in R&D networks (Hurmelinna-Laukkanen et al, 2012).

[26] Such as organizational culture, information flows, free riding, opportunistic behavior, etc. For a review of transaction costs involved in R&D networks, see section 2.3.4 Knowledge Spillovers, Transaction Costs and IPR.

[27] Kamien and Schwartz (1976) using theoretical formulations find that an intermediate level of rivalry would provide optimal results in terms of innovative achievements.

technological and knowledge spillovers are positive in a R&D network (and to some extent the reason why they exist in the first place), but, as pointed out previously, there are severe managerial threats when this "leaking knowledge" can affect agents' competitiveness. Therefore, research consortia outcomes have positive association with levels of R&D spillovers and negative association with the degree of market competition between members (Branstetter & Sakakibara, 2002).

Moreover, for managerial reasons, the configuration of a R&D network has influence on the capacity of this network in generating innovations (Liu & Chaminade, 2009), which can be attributed to aspects related to the aforementioned transaction costs involved in the relationship. Consequently, more perennial R&D partnerships increase trust and thus are more prone to provide higher quality results (Huggins, 2011; Rese & Baier, 2011; Musiolik, Markard & Hekkert, 2012; Mitsuhashi, 2003). However, as outlined previously in section 2.3.4, Mitsuhashi (2003) has found that high quality management, when it is achieved through network stability, may cause a lack of dynamism in innovative performance, where knowledge exchanges become redundant[28].

In geographical terms, cohesion seems to play an important role: R&D networks that are too dispersed experience worse technological performance (Barnard & Chaminade, 2011; Dyer & Powell, 2002). In this regard we should approach geography as a proxy for other influent variables in the process, such as cultural background, local market characteristics, language barriers and difficulties involving coordination from long distance. This latter aspect has been increasingly tackled at firms' operational levels through the use of modern IT systems[29], but considering R&D as a non-linear process and being subject to tactical and strategic plans, its international coordination implies different challenges.

[28] König et al (2012) find that the relationship between network efficiency and stability is highly related to industrial structure.

[29] Cooperative R&D relationships can benefit from internet-based real time connections between members to improve managerial quality of linkages (Kessler, 2003).

In addition, domestic linkages seem to be the most relevant determinant of innovative performance, where international linkages matter only in combination with domestic ones (Srholec, 2011). This poses a situation in which international R&D networks are effective when used as a *complement* of local networks. In this regard we should put some emphasis on the role played by country size in this perspective as already stated. However, Srholec's (2011) results refer to data from the UK, Norway and the Czech Republic, being the latter two considered as small economies, thus theoretically more prone to resort to international R&D networks. A potential explanation for such results lies on the construction of managerial capabilities regarding networks, i.e., those firms that are engaged in larger numbers of collaborative agreements are likely to develop the necessary know-how to properly manage such relationships. For proximity reasons, this learning process is expected to be stronger within national boundaries.

In terms of policymaking regarding networks' structure, Broekel, Schimke and Brenner (2011) suggest that collaborative RTD policy should focus on a large number of small projects instead of on a few large-scale ones. The authors also find that the success of collaborative R&D initiatives is more related to its specifications (number of supported projects, cooperative character and types of cooperation being supported) than to the amount of resources invested, putting emphasis on the relevance of the structural and managerial dimensions of R&D cooperation.

Follows a summary of the main features presented in this section, gathering evidence on R&D networks' outcomes regarding the three analyzed dimensions: Innovative Intensity & Performance, Corporate Performance and Network Structure & Management. Afterwards we outline the innovation policy elements involved in our analysis.

Aspect	Main Theoretical Findings	Main sources
Innovative Intensity & Performance	a) Firms engaging in technological cooperation outperform those that do not in terms of innovative performance b) R&D collaboration – especially at the international level - is positively associated w ith higher innovation expenditures c) Firms' reliance on external know ledge tends to increase its absorptive capacity d) R&D netw orks provide firms w ith better corporate results through better innovative outcomes e) R&D netw orks are highly dependent on external subsidies to achieve higher rates of R&D intensity	*Faems et al, 2010; Zeng, Xie & Tam, 2010; Cusmano, 2001; Beaudry, 2011; De Jong & Freel, 2010; Siebert, 1996; Czarnitzki, Ebersberger & Fier, 2007; Franco, Marzucchi & Montresor, 2011; Bogliacino & Pianta, 2010; Surroca Aguilar & Santamaría Sánchez, 2006; Stenbacka & Tombak, 1998*
Corporate Performance	a) R&D cooperation improves corporate performance and industry competitiveness b) International R&D collaboration provides firms w ith strategic flexibility c) Financial markets perceive international and cross-sectoral alliances as positive d) Commercialization of a given project involving R&D collaboration drives the project's positive or negative evaluation by participants e) Benefits from R&D cooperation seem to be largely intangible f) Timing of evaluation is key	*Hageddorn & Schakenraad, 1994; Sakakibara; 1997a; Hagedoorn, 2002; Bayona, Corredor & Santamaría, 2006*
Network Structure & Management	a) Importance of quality of coordination and levels of know ledge sharing for success in R&D netw orks b) Risks involved in R&D cooperation are mainly related to technological spillovers to (potential) competitors c) Vertical netw orks are easier to manage than horizontal ones d) Research consortia outcomes have positive association w ith levels of R&D spillovers and negative association w ith the degree of market competition betw een members of consortia e) R&D netw orks that are too geographically dispersed incur in w orse technological performance f) International linkages matter only in combination w ith domestic ones G) collaborative RTD policy should focus on a large number of small projects instead of on a few large-scale ones	*Dyer & Powell, 2002; Tao & Wu, 1997; Branstetter & Sakakibara, 2002; Barnard & Chaminade, 2011; Srholec, 2011; Broekel, Schimke and Brenner, 2011*

Table 4. Summary of findings on empirical outcomes of R&D cooperation

3. RTD policies in an integrated context: the case of the European Union

Provided that the assessment contained in this research makes central reference to results of companies engaged in R&D cooperation activities promoted by the Eureka initiative, our approach is can be related to innovation policy evaluation, as well as a contribution for an improved policymaking process. Therefore, the aim of this chapter is to build a robust background on Research, Technology & Development policies' rationale, the role played by evaluations, and some further notes on related aspects.

Technological innovation policies represent a strategic area in the field of public policy regardless of governments' political inclination or geographical relevance (national, regional, local or even supranational) (Aghion & Tirole, 1994). This is a result of the role that innovation and technological change play in fostering economic growth and its characteristics of public goods that are likely to create market failures (Álvarez, 2004; Molero & Fonfría, 2008; Branstetter & Sakakibara, 2002; Suurna & Kattel, 2010).

However, RTD policies need to evolve, along with a changing socioeconomic environment, as well as regarding issues that leave room for improvement. Thus, they are often evaluated, adapted and modified in order to provide society with better outcomes, and agents with a better framework of action. Adaptive policymaking is about facilitation (enabling innovation), understanding the existence of unpredictability and indeterminacy in the results of policy initiatives (Metcalfe & Georghiou, 1997). Furthermore, innovation processes happen in conditions of uncertainty and (in the capitalist system) of competition and so must be approached in a holistic manner, considering not only technical capabilities but also the market environment and the social context (Pavitt, 2003; Kline & Rosenberg, 1986).

In the following sections we focus on theoretical and empirical aspects concerning the foundations and justifications for governmental intervention in terms of innovation, as well as the role of continuous evaluation of such initiatives in shaping the evolution of RTD policies. Special attention is given to the integration of innovation systems via international R&D collaboration in the EU context.

3.1 The economic rationale behind RTD policies: a brief outline

Innovation is a costly process which can create market failures related to the nature of technological change, such as appropriability issues, amount of R&D investment, spillovers and externalities (Klette & Moen, 1999; Smith, 2000; European Commission, 2006a; NIST, 2006). Arrow (1962) argues that innovation's inherent characteristics demand governmental action in order for society to produce an optimal level of economic valuable knowledge.

This idea of "market failure" still is predominant in justifying the need for public policies that approach the problems related to the innovative process, fostering an innovation-driven environment (Bayona-Sáez & García-Marco, 2010; Nelson, 1959; Sanz Menéndez, 1995). The main argument is that in a context of perfect competition, there are not enough incentives for firms to innovate, given the lack of economic institutions that guarantee the return on investments. As examples of policies based on the "market failure" mindset we can highlight Intellectual Property Rights and R&D subsidies.

However, it is known that the mere understanding of market failures does not provide enough information for technological policymaking (Aghion, David & Foray, 2009). Even though neoclassical approaches have been widely recognized as useful for the RTD policymaking process, the evolutionary theory in economics has also contributed with a systemic orientation, mainly through the viewpoints contained in the National Innovation Systems' approach. The Innovation System approach considers the economic and social environment for innovation as one where agents do not innovate in isolation, but rather through systemic interactions. Hence, innovation policy must focus in identifying systemic failures in the set of relationships existing within Innovation Systems (Edquist, 2011).

This point of view regarding innovation policy highlights that innovation usually occurs within networks and alliances rather than in individual firms, stressing the relevance of a strongly interconnected innovation system (European Commission, 2002). We can mention the case of R&D cooperation policies as an example of "innovation systems"-oriented policies, since initiatives that promote R&D collaboration act as tools to foster not only innovation in participants, but also a *structural and behavioral change* in these agents (European Commission, 2002), with focus on existing and potential links between agents involved in innovative processes.

Thus, we can add behavioral change or *additionality* as a main goal of innovation policy (Fernández-Ribas & Shapira, 2009; Hayashi, 2003; PREST, 2002). Behavioral additionality refers to the fact that innovation policies have not only direct, but also indirect effects on companies' strategies, where direct effects are obvious and concern the intentions of a given initiative, and indirect effects regard longer-term behavioral changes in agents (Fernández-Ribas & Shapira, 2009; European Commission, 2006a).

Despite its differences, innovation policy, either neoclassical or systemic/evolutionary, involves industrial, environmental, labor and social aspects, aiming at the generation of economic competitiveness (Kuhlman & Edler, 2003). But, evolutionary theory influenced technological policies to become more oriented to adaptation of firms and markets in an environment of change (Nelson & Winter, 2002). They provide the framework for understanding endogenous systemic changes over time. Hence, existing institutional structures, including bodies of relevant law, and particular government policies and programs, can never be regarded as optimal and for this reason they are, and should be, always subject to evaluations and constructive criticism (Nelson, 2007).

During the last decades, globalization and the shift towards knowledge as the source of competitiveness rendered the traditional policy instruments less effective (Gilbert, Audretsch & McDougall, 2004), creating an environment that demands continuous adaptation in public policies and initiatives. Technology policies are part of a systemic economic landscape and must ensure that the main players - the firms - are able to realize their innovative potential (Molero, 2001), meaning that the appropriate R&D policymaking requires knowledge about context conditions, group behavior, instruments (and their mix) and policy effects (Ebersberger, Edler & Lo, 2006).

Referring to this latter argument, given the complexity of business environments and different sectoral characteristics, innovation policies cannot afford to be fully standardized, since there is no optimal design for them: these vary across countries, technological domains and stages of innovative processes (Raymond & St. Pierre, 2010; Klette & Moen, 1999). Provided there is a high level of complexity and dynamism in the policymaking process regarding innovative activities, as well as the need for adaptation at the innovation system level, evaluation activities become a key element in designing better programs to develop innovative capabilities and desired changes in behavior and structure. In section 3.2 we shall approach the issue of RTD policy evaluation and adaptation in further detail. Table 5 summarizes some of the key elements in the analysis of innovation policies' rationales.

Aspect	Main Theoretical Findings	Main sources
Market Failures	a) Appropriability issues b) Amount of R&D investment c) Technological spillovers d) Externalities e) IPRs and R&D subsidies (main kinds of intervention)	*Klette & Moen, 1999; Smith, 2000; European Commission, 2006a; NIST, 2006; Arrow, 1962; Bayona-Sáez & García-Marco, 2010; Nelson, 1959; Sanz Menéndez, 1995*
Innovation Systems	a) National Innovation Systems b)Complex interactions between agents in order to generate innovations (importance of networks and alliances) c) R&D cooperation initiatives (main kind of intervention)	*Aghion, David & Foray, 2009; Edquist, 2011; European Commission, 2002*
Behavioral Change/Additionality	a) Indirect effects of public intervention, generating long-term changes in agents' innovative strategies b) Policy focus should be upon agents that do not perform the desired conduct	*Fernández-Ribas & Shapira, 2009; Hayashi, 2003; PREST, 2002; Barge-Gil, 2010*
Adaptation	a) Globalization and the shift towards knowledge as the source of competitiveness rendered the traditional policy instruments less effective b) Necessity of knowledge about context conditions, group behavior, instruments, and policy effects c) There is no optimal design for R&D and innovation policies: these vary across countries, technological domains and stages of innovative processes d) Importance of RTD/innovation policy evaluation	*Raymond & St. Pierre, 2010; Klette & Moen, 1999; Ebersberger, Edler & Lo, 2006; Gilbert, Audretsch & McDougall, 2004; Nelson, 2007; Nelson & Winter, 2002; Kuhlman & Edler, 2003*

Table 5. Summary of findings on economic rationales behind RTD policies

3.1.1 Justifications for RTD policy in the European Union: Assessing international R&D integration and collaboration strategies[30]

Innovation policy proposals in the European Commission context have long been considered of high importance. One significant milestone was the Green Paper on Innovation, released in 1995 (European Commission, 1995) and which tackles innovation challenges in Europe, broadly discussing structural hindrances for innovation systems across the bloc. It outlines the dynamics of innovation, and it introduces a systemic context, where strategic linkages and interdisciplinary technologies are fundamental.

One of the pillars of this document is the so-called (and somewhat controversial) "European Paradox" concept, which states that Europe has a strong scientific base, lagging behind other countries (mainly Japan and the US) in terms of translating such knowledge into marketable outcomes, and to achieve this we can notice a strong political support to the creation of international R&D networks[31]. Georghiou (2008) had pointed out that technological policy reforms are needed for Europe to become a more research-friendly area. Several initiatives from the European Commission have tried to set the background for approaching this necessity effectively.

Currently, the European Commission publicly acknowledges the role that innovation may have in restoring the continent's economic competitiveness (seriously harmed by a series of crisis starting in 2008), thus generating the basis

[30] It should also be noticed that the approach here undertaken does not aim at reviewing exhaustively the context of RTD policies in the European Union, but rather to provide an outlook of this context with special emphasis on the implications for international R&D collaboration within the bloc.

[31] It should be noticed that this document is not the origin of collaborative support. Initiatives like the Framework Programmes and even Eureka (not subordinated to the EU) were going on since the 80's. The European Treaty itself, in articles 179-190 calls for R&D activities that are jointly undertaken by several Member States. Nonetheless, this Green Paper is an important landmark for innovation policy in Europe.

for economic recovery (European Commission, 2010b; 2010c; 2012[32]). The main goal seems to be to avoid what the commission (European Comission, 2010b) calls "*Sluggish Recovery*" and "*Lost Decade".* These are scenarios that represent a context in which the EU fails to address current obstacles to growth, thus facing wealth losses. The "*Sustainable Recovery*" optimistic scenario is one in which Europe is provided with conditions for closing the gap with the pre-crisis growth path, being able to raise its potential and achieve higher levels of output. The greatest challenge is, then, to invest in innovation-driven activities in a situation that involves political efforts towards governmental spending cuts (Mitsos et al, 2012).

In the Europe 2020 strategy, research and innovation appear in the five broad targets proposed by the commission as one of the core areas in the creation of a stronger and more competitive market in Europe. In another of its recent communications (European Commission, 2010b), the overall proposition is to enhance the European innovation system through a better institutional framework that promotes closer integration between countries (a recurrent subject in EC's communications, even before Europe 2020 strategy), hence achieving higher returns from innovation investments, i.e., increased productivity of the bloc's innovation system.

We can, thus, attribute to these initiatives the search for a stronger coordination of innovation policies across the European Union, as well as an approximation of Member States' innovation systems. According to the European Commission (2008; 2012), such integration, along with closer coordination in R&D efforts between Member States, is expected to foster both competition and cooperation within the bloc, thus providing the continental innovation system with more dynamic settings (Georghiou, 2001; European Commission, 2002; Álvarez, 2004; Kuhlman & Edler, 2003; Eureka, 2001). This trend represents that

[32] Before the crisis, the competitiveness issue had been raised a number of times by the EC, and innovation was also at the core of its propositions. See, for example, European Commission (2004).

technology is becoming international in nature, making it difficult to manage related policies solely on the national level (Archibugi & Iammarino, 1999).

In the center of this institutional “reform” lays the concept of the Innovation Union[33] flagship. One of the relevant issues is that there is still a high level of fragmentation and duplication in European innovative efforts, which is a result of domestically-oriented policies, as well as to transaction barriers (such as different legislations, IPR, languages, cultural backgrounds, etc.) that hamper EU’s functioning as a economic union.

The main strategy to tackle these challenges is the development of the ERA, which aims at bringing together regional and national innovative policies and initiatives[34]. The underlying rationale of the ERA relies on the concept of a European internal market and its economic implications, as well as a bloc-wide coordination of RTD policies (see, for example, European Commission 2006, among other EC’s communications that can be found in our References, and Georghiou, 1994[35]). The ERA builds upon an increase of the integration between EU Member States in terms of Science and Technology and also to augment the resources dedicated to such activities, thus generating a unique innovation system across Europe (European Commission, 2008). It seeks to support the proposition of the Lisbon Summit in 2000, i.e., to turn Europe into the most dynamic and competitive knowledge economy in the world (European Commission, 2007).

The importance of this integrated research area is reflected in the fact that in virtually every RTD policy communication from the EC it can be noticed that a substantial part is dedicated to the ERA’s implementation. Currently, one major

[33] The Innovation Union flagship is part of the Europe 2020 strategy and searches for innovative developments in key areas for society, such as: climate change, energy and resource efficiency, health, transport and demographic changes.

[34] For example, in our datasets, several companies have highlighted issues with the synchronization of funding between partners in the network. Georghiou et al (1999) had also identified such constraints. This aspect is of core interest to understand that networks’ transaction costs that affect their respective managerial stability can be highly influenced by external agents such as financing bodies.

[35] Georghiou (1994) makes reference to the specific case of the Framework Programme, where he states that this initiative is justified by its impacts on industrial competitiveness.

additional benefit that a strong ERA would generate is related to a more efficient use of existing resources, considering the economic turmoil which Europe has been facing for the past 5 years. In a recent evaluation of socio-economic benefits of the European Research Area, Mitsos et al (2012) argue that such efficiency is related to gains in economies of scale related to research efforts. The authors, however, highlight that the ERA does not aim at creating a centralized structure for RTD policy across Europe, but rather to provide a framework for *coordination* between regional, national and continental initiatives.

In 2011, the European Commission has released the Horizon 2020 initiative, which is part of the Innovation Union flagship[36]. This particular policy guideline is one of centralizing EU's innovation related activities, reducing wasteful duplication of efforts and building upon existing synergies in the bloc (for further details, see European Commission 2011a). It is expected that this centralization can minimize bureaucratic costs for research and innovation, thus providing innovation systems with more dynamic public responses.

One important implication for international R&D cooperation in Europe is that the Framework Programme is going to be part of this initiative, indicating its possible interactions with other pan-European actions. Moreover, the Horizon 2020 initiative is also explicit in highlighting the importance for the EU to develop closer ties with the international context (non-European nations), where economic approximation is understood as key to achieve competitiveness and to help developing connections with different innovation systems. This view is also shared by the EC in the definitions of the European Research Area (European Commission, 2007).

The review of the abovementioned reports provide a perspective that EU's innovation policy settings, as well as the promotion of the ERA, rest on a top-down

[36] In order to assess the evolution of these proposals, the European Commission evaluates a group of relevant indicators through Innovation Union Scoreboards (including a "linkages & entrepreneurship" section, dedicated to R&D cooperation).

structure of incentives and conditions for Member States' innovation systems to integrate into a continental-scale system that achieves higher performance in innovative capabilities. Nonetheless, it is important to highlight that such documents call for deeper private-side engagement in the new structural framework of the EU. It is a valid argument, since innovation will ultimately rely on their market exploitation[37].

But contributions of international cooperation in R&D, for as many benefits as they are expected to promote, must be addressed skeptically in terms of their actual assistance to innovation systems. While in impacts on individual firms contribute to a microeconomic understanding of these quasi-market relationships, more systemic (or macroeconomic) effects can be less prominent. Filippetti, Frenz and Ietto-Gillies (2009), for example, using recent data from the European Innovation Scoreboard and Community Innovation Survey, find no statistically significant relationship between internationalization and international collaboration constructs.

Similar findings are presented by Frenz and Ietto-Gillies in a different assessment, where they add that international cooperation is likely to provide firms with *lower* levels of benefits than domestic linkages (Frenz & Ietto-Gillies, 2009). Together with the growing trends of such activities, we can analyze this outcome as potentially representing that international R&D cooperation benefits in terms of innovative capacity are still predominant in microeconomic levels, whereas more systemic spillovers are not satisfactory. Nonetheless, further integration between Member States' economic (and innovation) systems can lead (in the long run) to a situation in which the terms "domestic" and "international" can merge within the European Union, thus maximizing the externalities of R&D alliances.

[37] One main practical reason that hampers closer interaction between companies across different nations in the EU (international R&D collaboration) is the high costs of cross-country patenting in Europe.

3.1.2 Theoretical notes on the effects of domestic and international R&D collaboration on trade policy: outlines for the implementation of the European Research Area

The increasing amount of international R&D networks is a phenomenon that also poses challenges for governmental intervention regarding industrial and trade policies. These aspects face a more complex landscape than that based solely on international R&D competition (often in an indirect basis) and which relies mainly on R&D subsidies for local companies - as international R&D cooperation of firms is not independent from commercial relationships between the involved countries (Zu et al, 2011).

It seems legitimate to assume that, for the reasons depicted in section 2.1, (international) R&D cooperation policies foster the competitiveness of local firms in any given country that engages in such industrial strategy. For example, domestic governmental R&D incentives provide firms with similar strategic outcomes to those achieved through export subsidies, with the clear advantage of being accepted by trade regulations (Spencer & Brander, 1983), not to mention the likelihood of increased welfare levels in the home-market.

If we transfer this rationale to the proposition of (international) R&D collaboration, outcomes would be similar, since they would indirectly reduce individual R&D costs for firms (Qiu & Tao, 1998; Zu et al, 2011). Nonetheless, considering the specific case of international networks, collusive agreements regarding agents' local markets could distort competitive equilibrium, making the case for close regulation of such agreements[38]. The relevance of this proposition is

[38] From the industrial economics perspective, Goyal and Moraga-González (2001) find that international R&D collaboration can offer firms with optimal profitability when these agents keep their activity in independent markets, suggesting that trade and FDI amongst collaborators' countries could lead to decreasing returns (which would hold for both homogeneous and differentiated goods).

conditional upon the level of existing rivalry/concentration of industries involved (as suggested by Motta, 1996).

Theoretical research regarding the role of international R&D cooperation in shaping countries' trade policy does not reach conclusive results, where implications are highly dependent on the structure of payoff matrixes, as well as on the competitive approach undertaken (Cournot *vs.* Bertrand). Considering welfare effects (which should act as the main element in economic policy choices), Carlson (2008) finds that international R&D cooperation does not provide countries with jointly optimal results, even though "governments have an incentive to commit themselves to allowing cooperation in R&D" (Carlson, 2008, p. 363), because of individual gains for allowing cooperation. To achieve such conclusions, she bases her developments on price competition (Bertrand), where R&D cooperation would act as profit maximizing considering its effects on the reduction of production costs in differentiated goods, even though cooperation would cause incentives for opportunistic behavior in face of high levels of technological spillovers.

On the other hand, Motta (1996), using a Cournot competition scheme finds that overall (domestic and foreign) welfare is improved when governments engage in international R&D cooperation initiatives. He also proposes that R&D cooperation policies foster firms' competitiveness in foreign markets when economic integration takes place.

However, the relationship between the promotion of international R&D cooperation and strategic trade policy seems to rely more on theoretical discussions than on empirical findings, considering worldwide trade laws that regulate free trade among countries, especially developed ones. This reduces governmental flexibility in defining "optimal" trade policies for domestic firms according to results found in literature. Especially in the EU, the existence of free flow of goods encompasses reduced levels of usefulness of such discussions.

Nonetheless, Zu et al (2011) assume that their model settings are particularly relevant for this specific case, achieving results that suggest that “bilateral trade liberalization may be detrimental to R&D collaboration” (Zu et al, 2011, p. 337), a proposition that is based on the doubtful assumption that increased competition hampers incentives for R&D investments[39]. Clearly the managerial trends of establishing R&D networks within this bloc point in a different direction as outlined in section 3.1.1[40]. The European Commission in its turn has recently published a communication which states that increased competition within the European Union is highly desirable for stronger innovative capabilities to arise in the continent (European Commission, 2012 – the same perspective is supported by Mitsos et al, 2012). In the same document, closer cooperation between firms, universities and research institutions is acclaimed as a fundamental tool to achieve more satisfactory results. We can find a similar position in the presentation of the Europe 2020 strategy (European Commission, 2010b), in the Green Paper about the European Research Area (European Commission, 2007), as well as in many other EC’s communications. Nonetheless, concerns about competitive dynamics exist (monopolies, collusive agreements, etc.), requiring industrial and market policies to be enforced (European Commission, 2008).

But even if we would extend this discussion to other countries, we do not have many examples of nations functioning as autarkies (one of extreme conditions that authors usually apply in opposition to “free trade”). Neary and O’Sullivan find that adversarial R&D policies perform better for domestic welfare than internationally collaborative initiatives. These studies focus solely on horizontal cooperation, thus not considering the widespread use of (international) collaboration as a source of extending firms’ capabilities in a vertical manner. Katz (1986), for example, considers that vertical cooperation would be the most

[39] Motta (1996) states that risks of international R&D collaboration in markets with free trade agreements lie upon the possibility of collusive agreements, not on reduced incentives to individual R&D because of increased competition. This proposition seems to better fit the usual economic rationale. A similar rationale is provided by Georghiou et al (1999) in a strategic evaluation of Eureka’s relevance in Europe.

[40] The European Commission (e.g., European Commission, 2009) recognizes the need for closer integration between countries as a mechanism not only of creating a larger market, but also to bring together a wider pool of competences, as well as to foster stronger competition within the bloc. Increased levels of trade would thus result in more incentives for firms to engage in activities that would grant them with higher levels of competitiveness.

beneficial in welfare terms (and it represents the bulk of Eureka's projects according to the sample used in this research).

3.2 How to achieve "optimal" RTD policy? The process of RTD policy evaluation

Since R&D policies can be considered fundamental for long-term development and are subject to an ever-changing environment, there is a strong need to continuously evaluate their effectiveness (Bayona-Sáez & García-Marco, 2010). Furthermore, as pointed out previously, emphasis should be given to policy trials and their evaluation, i.e., the process of adaptation may consist in trials and errors (Metcalfe & Georghiou, 1997). There is a continuous need for better understanding of innovation processes and policies aiming at its promotion (European Commission, 2002), especially because *innovation is disruptive by nature, and it breaks established patterns of behavior, giving rise to unpredictable consequences"* (Metcalfe, 1995).

This assertion brings to light the fact that investment in new knowledge is not an exact science and will not necessarily provide firms with the anticipated returns in terms of competitiveness, which also indicates that these investments may not turn into commercialization of outcomes (Audretsch & Keilbach, 2008). Nonetheless, it is fundamental for market-oriented innovation policies to take into account not only technical aspects, but also potential and actual market impacts of projects (NIST, 2006).

In order to cope with such aspects, technological policy evaluation provides a systematic and valuable way of adaptive learning based on the analysis of practical situations, thus representing a resource of great potential for policymakers (Georghiou, 2002; Malik & Cunningham, 2006; NIST, 2003). The process of analyzing and evaluating RTD policies represents the possibility of achieving improvements in policymaking process, both in terms of policies' suitability to a specific context and to achieve managerial progresses in existing programs.

The structure of relationships within a system, knowledge flows, existing capabilities and market conditions also shape the context for an innovative environment to develop. This poses the relevance of innovation policy in fostering a mosaic of desirable characteristics and that might take some time to be implemented, which can only be accomplished through methodical and frequent evaluation (European Commission, 2006a).

In historical perspective, research evaluation has been taking place in OECD countries since the 1970´s with a noticeable increase in the 1980's, when they were institutionalized in many different nations (Luukkonen, 2002; Langfeldt, 2004; European Commission, 2006a). In the 1990's, RTD evaluation has evolved towards a more formative activity in order to provide policymakers and other stakeholders with valuable insights and recommendations (European Commission, 2002). It is worth mentioning that in Europe there is not a homogeneous RTD evaluation culture yet (European Commission, 2006a). This might represent some extra challenges for policymakers, since the promotion of bloc-wide policies must consider the idiosyncrasies of Member States in order to be fully effective.

The European Research Area poses new opportunities for integration and evolution of the continent's innovative capabilities, but it also represents higher levels of difficulty in designing, managing and evaluating its related policy instruments (PREST, 2002). An interesting recommendation from this same report tells that it may be needed the creation of a "European Evaluation Area" which could offer common methodologies for the assessment of RD policies within the ERA.

Evaluation provides measures for success, thus contributing to evolution and improvements of existing initiatives (NIST, 2003), which is dealt mainly with assessments on programs' efficiency and efficacy, i.e., how well the initiative worked, if achieved its goals or not, and its contribution to the overall policymaking arena (European Commission, 2006a; Georghiou & Keenan, 2006). Hence, evaluation activities consist basically in systematically and objectively determining the relevance, efficiency and effect of an activity considering its objectives, providing policymakers with feedbacks on the impacts of such initiatives and creating fundamental knowledge for the promotion of necessary adjustments for future policies' formulation and implementation (Durieux & Fayl, 1997; European Commission, 2002). Besides making it possible for program managers to assess the benefits of a given initiative, and to identify opportunities for improvement, RTD policy evaluation allows the communication of program's results to society (US Department of Energy, 2007).

In addition to the capacity of providing feedback, a technological policy evaluation system must ensure the periodicity of analysis and guarantee the independence of evaluators (Georghiou, 1997). This implies the idea of permanent non-biased observation which in theory means the possibility of dynamic evolution of technological programs. Consequently, the significance of RTD evaluation lies on the assumption that better policymaking must be based upon knowledge and empirical evidence (European Commission, 2006a).

Currently, the growing complexity involved in technological generation increase uncertainties on impacts from RTD policies (European Commission, 2002). Moreover, policy instruments have become extremely diversified, thus implying a need of a more diverse and complete group of analytical tools. Accordingly, evaluation activities and the identification of policy "best practices" in OECD countries represent a complicated task given the myriad of technological initiatives that take place in these nations (ranging from basic research direct support to more indirect measures aimed at improving the capacity of firms to innovate and use new technologies) (Durieux & Fayl, 1997).

The simple input-output analysis (the famous linear model) does not necessarily allow the evaluator or researcher to assess innovation impacts thoroughly. For example, there is skepticism towards the validity of many evaluation measurements due to difficulties in attributing impact to particular initiatives (e.g., European Commission, 2002; Luukkonen, 2002; Gibbons & Georghiou, 1987[41]) and issues with lags between the time in which a project was undertaken and the time when the results arise (e.g., Luukkonen, 2002; Georghiou, 1999; Gibbons & Georghiou, 1987).

Like science in general, technological policy evaluation might also be considered as a research and scientific matter (Georghiou, 1999). As a consequence, evaluation of technological policies faces an inevitable dualism between quantitative and qualitative approaches. The distinction is made depending on the objective planned for the analysis: quantitative methods are focused on measurement of socioeconomic impacts and qualitative ones regard the evaluation of strategic importance of activities (Luukkonen, 2002).

Technically, the relationship between both approaches is complementary, providing a deeper understanding of a program's characteristics, benefits, and shortcomings, emphasizing that there is no single method in RTD evaluation that can answer all of the relevant questions involved (Durieux & Fayl, 1997; US Department of Energy, 2007; European Commission, 2006a). Roessner (2000) and Gibbons and Georghiou (1987) point out that any proposed opposition between quantitative and qualitative evaluation methods is a fallacy: the adequate methodological design must consider the objectives of the evaluation, *and not the other way around*. A clear implication of this conclusion is that there is no optimal approach for the evaluation of technological policies (Georghiou & Keenan, 2006). This does not mean, however, that some approaches are not better suited to

[41] These authors suggest that direct evaluations using tangible indicators would not capture improvements in firms' capabilities or an increased absorptive capacity. This critique to the use of tangible indicators is also supported by the evaluation guide "*Smart innovation: a practical guide to evaluating innovation programmes"* published by the European Commission (2006a). This latter document also highlights the virtual impossibility of identifying additionality in social sciences, given the incapacity of researchers to perform purely experimental studies.

respond specific evaluation concerns than others, but, as state above, that evaluation methodologies must be defined according to research intentions[42].

Some of the most well-known methods for innovation policy evaluation consist of independent expert panels, interviews, use of questionnaires, surveys, core indicators, case studies and micro-level econometric analysis (Durieux & Fayl, 1997; Grupp, 2000; European Commission, 2002)[43]. But any given evaluation method will at best provide partial answers to the numerous economic and societal goals of RTD policy (European Commission, 2006a). When framing such assessments in time, evaluation can be undertaken:

a) *Ex ante*, before the implementation of the program and focusing on its structure and goals;
b) During the course of the program, which can occur in the intermediate level, which analyzes the progress of the program, or in real-time, which follows the initiative in detail throughout its operation; and
c) *Ex post*, evaluating the results of a given policy, corresponding to the bulk of evaluation activities, which is usually an efficient tool to assess intermediate and long-term impacts (European Commission, 2006a).

Next, a set of examples (table 6) of evidences on policy evaluation drawn from some relevant sources (journals and reports) are provided, using the conceptual constructs shown in table 5, i.e. Market Failures, Innovation Systems, Behavioral change/Additionality and Adaptation of RTD policies. Also, on table 7, we offer an outline of the most relevant theoretical aspects gathered in this section.

[42] I would like to thank Prof. Vítor Simões for this contribution.
[43] One specific methodology that has been widely used regarding the latter approach (micro-level econometrics) is that of counterfactual analysis, or quasi-experimental methods, which consist in assessing firms' behavior with and without intervention, using two separate samples of very similar individuals (firms). We provide a discussion on this particular kind of evaluation in section 7.2 Methodological Discussion.

Scope	Findings	Authors
Market Failures	European Institutions support firms which are not dependent on governmental help, leaving those that need it the most without financial or networking support.	*Barañano, 1995*
	Incentives often do not reach the targeted population, since selection is not accurate enough.	*Blanes & Busom, 2004*
	Econometric analyses show an inherent selection bias in firms participating in R&D initiatives	*Czarnitzki & Licht, 2006*
Adaptation of RTD Policy	Frequent changes in RTD policy reduce its effectiveness	*Guellec & van Pottelsberghe de la Potterie, 2000*
	Success in a RTD program can come via: a) achievement of technical objectives; b) commercialization; c) patents; d) acquisition of new knowledge; and e) formation of networks.	*Dyer & Powell, 2002*
Behavioural change/additionality	Applying a linear idea to evaluate the impacts of an initiative such as the Framework Programme might lead to an underestimation of its impacts because of its systemic contributions.	*Georghiou, 1994*
	Formal R&D projects only capture part of firms' efforts to innovate and that their activities start previously and end after their participation in a given project.	*Georghiou, 2002*
	There is a large degree of additionality from public R&D support in both input (R&D expenditure) and output (patent applications) indicators.	*Czarnitzki and Licht, 2006*
	The issue of "additionality vs. substitution" regarding R&D interventions remains blurry as many conflicting answers have been provided by literature (using evidence from sources over a period of 35 years).	*David, Hall & Toole, 2000*

	The Small Business Innovation Research in the US generates a substitution effect on R&D spending instead of the desired additionality.	*Wallsten (2000*
	There is additionality in R&D subsidies, but only for the case of small firms.	*Loof and Heshmati (2005*
	The Framework Programme has been successful in promoting linkages between researchers in different countries, but it has failed in generating long-lasting networks of institutions and firms.	*Grande & Peschke, 1999*
	Technological policy effectiveness is usually assessed with a comparison of matching samples of companies, where researchers expect that the matched firm will behave in a similar way that the firm engaged in a technological program would without intervention, thus allowing an approximation of additionality measuring – nonetheless, the matching process raises doubts on assessing how similar firms can be.	*Georghiou, 2002*
Innovation Systems	There is little integration in terms of RTD policy in the European context.	*Malik & Cunningham, 2006*
	In the European Union, until the 1990s, the complexity of research activities and knowledge creation preceding the introduction of an innovation as well as the interaction between suppliers and users were largely ignored.	*Pianta & Vaona, 2009*
	It is difficult to attribute technological results to a specific technological policy, considering the array of variables playing a role in the process and that jointly influence outcomes.	*Georghiou, 2002*

Table 6. Examples of results on RTD policy evaluation

Aspect	Main Theoretical Findings	Main sources
Historical Perspective	a) Started in OECD countries in the 1970's with a noticeable increase in 1980's b) In the 1990's, RTD evaluation has evolved towards a more formative activity in order to provide policymakers and other stakeholders with valuable insights and recommendations	*Luukkonen, 2002; Langfeldt, 2004; European Commission, 2006a; European Commission, 2002*
Concept and Approaches	a) Evaluation activities consist in systematically and objectively determining the relevance, efficiency and effect of an activity considering its objectives, providing policymakers with feedbacks on the impacts of such initiatives and creating fundamental knowledge for the promotion of necessary adjustments for future policies' formulation and implementation b) Dualism (complementarity) between quantitative and qualitative approaches c) Some of the most well-known methods for innovation policy evaluation consist of independent expert panels, interviews, use of questionnaires, surveys, core indicators, case studies and micro-level econometric analysis	*Durieux & Fayl, 1997; European Commission, 2002; Luukkonen, 2002; US Department of Energy, 2007; European Commission, 2006a; Roessner, 2000; Gibbons & Georghiou, 1987*
Systemic Impacts	a) Skepticism towards the validity of many evaluation measurements due to difficulties in attributing impact to particular initiatives and lags between the time in which a project was undertaken and the time when the results arise	*European Commission, 2002; Luukkonen, 2002; Gibbons & Georghiou, 1987*
Market impacts	a) Uncertainty of results in terms of commercialization b) Inherent need for market-oriented policies to assess potential and actual market impacts	*Audretsch & Keilbach, 2008; NIST, 2006*
RTD Evaluation in Europe	a) No homogeneous RTD evaluation culture b) The European Research Area represents higher levels of complexity in designing, managing and evaluating its related policy instruments c) Potential need for an European Evaluation Area	*PREST, 2002; European Commission, 2006a*

Table 7. Summary of findings on RTD policy evaluation

4. 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; Kuhlman & Edler, 2003).

Eureka 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; Kuhlman & Edler, 2003). Eureka's goals can be summarized in five items (PREST, 2002):

a) Strengthen European competitiveness;

b) Promote market-driven collaborative R&D;

c) Bring together industries and research institutes across Europe;

d) Foster the use of advanced technologies; and

e) Achieve cost-effective products, processes and services.

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, the nature and scope of proposals is defined by proponents. Bottom-up approaches give micro-agents the opportunity of contributing to technological policies in a complementary way to that of predefining at the macro-level (governmental or supranational) specific areas of interest (Larédo, 1998). A methodological of this structure for this research is that it provides information on “natural” networking activities, i.e., those defined solely by firms’ interests, instead of directed efforts towards predefined areas of governmental focus. Results are then likely to provide measures that can be related to international R&D collaboration in general, not only to specific circumstances.

Eureka is present in 38 countries and does not act through financial support, but by providing projects with a seal of approval that facilitates access to governmental funds in the national level (Molero, 2001; Stubbs, 2001; Georghiou & Roessner, 2000). Moreover, Eureka promotes and facilitates access to public and private investment in R&D through well established collaborative research networks and proximity to market (Eureka, 2006).

Most operations are managed by national offices (NPCs), including the coordination of funding among participants’ countries of origin, where Eureka Member States play a central role in supporting (strategically and financially) coordination between Eureka projects and other related RTD initiatives at national and regional levels (Eureka, 2006a). The whole process is backed up by the Eureka Secretariat, which also is responsible for the continuous evaluation of individual projects[44] (Eureka, 2001; Eureka, 2002a).

Eureka has three categories of projects: individual, cluster and umbrella (Eureka, 2002):

a) ***Individual projects*** form the core of Eureka and represent projects comprising agents from at least two of the Eureka Member States, aiming at generating a significant technological advance. ***These individual projects represent the bulk of Eureka’s actions, and also the sample under analysis in the empirical stage of our research.***

[44] In Spain, this role is played by the Centro para el Desarrollo Tecnológico Industrial – CDTI, an agency of the Ministry of Economy.

b) ***Eureka cluster projects*** set a practical framework for cooperation, managed entirely by industry. These projects last longer than individual projects and work on generic technologies of high importance for European competitiveness.
c) The ***umbrellas*** represent thematic networks focusing on specific technological areas. In this approach the bottom-up structure is not valid.

4.1 The economic logic behind Eureka: signaling in a context of information asymmetry[45]

The creation of innovative networks across Europe with market oriented projects can be regarded as the ultimate goal of Eureka, and it represents its core contribution to EU's innovation system. Nonetheless, Eureka does not entitle firms to EU subsidies (it should be noticed that Eureka is not an EU program). The underlying *incentive* behind this initiative is based on its "seal of approval", which should enhance firms' ability to receive support from their respective national authorities (Marín & Siotis, 2008; Eureka, 2002). By conferring an objective seal of quality on a project, Eureka's labeling greatly aids the process of negotiation with public sources of finance. Many member countries even accord preferential treatment to labeled proposals by giving access to specifically reserved funding (Eureka Secretariat, 2005).

As basic microeconomic theory states, information asymmetry is a common feature of business and it means that the seller part of a transaction possesses more knowledge on the product being commercialized than the buyer does (Pindyck & Rubinfeld, 2009; Mankiw, 2008; Akerlof, 1970). In the case of Eureka, the R&D performing company uses the seal of approval in order to provide the

[45] Besides the perspective shown in this section, it can also be attributed to Eureka the role of reducing transaction costs involved in establishing international R&D partnerships by providing agents with a "platform" that sets an interface between firms and regulatory bodies (Georghiou et al, 1999).

market - especially the financial market – with information regarding its innovation project. In this context, Eureka's seal works as a signaling mechanism which aims at reducing the information asymmetry and helping to overcome market failures (on the definition of market signals: Pindyck & Rubinfeld, 2009; Varian, 1996; Mansfield & Yohe, 2003; Mankiw, 2008; Spence, 1973).

What brings special relevance to Eureka is that there is a high level of unpredictability of R&D projects and information on its potential is asymmetrically available between R&D performers (sellers) and investors (buyers) (Hoewer, Schmidt & Sofka, 2011). Edler (2007) also points out the importance of signaling policies regarding innovations. Several other authors 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; Socorro, 2007).

Nonetheless, Eureka faces problems in terms of funding amount and synchronization among partners as well as regarding the lack of private funding (Eureka, 2001a; Eureka, 2002). Also, the lack of funding harmonization between Member Countries hampers the effectiveness of Eureka (European Commission, 2008). More coordination between Eureka and the Framework Programme might reduce disadvantageous competition (for funding) between them, thus increasing their synergies (Kanninen *et al*, 2006). In this regard, the Eurostars Programme has been created, combining strengths from Eureka and the 7th Framework Programme and focusing on international R&D collaboration performed by SMEs with high R&D intensity (10% of total turnover or more).

4.2 General Requirements for Eureka's Individual Projects

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. In general terms Eureka projects must (PREST, 2002):

- Be high-tech, market-oriented R&D projects;
- Involve partners from at least two Eureka Member States;
- Aim to develop cutting-edge, civilian products, processes or services;
- Be funded by partners with public financing from national governments.

Furthermore, Eureka (2003a) launched a manual for firms to better understand the process of project evaluation. The central assessment criteria are grouped as follows (each group receives the same weight in the evaluation):

a) *Crucial Criteria* – financial capacity and formal agreement between partners
b) Basic Assessment Criteria - These criteria deal with the complete project set up and the capabilities of the partners in relation to their tasks in the project.
c) Technology and Innovation Criteria
d) *Market and Competitiveness Criteria* - contains 5 criteria of which 3 are related to market and profitability and 2 to competitive advantages

4.3 Evaluation of Eureka in perspective

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. In 1992-1993 Eureka had its first major evaluation, involving teams from 14 countries working together and conducting a survey with all of the participants (Georghiou & Roessner, 2000). Additionally, Eureka is the focus of several academic analyses. We offer some examples of relevant results found in these evaluations (both external and internal evaluations from Eureka):

- Bayona-Sáez and García-Marco (2010; 2007) demonstrate that participation in a Eureka Programme has a positive effect on ***firm's corporate 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's results, who also highlight an increase in labor productivity and price-cost margins for participants);

- 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;

- Marín and Siotis (2008) conclude that Eureka serves the purpose for which it was designed, namely to ***correct the market failures*** associated with the generation of economically valuable knowledge;

- Fölster (1995) hypothesizes that, given that Eureka projects require cooperation but do not require result-sharing agreements, the ***likelihood of cooperation is not increased***. They promote incentives to conduct R&D to the same extent as subsidies that do not require cooperation;

- Georghiou (2001) affirms that Eureka started with major projects but a ***decline*** since then took part driven by its divergence with national innovation policies;

- Kanninen et al (2006) find that Eureka is a ***beneficial and cost-effective tool for international R&D cooperation*** drawing results from a survey of Finnish companies. Also, ***the relevance of Eureka is influenced by the R&D activities of large companies***. The authors suggest ***that its future importance might decrease*** in face of the Joint Technology Initiatives (JTI) which has a better structure for funding and implementation of larger integrated R&D projects involving international cooperation;

- A report from PREST (2002) concludes that Eureka's ***impacts are often of a complex nature***, being remote from its causes (spatially and temporally), and generating from small scale to broad network effects and market changes. Even though ***they are very difficult to measure economically***, this is done and economic values are given to measurable results. This proposition highlights that evaluations of Eureka projects are ***sensitive to the timing of the evaluation***, since innovations might take some time to take-off in markets;

- The 2003/2004 annual report from Eureka shows that for innovative projects (mainly SMEs), joining Eureka provides a financial return of around €1 million (additional turnover) per participant, and that ***public funds invested are returned in less than two years after project completion*** (Eureka, 2004). This report also suggests strong evidence that ***for SMEs, participation in a Eureka project strengthens market position and facilitates access to new markets worldwide***;

- Over time, ***the rate of commercial achievements as perceived by companies participating in Eureka projects in their final reports has decreased***, with a larger percentage of respondents viewing their commercial achievements as bad or nil (Eureka, 2002);

- The 2005/2006 annual impact review of Eureka (Eureka, 2006) concludes that the initiative has been accomplishing its basic goals. This is gathered from 15 case studies and a descriptive analysis of final reports – 678 participants, 328 projects – between January, 2001 and December, 2005. The report also shows that ***turnover benefits are highly concentrated***, with 12% of projects representing 65% of additional turnover. This latter result is treated as expected given the nature of R&D activities. Additionally, ***the visibility of the Eureka label is seen is a relevant asset for SMEs***: the Eureka seal facilitates access to funding opportunities and increases market image. Another relevant finding of this report is that ***successful projects were never peripheral to firms***.

Such results offer some valuable information regarding our empirical assessment of the drivers of success in Eureka's networks. First of all, as some of the analyses reported above have shown, the effects of international R&D collaboration are often of a systemic nature, with minor *direct* effects, thus causing long term structural changes in firms and, consequently, innovation systems. This hinders the appropriation of short term indicators as complete sources of information, such as the ones used in our analysis. Nonetheless, this perspective can be useful in evaluating statistical outputs of our approach.

Furthermore, SMEs, contrary to our expectations based upon Absorptive Capacity literature, seem to receive more benefits from these projects than larger firms. Nonetheless, as Kanninen et al (2006) pointed out, networks are highly dependent on large companies that function as the core player of alliances. Therefore, some balance between the two kinds of firms seems to provide networks with the synergies required for increased performance.

Also, a combination of different results is somewhat interesting. While Georghiou have stressed the declining levels of technological relevance in Eureka's projects, Eureka itself (Eureka, 2002) has recognized an increasing level of commercial *dissatisfaction* from firms. Put together, both perspectives offer a complementary view of this phenomenon, where less relevant "innovations" will hardly provide economic agents with large commercial gains.

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 presented results are mainly positive, continuous assessments and 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. In table 8 we conclude this section with an outline of the most important features regarding the Eureka initiative and its individual projects.

Aspect	Main Theoretical Findings	Main sources
Objectives	a) Enhance competitiveness throughout Europe b) Provide a framew ork for market-oriented R&D collaboration based on international cooperation c) Generate behavioral additionality regarding international innovation netw orks	*León, 2006; Stubbs, 2001; Georghiou, 2001; Marín.& Siotis, 2008; Kuhlman & Edler, 2003; Georghiou & Roessner, 2000; Bayona-Sáez & García-Marco, 2010; Trabada, 2000; Molero & Fonfría, 2008; Marín.& Siotis, 2008; Kuhlman & Edler, 2003; PREST, 2002*
Economic Rationale	a) Information asymmetry reduction through market signals (Eureka label) b) Integration of European NSI c) Behavioral additionality	*Marín & Siotis, 2008; Eureka, 2002; Hoewer, Schmidt & Sofka, 2011; León, 2006; Stubbs, 2001; Georghiou, 2001; Marín.& Siotis, 2008; Kuhlman & Edler, 2003*
Characteristics	a) Bottom-up approach b) Market-oriented projects c) Decentralized	*Georghiou & Roessner, 2000; Bayona-Sáez & García-Marco, 2010; Trabada, 2000; Molero & Fonfría, 2008; Marín.& Siotis, 2008; Kuhlman & Edler, 2003; PREST, 2002*
Overview of Evaluations on Eureka	a) Positive impact on corporate performance w ith a 1-year time-lag after project completion b) Relevance of large companies' R&D activities in projects c) Reduces information asymmetry through an improved image of companies/agents d) Evaluations are sensitive to the timing of evaluation e) Results may be of a complex nature f) Enhances SMEs' market position both domestic and international g) Turnover benefits are highly concentrated h) Successful projects are not peripheral in firms' strategies	*Bayona-Sáez & García-Marco, 2010; 2007; Benfratello & Sembenelli, 2002; Barañano, 1995; Marín and Siotis, 2008; Kanninen et al, 2006; PREST, 2002; Eureka, 2004; Eureka, 2006*

Table 8. Summary of findings on the Eureka Program

5. A Brief Outline of the Spanish Relative Position

In this section we offer a restricted perspective on the Spanish Innovation System and some comparison with the benchmark countries of our analysis (Germany, France, UK, and Italy). It is not our intention to develop a thorough and exhaustive review on these aspects, but rather to offer enough contexts to base further analyses on, thus providing relevant knowledge for upcoming conclusions and implications.

Spain has suffered drastic economic changes as a result of its inclusion in the Eurozone, since above normal inflation and rising wages depleted the country's longstanding advantages in terms of international competition (Heijs, 2011). The construction of a modern and efficient innovation system is still a challenge for Spain. Even though, in the last decades, the country has experienced a modernization of its productive structure, which provided an improvement in economic and social indicators (MICINN, 2009), this situation did not reflect into a strong growth in technologically advanced sectors, keeping the country in a laggard position in comparison to other developed nations in terms of innovation (Molero, 2010; López, 2008).

We can attribute such condition to a lack of R&D investment from firms in these sectors (as well as the productivity of such investments), as research highlights the expected – and somewhat obvious - role played by R&D investment as a core determinant for firms in achieving higher rates of growth (Segarra & Teruel, 2011). In fact, the productive structure of the Spanish economy is still a barrier for a more innovation-oriented society: product innovation in Spain is largely based on developments from SMEs, while the majority of innovations lie in large corporations (CDTI, 2009), especially multinational ones (Revilla-Diez, 2000). This situation indicates a rather concentrated and internationally dependent structure of the Spanish Innovation System. While this indicates an apparent weakness, it highlights the importance that initiatives promoting the creation of the European

Research Area through integration of the NISs of EU's Member States (such as Eureka) can have in benefiting domestic firms in Spain.

The problem is that there is a great deal of such SMEs focused on traditional sectors and a absolute lack of a critical mass of R&D intensive national and large corporations that can play a leading role in establishing networks of innovation (Heijs, 2009). Moreover, the Spanish Centre for Industrial Technological Development (CDTI) claims in a 2009 report that there is a need for companies from this country to invest in innovation in order to become more competitive, a perspective that is also supported by a 2007 report by COTEC (Spanish Foundation for Technological Innovation). In summary, the main factors hampering innovation in Spain are associated with (González, Jaumandreu & Pazó, 2005):

a) A model of growth largely based in sectors with low innovative propensity;
b) Unavailability of venture capital;
c) Lack of coordination between the education system and companies' needs;
d) Rigidities in public administration; and
e) R&D subsidies acting more as substitutes to private investment than they act as generators of additional R&D expenditure.

However, it cannot be neglected that Spain's internal market has lower levels of financial strength to absorb innovative products and services, thus creating an environment which does not provide enough incentives for firms to invest larger fractions of their turnovers in R&D. This situation has been increased by the 2008 financial crisis and its direct impacts on the Iberian economy, causing a demand turmoil, hampering all kinds of investments from private entities.

From this context, it can be noticed that Spain suffers from endemic structural problems in terms of building efficient innovative capabilities. There is a great deal of disorganization playing a role in hindering a stronger NIS in this country. Even though financial investments are necessary, they will not be sufficient to tackle the situation in an optimal manner, since resources are prone to be ineffective in the current business and institutional configuration.

To support this perception, graphs 1, 2, and 3 offer both an *input* overview of the Spanish Innovation System, and an *output* approach, building a comparison with our benchmark countries (Germany, Italy, UK and France)[46]. Graph 1A shows a picture of Gross Expenditure in the Business Sector as a percentage of GDP, placing Spain and Italy with similar profiles, where both countries lag behind France and UK (in an intermediate position in this context), and Germany (the sole leader). Regarding innovation, this indicator summarizes the efforts firms dedicate toward structured R&D activities, thus comprising important information on the intensity devoted by companies in generating technological advancements. This picture supports the initial perspective that Spain plays a peripheral role in terms of innovation-driven economic development.

In graph 1B the picture follows a very similar pattern as to the previous one, now analyzing Total R&D Personnel, except that the distance between Germany, France and UK is reduced, putting these countries in a similar level, whereas Spain and Italy still lag behind in terms of innovation *input* indicators. This complementary information to that outlined in graph 1A presents the confirmation of the fact that Spanish firms lag behind its peers (except for Italy) regarding economic orientation towards RTD activities.

Concerning the information contained in graph 1C (Business enterprise R&D expenditure per manufacturing sectors according to technological content), Spanish firms clearly invest less than the benchmark countries in recent periods. What is more discomforting is that this difference is increased in sectors with higher technological content, possibly identifying an industrial structure not as intensive in innovative activities as the ones located in the other analyzed nations (as suggested by Heijs, 2009). For example, German firms invest ten times more than Spanish ones in High-Tech Manufacturing, whereas this difference drops to twice as much in traditional subsectors. Graph 1D confirms these same trends for human resources involved in R&D activities. This provides important information on

[46] Additional material can be found in Appendix I.

how fragile the Spanish Innovation System is in a context of developed countries. If Spain was in a similar level to that of Italy in graphs 1A and 1B, graphs 1C and 1D put them in different conditions, where the former lags behind the latter in these more specific indicators. This should be seen as a warning concerning the possibilities of Spain to achieve sustained growth over the long run.

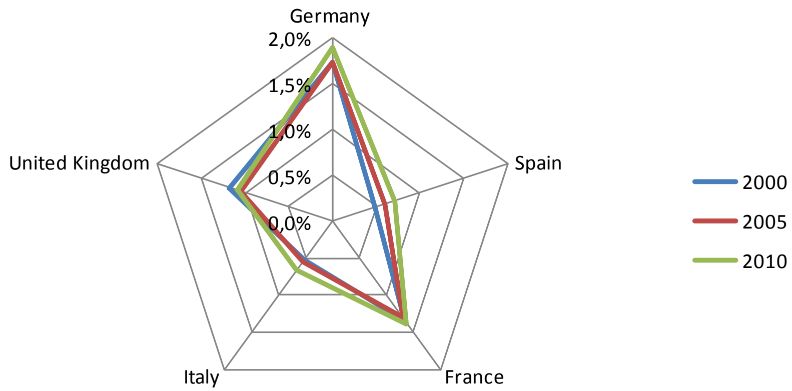
Turning to graph 2, we start to draw some lines along the perspective of innovation *output* indicators. Graph 2A brings information on the trade balance of High-Tech goods, where Spanish trade shows an increasing deficit trend until 2009, when this situation is attenuated (though this can account for the reduced importing capacity of the Spanish economy after 2008). In similar positions are Italy and the UK, where the former follows a parallel pattern to that of Spain (consistent deficit) and the latter has experienced losses in its High-Tech trade balance from 2002 on. France and Germany show a relatively stable situation of surplus throughout the series. This indicator makes it evident the lack of international competitiveness of the Spanish industrial structure over time.

Graph 2B highlights a similar assessment, but related to the balance of Royalties and License fees, a usual indicator of a more *soft side* of knowledge-intensive activities' internationalization. The picture here is somewhat different to that of trade, at least for the cases of UK and Germany, since the first operates surpluses, while the second ran deficits (except for the very end of the series). On the other hand, France maintains a positive balance, whereas Italy and Spain sustain deficits again.

In Graph 2C we analyze High-Tech patent applications to the European Patent Office. In this case, Spain lags behind all of the other countries, even though the difference to Italy is significantly less substantial (still, it represents about half of patent applications per million inhabitants in comparison to this nation). It is also worth noting a gradient reduction in applications across all countries under analysis.

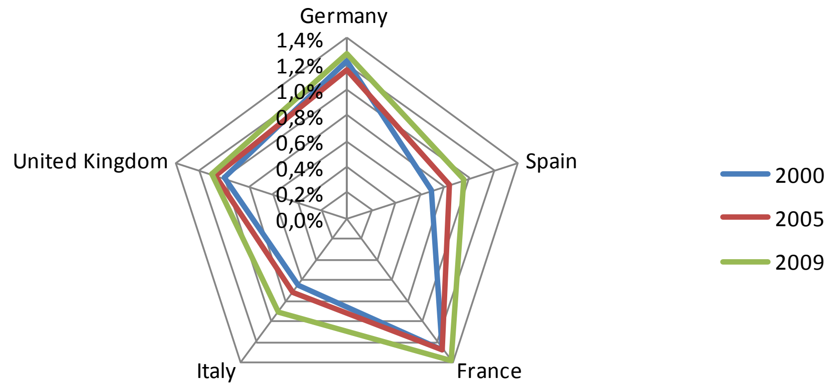
A

Gross Expenditure in R&D – Business Sector



B

Total R&D personnel as a percentage of active population (FTE)



C

Business R&D expenditure in manufacturing (millions of euro)

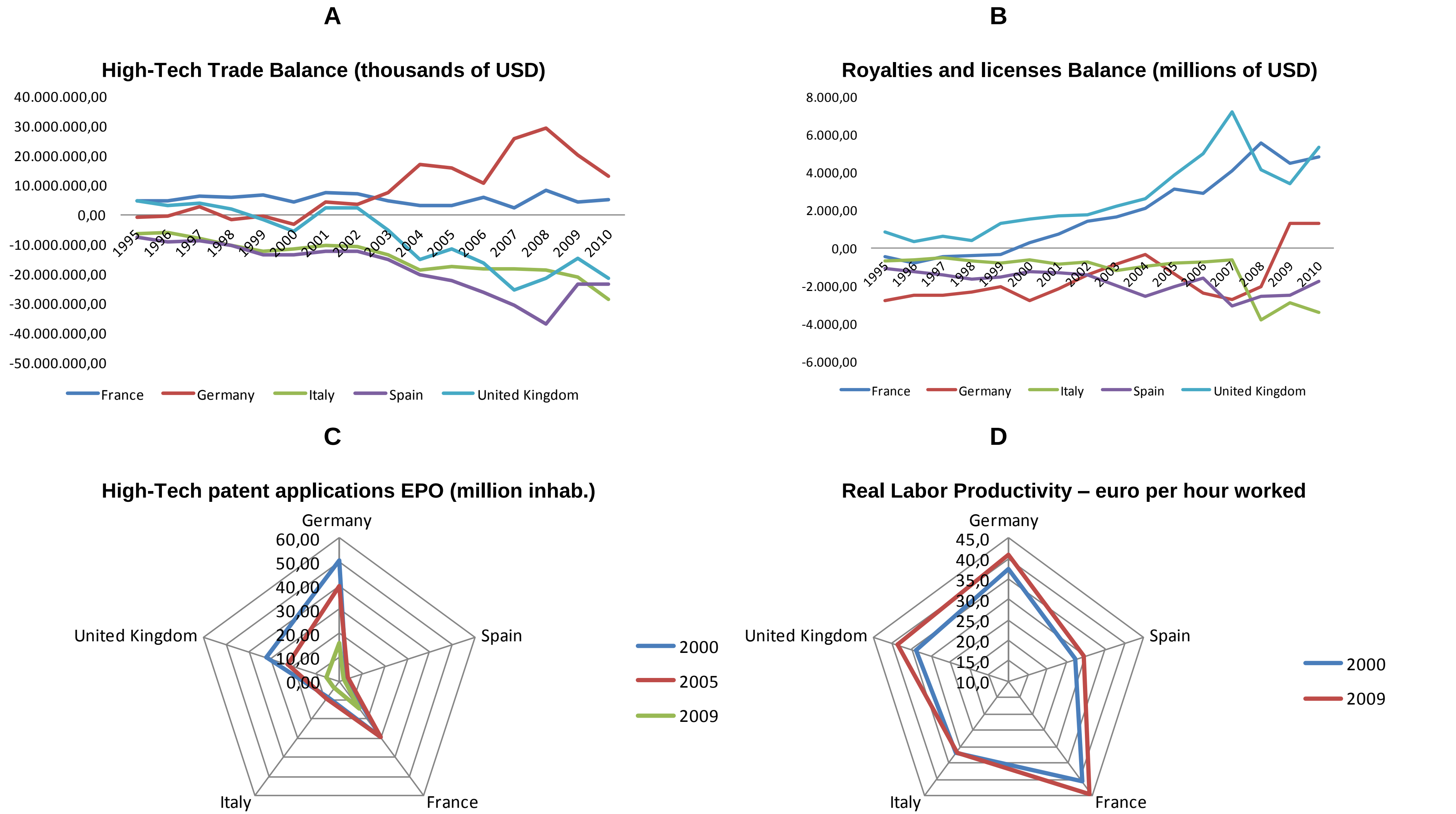
	Business Enterprise R&D expenditure - MANUFACTURING							
	High-Technology		Medium-High		Medium-Low		Low-Technology	
	2008	*2009*	*2008*	*2009*	*2008*	*2009*	*2008*	*2009*
Germany	9.889	9.711	27.009	24.907	2.809	2.984	1.071	1.109
Spain	***920***	***905***	***1.469***	***1.510***	***552***	***478***	***494***	***435***
France	4.340	4.208	8.002	6.930	1.765	2.178	789	749
Italy	1.678	1.806	4.049	3.867	820	729	691	729
United Kingdom	1.956	1.554	4.316	3.546	1.060	1.200	452	450

D

Total R&D personnel in manufacturing (FTE)

	R&D Personnel FTE - MANUFACTURING							
	High-Technology		Medium-High		Medium-Low		Low-Technology	
	2008	*2009*	*2008*	*2009*	*2008*	*2009*	*2008*	*2009*
Germany	73.438	68.891	180.875	171.719	24.573	24.297	10.457	9.840
Spain	***8.459***	***8.528***	***16.844***	***17.265***	***6.533***	***5.915***	***6.988***	***6.702***
France	35.101	33.264	62.226	54.966	17.830	20.144	8.211	8.360
Italy	na	15.104	na	38.682	na	10.066	na	11.320
United Kingdom	16.925	14.236	34.671	32.008	10.270	10.033	4.546	6.737

Graph 1. Summary of input indicators on National Innovation Systems for selected countries
Source: Eurostat, 2012 (A,B,C, D).



Graph 2. Summary of output indicators on National Innovation Systems for selected countries
Source: OECD Stat, 2012 (A) World Development Indicators, 2012 (B), Eurostat, 2012 (C, D).

	Composition of Enterprises - MANUFACTURING							
	High-Technology		Medium-High		Medium-Low		Low-Technology	
	2008	*2009*	*2008*	*2009*	*2008*	*2009*	*2008*	*2009*
Germany	4,1%	5,0%	20,4%	20,0%	35,3%	36,9%	40,2%	38,2%
Spain	***1,6%***	***3,9%***	***9,7%***	***14,4%***	***37,0%***	***29,4%***	***51,7%***	***52,4%***
France	2,2%	2,1%	11,2%	10,2%	27,3%	29,3%	59,3%	58,4%
Italy	1,6%	1,6%	12,6%	13,4%	35,6%	35,6%	50,2%	49,4%
United Kingdom	6,0%	6,1%	16,5%	15,7%	35,4%	36,3%	42,1%	41,9%

	Value Added at Factor Cost - MANUFACTURING							
	High-Technology		Medium-High		Medium-Low		Low-Technology	
	2008	*2009*	*2008*	*2009*	*2008*	*2009*	*2008*	*2009*
Germany	46.332	38.623	213.561	174.706	119.543	97.807	74.342	70.412
Spain	***7.819***	***7.444***	***32.066***	***28.521***	***45.914***	***28.743***	***40.905***	***36.117***
France	29.021	25.678	59.831	48.954	59.152	53.299	55.252	52.521
Italy	16.578	15.752	61.803	52.175	71.499	55.741	61.865	56.588
United Kingdom	29.834	23.930	49.885	37.288	50.463	35.925	55.047	46.351

	Composition of Enterprises - KNOWLEDGE-INTENSIVE SERVICES			
	High-Tech Services		Market Services	
	2008	*2009*	*2008*	*2009*
Germany	12,7%	12,6%	87,3%	87,4%
Spain	***7,1%***	***7,6%***	***92,9%***	***92,4%***
France	11,4%	na	88,6%	na
Italy	9,3%	9,1%	90,7%	90,9%
United Kingdom	21,8%	21,1%	78,2%	78,9%

	Value Added at Factor Cost - KNOWLEDGE-INTENSIVE SERVICES			
	High-Tech Services		Market Services	
	2008	*2009*	*2008*	*2009*
Germany	111.857	111.065	246.532	231.176
Spain	***39.549***	***38.538***	***86.232***	***79.010***
France	81.174	na	191.781	na
Italy	57.512	55.896	106.981	91.551
United Kingdom	122.722	106.537	252.511	215.716

Graph 3. Structural business indicators of National Innovation Systems for selected countries
Source: Eurostat, 2012.
Notes: (i) Monetary data are expressed in millions of euro; (ii) Value added at factor cost is the gross income from operating activities after adjusting for operating subsidies and indirect taxes. It can be calculated from turnover, plus capitalised production, plus other operating income, plus or minus the changes in stocks, minus the purchases of goods and services, minus other taxes on products which are linked to turnover but not deductible, minus the duties and taxes linked to production.

Up to this point, the Spanish Innovation System should be understood as consistently lagging behind France, United Kingdom, and Germany in terms of input and *output* indicators, standing next to the Italian Innovation System. However, Italy seems to be getting more from its inputs in terms of overall results, showing a picture that indicates a better organized (and more *productive*) Innovation System than that of Spain[47]. One other hypothesis that offers support for this aspect is that Italy is highly oriented towards *non-R&D* innovation (Potí & Reale, 2011), which would explain the lack of consistence between its input and output indicators (given that the former is assessed through R&D oriented indicators). For the case of the leading nations, the UK appears behind France and Germany in most analyses. The relative stability of countries' positions across indicators provides us with valuable information on the structure and conditions of their NISs, making it possible to classify them accordingly.

Moreover, in graph 3 we can notice aspects about the demography of enterprises in the left part and value added capacity in the right (for both manufacturing and services firms). What is remarkable in terms of composition of enterprises high-tech manufacturing is the Spanish astonishing growth from 2008 to 2009, placing well above Italy and France in 2009, but still lagging behind Germany and UK. A similar situation happens for Medium-High Tech manufactures, except that in this case Spain, UK and Italy are in equivalent positions, while Germany plays a leading role.

However, this picture must be considered in parallel to that of graph 1C, where it is shown that Spanish firms in these sectors perform a significantly lower level of R&D investments than its peers in our benchmark countries. This is largely supported by the analysis of Value Added at Factor Cost for manufacturing companies, where data for Spain puts this country in a laggard position across all levels of technological content of production, whereas Italy, France and UK are in an intermediate position while Germany plays a leading role. For the case of

[47] Even though it should be considered that Italy has a highly fragmented innovation policy context, where several measures take place without combining strengths (Potí & Reale, 2011).

Knowledge-Intensive Services (KIS), Spain also has the smallest share of High-Tech services amongst all of its KIS in comparison to the other countries. When verifying the Value Added indicator, once again the picture puts Spain in a poor relative situation.

This verification not only describes the situation contained in the tables, but it also highlights the abovementioned issue of Innovation Systems' productivity, considering input and output perspectives (González, Jaumandreu & Pazó, 2005). In this sense, even though Spain occupies a laggard position in terms of the former, the appropriation of RTD investments is extremely low (considering our benchmarks). This situation can only be explained by an economic environment with deep institutional problems, where innovation does not seem to play a big role in the overall analysis of companies' strategies. This can be attributed to two core features: lack of firms' innovative capabilities and/or lack of market incentives for innovation-driven development. In both cases governmental intervention and long term strategy is mandatory for the Spanish NIS to become more competitive. In this context, this brief comparative overview of these National Innovation Systems contributes to understanding some idiosyncrasies of these countries in terms of innovative efforts, as well as helping identifying differences between them.

However, RTD policies in Spain have faced an intensification in both quantitative and qualitative terms (Heijs, 2009), even though this picture changed dramatically after the 2008's economic turmoil. The country is in need of economic and industrial policies that reorganize its productive structure in order to cope with the current crisis (Segarra & Teruel, 2011). One step in this direction is that, despite the aforementioned lack of large companies to establish networks of innovation, RTD policies (at both national and regional levels) have a clear focus on stimulating firms to engage in closer interactions with other agents (Marzucchi, 2011), building a framework that facilitates R&D collaboration with national and/or international counterparts.

In terms of cooperation, external sources of innovation (such as collaboration agreements and external R&D, among others) play an important role in Spanish innovation – especially for low and medium-tech firms - according to empirical evidence found by Santamaría, Nieto and Barges-Gil (2009). Where it could be expected that a process of *catching-up* to more developed capabilities existing abroad would occur, Barge-Gil (2010) finds that cooperation in innovation can be more effective if promotes networking at the *national level*[48]. This is a strong hint of a low level of absorptive capacity regarding advanced technologies and techniques which might be available through interaction with foreign partners[49]. However, this picture seems to be changing as an increasing proportion of Spanish firms devote R&D investment to adopt external technology instead of generate its own (Busom & Fernández-Ribas, 2008). While this may have desirable effects upon absorptive capacities, it highlights the general level of dependency that Spanish firms have.

Perhaps, in this case, recognizing these weaknesses can be extremely beneficial in shaping the innovation policy-mix in Spain. If there are systemic difficulties in developing innovative capabilities in indigenous firms in the short run, promoting increased levels of cooperation with external partners can be a source of development over the long run, when a proper set of market incentives are in place and technological and managerial capabilities have been absorbed from foreign partners.

In this regard, empirical evidence shows that Spanish companies achieve improvements in technological capabilities following their participation in collaborative projects under the Framework Programme (analysis of years 1995-2005), where expectations are that further results might unfold in longer periods of

[48] Nonetheless, the Spanish economy lacks the existence of a critical mass of large domestic or multinational firms that can effectively promote the generation of RTD networks based in the Iberian country (Heijs, 2011).
[49] Heijs (2009) believes that this is partly due to the Spanish low level of English language skills, which hampers the opportunities for interaction with other members of the ERA and makes it more difficult to absorb knowledge generated abroad (Heijs, 2009).

time, depending on systemic and structural impacts on agents (Barajas, Huergo & Moreno, 2009). As previously addressed, this represents an extra challenge in terms of measurement. The same authors in a later study (Barajas, Huergo & Moreno, 2012) using data of Spanish firms participating in the Sixth Framework Programme (2002-2006) further add that international cooperation results in positive impacts, not only technological, but also economic for the case of SMEs in Spain.

With respect to the effectiveness of the RTD policymaking processes in Spain[50], Busom and Fernández-Ribas (2008) find evidence that public support to R&D collaboration promotes the creation of the intended networks and also generates behavioral change in participants. On the other hand, Acosta and Mondrego (2001) point out that the financial incentives for R&D cooperation in Spain are not directed to those companies that actually need it (*adverse selection*) and also do not provide efficient incentives for actual collaboration (*moral hazard*) (Acosta & Mondrego, 2001). Such micro-based evidence supports the lack of efficient coordination within the Spanish Innovation System, where resources are not as productive as they could be under a more functional framework.

Another shortcoming on this realm is that such engagements in collaborative projects show signs of instability regarding international interactions when compared to more developed economies of the EU (Segarra, 2011). We can relate this volatility to the orientation of Spanish cooperation. López (2008) finds that cost-sharing is the single most important determinant for Spanish manufacturing firms to engage in R&D cooperation – which the author relates to the lack of private financial resources for R&D projects in Spain. We can, thus, criticize overall participation of Spanish companies in international R&D networks if the conclusions of these authors hold true for this particular population. This is because, as pointed out in our literature review: a) several authors highlight the

[50] CDTI is the governmental office responsible for cooperative R&D policies, and also for promoting industrial exploitation of technologies developed by firms, enhancing collaboration between industries and research centers and managing Spanish firms' participation in international R&D programs (Acosta & Modrego, 2001).

importance of network stability in shaping an environment of trust and improved management among partners (see, for example, Huggins, 2011; Rese & Baier, 2011; Musiolik, Markard & Hekkert, 2012; Mitsuhashi, 2003); and b) cost-sharing motives for R&D collaboration are representative of poorer performance in the long run. On the other hand, even though the Spanish political discourse mentions the importance of domestic agents to engage in international R&D networks, only marginal funds are dedicated to it (Heijs, 2011). This approach to international R&D networks is not likely to guarantee long term relationships when compared to strategic-oriented linkages, aiming at continuous generation of knowledge, technology, and innovation.

Analyzing the background of R&D cooperative settings in the remaining countries, dedicated policies are found in all of them, except for the case of the UK, which follows a different approach. In the case of Italy, the Ministry of University and Research gives strong emphasis to participation in European collaborative projects, such as ERA-NETs, Framework Programme's projects and Joint Technological Initiatives, while he "Industria 2015" is an example of a national project in Italy that aims at fostering large cooperative projects (Potí & Reale, 2011).

Rammer (2011), in an assessment of Germany's innovation system, points out that the achievement of improvements in the science-industry relationship is a key element of German innovation policies. Furthermore, RTD programs in this country are open to participants from other countries, setting the stage for incentives in terms of international R&D collaboration. Germany currently has over 200 bilateral and multilateral agreements of technological and scientific exchange and cooperation (with stronger emphasis on the European context).

In France, innovation policy is strongly oriented towards SMEs, while domestic collaboration aims at enforcing public-private linkages through cluster support (Zaparucha & Muths, 2011). The internationalization of this specific innovation system relies in governmental subsidies to local SMEs to engage in international (mainly European) networks related to FP's initiatives and other sorts of technological partnerships (though the latter is diffused across a myriad of programs, each receiving only marginal support when compared to FP activities).

The British innovation policy framework follows a different pattern, where it does not address domestic RTD collaboration explicitly, and incentives to international cooperation seem limited to participation in European initiatives (Eureka, FP, ERA-NETs), characterizing a low level of intervention in this particular field (Cunningham, Sveinsdottir & Gok, 2011). UK innovation measures are also widely closed for foreign participation.

In graph 4 we offer a summary of R&D cooperation for Spain and our benchmark countries[51] using data from the Community Innovation Surveys (waves 4, 5, and 6). As it can be noticed, Spanish innovative firms cooperate moderately in manufacturing, while this behavior plays a marginal role in services. French companies show a much more cooperative pattern in this regard, followed by its British counterparts. This picture is stable regarding the perception of cooperation at the National and European (at a smaller share for all countries) levels, while for cooperation with partners located elsewhere, Spain and Italy seem to be less prone to engage in collaborative arrangements. Especially in the case of cooperation in services, Spanish firms do not appear to be oriented to cooperative settings, even though this situation has been improving at a faster pace than for manufacturing.

Such context leads us to the conclusion that Spain represents an interesting case of study for cooperative R&D, especially at the international level. For as much as Spain is one of the most dedicated participants in Eureka, it still shows a low level of R&D collaboration between agents, at the same time being historically dependent on foreign sources of technology and showing a low firm propensity to develop open innovation strategies (COTEC, 2007; Fernández, Junquera & Vázquez, 1996; Vega-Jurado, Gutiérrez-Gracia & Fernández-de-Lucio, 2008).

[51] In Appendix I we have the information contained in graph 4 divided by firm size.

SUMMARY OF COOPERATIVE BEHAVIOR IN INNOVATIVE ACTIVITIES - MANUFACTURING												
	Total Cooperation in Innovation (% of Innovative Firms)			Cooperation in Innovation at the National Level (% of Innovative Firms)			Cooperation in Innovation at the European Level (% of Innovative Firms) - excluding National cooperation			Cooperation in Innovation with Countries outside the European Region (% of Innovative Firms)		
	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6
Germany	19,2%	21,3%	22,9%	18,1%	na	22,1%	6,6%	na	7,3%	3,8%	na	4,9%
Spain	***18,6%***	***18,1%***	***18,8%***	***17,5%***	***16,8%***	***17,7%***	***4,6%***	***4,7%***	***4,8%***	***1,5%***	***1,7%***	***2,0%***
France	38,8%	48,3%	43,9%	36,2%	43,8%	40,5%	17,5%	25,2%	17,9%	10,0%	13,5%	10,2%
Italy	11,0%	11,3%	13,6%	10,5%	na	12,4%	2,3%	na	3,5%	0,9%	na	1,8%
UK	28,9%	30,8%	na	na	na	na	na	na	na	na	na	na

SUMMARY OF COOPERATIVE BEHAVIOR IN INNOVATIVE ACTIVITIES - SERVICES												
	Total Cooperation in Innovation (% of Innovative Firms)			Cooperation in Innovation at the National Level (% of Innovative Firms)			Cooperation in Innovation at the European Level (% of Innovative Firms) - excluding National cooperation			Cooperation in Innovation with Countries outside the European Region (% of Innovative Firms)		
	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6
Germany	na	na	na	na	na	na	na	na	na	na	na	na
Spain	***12,7%***	***11,6%***	***15,5%***	***12,1%***	***11,0%***	***15,0%***	***2,9%***	***2,3%***	***3,1%***	***0,6%***	***1,3%***	***1,6%***
France	37,7%	na	38,1%	35,8%	na	36,0%	11,2%	na	11,0%	7,6%	na	8,5%
Italy	15,9%	13,3%	18,9%	15,6%	na	17,6%	2,4%	na	5,3%	1,1%	na	2,5%
UK	na	na	na	na	na	na	na	na	na	na	na	na

Graph 4. Summary of Cooperative Behavior in Innovative Activities (Community Innovation Survey – waves 4, 5, and 6) for selected countries. Manufactures and Services
Source: Eurostat, 2012.

As it can be seen in figure 1, the profile of Spanish cooperation regarding Eureka individual projects initiated by Spanish agents (2001-2008) show firstly an orientation towards (dark blue territories) contiguous countries, i.e., Portugal and France. Also, Germany, Italy, and the United Kingdom have an extensive record of Eureka projects initiated by Spanish institutions and firms (being 4 of these our benchmark countries, namely Germany, France, Italy, and the UK). This profile indicates a moderate level of concentration for Spanish projects, where we can notice that there is a search not only for more developed economies (in general terms and in innovative capabilities), but also for countries that are located close to Spanish borders.

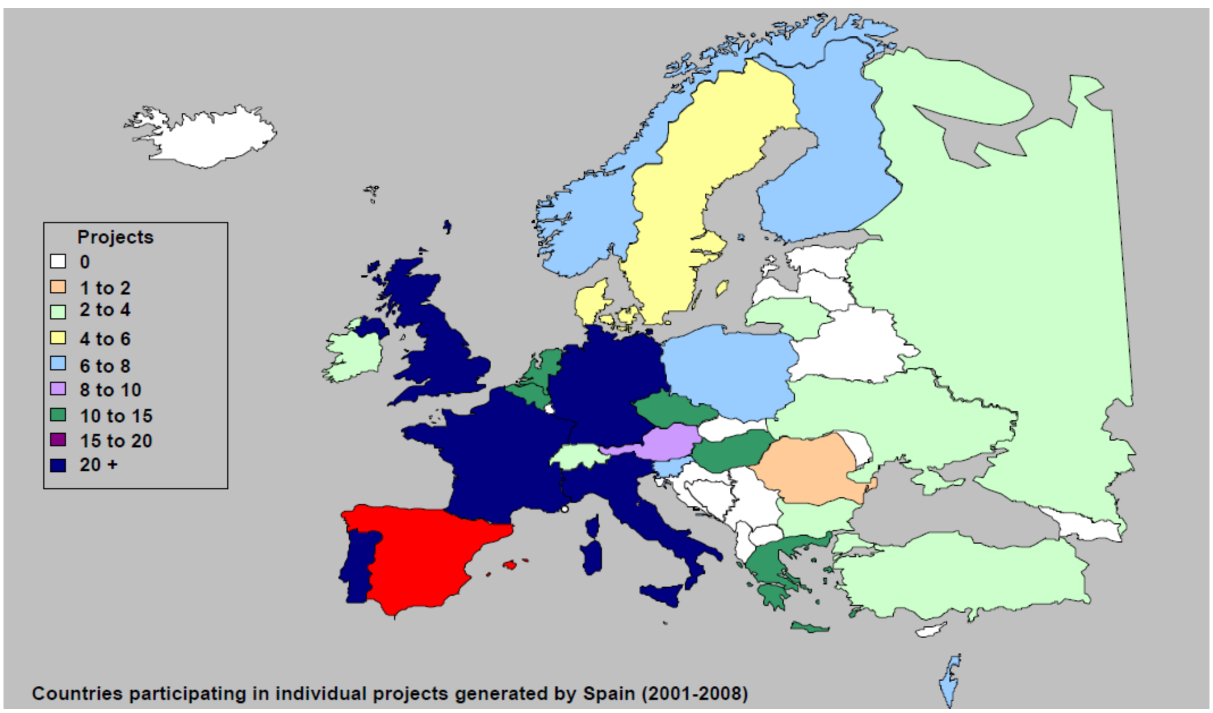


Figure 1. Countries participating in individual projects generated by Spain (2001-2008)
Source: Eureka, 2008.

We should also mention relatively high levels of cooperation with the Czech Republic, Greece, Hungary, Belgium, the Netherlands, and Austria. Playing a moderate role we have Israel, Poland, Norway, Finland, Poland, Sweden and

Slovenia, while Turkey, Ireland, Switzerland, Russia, Lithuania, Ukraine, Bulgaria, and Romania appear as marginal collaborators in projects started by Spanish companies in Eureka (2001-2008).

The background offered in this chapter allows to contextualize the situation of the country which represents the focus of the analysis undertaken, i.e., Spain, as well as confronting the situation of its National Innovation Systems to those of Italy, Germany, France and UK, our benchmark countries. The relevance of such information lies on the need to frame the hypotheses described in the next chapter in terms of the theoretical and empirical literature organized in chapters 2 to 4, thus taking into consideration the characteristics of the respective economies.

Spain faces some structural issues in terms of its innovative capacity, especially regarding its innovative *output* abilities. The country that seems to be in a closer situation is Italy, even though this nation seems to be achieving more from a relatively similar level of *input*. France, UK, and – mainly – Germany are in better position in terms of Innovation System development. Therefore, a natural classification for these countries arises, where:

- Spain occupies a laggard position in comparison to other countries, considering the structural indicators of its National Innovation System outlined above.
- Italy, UK and France represent an intermediate position. Italy is in a lower-intermediate level, France in an upper-intermediate condition and the UK lies in the middle.
- Germany is a clear case of a leader NIS, taking into account the countries we have analyzed and the set of indicators used.

6. Putting literature in context: Research Hypotheses

A first aspect to be included in this chapter is a clear reference to the *Research Question*, which guides the efforts towards analyzable and useful results from this investigation:

What factors determine firms' performance as a result of their participation in international R&D cooperation projects?

The aim of this question is to identify the main drivers of innovative performance for these companies (our main goal as previously stated), in a process that offers both managerial information and policymaking evaluative analysis. Thus, our emphasis when proposing the hypotheses will lie upon three analytical dimensions:

a) **Microeconomic dimension -** Aspects related to ***firms' inherent characteristics*** as influential variables in their outcomes, using the foundations of R&D cooperation from chapter 2. It largely supports a ***Resource-Based View*** approach of collaboration, with emphasis on absorptive capacity of agents;

b) **Contextual dimension** - Firms' aspects related to their ***participation in cooperative settings*** (in this case, their participation in a Eureka individual project), as well as the institutional framework represented by ***RTD policy incentives***, therefore considering the aspects highlighted in chapters 3 and 4. This dimension comprises aspects related to a ***Transaction Costs*** approach.

c) **Macroeconomic dimension** - Representing the general features of the ***National Innovation Systems*** in which these cooperating firms are embedded, according to developments of chapter 5. This last dimension tests the validity of a **NIS-oriented** perspective.

This view does not imply a segmented approach of such dimensions or even the existence of independence among them. The macroeconomic dimension as we define it here is largely determined by microeconomic behavior, but it also exerts some level of influence upon firm related aspects. Similarly, the contextual dimension might be affected by both micro and macroeconomic situation. This arbitrary division is a simplification that allows a workable assessment of the phenomena under scrutiny in this research. Based on this perspective, the core hypothesis proposed rests on the interactions between these 3 dimensions, i.e.:

> ***H_{core}: Firms´ performance as a result from their participation in international R&D cooperation projects is determined by the interaction of three influential dimensions: Microeconomic, Contextual, and Macroeconomic.***

We must remind that these dimensions are constructs in which hypotheses are developed rather than exhaustive proposals of such areas of economic studies. The analytical approach only captures glimpses of micro, macro and contextual aspects of firms. They were designed with the intention of situating the reader and, hence, should not mean that every aspect related to them are included in our analysis, which seeks only to contribute marginally to each one of them.

In order to comply with the broad aspects raised by H_{core}, we developed a set of testable propositions - our operational hypotheses - to be confronted with the empirical data. These hypotheses are developed with specific focus on the features of each dimension that integrates the core hypothesis, also considering data restraints from our datasets (for a further discussion on the data, see chapter 7).

6.1 Microeconomic Dimension's Hypothesis

By providing firms with access to capabilities located abroad, international R&D cooperation requires the existence of a certain level of *absorptive capacity* in order to be effective. According to table 3 (chapter 2), some authors point out that the expected impact of R&D cooperation is larger for large corporations, which is supported by their perception that these firms are in a better position to capture benefits from R&D cooperation, which is linked to their higher absorptive capacities (as well as financial capabilities). On the other hand, the signaling characteristic of Eureka shall bring more *relative* benefits for SMEs, since large companies rely on other (*stronger*) forms of reducing information asymmetry for project funding. In this sense, when analyzing data from Eureka projects, we should also consider this perspective.

Furthermore, another suitable approach is to take into account the innovative intensity of a given firm as a potential determinant of cooperative projects' outcomes. We should put special emphasis on its effects upon the technological results (direct effect), more than on commercial achievements (indirect effect), which is expected because the concept of *absorptive capacity* as assessed in our research is technique-oriented, whereas market results shall be influenced by technological development, but not necessarily, since innovation is inherently a risky process, facing both *technical* and *market* challenges.

> ***H_1: Absorptive capacity has a positive influence on organizational outcomes arising from firms' participation in international R&D cooperation projects, being this effect more pronounced on technological than on commercial attainments.***

H_{1a}: Considering firm size as a proxy for absorptive capacity, large companies achieve better outcomes than SMEs[52].

H_{1b}: Considering R&D intensity (measured as a percentage of turnover invested in R&D) as a proxy for absorptive capacity, more intensive firms achieve better outcomes, regardless of their size[53].

6.2 Contextual Dimension's Hypotheses

The inherent complexity of international R&D cooperation stresses the importance of the quality of project management. Risks related to *free riding*, *opportunism,* and *moral hazard* issues, as well as different *modus operandi* of firms - provided their distinct cultural backgrounds - are present in any kind of cooperative engagement, highlighting the important role that transaction costs are likely to play in this context. However, when dealing with foreign partners, they are maximized, since cultural ties are likely to differ in a higher degree and monitoring costs of principal-agent relationships also rise significantly. In this sense, we developed the following proposition:

H_2: The management quality of a given cooperative R&D project undertaken at the international level will influence the ultimate corporative outcomes of such project, both at the technological and economic (commercial) levels.

[52] Under an empirical perspective, Georghiou (1994) found that initiatives carried out under the Framework Programme were likely to yield significant results only to a minority of SMEs, which provides further support for this hypothesis (even though he did not approach it via an "absorptive capacity" rationale).

[53] Cohen and Levinthal (1990) and Lin et al (2012) are examples of authors who have approximated absorptive capacity using R&D intensity. Nonetheless, we recognize that If absorptive capacity is path dependent, using R&D intensity as a proxy for it can be tricky, since it does not highlight prior behavior in this regard. The additional use of firm size in this case can be helpful in order to overcome this shortcoming.

To this we must add the risks of *critical knowledge spillovers*, i.e., unwanted knowledge sharing to other firms/agents involved in the cooperative project. As stated in table 4 (chapter 2), empirical evidence suggests that vertical networks perform better than horizontal ones, suggesting that cooperative engagement between competitors might harm the potential outcomes from the relationship. Therefore:

H_3: R&D cooperation projects involving rival firms are likely to achieve worse overall results than networks formed by non-rival agents.

A next step lies in considering the endogenous impacts of technological achievements on the commercial side of firms' results (Rese & Baier, 2011). Technical outcomes *per se* do not lead to successful *innovations,* since the marketability of such attainments must be taken into account. Nevertheless, technology is a *necessary* condition in this process (though not *sufficient*).

To this we should add that such impact might not be *optimal* in terms of its timing when considering a cooperative project's duration, i.e., in some cases it might impact immediately after the project's completion, while in others it might take a longer period of time.

H_4: Technological achievements in an international R&D cooperation project influence positively the commercial achievements of firms.

H_{4a}: Impacts of technological achievements shall be regarded not only as those that unfold by the end of a given project, but also as those being expected after the project's completion.

6.3 Macroeconomic Dimension's Hypothesis

As previously described, this dimension makes exclusive reference to aspects related to National Innovation Systems. In no way we believe that other macroeconomic constructs *do not* play a role in shaping the environment that influences firms' outcomes for innovative activities. However, the focus of this approach lies on the capabilities developed by countries in terms of some specific characteristics regarding their performance in terms of innovative *input* and *output*.

Thus, we are also taking the dynamics of systems as exogenous for simplicity's sake. To justify this action we must remind that the content of this research is microeconomic-oriented, whereas results shall also impact on innovation policy evaluation: the macroeconomic dimension in this case functions as an approximation of the macro environment in which firms are embedded as a control variable in our analysis.

Table 3 (chapter 2) summarizes some influential aspects that National Innovation Systems are likely to play in the process of R&D cooperation at the international level. We must consider that the countries being analyzed are of relatively similar sizes, as well as of similar levels of development in a global perspective. Even though there is no reason to believe that any of the National Innovation Systems under scrutiny (Spain as the central focus, but also Germany, Italy, UK, and France) can be regarded as a "*less-developed Innovation System*", they differ substantially in terms of the indicators presented in chapter 5. This validates the perception that their national environments in terms of innovation capabilities may affect their microeconomic structure, as well as *represent* some aggregated features of firms. In this sense, we agree with economic growth theory (e.g. Weil, 2006) and propose that firms located in laggard Innovation Systems can benefit more in comparative terms from R&D cooperation with foreign Innovation Systems.

H_5: Firms located in relatively laggard Innovation Systems will achieve better outcomes from international R&D cooperation projects than those firms located in leading Innovation Systems, provided that such Systems are above a threshold of development.

7. Methodological Approach and Rationale

In this chapter we outline the method used in our attempt to contribute in the process of evaluating international R&D cooperation with focus on the case of Spanish firms participating in such activities (using data from the Eureka Initiative). First we put forward some general aspects of the research, offering remarks regarding the framework of the intended assessment. In a second stage, the operational settings are developed, which consists in a relatively novel manner of combining statistical tools for economic analysis. A discussion on the choice of such method follows, building upon a criticism on technique-led evaluations. Lastly, the main shortcomings of the methodology are presented.

7.1 Scope of Research

The developed methodology focuses in providing useful ways of complying with the proposed objectives and hypotheses of this research, thus building an approach that can offer helpful and reliable knowledge on processes related to international R&D cooperation, with central focus on the Spanish case (through data of Eureka's individual projects).

The general scope of this assessment is based on *ex post* data gathered from Eureka's Final Reports, which offer a rich and practical source of relevant information on projects and firms' characteristics. For such characteristics, this study can be considered as an economic analysis of international R&D cooperation in its broad sense, as well as an evaluation of an innovation policy initiative, given the specific aspect of data being analyzed.

Besides answering to the proposed inquiries, this methodology is built as an alternative form of attaining positive *and* normative results. This attempt is in consonance with the proposition that more structured data and proxies are needed for a better understanding of R&D productivity (Mairesse & Mohnen, 2002). Such statement justifies the use of combinations of statistical tools for the generation of a more complete capacity of understanding and tackling economic events related to innovation.

7.2 Operational Aspects[54]

7.2.1 Data

Data for this research comes almost exclusively from Eureka individual projects' dataset of final reports[55], which was provided by the Eureka Secretariat. Such reports are structured as questionnaires, containing several questions on different aspects. For the purposes of this particular assessment, the information is rich in terms of what we defined as the *Contextual Dimension* (for a description of the primary variables included in our estimations, please refer to table 9). This sort of survey method, by collecting data from individuals, allows a thorough analysis of relationships, and comparison of groups (US Department of Energy, 2007), thus being an adequate tool to comply with the objectives and hypotheses of this study.

The timeframe used is based on two different periods: 2000-2005 and 2006-2008 (dates of projects' *conclusion*). These datasets are analyzed separately for some simple operational aspects. The instrument of data collection suffered changes in between these periods, altering aspects such as the existence of certain variables of interest, as well different sorts of measurement scales. The first issue is relevant for the variables COMPETITOR and FUNCTIONING (refer to table 9, 10 and 11 for codes and descriptions of variables), which are present in the 2000-2005 datasets, but not for 2006-2008. This is unfortunate, given the contribution of these aspects in order to confront hypotheses H_2 and H_3 with the

[54] I would like to thank Daniela Benzano for her patience and valuable insights on the statistics of this research.

[55] Exception is the data used in the ANOVA tests described below for the analysis of Spanish firms' results arising after project completion, Return on Total Assets.

results of the empirical work. In order to merge both datasets, we would either have to drop such variables from the analysis, or work with a significant number of missing cases. The solution was to assess these hypotheses through 2000-2005 data, keeping datasets separate.

Code	Description	Structure 2000-2005	2006-2008
TOT_COST	Total cost of project(s) carried out by firms. Source: Eureka	Millions of euros	Millions of euros
DURATION	Duration of project(s). Source: Eureka.	Months	Months
ORG_TYPE	Firm size. Source: Eureka	1 = Large company 0 = SME	1 = Large company 0 = SME
NIS*	Consists of countries' categories to w hich firms belong, i.e., Spain, Germany, France, UK, and Italy. It functions as a proxy for National Innovation Systems' characteristics.	1 = Spain 2 = Italy; United Kingdom; France (Intermediate) 3 = Germany (Leader)	1 = Spain 2 = Italy; United Kingdom; France (Intermediate) 3 = Germany (Leader)
RATIO_RD	Ratio betw een R&D expenditure and total turnover. Source: Eureka	1 = <2% 2 = 2 to 10% 3 = >10%	1 = <2% 2 = 2 to 10% 3 = >10%
COMPETITOR	Existence of at least one competitor among participants of the project. Source: Eureka	1 = Yes 0 = No	Not included
IND_EXP	Industrial exploitation of results by the company at the end of	1 = Yes 0 = No	1 = Yes 0 = No
FUNCTIONING**	Evaluation of functioning's quality of project's participants. Source: Eureka	1 = Excellent 2 = Good 3 = Weak/Bad	Not included

Table 9. Independent Primary variables of analysis

* Methodological note I: Countries' codes are assigned according to their relative position in terms of the stage of development of their National Innovation Systems. The higher the rank, the more developed. Furthermore, they were grouped in three categories, where Spain is referred to as a laggard Innovation System and it is analyzed alone, provided that it is the core country of our analysis; Italy, UK and France are classified as intermediate Innovation Systems (including, thus, lower intermediate, Italy, intermediate, UK, and upper intermediate, France); and Germany is regarded as the leading nation in terms of IS capacities. This procedure was undertaken in order to provide each group with a significant number of observations for the regression assessments. Such classification followed suggestions from the analysis made in chapter 5. This structure is also relatively compatible with that shown in the Innovation Union Scoreboard 2011, where Germany appears as an Innovation Leader, France and UK as Innovation Followers, while Italy and Spain are classified as Moderate Innovators. Nonetheless, Italy's innovation level is above that of Spain, suggesting that our relative classification is representative of the current context of these Innovation Systems.

** Methodological note II: Categories 3 and 4 (Weak and Bad Functioning, respectively) were merged in order to have analyzable data, since information for category 4 was scarce.

However, estimations could be made for both periods altogether in terms of the remaining variables, but this is where the problem with measurement scales arise. Both COMMACHIEV and EXP_IMPACT (table 10), which deal with market impacts of collaborative projects on firms, have their scale changed from a purely subjective evaluation scale to a objective-oriented one: while in the 2000-2005 questionnaires they were classified as Excellent, Good, Weak, etc., in the 2006-2008 form, their situation is focused less on perception and more on a R&D investment comparison basis. To build a correspondence scheme between such scales would provide interpretative alterations to the dataset. This could potentially cause undesirable effects on firms' perceptions. For this reason, we kept distinct datasets, allowing a comparison between different periods. As a result, 2006-2008 functions as a robustness check sample.

Code	Description	Structure	
		2000-2005	**2006-2008**
TECHACHIEV*	Evaluation of Overall technological achievements in the project. Source: Eureka	1 = Excellent/Good 0 = Weak/Bad	1 = Excellent/Good 0 = Weak/Bad
COMMACHIEV*	Evaluation of commercial achievements as a results of the project. Source: Eureka	1 = Excellent/Good 0 = Weak/Bad/Nil	1 = 2-5 times RTD investment/+-10 times RTD inv./<100 times RTD inv./More 0 = Very low /< or = RTD investment
EXP_IMPACT*	Expected future impact of results from the project. Source: Eureka	1 = Very Large/Large 0 = Medium/Small/Nil	1 = 2-5 times RTD investment/+-10 times RTD inv./<100 times RTD inv./More 0 = Very low /< or = RTD investment

Table 10. Dependent Primary variables of analysis

* Methodological note I: The original categories of these variables were dichotomized in order to produce significant numbers of observations for categories. The underlying rationale in this procedure is one of grouping positive perceptions on the one hand, and negative perceptions on the other. As it will be further discussed in chapter 8, the high concentration of positive results in TECHACHIEV generated some problems for statistical analyses.

Furthermore, data is available for Spanish firms, as well as for 4 countries which we take as elements of contrast (*benchmark countries*) in our analysis:

Germany, France, UK, and Italy. Together, these five countries can be regarded as highly representative of the European situation, gathering data for the largest economies and which face different stages of development in terms of their innovation systems. Rates of response for Spanish projects were 24.7% (91 reports in 2000-2005), and 26.9% (50 reports in 2006-2008). Data for non-responded reports regarding the benchmark countries was not provided.

It is important to notice that such observations referred to finished *projects*, while our analyses used firm-level data. This is justified by the fact that by using data of projects we would inflate the influence of variables related to companies, i.e., variables related to the *Microeconomic Dimension*, such as firm size, since some companies – especially large corporations – were involved in more than one project. Thus, we merged data for such companies. The resulting structures of datasets were the following:

a) *2000-200*5 - 77 Spanish firms; 60 German firms; 34 French firms; 27 Italian firms; 17 British firms. N = 215.
b) *2006-2008* – 36 Spanish firms; 52 German firms; 19 French firms; 6 Italian firms; 2 British firms. N = 115.

Data from Universities, Research Centers and other institutions were dropped. As the scope of this analysis deals with innovation and its impacts on agents' success in terms of marketability of results from international R&D cooperation, dealing with other sorts of organizations would distort our assessment, while also driving us away from our focus: companies represent the core of economic systems in terms of innovation (Molero, 2010). Unfortunately, sectoral data (NACE classification) was not available in the database. As companies' names were censored for confidentiality issues, any attempt to overcome this matter was not feasible.

While such samples are not quantitatively meaningful in the broad environment of international R&D cooperation, they provide important qualitative information on projects' development. To use such information through statistical techniques shall contribute to the subject of analysis on suggestive terms, rather providing consistent conclusions. Therefore, definitions of impacts and characteristics of relationships are to be analyzed not through precise estimation of statistical coefficients, but via relevant indications they shall supply.

Another approach undertaken was an *ad hoc* exploration of datasets. This step aims at examining additional elements of datasets which are not directly relevant for the presented hypotheses. However, they generate further comprehension of firms' (and projects') features, allowing a deeper appreciation of the phenomena under investigation. Variables involved in this assessment are described in table 11. Descriptive statistics of variables are presented together with the evaluation of results.

Code	Description	Structure 2000-2005	Structure 2006-2008
PROD_INNO	Companies that achieved product innovation (new product or improved products). Source: Eureka	1 = Yes 0 = No	1 = Yes 0 = No
PROC_INNO	Companies that achieved process innovation (new process or improved processes). Source: Eureka	1 = Yes 0 = No	1 = Yes 0 = No
SERV_INNO	Companies that achieved service innovation (new services). Source: Eureka	1 = Yes 0 = No	1 = Yes 0 = No
STRAT_ALL	Companies that achieved strategic industrial alliances (new or improved). Source: Eureka	1 = Yes 0 = No	1 = Yes 0 = No

Table 11. Secondary variables of analysis

7.2.2 Binary Logistic (Logit) models

This section describes the regression models applied in identifying determinants of success at both technological and market levels as results from firms' participation in international R&D cooperation. Here we present the binary logit models built according to data contained in Eureka's datasets for periods 2000-2005 and 2006-2008 in Spain (the core of our analysis) Germany, France, UK, and Italy (*Benchmark countries*).

Even though the original structures of the dependent variables to be analyzed (TECHACHIEV, COMMACHIEV, EXP_IMPACT) are multinomial (table 9), the number of observations per category represented a risk for models' stabilities. As preliminary assessments revealed, the use of Multinomial (or Ordinal) Logit Models could potentially lead to interpretation issues in regressions' validity (such assessments suggested a need for merging categories). Therefore, in order to achieve statistically representative results, we resorted to data transformation in order to run the binary models.

For the purposes of this research, the required data transformation (detailed below) did not affect the logical arrangement of statistical analyses performed. Such transformations basically consisted in grouping responses in: (i) *success*, which represents technological or market results (and expectations) that are perceived as positive by companies (regardless of level); and (ii) failure, corresponding to technological or market results (and expectations) that were regarded as negative by respondents (regardless of level). This procedure also helps reducing disturbances caused by subjectivity of answers, since what firm A considers an *excellent* result, firm B might classify a similar achievement as *good*, where factual attainments are hardly likely to be interpreted as negative. This approximation results in a workable outcome for policy and managerial analyses.

In order to verify associations between variables, we applied chi-square tests, odds ratio analyses, and Spearman's rho for the exploration of associations between pairs of variables (which might also lead to the verification of latent collinearity amongst categorical independent variables). As a byproduct of this approach, both methods help to enrich the robustness of the analysis, providing statistical support for determining influent factors on the innovative process through international R&D cooperation.

The binary logit models function as regressions for dummy dependent variables (Hair *et al*, 2005; Gujarati, 2002). As already stated, this research aims at exploring the described datasets in order to attain a body of evidence regarding influential factors on technological and market success arising from firms' participation in cooperative R&D settings at the international level. These approaches are built for 2000-2005 and 2006-2008 datasets.

The broad model from which the operational equations shall derive takes into account the perspective offered by the hypotheses described previously. Hence, its structure is largely based on theoretical and empirical findings regarding economics of innovation - as well as innovation policy – literature. It should also be reminded that the described equations were assessed through binary logit regressions.

$$\boldsymbol{ACHIEVEMENTS_i = MIC_i + CXT_{ij} + MAC_i + \varepsilon}$$

Equation 1

Where:

$ACHIEVEMENTS_i$: Technological, commercial, and expected success of firm "i". It takes the value 1 if the firm's participation in international R&D cooperation was classified as successful and 0 otherwise (see next equations' definitions of success for clarification).

MIC_i: Corresponds to the *Microeconomic Dimension* of firm "i".

CXT_i: Corresponds to the *Contextual Dimension* of firm "i" and project(s)[56] "j".

MAC_i: Corresponds to the *Macroeconomic Dimension* in which firm "i" is embedded.

ε: Error term.

[56] It is worth reminding that some firms were engaged in more than 1 cooperative project.

A first operational assessment considers TECHACHIEV, i.e., companies' perception of overall technological achievements, as the dependent variable (2000-2005 and 2006-2008). It can be noticed (table 10) that this variable is structured in categories that range from 1 (excellent) to 4 (bad). In order to build effective binary models, we propose the following intuitive classification:

a) Success (1) – contains responses that rated technological achievements as *excellent* and as *good*.
b) Failure or Absence of Success (0) – contains responses that rated technological achievements as *weak* and as *bad*.

The resulting equation for technological achievements will, thus, assume the structure defined by equation 2 (definitions of variables can be found in table 9):

$$TECHACHIEV_i = \beta_1 + \beta_2 ORG\_TYPE_i + \beta_3 RATIO\_RD_i + \beta_4 COMPETITOR_j + \beta_5 FUNCTIONING_j + \beta_6 TOT\_COST_j + \beta_7 COUNTRY_i + \varepsilon$$

Equation 2

Where:

- "i" refers to variables inherently related to firms.
- "j" refers to variables related to cooperative projects.
- β_1 is the intercept.
- MIC_i is represented by ORG_TYPE and RATIO_RD;
- CXT_i: is represented by COMPETITOR and FUNCTIONING; TOT_COST is added as a proxy for project size in terms of R&D invested in project "j".
- MAC_i: is represented by COUNTRY.

This assessment, as it can be noticed, produces estimates for the parameters of variables that represent the hypotheses proposed above, while overall composite results shall provide an initial appraisal of the main goal of this research regarding technological results arising from R&D cooperation. Nonetheless, even *technological* innovation cannot be regarded by only technical outcomes. Technological advancements might not qualify as innovation *per se* if they provide no economic impacts on firms. For this reason, we complement the approach described in Equation 2 with a *market-oriented* perspective, both achieved and expected described in Equations 3 and 4.

Beforehand, the following approaches consider COMMACHIEV and EXP_IMPACT, i.e., companies' perception of actual commercial achievements and of potential future corporate achievements, as the dependent variables. Both variables are depicted in table 10 and it can be noticed that they range from 1 (excellent/very large) to 5 (nil) in the 2000-2005 dataset; and from 1 (very low) to 6 (more than 100 times the RTD investment) for 2006-2008 data. In order to build effective binary models, we propose the following intuitive:

a) Success/Expected Success (1) – contains responses that rated commercial achievements as *excellent* and *good*, and expected impacts as *very large*, *large*, and *medium* in the 2000-2005 dataset. For 2006-2008 projects, we define in this category projects that were rated as 2-5 times RTD investment or more.
b) Failure or Absence of Success (0) – contains responses that rated commercial achievements as *weak*, *bad*, or *nil*, and expected impacts as *small*, or *nil* the 2000-2005 dataset. For 2006-2008 projects, we define in this category projects that were rated as having *Very Low* impacts, and impacts that are smaller or equal to RTD investment.

In Equation 2 we have the structure of the commercial achievements' evaluation

$$COMMACHIEV_i = \beta_1 + \beta_2 ORG\_TYPE_i + \beta_3 COMPETITOR_j + \beta_4 TECHACHIEV_i + \beta_5 IND\_EXP_i + \beta_6 FUNCTIONING_J + \beta_7 DURATION_J + \beta_8 COUNTRY_i + \varepsilon$$

Equation 3

Where:

- "i" refers to variables inherently related to firms.
- "j" refers to variables related to cooperative projects.
- β_1 is the intercept.
- MIC_i is represented by ORG_TYPE. RATIO_RD was dropped in this analysis, given its technical characteristic: while it is expected that it might lead to better technological outcomes, we do not foresee a direct relationship with commercial achievements;
- CXT_i: is represented by COMPETITOR, FUNCTIONING, TECHACHIEV, and IND_EXP. In this case, it should be noticed that TECHACHIEV performs the role of independent variable, since technical outcomes from innovation projects are expected to influence the market dimension. DURATION of project "j" was added as a control variable, where its expected influence regards the idea that the longer a project is, the more likely it is to produce marketable outcomes before it comes to an end;
- MAC_i: is represented by COUNTRY.

Next, we present Equation 4, which works with the idea of future developments resulting from firms' participation in international R&D cooperation. This is a rough approximation of outcomes that might arise after a projects' completion, since it is based on expectations rather than on objective facts. Nonetheless, it is assumed that such prospects shall be based not only on confidence (or lack of it), but that they may reveal the existence or not of achievements that are on their way to reach markets (if they will ultimately succeed or not cannot be identified, given the inherent risk of innovative activities).

$$EXP\_IMPACT_i = \beta_1 + \beta_2 ORG\_TYPE_i + \beta_3 COMPETITOR_j + \beta_4 TECHACHIEV_i + \beta_5 FUNCTIONING_J + \beta_6 COUNTRY_i + \varepsilon$$

Equation 4

Where:

- "i" refers to variables inherently related to firms.

- "j" refers to variables related to cooperative projects.
- β_1 is the intercept.
- MIC_i is represented by ORG_TYPE;
- CXT_i: is represented by COMPETITOR, FUNCTIONING, TECHACHIEV. As IND_EXP represents the existence of industrial exploitation of results by the end of the project, its impacts on future developments are not necessarily related, therefore the variable was dropped from this model.
- MAC_i: is represented by COUNTRY.

7.2.3 Complementary *ad hoc* analyses

The *ad hoc* approach described in this section develops a complementary assessment of datasets and which are not directly related to the objectives and hypotheses of this research, thus not relying on theoretical or empirical support contained in our framework of assessment. Nonetheless, such approach shall shed light on supplementary considerations on influential matters. Such perspective aims at improving the managerial and policymaking aspects of international R&D networks through the use of workable indicators with potential latent effects on networks' achievements.

The applied procedures consist of an additional set of equations (Equations 5 – 8) based on similar settings to those outlined above. Before we describe each model, it is worth pointing out that they follow the basic structure of Equations 2 to 4, except that they include those theoretically grounded predictors that are statistically significant, plus an additional set of variables (table 12). These *ad hoc* assessments were designed to provide insights for a better discussion of outcomes. Related procedures are similar to those outlined for previous models, such as contingency tables, chi-square, and correspondence analysis.

Dependent Variable	Theoretically Grounded Predictors	*Ad Hoc* Predictors	Rationale
TECHACHIEV	- ORG_TYPE - RATIO_RD - COMPETITOR* - FUNCTIONING* - TOT_COST - COUNTRY	- PROD_INNO - PROC_INNO - SERV_INNO	This *ad hoc* estimation investigates types of innovations´effects on technological achievements. The goal is to provide information on the influence of projects' innovative character in terms of their capacity of generating successful results.
COMMACHIEV	- ORG_TYPE - COMPETITOR* - FUNCTIONING* - TECHACHIEV - IND_EXP - DURATION - COUNTRY	- PROD_INNO - PROC_INNO - SERV_INNO	The underlying rationale behind this assessment is similar to that described for technological achievements. Nonetheless, this estimation searches for market impacts resulting from different types of innovation being explored by firms.
EXP_IMPACT	- ORG_TYPE - COMPETITOR* - FUNCTIONING* - TECHACHIEV - COUNTRY	- PROD_INNO - PROC_INNO - SERV_INNO - STRAT_ALL	In addition to the effects that different sorts of innovation may have, this approach also looks to the generation of longer term relationships betw een companies involved in the netw orks analyzed as a potential determinant of future achievements.
STRAT_ALL	-	- ORG_TYPE - FUNCTIONING - COMPETITOR - TOT_COST - TECHACHIEV - COMMACHIEV	This last *ad hoc* approach brings a new dependent variable, w hich is the generation of lasting relationships betw een companies involved in international cooperative R&D netw orks. Even though this structure is not contained in the hypotheses of this research, it may help in exploring the idea of the formation of long lasting netw orks w ithin Europe, a relevant goal of Eureka.

Table 12. Relationships of interest between primary and secondary variables of analysis

*These variables are available only for 2000-2005 data.

The first *ad hoc* equation uses the dependent variable TECHACHIEV. The additional secondary variables represent the sort of innovation that was in fact achieved by firms during their participation in a Eureka individual project. In this regard, this first supplementary model aims at identifying the impacts of the area of innovation in which firms are involved (or areas, since firms can have the three types of innovation simultaneously).

It is important to notice that there is no theoretical or empirical support for any expectation for this set of complementary variables. While one might argue about relative impacts of different kinds of innovation on firms' technological capabilities, it must be highlighted that such achievements are evaluated by respondents according to organizational objectives that were set *a priori*. Therefore, related impacts should be in accordance to companies' objectives, not to their absolute value. The model's structure is the following:

$$TECHACHIEV_i = \beta_1 + (\beta_2 X_1 \ldots + \beta_k X_k) + \beta_{k+1} PROD\_INNO_i + \beta_{k+2} PROC\_INNO_i + \beta_{k+3} SERV\_INNO_i + \varepsilon$$

Equation 5

Where:

- "i" refers to variables inherently related to firms.
- β_1 is the intercept.
- The term $(\beta_2 X_1 \ldots + \beta_k X_k)$ represents the theoretically grounded predictors which are added to the model according to their significance as per results of previous models. This procedure is undertaken in order to maintain a relative parsimony in regressions, given the number of observations (N = 215 and 115 for 2000-2005 and 2006-2008, respectively).

The following model provides an analogous approach for the case of commercial impacts, adding the secondary variables related to types of innovation that were achieved:

$$COMMACHIEV_i = \beta_1 + (\beta_2 X_1 \ldots + \beta_k X_k) + \beta_{k+1} PROD\_INNO_i + \beta_{k+2} PROC\_INNO_i + \beta_{k+3} SERV\_INNO_i + \varepsilon$$

Equation 6

Where:

- “i" refers to variables inherently related to firms.
- β_1 is the intercept.
- The term ($\beta_2 X_1 \ldots + \beta_k X_k$) represents the theoretically grounded predictors which are added to the model according to their significance as per results of previous models. This procedure is undertaken in order to maintain a relative parsimony in regressions, given the number of observations (N = 215 and 115 for 2000-2005 and 2006-2008, respectively).

Equation 7 describes the *ad hoc* complementary approach for EXP_IMPACT.

$$EXP\_IMPACT_i = \beta_1 + (\beta_2 X_1 \ldots + \beta_k X_k) + \beta_{k+1} PROD\_INNO_i + \beta_{k+2} PROC\_INNO_i + \beta_{k+3} SERV\_INNO_i + \varepsilon$$

Equation 7

Where:

- “i" refers to variables inherently related to firms.
- β_1 is the intercept.
- The term ($\beta_2 X_1 \ldots + \beta_k X_k$) represents the theoretically grounded predictors which are added to the model according to their significance as per results of previous models. This procedure is undertaken in order to maintain a relative parsimony in regressions, given the number of observations (N = 215 and 115 for 2000-2005 and 2006-2008, respectively).

The last of the *ad hoc* complementary models does not correspond to any original, theoretically grounded, approach. Its structure is based on the predictors of companies' achievements of long term strategic alliances (new or improved ones, measured by STRAT_ALL). Our interest in this variable is related to the inherent features of the Eureka Initiative, which is to provide incentives to build a more integrated R&D context within Europe. While this variable does not necessarily correspond to behavioral change or additionality, it is capable of providing hints on the systemic impacts of international R&D cooperation. It consists of an exploratory approach and follows the structure outlined in Equation 8:

$$STRAT\_ALL_i = \beta_1 + \beta_2 ORG\_TYPE_i + \beta_3 COMPETITOR_j + \beta_4 TECHACHIEV_i + \beta_5 FUNCTIONING_J + \beta_6 TOT\_COST_J + \beta_7 COMMACHIEV_i + \beta_8 COUNTRY_i + \beta_9 EXP\_IMPACT_i + \varepsilon$$

Equation 8

Where:

- "i" refers to variables inherently related to firms.
- "j" refers to variables related to cooperative projects.
- β_1 is the intercept.
- ORG_TYPE is set in order to check the influence of firm size on the propensity to engage in longer term strategic alliances in R&D activities.
- COMPETITOR is expected to be negative, since networks formed by rival firms are less likely to succeed (according to empirical findings previously stated in this research).
- TECHACHIEV, COMMACHIEV and EXP_IMPACT are expected to be positively related to the formation of more stable networks, based on the success that has already been achieved by firms, as well as the expected outcomes. A similar expectation is related to managerial aspects as approximated by FUNCTIONING.
- TOT_COST is an approximation of project "size" in financial terms. We expect that "larger" projects indicate a higher propensity of engaging in longer term

relationships. Ideally, this variable should be stated in relative terms (regarding firms' turnover). However, this information is not consistently available for firms and it is not available for networks' partners.

- COUNTRY refers to the home/host nation of the company under scrutiny, where this aspect tries to gather information on the NIS influence on the propensity of firms to engage in long-lasting R&D networks.

After analyzing results from the 7 operational equations described above, the relevant determinants of international R&D cooperation outcomes are likely to become clear, thus generating answers for our research question and evidence concerning our hypotheses. Nonetheless, another step is taken: we developed a taxonomical approximation based on the outcome variables (TECHACHIEV, COMMACHIEV, and EXP_IMPACT) through clustering techniques, which corresponds to the content of the next section.

7.2.4 Clusters

Based on the outcome aspects of projects, we proceeded to a categorization of the firms being analyzed for both periods under study (2000-2005 and 2006-2008). 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, offering the possibility of suggesting latent taxonomies (Hair *et al*, 2005). Also, we used Log-likelihood distances to build the clusters, since this procedure allows the use of categorical variables, which is not possible with Euclidean estimations (SPSS TwoStep Cluster's algorithms are detailed in Appendix II).

Outcome variables, i.e., TECHACHIEV, COMMACHIEV and EXP_IMPACT were included in the procedure according to their original categorical structures, instead of the dichotomized ones used in the regression analysis. This allowed a better interpretation of results, which did not face the statistical constraints pointed out for the logit equations (table 13).

Code	Description	Structure	
		2000-2005	**2006-2008**
TECHACHIEV*	Evaluation of Overall technological achievements in the project. Source: Eureka	1 = Excellent 2 = Good 3 = Weak 4 = Bad	1 = Excellent 2 = Good 3 = Weak 4 = Bad
COMMACHIEV*	Evaluation of commercial achievements as a results of the project. Source: Eureka	1 = Excellent 2 = Good 3 = Weak 4 = Bad 5 = Nil	3 = 2-5 times RTD investment 4 = +-10 times RTD inv. 5 = <100 times RTD inv. 6 = More 1 = Very low 2 = < or = RTD investment
EXP_IMPACT*	Expected future impact of results from the project. Source: Eureka	1 = Very Large 2 = Large 3 = Medium 4 = Small 5 = Nil	3 = 2-5 times RTD investment 4 = +-10 times RTD inv. 5 = <100 times RTD inv. 6 = More 1 = Very low 2 = < or = RTD investment

Table 13. Outcome variables' structure for cluster analysis

To establish the optimal number of clusters we developed on the structure proposed by Fischer and Molero (2012). Thus, we shall test for the consistency of 3 clusters. It was proposed the following categorization of firms in an exploratory assessment of Spanish firms in Eureka 2000-2005:

1. ***Risky Innovators -*** companies included in this cluster had the best technical outcomes out of the three clusters, but only partially they can obtain satisfactory market results.

2. ***Inventors -*** These companies were 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*.

3. ***Consistent Innovators -*** These companies had poorer technical results than *risky innovators*, but they consistently achieve positive commercial results.

In operational terms, the clusters were calculated for:

a) *All firms* – this procedure aimed at generating clusters of firms from all countries included (Spain, Germany, France, UK, and Italy), checking for robustness over time through the comparison of cluster structure between 2000-2005 and 2006-2008 datasets. The goal here is to provide a consistent perspective of behavioral patterns of agents, according to their projects' outcomes, thus identifying further relationships among variables in our analysis, creating an element of comparison with the regression models outlined above.

b) *Spanish firms 2000-2005* – in this step the clusters are built exclusively for Spanish participants. This approach allows an examination of Spanish firms' results that unfold *before* and *after* project completion using ANOVA tests, i.e., verifying differences between groups in terms of overall corporate performance (Return on Total Assets data from the SABI database – *Bureau van Dijk*). Using this method we might identify how such clusters evolve over time, since longer-term results according to clusters might be a hint of structural change. The timeframe for ROA analysis is relative, i.e., they comprise firms' results from year -3 until year +3, where year 0 (zero) is the year of projects' completion (2000-2005). With this procedure (*ex ante* and *ex post* evaluation), we can avoid interferences of pre-existent characteristics in the evaluation, as well as erratic fluctuations. Furthermore, this approach complements the evaluation of Eureka projects' impacts on firms' overall performance.

Furthermore, we tested for differences between clusters in terms of some variables of interest, namely: TOT_COST, DURATION (via parametric tests, i.e., ANOVA), RATIO_RD, FUNCTIONING, and COUNTRY (via non-parametric tests, using Mann-Whitney U statistics, provided that these variables are ordinal). This assessment allows a deeper comprehension of clusters, as well as a complementary approach to relationships between variables that can indicate some form of association which can be regarded as an influential cause of success in international R&D cooperation projects.

The use of clustering algorithms can be regarded as an interesting tool for policy monitoring and *post hoc* evaluation, since it offers a dynamic view of the interaction between influential variables in the determination of agents' relative position in the process.

7.2 Methodological Discussion

The methodological approach used in this assessment relies on a set of statistical techniques that are well-known, but to our knowledge have not been used jointly in an attempt of building an evaluation of firms' participation in innovation related policy initiatives. This can potentially add relevant information on the debate on international R&D cooperation as well as serve as a starting point for alternative appraisals of similar economic phenomena.

What we tried to cope with was a manner of extracting valuable insights and conclusions from the data available, thus avoiding any kind of "obsession" with some specific method and then trying to adapt reality to a preexistent mindset. We understand that this is a weakness that many policy and scientific evaluations face: being purely led by technique or method (European Commission, 2002). In fact, there is a broad diversity of methods that can be applied in RTD policy evaluation, suggesting that there are many dimensions of analysis existing in this context (European Commission, 2002). Our objective here is to contribute by making use of such a myriad of tools.

For some decades now, there has been great concern in analyzing if a RTD program can be defined as successful or not, and the widespread approach in the economic realm is that of quasi-experimental methodologies. For the case of Eureka, Bayona-Sáez and García-Marco (2010) have recently provided interesting results using this methodology through econometric regressions. The goal in such sort of research is to emulate a control group using companies under "treatment" (that have participated in a policy initiative) and other companies that have similar profiles and which did not receive any support (did not participate in such initiatives) (NIST, 2006). Results are likely to identify the effects of "treatment" being administered to these "patients", since differences between similar companies should be attributed to the event being analyzed, i.e., the policy intervention. Therefore, this approach is regarded as an effective way of dealing with self-selection bias.

A problem with such assessments concerns the impacts of innovation policy on firms' results. Analysis that use corporate performance data (such as ROA) as dependent variables in econometric models, checking for impacts of a specific initiative without proper control variables can often be found in literature. Even an optimistic policymaker would not expect such a direct relationship that omits market oriented dimensions from the investigation (e.g., demand growth in particular sectors, firms' rate of investment, industrial structure).

This is more pronounced for Eureka individual projects, given its decentralized structured. This means that assessing projects' results as homogeneous (even to a small extent) might lead to spurious results. Here, we understand homogeneity as the perspective that participation in Eureka is beneficial, regardless of actual achievements, as demonstrated in the work of Bayona-Sáez and García-Marco (2010). A simple exercise proves the validity of such concern. We regressed 77 Spanish companies' achievements (TECHACHIEV, COMMACHIEV, and EXP_IMPACT) on firms' Return on Total Assets at the time of project completion (ranging from 2000 to 2005 for each firm) and on years +1, +2, and +3 to check for relationships (table 14)[57].

One would expect a positive relationship between independent and dependent variables if Eureka projects were to impact on firms' overall corporate performance. However, as it can be noticed, this is not the case for any period. This assessment, together with quasi-experimental findings, suggests that companies differ in aspects other than those included in conventional models. Furthermore, it gives a strong hint in the direction of understanding that those companies that already outperform their "similar peers" are more prone to engage in such activities as those supported by Eureka. Perhaps the matching-samples do not match the "treated" sample as well as intended.

Independent Variable	**Dependent variable: Return on Total Assets**			
	Standardized Coefficients - Sig. in parentheses			
	Year of Completion	**Completion +1**	**Completion +2**	**Completion +3**
TECHACHIEV	.208 (.093)	-.007 (.959)	-.132 (.305)	.097 (.455)
COMMACHIEV	.099 (.805)	.056 (.684)	.046 (.730)	.020 (.884)
EXP_IMPACT	-	.076 (.560)	.060 (.642)	.031 (.811)
R sq.	.066	.012	.022	.012
Model Sig.	.095	.853	.674	.849
Durbin Watson	2.057	2.138	1.952	1.788

Table 14. Regressions of Spanish firms' outcomes from Eureka projects (2000-2005) on their overall corporate performance (Return on Total Assets for year of project completion, year +1, +2, +3)

[57] The variable EXP_IMPACT was not regressed for the year of project completion, since it is not likely to impact immediately on firms´ performance. This aspect is gathered by COMMACHIEV.

Are quasi-experimental methodologies a useful approach for RTD policy or any other kind of policy evaluation? Yes. Are they *optimal*? Not at all. Professor Giovanni Dosi in the opening speech of DIME's Final Conference held in Maastricht, 2010, criticized the economic perspective that firms are equal, or possibly similar to some extent. Firms are different, he stated. It seems obvious, but for the sake of "good econometrics" this is often omitted. Quasi-experimental forms of analyzing firm behavior are bound to fail in capturing such differences, for one of its premises is to rely on the aforementioned "control group".

Moreover, it creates an aggregated figure of the situation, identifying if the initiative was or was not successful in terms of the relevant indicators under examination. This means that such approach does neither provide consistent answers on the heterogeneity of firms participating in a given program, nor information on the influential characteristics of such program on companies' results (this view is also supported by Lepori, 2006).

We recognize that there is a lack of approaches that aim at understanding quantitatively *how* such programs perform. Ultimately, it is not a program that succeeds or not, but agents. Programs might provide *incentives* for these agents, but their capabilities combined with market and other contextual contingencies that will determine *economic* (and also technological) performance. It is important to consider that in order to translate new scientific knowledge into commercial innovation is a process that involves obstacles and bottlenecks (Balconi, Brusoni & Orsenigo, 2010). Verifying factors other than just "better or worse than without the initiative" is fundamental for moving forward in RTD evaluation – thus avoiding a methodological lock-in.

7.4 Methodological Shortcomings

Our methods of choice offer some alternatives in explaining the phenomenon of R&D cooperation at the international level, covering some aspects that are usually neglected by the most usual econometric approaches. Nonetheless, this also represents that we had to incur in some tradeoffs, as well as in relevant shortcomings that deserve to be mentioned.

First of all, we recognize that, by using exclusively data from Eureka participants, self-selection issues arise (Branstetter & Sakakibara, 2002; Colombo & Garrone, 1996). As our goal is *process oriented*, i.e., it focuses on influential aspects on firms determinants of success (rather than in identifying if the initiative as a whole is effective or not), there is no reason to believe that such issue can be considered as significantly relevant. For obvious reasons, results should be regarded carefully for R&D cooperation that takes place outside of the Eureka framework, since such spurious inference might lead to misleading conclusions, even though outlined results can shed some light on these events.

In this regard we must also understand that there is a variability of motives behind the engagement in R&D cooperation, which are hard to identify, but certainly influence the outcomes from collaboration. While some collaborative projects on R&D may signal only the limited internal capabilities of firms, others might be related to a more strategic sourcing of knowledge. Therefore, the comparison between different partnerships is complicated (Srholec, 2011a).

On a different subject, the approach used fails in providing answers to a systemic perspective of innovative outcomes. For as we tried to take into account results that unfold after the project completion, we deal with a limited timeframe, while the impact of RTD policy usually takes years to be fully visible (European Commission, 2006a). Furthermore, the demonstration of cause-effect relationships in innovation systems is often a problem for technological policy evaluation (Edler & Flanagan, 2011). Also, our analysis can deal with firm-level data only, where analyzing firms participating in the Eureka initiative individually does not provide an assessment of the whole picture: an ideal approach would be to verify the performance dynamics of the consortia (Bayona-Sáez & García-Marco, 2010).

This is an important feature to be considered and possibly tackled by future research, since international R&D cooperation, and especially the case of Eureka, is expected to have deep structural impacts that take a relatively long time span to create the desired outcomes, and even then, it can be an arduous – if possible – task to define causality. In this sense, there is currently a lack of indicators that can properly measure impacts of internationalized R&D activities (Edler & Flanagan, 2011). In order to provide our conclusions, we cannot deal optimally with such matters, thus resorting to a simplification of facts in which a linear approach is used aiming at creating an analysis that is organized and structured in a workable manner (European Commission, 2002; Balconi, Brusoni & Orsenigo, 2010).

As we understand it, a good form of partially overcoming this situation is by applying social network analysis. Network analysis is a methodology of increasing interest in the evaluation of the dynamics of RTD programs' evaluation (NIST, 2006). It provides information regarding a network's characteristics by using data on its size, density and knowledge flows, thus helping to predict and improve the quality of the network itself (US Department of Energy, 2007). This approach can be very useful in future developments of Eureka evaluation, especially because it provides information on behavioral patterns. But in order for such sort of assessment to take place, data must be properly gathered and structured. For this particular research, such "network data" was not available, thus our focus is solely directed to individual agents.

8. Results

In this chapter the results of analyses are presented. Initially, we provide an overview of data composition, i.e., descriptive statistics of variables. In a second moment we turn to the outcomes of each logistic equation, where lastly we provide a summary of findings that confront hypotheses with results from the empirical assessment. In the last part, clusters are developed, as well as statistically analyzed against a set of variables of interest, thus building a framework for the comprehension of firms' profiles when engaging in international R&D cooperation.

8.1 Sample Description

Descriptive statistics of data used in our analyses are presented in table 15. Composition of groups are provided considering: a) All countries (Spain, Italy, France, UK, and Germany); b) Benchmark countries (Italy, France, UK, and Germany); and c) Spain. This assessment is available for the 2000-2005 and 2006-2008 datasets.

As previously stated, it can be noticed that there are some changes in variables' structures between these two periods of analysis. First of all, COMPETITOR and FUNCTIONING are not available for 2006-2008 data. Also, COMMACHIEV and EXP_IMPACT follow different categorical compositions regarding the form of assessment. TECHACHIEV, COMMACHIEV, and EXP_IMPACT are reported according to their original arrangements (not dichotomized), but their binary equivalent can be easily obtained through the replication of the simple procedure described in the methodology chapter (grouping of levels). Not all variables' percentages sum up to 100% due to missing data.

2000-2005

Variable	Categories	Percentage: All Countries	Percentage: Benchmark Countries	Percentage: Spain
ORG_TYPE	SMEs	60.9%	60.1%	62.3%
	Large Companies	39.1%	39.9%	37.7%
RATIO_RD	<2%	15.3%	8.7%	27.3%
	2 to 10%	45.6%	50.7%	36.4%
	>10%	22.3%	28.3%	11.7%
COMPETITOR	Yes	24.2%	24.6%	23.4%
FUNCTIONING	Excellent	27.4%	28.3%	26.0%
	Good	63.7%	65.2%	61.0%
	Weak/Bad	7.9%	6.5%	10.4%
COUNTRY	Laggard IS	35.8%	-	-
	Intermediate IS	36.3%	56.5%	-
	Leader IS	27.9%	43.5%	-
PROD_INNO	Yes	63.7%	60.9%	68.8%
PROC_INNO	Yes	50.2%	47.1%	55.8%
SERV_INNO	Yes	14.0%	11.6%	18.2%
IND_EXP	Yes	82.3%	82.6%	81.8%
STRAT_ALL	Yes	17.7%	21.0%	11.7%
TECHACHIEV	Excellent	25.1%	25.4%	24.7%
	Good	66.0%	65.2%	67.5%
	Weak	7.0%	6.5%	7.8%
	Bad	1.9%	2.9%	-
COMMACHIEV	Excellent	8.8%	7.2%	11.7%
	Good	43.3%	44.2%	41.6%
	Weak	21.9%	23.2%	37.7%
	Bad	3.3%	3.6%	24.7%
	Nil	22.8%	21.7%	7.8%
EXP_IMPACT	Very Large	5.1%	5.1%	5.2%
	Large	20.5%	18.1%	24.7%
	Medium	36.7%	36.2%	37.7%
	Small	25.1%	25.4%	24.7%
	Nil	12.6%	15.2%	7.8%

2006-2008

Variable	Categories	Percentage: All Countries	Percentage: Benchmark Countries	Percentage: Spain
ORG_TYPE	SMEs	70.4%	69.6%	72.2%
	Large Companies	29.6%	30.4%	27.8%
RATIO_RD	<2%	16.5%	16.5%	17.6%
	2 to 10%	41.7%	44.3%	36.1%
	>10%	35.7%	32.9%	41.7%
COUNTRY	Laggard IS	31.3%	-	-
	Intermediate IS	23.5%	34.2%	-
	Leader IS	45.2%	65.8%	-
PROD_INNO	Yes	63.5%	58.2%	75.0%
PROC_INNO	Yes	37.4%	35.4%	41.7%
SERV_INNO	Yes	22.6%	20.3%	27.8%
IND_EXP	Yes	68.7%	64.6%	77.8%
STRAT_ALL	Yes	29.6%	25.3%	38.9%
TECHACHIEV	Excellent	32.2%	26.6%	44.4%
	Good	55.7%	57.0%	52.8%
	Weak	8.7%	12.7%	-
	Bad	3.5%	3.8%	2.8%
COMMACHIEV	1 = Very low	52.2%	55.7%	44.4%
	< or = RTD investment	26.1%	22.8%	33.3%
	2-5 times RTD investment	16.5%	15.2%	19.4%
	+-10 times RTD inv.	4.3%	5.1%	2.8%
	<100 times RTD inv.	-	-	-
	More	0.9%	1.3%	-
EXP_IMPACT	1 = Very low	15.7%	20.3%	5.6%
	< or = RTD investment	18.3%	20.3%	13.9%
	2-5 times RTD investment	38.3%	36.7%	41.7%
	+-10 times RTD inv.	25.2%	19.0%	38.9%
	<100 times RTD inv.	1.7%	2.5%	-
	More	0.9%	1.0%	-

2000-2005

Variable	Mean (Std. Dev. In parentheses): All Countries	Benchmark Countries	Spain
TOT_COST	5.973 (14.521)	7.300 (17.422)	3.595 (6.138)
DURATION	42.81 (21.195)	43.72 (21.413)	41.18 (20.839)

2006-2008

Variable	Mean (Std. Dev. In parentheses): All Countries	Benchmark Countries	Spain
TOT_COST	2.615 (4.886)	2.736 (4.534)	2.350 (5.643)
DURATION	34.30 (14.217)	35.24 (14.525)	32.22 (13.480)

Table 15. Data description

Categorical variables are described in terms of percentages in terms of the composition of datasets. At the bottom of table 15 we present a brief description of scale variables, i.e., TOT_COST and DURATION.

The importance of this perspective lies in a primary observation of trends and characteristics of data which are applied in statistical models with inferential content. Furthermore, some insights can be drawn for better interpretation of further assessments.

In the Microeconomic Dimension, there is a predominance of SMEs over Large companies, with no clear distinction between subjects (all countries, benchmark countries, and Spain), showing a relatively stable trend, which increases by roughly 10% from the 2000-2005 period to 2006-2008. On the other hand, RATIO_RD puts Spain as a participant with low R&D intensity firms in 2000-2005, whereas in 2006-2008 projects, such firms present a higher level of R&D investments in comparison to benchmark countries, especially regarding the highest level of R&D intensity (>10% of turnover). In general terms, the bulk of participants can be considered on the higher levels of innovative intensity (ranging from 2% to more than 10% of R&D expenditures in terms of its ratio with companies' turnovers).

Regarding the Contextual Dimension, Spain presents slightly worse results in terms of project functioning (FUNCTIONING) than the benchmark countries. Overall results point towards fair perceptions of such interactions (Excellent and Good classifications). The presence of competitors in cooperative projects (COMPETITORS) happens in about one quarter of cases. The mean of projects' costs (TOT_COST) is a weak indicator, considering the high dispersion of results. A similar situation happens for projects' duration (DURATION). Nonetheless, Spanish firms seem to engage in projects that cost less than those in which benchmark countries' firms are involved, even though they have similar durations.

The Macroeconomic Dimension which is approximated by the variable COUNTRY puts the laggard Innovation System (IS), i.e., Spain, with nearly one third of analyzed companies in both timeframes. In 2006-2008 the Leader IS (Germany) has a significant increase in terms of participation at the expense of Intermediate IS' (France, Italy, and UK) firms, which decrease in contribution.

The evaluation of types of achieved innovations (PROD_INNO, PROC_INNO, and SERV_INNO) suggests a higher level of the three kinds of achievements for Spanish firms in comparison to the benchmark countries for both periods (which is in accordance with H_5). The overall picture implies a strong orientation towards product innovation in Eureka projects, where process innovation plays a secondary role, and service innovation has a marginal significance. Results are also largely exploited by the end of projects (IND_EXP). In terms of the generation of strategic alliances (STRAT_ALL), this outcome varies between periods, and Spanish firms seem to have increased their relative position in terms of the generation of long-lasting international R&D networks.

On the subject of general achievements, three variables are considered: TECHACHIEV, COMMACHIEV, and EXP_IMPACT. TECHACHIEV highlights the high rate of technological/technical success of Eureka projects, and Spanish firms again plays a leading role in terms of successful results (combination of Excellent and Good technological achievements), which provides another support for H_5. Nonetheless, this high concentration of positive results in technological aspects of cooperation indicates statistical constraints for logistic models. Furthermore, even though this aspect emerges as a positive situation at first, it might also indicate the precision of Georghiou's (2001) criticism of diminishing quality of Eureka's innovation projects, where “safer” intentions might lead to better outcomes.

However, this consistency of successful results vanishes when analyzing market outcomes, as well as future expected impacts. Positive COMMACHIEV results (considered as those rated as Excellent and Good in the 2000-2005 dataset, and those that exceed the R&D investment in at least twice its amount for 2006-2008 data) represent roughly 50% of cases in the 2000-2005 period across groups (All countries, Benchmark countries, and Spain), and about 20% for the 2006-2008 timeframe. However, in both cases, Spanish firms perform somewhat better than those from benchmark nations. For the EXP_IMPACT variable, results vary between datasets, where for 2006-2008 projects, future impacts seem to be more significant. Again, there is an indication that Spanish firms achieve better outcomes.

8.2 Analysis of Logistic Regressions

In this part of the analysis of results, focus will be directed to logistic regressions. Each section contains the respective approaches for 2000-2005 and 2006-2008 estimations. Also, results are presented jointly for theoretically grounded equations (2-4) and the correspondent *ad hoc* assessments (5-7). Exception is made for Equation 8, which does not contain a correspondent approach based on theory.

For a thorough examination of relationships between variables and their statistical validity, preliminary assessments are provided before actual estimations' reports. This was done through the analysis of crude odds-ratio results, i.e., a bivariate estimation of logistic association between each predictor and dependent variables. Also, non-parametric correlations (Spearman's rho coefficients) are presented.

The last part of the analysis of logistic regressions brings a summary of results of the set of equations (Equations 2, 3, and 4) which test the hypotheses of this research. Findings are confronted with expected results according to each hypothesis, thus allowing a comprehension of empirical implications for investigation on international R&D cooperation.

8.2.1 Equations 2 and 5

This section presents the results of analyses undertaken for equations 2 and 5 in periods 2000-2005 and 2006-2008. Such estimations consider the variable TECHACHIEV as the dependent element of regressions, where results take the value of 0 whenever they were regarded as "failures" (Weak and Bad

Technological Outcomes), and the value of 1 when they were perceived as "successes" (Excellent and Good Technological Outcomes). A first shortcoming of these equations is represented by the general feature of this variable: as reported in the description of datasets, "success" represent a high proportion of results (around 90% of cases), thus interfering with statistical prowess to provide relevant results for identification of determinants.

In the 2000-2005 estimations, preliminary assessments show significant values for crude odds-ratio regarding the variables FUNCTIONING, PROD_INNO, and PROC_INNO. Such relationships are also supported by significant non-parametric correlations (table 16). Results indicate that better rates of projects' functioning are associated with success in the achievement of positive technological results. The same is true for the attainment of product and process innovations, but not for service innovations, which can be related to the intangible character of innovations in this latter aspect (even though SERV_INNO is significantly correlated with PROD_INNO in this case). Microeconomic dimension's variables, as well as Macroeconomic, do not receive statistical support concerning their influence on technological achievements.

Some further exploration of preliminary results shows a higher propensity of Large Companies in achieving positive technological outcomes, provided that its crude odds-ratio exceeds the benchmark of 1 designated for SMEs, even though this indication is not statistically significant. Similarly, higher rates of R&D intensity are related to better technological results (not significantly). However, TOT_COST ($p = .379$) suggests that higher levels of investment are related to worse technological results.

On the macroeconomic dimension, levels of significance are well above common thresholds of statistical relevance for relationships with TECHACHIEV, but it is interesting to notice a correlation coefficient that indicates higher R&D intensities (RATIO_RD) in firms belonging to more developed Innovation Systems.

Dimension	Independent Variable	D.V. Description	TECHACHIEV SUCCESS (1)	Crude Odds Ratio - Exp (B)	Confidence Interval (95%)	Sig.
	ORG_TYPE	Large Company (1)	88.1%	1.832	.711 - 4.716	.210
		SME (0)	93.1%	1	-	-
Microeconomic	RATIO_RD	<2% (1)	90.9%	.667	.126 - 3.526	.633
		2-10% (2)	89.8%	.587	.154 - 2.239	.435
		>10% (3 - Ref. Cat.)	93.8%	1	-	-
	TOT_COST	M. Euro	-	.990	.967 - 1.013	.379
	COMPETITOR	Yes (1)	92.3%	1.216	.385 - 3.841	.739
Contextual		No (0)	90.8%	1	-	-
	FUNCTIONING	Excellent (1)	94.9%	7.778	1.632 - 37.059	.010
		Good (2)	92%	4.773	1.421 - 16.032	.011
		Weak/Bad (3 - Ref. Cat.)	70.6%	1	-	-
	COUNTRY	Spain (1)	92.2%	1.038	.301 - 3.576	.953
Macroeconomic		Intermediate ISs (2)	89.5%	.746	.231 - 2.406	.623
		Leader IS (3 - Ref. Cat.)	91.9%	1	-	-
	PROD_INNO	Yes (1)	97.1%	7.917	2.524 - 24.827	.000
		No (0)	80.8%	1	-	-
Ad hoc	PROC_INNO	Yes (1)	99.1%	21.640	2.833 - 165.302	.003
		No (0)	83.2%	1	-	-
	SERV_INNO	Yes (1)	96.7%	3.126	.402 - 24.327	.276
		No (0)	90.3%	1	-	-

	TECHACHIEV	***ORG_TYPE***	***FUNCTIONING***	***COUNTRY***	***COMPETITOR***	***TOT_COST***	***RATIO_RD***	***PROD_INNO***	***PROC_INNO***	***SERV_INNO***
TECHACHIEV	1									
ORG_TYPE	-.087	1								
FUNCTIONING	-.156*	.017	1							
COUNTRY	-.008	.045	-.073	1						
COMPETITOR	.023	.037	-.094	.112	1					
TOT_COST	.110	.246**	.055	.124	.118	1				
RATIO_RD	.041	-.364**	-.025	.227**	.064	-.066	1			
PROD_INNO	.276**	-.149*	-.082	-.101	-.093	.003	.008	1		
PROC_INNO	.280**	-.080	-.113	-0.65	.041	.035	-.093	.158*	1	
SERV_INNO	.078	-.157*	.025	-.036	.023	-.027	.077	.220**	.025	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 16. Equations 2 and 5 (2000-2005): Crude Odds-Ratio and Non-Parametric (Spearman) Correlations

Independent Variable		Adjusted Odds Ratio - Exp (B) Sig. in parentheses	
		Equation 2	Equation 5
ORG_TYPE	Large Company (1)	.696 (.555)	-
	SME (0)	-	-
COMPETITOR	Yes (1)	1.412 (.667)	-
	No (0)	-	-
FUNCTIONING	Excellent (1)	5.634 (.063)	7.403 (.030)
	Good (2)	3.616 (.105)	5.261 (.028)
	Weak/Bad (3 - Ref. Cat.)	-	-
RATIO_RD	<2% (1)	.745 (.764)	-
	2-10% (2)	.726 (.670)	-
	>10% (3 - Ref. Cat.)	-	-
COUNTRY	Spain (1)	.597 (.511)	-
	Intermediate ISs (2)	.593 (484)	-
	Leader IS (3 - Ref. Cat.)	-	-
TOT_COST	Million Euro	.987 (.335)	-
PROD_INNO	Yes (1)	-	7.330 (.002)
	No (0)	-	-
PROC_INNO	Yes (1)	-	16.757 (.007)
	No (0)	-	-
SERV_INNO	Yes (1)	-	1.664 (.649)
	No (0)	-	-
Hosmer-Lemeshow Test		.980	.672
Nagelkerke R sq.		.077	.362
% of Correct Predictions (Intercept Only)		91%	91.1%
% of Correct Predictions		91%	91.5%

Table 17. Equations 2 and 5 (2000-2005): Logistic regressions' results

In table 17, results for the multivariate binary logistic regressions corresponding to equations 2 and 5 (2000-2005) perform consistently with preliminary statistics. Equation 2 is significant as a whole, according to the Hosmer-Lemeshow Test for goodness-of-fit, indicating that the model adequately fits the data. However, both Nagelkerke R^2 and the evaluation of the model's correct predictions in comparison to an intercept only assessment show a weak explanatory power. Similar conclusions can be made for the *ad hoc* equation

(Equation 5), even though there is an increase in regression's fit. This can be explained by the inclusion of PROD_INNO and PROC_INNO, variables which were identified as having potential influence over TECHACHIEV.

Even though FUNCTIONING is not significant at 5% in Equation 2, an Excellent rate of functioning has an Adjusted Odds-Ratio that represents a positive influence on technological attainments at a level of significance of 10%. On the other hand, this does not hold for Good functioning in Equation 2 (it is slightly above 10%). Nevertheless this provides an indication of the importance of such aspect in determining technical outcomes in international R&D projects, controlling for the set of theoretically grounded variables included in this equation.

In the *ad hoc* approach, FUNCTIONING was kept in the analysis, provided its statistical significance and the three possible types of innovation were added. Coefficients and relevance of variables indicate that better technological outcomes are related to PROC_INNO more than to any other variable of this model. The existence of Excellent levels of projects' functioning and the achievement of product innovations have similar impacts on technical outcomes, where Good project functioning also is statistically relevant as a predictor of technological success. The case of SERV_INNO indicates a positive relationship with the dependent variable, but this cannot be regarded as statistically representative.

When we turn to the 2006-2008 dataset (Equations 2 and 5, tables 18 and 19) some relevant differences with the 2000-2005 period can be noticed. First of all, we remind that the variable FUNCTIONING, which turned out to be a significant determinant of technological achievements, is not available in this case. However, using the crude odds-ratio table and the Spearman's rho correlation coefficients in a direct comparison with the 2000-2005 application of Equations 2 and 5, PROD_INNO, and PROC_INNO keep their validity as *ad hoc* predictors for technical success in international R&D cooperation, whereas SERV_INNO does not show statistical relevance.

Dimension	Independent Variable	D.V. Description	TECHACHIEV SUCCESS (1)	Crude Odds Ratio - Exp (B)	Confidence Interval (95%)	Sig.
Microeconomic	ORG_TYPE	Large Company (1)	85.3%	.725	.224 - 2.348	.592
		SME (0)	88.9%	1	-	-
	RATIO_RD	<2% (1)	89.5%	1.750	.328 - 9.351	.513
		2-10% (2)	91.7%	2.265	.613 - 8.372	.220
		>10% (3 - Ref. Cat.)	82.9%	1	-	-
Contextual	TOT_COST	M. Euro	-	1.007	.891 - 1.138	.911
Macroeconomic	COUNTRY	Spain (1)	97.2%	7.326	.885 - 60.642	.065
		Intermediate ISs (2)	85.2%	1.203	.334 - 4.337	.777
		Leader IS (3 - Ref. Cat.)	82.7%	1	-	-
Ad hoc	PROD_INNO	Yes (1)	97.3%	14.200	2.994 - 67.346	.001
		No (0)	71.4%	1	-	-
	PROC_INNO	Yes (1)	97.7%	9.254	1.165 - 73.491	.035
		No (0)	81.9%	1	-	-
	SERV_INNO	Yes (1)	96.2%	4.276	.532 - 34.351	.172
		No (0)	85.4%	1	-	-

	TECHACHIEV	***ORG_TYPE***	***COUNTRY***	***TOT_COST***	***RATIO_RD***	***PROD_INNO***	***PROC_INNO***	***SERV_INNO***
TECHACHIEV	1							
ORG_TYPE	-.050	1						
COUNTRY	-.183	.003	1					
TOT_COST	-.139	.212*	-.191*	1				
RATIO_RD	-.100	-.265**	-.047	-0.16	1			
PROD_INNO	.380**	-.142	-.100	-.152	-.010	1		
PROC_INNO	.233*	.090	-.015	.026	-.064	.176	1	
SERV_INNO	.138	-.122	-.139	.089	-.173	.108	.227*	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 18. Equations 2 and 5 (2006-2008): Crude Odds-Ratio and Non-Parametric (Spearman) Correlations

Furthermore, in this preliminary assessment, it should be noticed that Spanish firms show significant *better* technological outcomes than firms from intermediate (Italy, UK, and France) and leading (Germany) Innovation Systems (this result did not hold for the equivalent estimation for period 2000-2005). In the microeconomic dimension, neither RATIO_RD nor ORG_TYPE contribute to the analysis. Nonetheless, coefficients suggest that companies with intermediate R&D intensity are those that benefit more from projects in technical terms (followed by companies with low R&D intensity). This could be interpreted using the concepts of absorptive capacity and distance from technological frontier, i.e., those companies above a threshold of available knowledge will perform better than the technological leaders from cooperative projects.

As this situation is not consistent with the previous (2000-2005) analysis, this interpretation cannot be regarded as consistent (similar variability happens for the variable ORG_TYPE, where analogous interpretations and considerations apply). It should also be pointed out that the distribution structure of ultimate technical outcomes is strongly biased towards successful projects. This statistical shortcoming may explain the inconsistencies between periods of analysis. A confirmation of this shortcoming in equations 2 and 5 can be seen in the model´s overall indicators for the period 2006-2008 (which are somewhat similar to those found in the 2000-2005 approach). Even though the Hosmer-Lemeshow test (table 19) validates the significance of the group of predictors, Nagelkerke's R^2 is particularly small for Equation 2, and the classification capacity of models (both equations) does not increase with predictors in a direct comparison to the model based only on the intercept.

The evaluation of variables' features in the multivariate binary logistic regression performs as expected, according to the preliminary tables. The only significant variable in equation 2 is COUNTRY for the case of Spanish firms, with an adjusted odds-ratio that exceeds those of intermediate ISs and Leader (Reference Category).

Independent Variable		Adjusted Odds Ratio - Exp (B) Sig. in parentheses	
		Equation 2	Equation 5
ORG_TYPE	Large Company (1)	.584 (.472)	-
	SME (0)	-	-
RATIO_RD	<2% (1)	2.447 (.342)	-
	2-10% (2)	2.954 (.123)	-
	>10% (3 - Ref. Cat.)	-	-
COUNTRY	Spain (1)	7.242 (.070)	5.715 (.126)
	Intermediate ISs (2)	.984 (.981)	1.714 (.474)
	Leader IS (3 - Ref. Cat.)	-	-
TOT_COST	Million Euro	1.037 (.633)	-
PROD_INNO	Yes (1)	-	10.572 (.004)
	No (0)	-	-
PROC_INNO	Yes (1)	-	6.442 (.095)
	No (0)	-	-
SERV_INNO	Yes (1)	-	2.235 (.490)
	No (0)	-	-
Hosmer-Lemeshow Test		.270	.786
Nagelkerke R sq.		.130	.380
% of Correct Predictions (intercept only)		88%	87.8%
% of Correct Predictions		88%	87.8%

Table 19. Equations 2 and 5 (2006-2008): Logistic regressions' results

However, when controlling for the *ad hoc* variables, COUNTRY/Spanish firms loses ground in terms of statistical significance, where PROD_INNO stands as the main determinant of technical success in Eureka's projects. PROC_INNO also should be regarded as an important aspect in this case. If we confront these results with those of the 2000-2005 analysis, we find a robust evidence that tangible innovations are more likely to be related to successful projects (in technical terms) than service innovations (which are largely intangible). This is not surprising when thinking that such results apply for international RD cooperation, being Research and Development strongly oriented towards product and process innovation.

8.2.2 Equations 3 and 6

This step takes into account a market oriented perspective as the dependent variable in the analysis: COMMACHIEV. As previously stated, evaluation of results between periods can be rather sensitive to alterations in scales and structures of measurements. Please, refer to table 10 and notes on the methodological sections for a discussion on this regard. Furthermore, descriptive statistics (table 15), highlight homogeneous groups in terms of what we classify as commercial "success" and "failure" in comparison to the variable TECHACHIEV. *A priori,* this represents a better statistical fit for binary logistic regressions.

Starting with the preliminary statistics (crude odds-ratio and Spearman's rho correlation coefficients) for the 2000-2005 dataset, some interesting insights arise. FUNCTIONING is significant at both Excellent and Good levels, since both exceed the value assigned to the Reference Category (Weak/Bad). This is in accordance to results found for Equations 2 and 5 (2000-2005), supporting the idea that partners' capacity of properly managing an international R&D cooperation project is a relevant determinant of ultimate success (in both technical and commercial dimensions). Also, technological achievements (TECHACHIEV) appear as an important predictor of market success, which puts this feature as a necessary condition for appropriation of innovations in the economic realm.

The capacity of having industrial exploitation of results (IND_EXP) by the end of projects is also a significant factor of success. But if we turn to descriptive statistics, we can find that the occurrence of such activity (industrial exploitation) exceeds that of commercial success, indicating an approximation of a "rate of commercial failure", i.e., projects that reached practical application but did not result in beneficial commercial impacts, which is an expected phenomenon in the study of innovation economics and management (representing commercialization *risks*). An additional aspect related to IND_EXP is its significant correlation with TECHACHIEV, which provides further support for the expectation that technical aspects are a necessary, but not sufficient, condition for market performance. Results also indicate an acceptable level of significance for PROD_INNO and PROC_INNO, designating a consistent pattern in terms of supporting a relationship between projects' success and tangibility of innovative attainments.

In this case, the Macroeconomic Dimension of the equation can be disregarded as an influential factor. Not only its related instruments are not significant, but values are close to the benchmark set for the Reference Category, thus not indicating any relevant information for the model. For the Microeconomic dimension, represented in these equations by the variable ORG_TYPE, results are not significant in this preliminary assessment, even though the coefficient suggests a weak relationship between SMEs and better commercial achievements. In the Contextual dimension, besides TECHACHIEV, IND_EXP, and FUNCTIONING, the existence of rival firms in the network (COMPETITOR) and its duration (DURATION) did not show any evidence of statistical significance.

Outcomes of the multivariate binary logistic estimation for Equation 3 are shown in table 21 and they basically confirm the perceptions brought by the bivariate estimations form crude odds-ratio analysis, as well as the non-parametric correlation matrix. Model's overall estimates for this particular equation provide information that allows confirming its adequate fit. Hosmer-Lemeshow exceeds the statistical threshold at 1%, 5%, and 10% of model's validity, while Nagelkerke's R^2 and the difference between the percentages of correct predictions with predictors *versus* the intercept only estimation indicate an acceptable explanatory capacity of this regression.

Dimension	Independent Variable	D.V. Description	COMMACHIEV SUCCESS (1)	Crude Odds Ratio - Exp (B)	Confidence Interval (95%)	Sig.
Microeconomic	ORG_TYPE	Large Company (1)	46.4%	.689	.397 - 1.194	.184
		SME (0)	55.7%	1	-	-
Contextual	IND_EXP	Yes (1)	62.1%	29.552	6.891 - 126.732	.000
		No (0)	5.3%	1	-	-
	COMPETITOR	Yes (1)	52.8%	.895	.479 - 1.672	.729
		No (0)	50%	1	-	-
	DURATION	Months	-	1.001	.989 - 1.014	.847
	TECHACHIEV	Success (1)	56.6%	23.506	3.077 - 179.584	.002
		Failure (0)	5.3%	1	-	-
	FUNCTIONING	Excellent (1)	62.7%	26.909	3.335 - 217.136	.002
		Good (2)	54%	18.794	2.424 - 145.700	.005
		Weak/Bad (3 - Ref. Cat.)	5.9%	1	-	-
Macroeconomic	COUNTRY	Spain (1)	53.2%	1.068	.547 - 2.086	.848
		Intermediate ISs (2)	51.3%	.988	.505 - 1.933	.972
		Leader IS (3 - Ref. Cat.)	51.6%	1	-	-
Ad hoc	PROD_INNO	Yes (1)	60.6%	2.597	1.464 - 4.606	.001
		No (0)	37.2%	1	-	-
	PROC_INNO	Yes (1)	60.2%	1.930	1.122 - 3.319	.018
		No (0)	43.9%	1	-	-
	SERV_INNO	Yes (1)	63.3%	1.709	.770 - 3.790	.187
		No (0)	50.3%	1	-	-

	COMMACHIEV	***TECHACHIEV***	***ORG_TYPE***	***FUNCTIONING***	***COUNTRY***	***COMPETITOR***	***DURATION***	***IND_EXP***	***PROD_INNO***	***PROC_INNO***	***SERV_INNO***
COMMACHIEV	1										
TECHACHIEV	.292**	1									
ORG_TYPE	-.091	-.087	1								
FUNCTIONING	-.235**	-.156*	.017	1							
COUNTRY	-.014	-.008	.045	-.073	1						
COMPETITOR	-.024	.023	.037	-.094	.112	1					
DURATION	-.007	.015	.208**	.078	.117	.121	1				
IND_EXP	.434**	.371**	-.154*	-.190**	.049	.091	.038	1			
PROD_INNO	.225**	.276**	-.149*	-.082	-.101	-.093	-.006	.259**	1		
PROC_INNO	.163*	.280**	-.080	-.113	-.065	.041	.082	.222**	.158*	1	
SERV_INNO	.091	.078	-.157*	.025	-.036	.023	-.024	.081	.220**	.025	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 20. Equations 3 and 6 (2000-2005): Crude Odds-Ratio and Non-Parametric (Spearman) Correlations

Independent Variable		Adjusted Odds Ratio - Exp (B) Sig. in parentheses	
		Equation 3	Equation 6
ORG_TYPE	Large Company (1)	.910 (.780)	-
	SME (0)	-	-
COMPETITOR	Yes (1)	.626 (.215)	-
	No (0)	-	-
FUNCTIONING	Excellent (1)	18.455 (.009)	18.800 (.008)
	Good (2)	12.921 (.019)	14.494 (.014)
	Weak/Bad (3 - Ref. Cat.)	-	-
TECHACHIEV	Success (1)	8.329 (.007)	3.323 (.165)
	Failure (0)	-	-
IND_EXP	Yes (1)	13.828 (.000)	12.146 (.000)
	No (0)	-	-
COUNTRY	Spain (1)	1.296 (.515)	-
	Intermediate ISs (2)	1.067 (.871)	-
	Leader IS (3 - Ref. Cat.)	-	-
DURATION	Months	1.002 (.828)	-
PROD_INNO	Yes (1)	-	1.752 (.106)
	No (0)	-	-
PROC_INNO	Yes (1)	-	1.163 (.643)
	No (0)	-	-
SERV_INNO	Yes (1)	-	1.324 (.548)
	No (0)	-	-
Hosmer-Lemeshow Test		.636	.902
Nagelkerke R sq.		.326	.333
% of Correct Predictions (Intercept only)		52.6%	52.6%
% of Correct Predictions		73.2%	73.2%

Table 21. Equations 3 and 6 (2000-2005): Logistic regressions' results

In Equation 6, the lack of individual significance for the variables TECHACHIEV, PROD_INNO, and PROC_INNO is in conflict with the preliminary indicators, suggesting the existence of collinearity effects among these variables (which is supported by their significant correlation coefficients). Nonetheless, the general features of the model remain relatively stable in a direct comparison to those of Equation 3, indicating a strong influence of FUNCTIONING and IND_EXP as core determinants of ultimate commercial achievements.

It is interesting to remind that projects' functioning already performed significantly in the TECHACHIEV model (especially for the Excellent Functioning instrument). This contextual feature of projects seems to lie at the heart of networks' success, providing H_2 with robust support from empirical data.

Unfortunately, for the 2006-2008 approach (tables 22 and 23), FUNCTIONING is not available for analysis, thus making it difficult the comparison between datasets, provided that this element has been proven useful in determining firms' outcomes from international collaborative R&D projects. The bivariate estimations for crude odds-ratio and correlations between pairs of variables indicate the maintenance of IND_EXP validity (at 10%), while TECHACHIEV is (somewhat surprisingly) not relevant in this case. On the Microeconomic Dimension, ORG_TYPE suggests that Large Companies experience better commercial achievements, but without statistical relevance.

Spain, or Spanish firms (as an instrument of COUNTRY), which resulted significant in Equation 2 (2006-2008), becomes irrelevant when considering the market perspective. DURATION slightly exceeds the 10% threshold of significance, but its odds-ratio suggests the opposite of the logical expectation, where projects with shorter durations are related to better market results. One possible explanation for this is related to the hypothesis that the capacity of firms generating marketable products in successful conditions is related to a shorter time-to-market period. However, this is only speculation, since the 2000-2005 dataset does not provide any support for such conclusion (statistical measurements of relevance also do not comply with this trend).

Dimension	Independent Variable	D.V. Description	COMMACHIEV SUCCESS (1)	Crude Odds Ratio - Exp (B)	Confidence Interval (95%)	Sig.
Microeconomic	ORG_TYPE	Large Company (1)	26.5%	1.462	.572 - 3.736	.427
		SME (0)	19.8%	1	-	-
Contextual	IND_EXP	Yes (1)	26.6%	2.897	.914 - 9.176	.071
		No (0)	11.1%	1	-	-
	DURATION	Months	-	.973	.939 - 1.008	.129
	TECHACHIEV	Success (1)	23.8%	4.052	.504 - 32.594	.188
		Failure (0)	7.1%	1	-	-
Macroeconomic	COUNTRY	Spain (1)	22.2%	1.065	.380 - 2.982	.905
		Intermediate ISs (2)	22.2%	1.065	.346 - 3281	.913
		Leader IS (3 - Ref. Cat.)	21.2%	1	-	-
Ad hoc	PROD_INNO	Yes (1)	30.1%	5.608	1.565 - 20.095	.008
		No (0)	7.1%	1	-	-
	PROC_INNO	Yes (1)	30.2%	2.167	.882 - 5.322	.092
		No (0)	16.7%	1	-	-
	SERV_INNO	Yes (1)	42.3%	3.929	1.497 - 10.310	.005
		No (0)	15.7%	1	-	-

	COMMACHIEV	***TECHACHIEV***	***ORG_TYPE***	***COUNTRY***	***DURATION***	***IND_EXP***	***PROD_INNO***	***PROC_INNO***	***SERV_INNO***
COMMACHIEV	1								
TECHACHIEV	.132	1							
ORG_TYPE	.074	-.050	1						
COUNTRY	-.012	-.183	.003	1					
DURATION	-.190*	-.099	.133	-.004	1				
IND_EXP	.174	.207*	-.056	-.128	-.139	1			
PROD_INNO	.268**	.380**	-.142	-.100	-.172	.189*	1		
PROC_INNO	.159	.233*	.090	-.015	.056	.057	.176	1	
SERV_INNO	.270**	.138	-.122	-.139	-.021	.096	.108	.227*	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 22. Equations 3 and 6 (2006-2008): Crude Odds-Ratio and Non-Parametric (Spearman) Correlations

Furthermore, *ad hoc* variables (PROD_INNO, PROC_INNO, SERV_INNO) are all statistically significant and their presence is related to better market performance of projects' results. In this case, SERV_INNO presents an interesting statistical merit within this group of predictors. This can be interpreted as an indication of the relevance of such variable, even when it does not correspond to technical aspects of projects.

In the multivariate estimations (table 23 below), results provide rather blurry information on the determinants of commercial achievements for the period under scrutiny.

Independent Variable		**Adjusted Odds Ratio - Exp (B) Sig. in parentheses**	
		Equation 3	**Equation 6**
ORG_TYPE	Large Company (1)	1.862 (.226)	
	SME (0)	-	-
TECHACHIEV	Success (1)	3.410 (.267)	
	Failure (0)	-	-
IND_EXP	Yes (1)	2.550 (.125)	2.518 (.146)
	No (0)	-	-
COUNTRY	Spain (1)	.764 (.633)	
	Intermediate ISs (2)	1.217 (.747)	
	Leader IS (3 - Ref. Cat.)	-	-
DURATION	Months	.971 (.127)	
PROD_INNO	Yes (1)	-	4.879 (.019)
	No (0)	-	-
PROC_INNO	Yes (1)	-	1.567 (.372)
	No (0)	-	-
SERV_INNO	Yes (1)	-	3.379 (.021)
	No (0)	-	-
Hosmer-Lemeshow Test		.772	.847
Nagelkerke R sq.		.114	.232
% of Correct Predictions (Intercept only)		78.3%	78.3%
% of Correct Predictions		78.3%	78.3%

Table 23. Equations 3 and 6 (2006-2008): Logistic regressions' results

Whereas the model as a whole is significant, it neither contributes importantly to the classification of cases, nor presents predictors with individual significance (Equation 3). IND_EXP, which was perceived as significant in the bivariate procedures, becomes statistically irrelevant. This highlights a possible case of collinearity between this variable and TECHACHIEV, according to correlation coefficients. Nonetheless, we keep this variable in Equation 6, given that TECHACHIEV is not present in this case and considering its original relevance.

In Equation 6, there is an increase in Nagelkerke's R^2, but the capacity of correctly classifying cases is not incremented with the predictors in comparison to the estimation using only the intercept, indicating a structural weakness of such assessment. Again, IND_EXP indicates a positive influence on market outcomes, but without statistical significance. This can possibly be in function of this particular variable's relationship with PROD_INNO (see table 22 for correlation coefficients). PROD_INNO, and SERV_INNO come out as the main aspects influencing such results for companies in the 2006-2008 period, where it is worth noticing the presence of a relatively high correlation between the latter and PROC_INNO.

Such results are partially in accordance with estimations for 2000-2005, especially when considering the directions of influence (positive or negative) for the variables TECHACHIEV, IND_EXP, DURATION, PROD_INNO, PROC_INNO, and SERV_INNO. On the other hand, these aspects lack statistical significance, being rather suggestive, not conclusive.

8.2.3 Equations 4 and 7

This section approaches results for Equations 4 and 7, which deal with the variable EXP_IMPACT as the dependent element in regressions. This particular item deals with relatively higher levels of subjectivity, since it is based on perceptions of future returns arising from international R&D cooperation projects. Nonetheless, *expectations* are known to play a decisive role in economics, shaping today's behavior in face of envisaged scenarios. Considering this logic, such results can be considered as valid instruments for such evaluation. Furthermore, future impacts (or *expected* future impacts) represent an important feature of innovative projects, since time-to-market for products, process, or services is not immediate.

Table 24 brings results for the preliminary assessments on models' characteristics (2000-2005). In this case, TECHACHIEV does not come out as a relevant determinant of future success. This gives a hint on the systemic role played by Eureka in increasing firms' competitiveness in the longer run, even if by the end of projects, expected technical results were not achieved. Thus, such projects might actually increase participants' competitiveness, even when they are not regarded as "successful" by the time of their completion. Nonetheless, this is a suggestion, not a conclusive statement, since statistical evidence provides no robust information in this case.

On its turn, the instrument "Excellent" from the variable FUNCTIONING is also significant, and its crude-odds ratio indicates that projects having an outstanding level of coordination are more likely to be related to *positive* future returns. However, projects with Good functioning do not perform in the same direction, since this instrument is not significant, and its coefficient indicates a *lower* probability of future success than the reference category (Weak/Bad functioning). Nonetheless, the non-parametric correlation coefficient indicates a significant and relatively high connection between FUNCTIONING and EXP_IMPACT, thus pointing towards a moderate association between these variables.

On the Microeconomic dimension, it is valid to affirm that SMEs expect better outcomes in the future (arising as a result of their participation in such projects) than Large Companies. This leads us towards the expectation that such firms increase their absorptive capacity through participation in international R&D networks, thus benefitting from these activities in the long run, while results for Large Firms are not expected to have such a relevant impact. COMPETITOR is not significant in this analysis, maintaining its characteristic of being a weak predictor of success in international R&D collaboration.

On the Macroeconomic dimension, instruments of the variable COUNTRY perform significantly, and according to theoretical expectations (further discussions on the relationships between empirical results and theoretically grounded hypotheses are offered below). Spanish firms are more likely than those from intermediate Innovation Systems to foresee positive outcomes, whereas those from intermediate ISs are more likely than those from the Leader IS to expect good results in the future. This indicates some level of convergence in the long run, where firms from relatively laggard systems benefit *more* from international R&D networks than those firms from Innovation Systems that are in a relatively better position (based on our limited sample). This is especially true for Spain, since its Eureka's projects are largely connected with organizations from more advanced economies (apart from Portugal). Nonetheless, this can be contingent upon expectation levels.

In terms of the *ad hoc* variables, only PROD_INNO results as a significant predictor in this bivariate analysis (crude odds-ratio), where firms with product innovation seem to have twice the probability of those which are not involved with such kind of innovation when considering their expectations of future achievements.

In the multivariate estimations (table 25), the overall statistics of the model are reasonable. There is a small increase in the classification capacity with the use of predictors (for both Equations 4 and 7). Nagelkerke's R^2 is acceptable, and the general estimations are significant (Hosmer-Lemeshow tests). Individual variables' characteristics remain similar to those of preliminary assessments, thus providing a relatively accurate diagnosis of models' stability.

Dimension	Independent Variable	D.V. Description	POSITIVE EXP_IMPACT (1)	Crude Odds Ratio - Exp (B)	Confidence Interval (95%)	Sig.
Microeconomic	ORG_TYPE	Large Company (1)	16.7%	.439	.222 - .869	.018
		SME (0)	31.3%	1	-	-
Contextual	COMPETITOR	Yes (1)	23.1%	.837	.402 - 1.743	.635
		No (0)	26.4%	1	-	-
	FUNCTIONING	Excellent (1)	50.8%	4.828	1.255 - 18.573	.022
		Good (2)	16.1%	.893	.237 - 3.368	.867
		Weak/Bad (3 - Ref. Cat.)	17.6%	1	-	-
	TECHACHIEV	Success (1)	26.5%	1.926	.539 - 6.880	.313
		Failure (0)	15.8%	1	-	-
Macroeconomic	COUNTRY	Spain (1)	29.9%	2.414	1.021 - 5.706	.045
		Intermediate ISs (2)	29.5%	2.320	1.003 - 5.598	.049
		Leader IS (3 - Ref. Cat.)	15%	1	-	-
Ad hoc	PROD_INNO	Yes (1)	30.7%	2.211	1.100 - 4.440	.026
		No (0)	16.7%	1	-	-
	PROC_INNO	Yes (1)	28.7%	1.392	.752 - 2.579	.293
		No (0)	22.4%	1	-	-
	SERV_INNO	Yes (1)	33.3%	1.556	.678 - 3.568	.297
		No (0)	24.3%	1	-	-

	EXP_IMPACT	***TECHACHIEV***	***ORG_TYPE***	***COUNTRY***	***FUNCTIONING***	***COMPETITOR***	***PROD_INNO***	***PROC_INNO***	***SERV_INNO***
EXP_IMPACT	1								
TECHACHIEV	.070	1							
ORG_TYPE	-.164*	-.087	1						
COUNTRY	-.127	-.012	.054	1					
FUNCTIONING	-.321**	-.156*	.017	-.068	1				
COMPETITOR	-.032	.023	.037	.118	-.094	1			
PROD_INNO	.154*	.276**	-.149*	-.099	-.082	-.093	1		
PROC_INNO	.072	.280**	-.080	-.066	-.113	.041	.158*	1	
SERV_INNO	.072	.078	-.157*	-.062	.025	.023	.220*	.025	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 24. Equations 4 and 7 (2000-2005): Crude Odds-Ratio and Non-Parametric (Spearman) Correlations

Independent Variable		Adjusted Odds Ratio - Exp (B) Sig. in parentheses	
		Equation 4	Equation 7
ORG_TYPE	Large Company (1)	.432 (.028)	.466 (.050)
	SME (0)	-	-
TECHACHIEV	Success (1)	1.449 (.602)	-
	Failure (0)	-	-
COMPETITOR	Yes (1)	.955 (.915)	-
	No (0)	-	-
COUNTRY	Spain (1)	3.209 (.019)	3.147 (.021)
	Intermediate ISs (2)	3.023 (.027)	3.316 (.016)
	Leader IS (3 - Ref. Cat.)	-	-
FUNCTIONING	Excellent (1)	6.544 (.011)	6.614 (.010)
	Good (2)	1.072 (.922)	1.063 (.931)
	Weak/Bad (3 - Ref. Cat.)	-	-
PROD_INNO	Yes (1)	-	1.759 (.165)
	No (0)	-	-
PROC_INNO	Yes (1)	-	1.139 (.719)
	No (0)	-	-
SERV_INNO	Yes (1)	-	1.521 (.388)
	No (0)	-	-
Hosmer-Lemeshow Test		.231	.137
Nagelkerke R sq.		.243	.263
% of Correct Predictions (Intercept only)		74.2%	74.2%
% of Correct Predictions		75.1%	75.1%

Table 25. Equations 4 and 7 (2000-2005): Logistic regressions' results

In Equation 4, determinants of EXP_IMPACT are strongly related to the instrument Excellent of the variable FUNCTIONING. Also, firms from Spain and Intermediate Innovation Systems (COUNTRY) represent significant and strong predictors of such future results. ORG_TYPE follows the pattern described above, where Large Companies are *less likely* to perceive future impacts as positive in comparison to SMEs.

In Equation 7 we keep these significant predictors in the model, adding the *ad hoc* variables. In this case, all theoretically grounded predictors remain relatively stable, where PROD_INNO, which was the only *ad hoc* variable to show an acceptable level of significance in the preliminary assessments, turns out as non-significant. A potential explanation for this situation is related to its significant correlation to the ORG_TYPE predictor, which might add collinearity issues to the estimation, thus influencing the behavior of this particular element.

The analyses for Equations 4 and 7 considering projects finished in the period 2006-2008 are presented in tables 26 and 27. Similarly to previous comparisons between datasets, results are somewhat distinct to those found for projects completed within the 2000-2005 timeframe. In this case, however, differences are more related to statistical significance than to odds-ratio values, i.e., suggestions arising from this approach help building a clearer picture for the determinants of projects' expected outcomes.

The preliminary bivariate assessment does not provide statistical significance for ORG_TYPE, but the crude odds-ratio suggests a relationship between SMEs and more positive expectations of impacts occurring as a consequence of Eureka projects. TECHACHIEV, which resulted as a non-significant determinant for the 2000-2005 analysis, is significant in this case and it influences positively firms' perceptions for the EXP_IMPACT dependent variable.

The Macroeconomic dimension of analysis puts the laggard Innovation System (Spain) in a position in which its firms are positively associated with better expected outcomes. However, unlike findings for 2000-2005, this does not hold for intermediate Innovation Systems, and these are more associated with poorer expected impacts than the Leader IS. Nonetheless, this latter relationship is not statistically supported.

Dimension	Independent Variable	D.V. Description	POSITIVE EXP_IMPACT (1)	Crude Odds Ratio - Exp (B)	Confidence Interval (95%)	Sig.
Microeconomic	ORG_TYPE	Large Company (1)	61.8%	.764	.332 - 1.759	.526
		SME (0)	67.9%	1	-	-
Contextual	TECHACHIEV	Success (1)	71.3%	6.207	1.801 - 21.386	.004
		Failure (0)	28.6%	1	-	-
Macroeconomic	COUNTRY	Spain (1)	80.6%	2.806	1.039 - 7.583	.042
		Intermediate ISs (2)	59.3%	.985	.382 - 2.539	.976
		Leader IS (3 - Ref. Cat.)	59.6%	1	-	-
Ad hoc	PROD_INNO	Yes (1)	74%	2.584	1.161 - 5.750	.020
		No (0)	52.4%	1	-	-
	PROC_INNO	Yes (1)	74.4%	1.851	.805 - 4.258	.147
		No (0)	61.1%	1	-	-
	SERV_INNO	Yes (1)	61.5%	.773	.313 - 1.913	.578
		No (0)	67.4%	1	-	-

	EXP_IMPACT	***TECHACHIEV***	***ORG_TYPE***	***COUNTRY***	***PROD_INNO***	***PROC_INNO***	***SERV_INNO***
EXP_IMPACT	1						
TECHACHIEV	.295**	1					
ORG_TYPE	-.059	-.050	1				
COUNTRY	-.177	-.183	.003	1			
PROD_INNO	.220*	.380**	-.142	-.100	1		
PROC_INNO	.136	.233*	.090	-.015	.176	1	
SERV_INNO	-.052	.138	-.122	-.139	.108	.227*	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 26. Equations 4 and 7 (2006-2008): Crude Odds-Ratio and Non-Parametric (Spearman) Correlations

Results for the *ad hoc* variables are similar to those previously found. Only PROD_INNO is significant, showing a positive influence on future outcomes. The stability of this variable across different estimations supports the idea that projects involving product innovations achieve more consistent results, whatever the measure applied (in this case, technological, commercial, and expected/future impacts).

Independent Variable		Adjusted Odds Ratio - Exp (B) Sig. in parentheses	
		Equation 4	Equation 7
ORG_TYPE	Large Company (1)	.810 (.642)	
	SME (0)	-	-
TECHACHIEV	Success (1)	5.120 (.011)	3.957 (.050)
	Failure (0)	-	-
COUNTRY	Spain (1)	2.244 (.123)	2.400 (.102)
	Intermediate ISs (2)	.952 (.923)	1.171 (.764)
	Leader IS (3 - Ref. Cat.)	-	-
PROD_INNO	Yes (1)	-	1.711 (.249)
	No (0)	-	-
PROC_INNO	Yes (1)	-	1.555 (.351)
	No (0)	-	-
SERV_INNO	Yes (1)	-	.475 (.156)
	No (0)	-	-
Hosmer-Lemeshow Test		.814	.208
Nagelkerke R sq.		.145	.182
% of Correct Predictions (Intercept only)		66.1%	66.1%
% of Correct Predictions		71.3%	72.2%

Table 27. Equations 4 and 7 (2006-2008): Logistic regressions' results

In the multivariate estimation for Equation 4 and 7 (2006-2008), overall aspects of the models support the significance of predictors (Hosmer-Lemeshow), even though its accuracy in terms of classifying cases is not particularly strong in a direct comparison with the estimation using only the intercept. Nagelkerke R^2 can also be regarded as relatively low for both cases.

Analyzing variables individually, the instrument Spain (variable COUNTRY) is not significant, unlike noticed for the bivariate relationships. We chose to keep this variable in Equation 7 because of its identified relevance in the preliminary assessments. As a result, Spain is slightly above the 10% threshold, indicating a potential effect on EXP_IMPACT that should not be neglected.

TECHACHIEV is significant and the most influent aspect in both equations. Nonetheless, it probably exerts some influence on results for PROD_INNO, given the relatively high non-parametric correlation between these variables. Unlike results for the 2000-2005 period, technological achievements seem to play *more* than a "*necessary, but not sufficient"* role, since it is highly related to firms' expectations of impacts unfolding in the future.

A possible explanation for such finding may lie on a simple analysis of correlation coefficients. For 2000-2005 projects, TECHACHIEV and COMMACHIEV have a .292 Spearman coefficient which is significant at 1%. However, the same bivariate correlation for 2006-2008 projects is of only .132, and it is not statistically significant. On the other hand, Spearman's coefficient for TECHACHIEV and EXP_IMPACT is of .070 (not significant) in 2000-2005, while it has the value of .295 (significant at 1%) for 2006-2008 projects.

If we refer to the overall structure of projects' durations, we can see that projects finished within 2000-2005 last roughly 8 months (42.81 months) more than those that were completed within 2006-2008 (34.30 months). Hence, firms from the second dataset may be more likely to achieve desirable market effects *after* project completion, while those in the 2000-2005 dataset may attain similar outcomes *by the time* the project ends. Considering this rationale as valid, TECHACHIEV gains ground as an important determinant of market success for firms engaged in Eureka projects.

8.2.4 Equation 8

The last part of the binary logistic regressions analysis points towards understanding the systemic role involved in the formation of long lasting R&D networks across Europe as a result of companies' participation in Eureka projects. Therefore, the dependent variable of interest is STRAT_ALL, which highlights the formation or improvement of strategic R&D alliances between members of organizational arrangements oriented toward innovation.

Tables 28 and 29 present results for estimations regarding projects completed in the period 2000-2005, according to same structure set for previous equations. From the preliminary analysis we gather the inexistence of statistically significant coefficients of defined predictors and STRAT_ALL (which holds for both non-parametric correlations and crude odds-ratio analysis).

Nonetheless, some abnormal results (at least as to what one would expect based on economic theory and empirical evidence) come to mind when verifying these results closely. The first one regards the statistical irrelevance of FUNCTIONING. Even though odds-ratio coefficient indicates a relationship that favors the creation of strategic alliances (for both Excellent and Good instruments this coefficient exceeds that of the Reference Category), this association is much weaker than previously noticed in Equations 2 to 7. One would expect that such situation would hold in this case, but according to the set of predictors, factors that escape from Eureka's Final Reports seem to play a decisive role here. Not surprisingly, the same situation also takes place when verifying COMMACHIEV, TECHACHIEV, and EXP_IMPACT. This is expected considering the relevant associations between these variables and FUNCTIONING.

Dimension	Independent Variable	D.V. Description	POSITIVE STRAT_ALL (1)	Crude Odds Ratio - Exp (B)	Confidence Interval (95%)	Sig.
Microeconomic	ORG_TYPE	Large Company (1)	17.9%	1.021	.498 - 2.091	.955
		SME (0)	17.6%	1	-	-
Contextual	COMMACHIEV	Success (1)	21.4%	1.734	.842 - 3.569	.135
		Failure (0)	13.6%	1	-	-
	TOT_COST	M. Euro	-	.992	.962 - 1.024	.633
	EXP_IMPACT	Positive (1)	21.8%	1.438	.669 - 3.092	.352
		Negative (0)	16.2%	1	-	-
	FUNCTIONING	Excellent (1)	22%	2.120	.428 - 10.485	.357
		Good (2)	16.8%	1.513	.324 - 7.072	.599
		Weak/Bad (3 - Ref. Cat.)	11.8%	1	-	-
	COMPETITOR	Yes (1)	25%	1.840	.862 - 3.929	.115
		No (0)	15.3%	1	-	-
	TECHACHIEV	Success (1)	18.9%	4.189	.542 - 32.382	.170
		Failure (0)	5.3%	1	-	-
Macroeconomic	COUNTRY	Spain (1)	11.7%	.529	.207 - 1.355	.185
		Intermediate ISs (2)	21.8%	1.115	.486 - 2.557	.798
		Leader IS (3 - Ref. Cat.)	20%	1	-	-

	STRAT_ALL	***EXP_IMPACT***	***TECHACHIEV***	***ORG_TYPE***	***COUNTRY***	***TOT_COST***	***COMPETITOR***	***FUNCTIONING***	***COMMACHIEV***
STRAT_ALL	1								
EXP_IMPACT	.064	1							
TECHACHIEV	.101	.070	1						
ORG_TYPE	.004	-.164*	-.087	1					
COUNTRY	.095	-.127	-.012	.054	1				
TOT_COST	.126	-.084	.110	.246**	.120	1			
COMPETITOR	.108	-.032	.023	.037	.118	.118	1		
FUNCTIONING	-.076	-.321**	-.156*	-.156*	-.068	.055	-.094	1	
COMMACHIEV	.103	.328**	.292**	-.091	-.025	.104	-.024	-.235**	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 28. Equation 8 (2000-2005): Crude Odds-Ratio and Non-Parametric (Spearman) Correlations

Furthermore, COMPETITOR, even though without statistical significance, points towards a *positive* association between the existence of rival firms and the generation of such strategic agreements. This is an interesting indication of stronger ties between firms from similar sectors, from different European countries, joining in R&D development. This perspective is in accordance with the idea that such kind of relationship involves a greater amount of risk, thus requiring stronger means of coordination (leading to more stable connections).

Independent Variable		**Adjusted Odds Ratio - Exp (B) Sig. in parentheses**
		Equation 8
ORG_TYPE	Large Company (1)	1.291 (.521)
	SME (0)	-
COMPETITOR	Yes (1)	2.432 (.039)
	No (0)	-
TECHACHIEV	Success (1)	3.441 (.253)
	Failure (0)	-
FUNCTIONING	Excellent (1)	1.006 (.995)
	Good (2)	.841 (.840)
	Weak/Bad (3 - Ref. Cat.)	-
COUNTRY	Spain (1)	.551 (.235)
	Intermediate ISs (2)	1.451 (.423)
	Leader IS (3 - Ref. Cat.)	-
EXP_IMPACT	Positive (1)	1.129 (.796)
	Negative (0)	-
COMMACHIEV	Success (1)	1.688 (.221)
	Failure (0)	-
TOT_COST	M. Euro	.977 (.269)
Hosmer-Lemeshow Test		.274
Nagelkerke R sq.		.096
% of Correct Predictions (Intercept only)		82.2%
% of Correct Predictions		82.2%

Table 29. Equation 8 (2000-2005): Logistic regressions' results

For the variable COUNTRY, indications are that Spanish firms are less likely to engage in more stable international R&D strategic alliances. This is in conflict with the positive results achieved by these firms in comparison to those attained by companies from the benchmark countries, whereas firms from Intermediate Innovation Systems and from the Leader IS have a similar probability of engaging in long lasting relationships.

Results for the multivariate estimation are provided in table 29 (above) and confirm the projections from the preliminary statistics. The model as a whole is significant (Hosmer-Lemeshow), but Nagelkerke's R^2 shows that its prediction power is rather weak, which can be confirmed by the comparison between the model with and without the established predictors.

For the case of projects finished during the years 2006-2008, the situation is analogous to that examined above for some particular variables, but some remarkable changes deserve to be noticed. First of all, COMMACHIEV and TECHACHIEV are significantly related to STRAT_ALL, where better outcomes indicate a higher propensity for firms to maintain their relationship after the particular Eureka project is finished. Therefore, the indication is similar to that found for the 2000-2005 dataset, but with an increased relevance for practical analysis. However, EXP_IMPACT does not show any particular trend in this case.

Two important differences arise when comparing the presently discussed results with those found for the 2000-2005 dataset. The first one regards the probability of Large Companies engaging in strategic R&D alliances (variable ORG_TYPE). While the odds-ratio coefficient previously found for this case showed a value that basically matched that of SMEs, 2006-2008's empirical results imply (significantly) that Large Companies are actually less likely than SMEs to develop long lasting R&D relationships with partners located abroad.

Dimension	Independent Variable	D.V. Description	POSITIVE STRAT_ALL (1)	Crude Odds Ratio - Exp (B)	Confidence Interval (95%)	Sig.
Microeconomic	ORG_TYPE	Large Company (1)	14.7%	.309	.108 - .885	.029
		SME (0)	35.8%	1	-	-
Contextual	COMMACHIEV	Success (1)	44%	2.289	.911 - 5.748	.078
		Failure (0)	25.6%	1	-	-
	TOT_COST	M. Euro	-	1.024	.949 - 1.106	.537
	EXP_IMPACT	Positive (1)	30.3%	1.105	.471 - 2.590	.819
		Negative (0)	28.2%	1	-	-
	TECHACHIEV	Success (1)	32.7%	6.309	.791 - 50.298	.082
		Failure (0)	7.1%	1	-	-
Macroeconomic	COUNTRY	Spain (1)	38.9%	1.727	.697 - 4.283	.238
		Intermediate ISs (2)	22.2%	.776	.259 - 2.318	.649
		Leader IS (3 - Ref. Cat.)	26.9%	1	-	-

	STRAT_ALL	***EXP_IMPACT***	***TECHACHIEV***	***ORG_TYPE***	***COUNTRY***	***TOT_COST***	***COMMACHIEV***
STRAT_ALL	1						
EXP_IMPACT	.021	1					
TECHACHIEV	.183	.295**	1				
ORG_TYPE	-.211*	-.059	-.050	1			
COUNTRY	-.099	-.177	-.183	.003	1		
TOT_COST	.115	-.006	-.139	.212*	-.191*	1	
COMMACHIEV	.167	.333**	.132	.074	-.012	.024	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 30. Equation 8 (2006-2008): Crude Odds-Ratio and Non-Parametric (Spearman) Correlations

The second main inconsistency regards data for the variable COUNTRY and its instruments. Even though coefficients remain non significant, Spain now shows a higher odds-ratio than those of the benchmark countries in terms of participating in strategic alliances, while those companies located in intermediate Innovation Systems have the lower probability of doing so.

Independent Variable		Adjusted Odds Ratio - Exp (B) Sig. in parentheses
		Equation 8
ORG_TYPE	Large Company (1)	.228 (.013)
	SME (0)	-
TECHACHIEV	Success (1)	6.271 (.098)
	Failure (0)	-
COUNTRY	Spain (1)	1.708 (.288)
	Intermediate ISs (2)	.601 (.424)
	Leader IS (3 - Ref. Cat.)	-
EXP_IMPACT	Positive (1)	.502 (.192)
	Negative (0)	-
COMMACHIEV	Success (1)	3.455 (.025)
	Failure (0)	-
TOT_COST	M. Euro	1.064 (.204)
Hosmer-Lemeshow Test		.787
Nagelkerke R sq.		.210
% of Correct Predictions (Intercept only)		70.4%
% of Correct Predictions		71.3%

Table 31. Equation 8 (2006-2008): Logistic regressions' results

As a result of this better statistical adequacy of variables in the bivariate evaluation, multivariate estimations represent a more robust outcome for the model's overall aspects. This can be noticed via Nagelkerke's R^2, which is higher than that of the estimations for the 2000-2005 period, and the increase in the classification power of the model when considering the comparison with the intercept only estimation (even though such increase is minimal).

TECHACHIEV (at 10%), COMMACHIEV (at 5%), and ORG_TYPE (at 5%) are statistically significant, where technological achievements seem to be the most important elements in influencing the probability of firms in achieving strategic alliances. Support for this situation is also given by adjusted odds-ratio in 2000-2005 projects, even though they lack statistical significance.

8.5 Summary of Results: Verification of Research Hypotheses

In this section we bring an overall evaluation of results from the theoretically grounded equations (Equations 2, 3, and 4), comparing achieved results with the hypotheses of this research, thus providing a structured perspective of our expectations' validity based on the specialized literature. Given the scope of the *ad hoc* equations (Equations 5, 6, 7, and, 8), such appraisal is not provided for them (as there are no hypotheses in this text to compare them with, being their purpose to complement the core propositions of this analysis). It is also important to notice that not *all* variables are included in this summary. This procedure makes reference to those variables of theoretically predicted *influence* on outcomes. The set of outcomes *per se* is explained for each approach in the previous sections.

Thus, Table 32 consists in a report of such relationships, assessing the empirical findings of this research in face of the set of hypotheses that are described in chapter 6. For each variable, one corresponding hypothesis is listed, as well as the conclusion on its empirical relevance according to our datasets. Findings are described according to theoretical expectations, and to results from 2000-2005 and 2006-2008 datasets. Coefficients correspond to adjusted odds-ratio for each variable, i.e., the coefficient from multivariate estimations for each model. Thus, when the influence is expected to be *positive*, this is represented by an odds-ratio above the level of 1 (>1), and below this level if otherwise (in opposition to coefficients which range from negative to positive values). For the case of Reference Categories, the exact value of 1 is assigned, so other categories are actually compared to these. In the case of dichotomous variables, the Reference Category is implicit, being related to the value 0 (absence) of the observation (e.g., 0 is the Reference Category for COMPETITOR, thus indicating that rival firms are not part of the network).

Results are primarily evaluated based on their statistical merit and direction of influence (positive or negative), but we recognize that samples are not large enough as to provide the analysis with conclusive statements. Since we refer to this set of outcomes as suggestive indications, we must also focus on the information about trends in the sample (even if they are not significant). This course of action allows us to optimize the use of information available from datasets, as we are also aware of its limitations.

The order of variables follows that of dimensions under scrutiny, i.e., Microeconomic (ORG_TYPE; RATIO_RD), Contextual (COMPETITOR; FUNCTIONING; TECHACHIEV; TOT_COST; IND_EXP; DURATION), and Macroeconomic (COUNTRY). We shall follow the same order for further discussions.

COMPETITOR is a variable that is directly related to hypothesis ***H1a***, which predicts that ***Large Companies are capable of achieving better results than SMEs thanks to their higher absorptive capacity in terms of R&D***. This is expected to be relevant in technical (TECHACHIEV, Equation 2) and economic aspects (COMMACHIEV, Equation 3; EXP_IMPACT, Equation 4). However, with the exception of 2006-2008 results for Equation 3 (non significant), the set of outcomes points in the opposite direction, and this is statistically significant for the case of Equation 4 (2000-2005), which deals with future commercial impacts arising from firms' participation in Eureka projects (controlling for R&D intensity, as suggested by López, 2008). Therefore, ***H1a is rejected***.

The rejection of hypothesis H1a can imply that that SMEs are likely to benefit more than Large Companies from cooperative R&D agreements at the international level or that are no relevant differences between their results. A possible explanation for this situation lies in the argument made by Bayona, Corredor and Santamaría (2006) and Chun and Mun (2012), where they state that firms can increase their individual R&D investment capacity through participation in networks. In this case, SMEs would suffer a higher impact from such connections, thus multiplying their R&D expenditure to a more significant level in comparison to the impacts that such combination of resources would have in larger corporations. This is especially true for the case of microeconomic analysis, since we are considering perceptions of individual firms, where SMEs would achieve this result regardless of the fact that they are engaging in a relationship with companies of similar sizes or not.

The following analysis seeks to assess ***the role played by R&D intensity in firms' ultimate technological and commercial outcomes arising from their participation in international R&D cooperation***. ***H1b*** is approached as a microeconomic hypothesis, but its assessment occurs through the use of three variables, namely: RATIO_RD (Microeconomic Dimension), TOT_COST (Contextual Dimension), and DURATION (Contextual Dimension). The use of the two latter variables functions as a complementary way of understanding firm behavior through project-specific engagement, thus the use of projects' costs and their respective duration. Such aspects help verifying (approximately) the innovative intensity of firms in specific projects.

As it can be gathered from table 32, these three variables perform erratically across datasets. The two variables used in the technological achievements approach (Equation 2) are inconsistent: RATIO_RD seems to matter for 2006-2008 companies, but not for 2000-2005, and such relationship is not significant in both cases. TOT_COST has a similar pattern, even though both variables are actually not significantly correlated with each other (and the sign of the association is negative: -.066). For the case of DURATION, its behavior is also inconsistent, but in the opposite direction from the other two variables used in the assessment of ***H1b*** (and this particular variable is applied for the commercial achievements' approach, Equation 3). Longer projects in 2000-2005 are associated with better outcomes, while for 2006-2008, shorter projects are associated with superior outcomes. Nonetheless, these associations are not statistically significant. Therefore, ***H1b is also rejected***.

The relationship between these variables, not only their impacts on analyzed outcomes, deserves some further discussion. Non-parametric correlations are useful in this regard. First of all, Large Companies have significantly higher investments in projects (TOT_COST; Spearman correlation coefficient for 2000-2005 is .246 and significant at 1%, and .212 and significant at 5% for 2006-2008). However, these firms are less R&D intensive than SMEs (RATIO_RD; Spearman correlation coefficient for 2000-2005 is -.364 and significant at 1% and -.265 and significant at 1% for 2006-2008). This implies that Large Companies' are endowed with a higher absolute investment capacity, but a less innovative profile than SMEs for the scrutinized samples. Such aspects must be kept in mind when considering that absorptive capacities in this case may actually be higher in SMEs, provided they are likely to spend more (relatively) in innovative activities.

After analyzing hypothesis ***H1 (a and b)***, the conclusion is that the Microeconomic Dimension from $\boldsymbol{H_{core}}$ is not relevant for this particular sample, considering the variables we have used to approximate this result. There are two aspects to be considered here. The first one regards the limitation of instruments to make operational the complexity represented by firms. In this case we are approaching the microeconomic dimension through an extremely simplified version of what a firm is.

Nonetheless, and introducing the second aspect, firm behavior is filled with contingencies, where no firm is in reality equal to another. Hence, firms' generic characteristics, such as size or R&D intensity, may not be representative of impacts since the perception of such influence is likely to vary among a sample of companies. In this case, firms' static features can actually be expected *not to* be related to their tactical and strategic goals, which are deemed to be case-specific. In this case, it is not as surprising to achieve results that correspond to the rejection of ***H1***.

The second hypothesis to be verified already falls entirely under the Contextual Dimension, and makes reference to ***the management quality of cooperative R&D projects as a determinant of technical and commercial outcomes (H2)***. The assessment of this hypothesis is done via FUNCTIONING, which unfortunately is only available for 2000-2005 projects, thus not allowing its robustness test via assessments of the 2006-2008 dataset. Nevertheless, this variable shows a stable and significant influence on firms' results for all levels of analysis, i.e., technological (Equation 2), commercial (at the end of the project, Equation 3), and expected future impacts (Equation 4). This is true especially for commercial impacts, since instruments (Excellent, and Good, plus the Reference Category: Weak/Bad) in this case are all positive (above 1 as expected) and significant. The predictive strength found in this variable allows us to ***accept H2***.

On the other hand, some comments must be made on this outcome. As data analyzed can be regarded as subjective, the relationship between better rates of functioning and firms' successful results can also indicate a biased perception of Final Reports' respondents. Since results were positively achieved, or maybe even exceeded prior expectations, problems in conducting the collaboration between partners tend to be minimized. Since this aspect is hardly observable in objective terms, this result offers rich insights in terms of policy coordination and network management, but it should also be regarded cautiously.

Summary of Adjusted Odds-Ratio												
		Equation										
		2			3			4				
Variable		Expected	Verified		Expected	Verified		Expected	Verified		Corresponding Hypotheses	Confirmation
			00-05	06-08		00-05	06-08		00-05	06-08		
ORG_TYPE		>1	.696	.584	>1	.910	1.862	>1	.432**	.810	H1a	No. Results point in the opposite direction of the hypothesis, w here SMEs seem to achieve better outcomes.
RATIO_RD	<2% (1)	<1	.745	2.447							H1b	No. Results are inconsistent betw een periods.
	2-10% (2)	<1	.726	2.954								
	>10% (3 - Ref. Cat.)	Ref. Cat.										
COMPETITOR		<1	1.412	NA	<1	.626	NA	<1	.955	NA	H3	No. It seems to be related to commercial achievements w ithout statistical significance.
FUNCTIONING	Excellent (1)	>1	5.634*	NA	>1	18.455***	NA	>1	6.544**	NA	H2	Yes. Better outcomes are influenced by the quality of projects' functioning.
	Good (2)	>1	3.616	NA	>1	12.921**	NA	>1	1.072	NA		
	Weak/Bad (3 - Ref. Cat.)	Ref. Cat.		NA	Ref. Cat.		NA	Ref. Cat.		NA		
TECHACHIEV					>1	8.329***	3.410	>1	1.449	5.120**	H4	Yes. Technical outcomes are positively related to market (immediate and future) achievements.
TOT_COST		>1	.987	1.037							H1b	No. Results are inconsistent betw een periods.
DURATION					>1	1.002	.971				H1b	No. Results are inconsistent betw een periods.
COUNTRY	Spain (1)	>1	.597	7.242*	>1	1.296	.764	>1	3.209**	2.244	H5	Partially. Its results point in the direction of greater commercial results (immediate and future) for the laggard innovation system (Spain).
	Intermediate ISs (2)	>1	.593	.984	>1	1.067	1.217	>1	3.023**	.952		
	Leader IS (3 - Ref. Cat.)	Ref. Cat.			Ref. Cat.			Ref. Cat.				

* Significant at the 0.10 level (2-tailed)
** Significant at the 0.05 level (2-tailed)
*** Significant at the 0.01 level (2-tailed)

Table 32. Summary of equations' results and confrontation with research hypotheses. Results are reported for the theoretically grounded equations, i.e., Equations 2, 3, and 4

The third hypothesis to be confronted with empirical data from regression estimations makes reference to the ***absence of competing firms in a network as a relevant factor in determining its success*** - ***H3***. This approach also belongs to the Contextual Dimension of analysis and is centered on the variable COMPETITOR. As in the case of ***H2***, such measurement is only available for 2000-2005 projects, thus a robustness contrast across datasets is not possible. Regarding statistical merits, COMPETITOR is not significantly related to any of the three dependent variables in the abovementioned equations (TECHACHIEV, COMMACHIEV, and EXP_IMPACT). Furthermore, this variable, as it can be gathered from correlation matrices, does not show significant association with any of the other variables of interest.

Nonetheless, it is important to remind that resorting solely to statistical significance shall provide a narrow view of the phenomena, especially considering the size of the sample. It is important to notice that around 25% of companies were involved in projects with competitors, which is by itself a valuable information. This can be influenced by a non-direct form of competition, since this analysis deals with R&D cooperation between firms from different nations, thus rivalry risks are likely to be somewhat minimized. This is reflected in the positive (non significant) association of the presence of rival firms and successful technological achievements. However, when we turn to commercial achievements, a more sensitive area of innovation when it comes to projects involving competitors, there is an indication of a *negative* association with better results. However, this result does not allow us to accept ***H3*** based on statistical merits of the sample. Therefore, ***H3 is rejected***.

The following proposition is that ***technological achievements arising from firms' participation in international R&D cooperation projects represent a necessary condition (but not sufficient) in determining market outcomes (achieved and expected) - H4 and H4b***. To make this aspect operational, we used the variable TECHACHIEV, which is a dependent variable in Equation 2, and also a predictor in Equations 3 and 4. In this sense, results consistently point towards the hypotheses' relevance, where they are always positive (above 1), and significant for commercial achievements (2000-2005), and expected impacts (2006-2008). As previously discussed, this structure of statistical significance might be related to longer projects in the 2000-2005 datasets, where innovation results are more likely to be captured within projects' lifecycle (the adjusted odds-ratio for DURATION indicates that). In face of these estimates, ***H4 and H4b are accepted.***

The last hypothesis to be tested represents an approximation of the ***effects that National Innovation Systems might have as a determinant of firms' results in international R&D networks*** (***H5***). Obviously, this is a rough estimate of impacts that macroeconomic conditions might play in this realm, with all of its inherent complexities and multiple facets. Our classification of countries as laggard, intermediate, or leader Innovation Systems is based on the presumptions made in chapter 5, where these classifications should be regarded as *relative positions*, not absolute. According to our prior expectations, a catching-up process was expected, with special strength in Spanish firms (laggard IS).

Empirical results are somewhat controversial. For the technological dimension, 2000-2005 projects from laggard and intermediate ISs are actually outperformed by those projects in which German firms were involved[58]. For Spain, this situation is largely (and significantly) reversed in the analogous assessment for 2006-2008 projects, while this does not hold for intermediate ISs' firms.

In the evaluation of commercial achievements, adjusted odds-ratio vary between periods for the Spanish case, while they hold constantly positive (above 1) for intermediate ISs' firms. However, such results are not only non-significant, but they also range near the reference value of 1. Therefore, it is not safe to assume that such values are representative of valid trends in samples.

[58] It is important to remind that such projects involved firms from multiple countries, but questionnaires represented each firm's perception on results. Thus, we are not ruling out the fact that, for example, German companies are involved with organizations from less advanced innovation systems, but that impacts as they were captured are inherently individual (and do not necessarily represent the perception of other participants in the network).

In Equation 4, however, the picture is clearer for the Spanish case, where results are well above the benchmark threshold (and they are significant for 2000-2005 projects). The situation of intermediate innovation systems is a bit distinct, since they represent the expected behavior in 2000-2005 (above 1, significant, and below Spain), but this does not hold for 2006-2008 projects. The conclusion in this case is in favor of a ***partial acceptance*** of ***H5***, with special emphasis on the case of the laggard innovation system, i.e., Spain, where its firms seem to benefit more from international R&D networks than its peers in more developed innovation systems.

The next stage of this research consists in an assessment of firms' profiles according to the characteristics of samples, testing for differences in terms of results via the construction of clusters based on log-likelihood distances. Furthermore, clusters' features are tested against a set of variables, providing further consistency in the evaluation of determinants of success in R&D collaboration at the international level.

8.6 Cluster Analyses

This section contains three estimations of clusters. The first one represents clusters for 2000-2005 firms according to their outcomes (technological, commercial, and expected). These results are confronted with those found by Fischer and Molero (2012)[59] in an exploratory assessment of Eureka's projects in

[59] Fischer and Molero (2011) use a dataset consisting of Spanish companies only, similar to that used in the third part of the cluster analysis developed in this research. However, criteria for groups are refined in this present work, since focus is given on firms' outcomes. Evaluation between groups characteristics regarding other aspects of microeconomic, contextual, and macroeconomic dimensions are tested statistically through parametric (ANOVA) and non-parametric (Mann-Whitney) approaches. This procedure makes possible a stronger internal consistency within clusters, while statistical tests provide more robust perceptions on their differences regarding other variables of interest.

Spanish firms. This suggested taxonomy is applied to clustering structures, and similarities, as well as differences, are discussed. In order to further exploit the usefulness of achieved clusters we test for differences between groups according to variables which correspond to Microeconomic (RATIO_RD), Contextual (FUNCTIONING, TOT_COST, DURATION), and Macroeconomic (COUNTRY) dimensions. For this, ANOVA estimations and non-parametric (Mann-Whitney) statistics are applied. A second stage contains a similar assessment for 2006-2008 data.

The last part of this analysis provides cluster estimates for Spanish firms only in the period 2000-2005 (77 firms). With this subsample we could gather Return Over Total Assets (ROTA) data for three periods before projects' completion, period of project completion, and three periods after projects' completion. With such information we can assess the existence or not of differences between clusters before and after Eureka projects were finished, considering the structure of outcomes of each cluster. Such assessment gives the opportunity of approximating the actual impacts of Eureka at the corporate level of participants (and its evolution over time), while also confronting perceptual variables (those gathered via Eureka's Final Reports) and an objective indicator (ROTA) with the control of previous periods' results.

8.6.1 2000-2005 (All Countries)

This first part of our cluster analyses considers results for companies with Eureka projects ending within the period 2000-2005. Results regarding clusters' structures are provided in table 33. Distribution of cases is mainly concentrated in cluster 1, while clusters 2 and 3 are of similar sizes. Variables used in this analysis turned out to be statistically significant separators of the three obtained groups. In a first moment, we verify clusters' features in order to observe the main trends in terms of outcomes (technological, commercial, and expected) and then we confront these findings with the taxonomy proposed by Fischer and Molero (2012).

Cluster Distribution			***Correspondence to Fischer and Molero's (2011) Classification***
	Cluster 1	116 (54.2%	Consistent Innovators
	Cluster 2	46 (21.5%)	Inventors
	Cluster 3	52 (24.3%)	Risky Innovators
	Missing	1 (.5%)	

Cluster Profiles and Main Trends

	Cluster 1	**Cluster 2**	**Cluster 3**
TECHACHIEV	Good Technological Achievements (94%)*	Good Technological Achievements (71.7%)*	Excellent Technological Achievements (98.1%)*
COMMACHIEV	Good (58.6%), and Weak (36.2%) Commercial Achievements*	Nil Commercial Achievements (89.1%)*	Excellent (26.9%), and Good (48.1%) Commercial Achievements. Also, 13.5% of Nil Commercial Achievements*
EXP_IMPACT	Large (22.4%), Medium (42.2%), and Small (30.2%) Expected Impacts*	Medium (19.6%), Small (32.6%), and Nil (45.7%) Expected Impacts*	Very Large (19.2%), Large (32.7%), and Medium (40.4%) Expected Impacts*

*Clusterwise Importance (chi-square at 95% confid.)
Percentages correspond to within cluster data.

Table 33. 2000-2005 Clusters

Cluster 1 has a strong orientation towards fair (but not exceptional) achievements. This cluster is characterized by firms achieving *Good Technological* results. Furthermore, commercial achievements are positive, even though there is a relevant presence of firms with *Weak* attainments in this regard. Lastly, expected impacts for cluster 1 are also positive, but not outstanding, where Medium and Small impacts are predominant. Cluster 1, thus, can be pointed as analogous to the *Consistent Innovators* group, where firms have good technological results (but poorer to those attained by cluster 3, as we shall discuss below) and consistent market outcomes (achieved and expected).

Such firms represent the bulk of this particular dataset, where innovation is likely to take place, and competitiveness of companies shall be maintained (or even increased). Nonetheless, it is not likely that such outcomes will have the broad impact that can be expected from *groundbreaking* innovations. We find support to this result in Georghiou's (2001) criticism on the declining impacts of Eureka projects in general, where risks are not being fully taken by agents.

Cluster 2 is similar to cluster 1 in terms of technological results, where they are largely rated as *Good*. Nonetheless, perceptions on market impacts point in a different direction, where Nil Commercial achievements are predominant. If this could indicate that such firms may have a longer time-to-market period, the analysis of EXP_IMPACT shows that in reality these agents also do not expect further results to unfold over time.

The relative position of cluster 2 is the worst out of the three clusters in terms of market appropriation of results (and expectations regarding future outcomes). There is a strong correspondence between this particular group of firms and the *Inventors* classification, where the technological part of projects is fair, but market results are disappointing, indicating that little economic impact arose from participation in an international R&D cooperation project. Nonetheless, such activity might have played a role in enhancing firms' absorptive capacities and technological capabilities, thus contributing to its overall performance in structural terms.

Cluster 3 shows a strong participation of firms with *Excellent* technological results, thus rating this particular cluster in a better position than the other two. In commercial terms, this cluster also contains companies with the best results, even though there is a higher level of variability in this regard that is not observed in the other clusters. For cluster 3, *Excellent* commercial results are reported, but also *Nil* commercial results. Nonetheless, future results are expected to be better than those perceived by respondents of the other groups.

The correspondence of this cluster with Fischer and Molero's (2012) taxonomy finds no perfect match, but the presence of an unexpected variability in commercial achievements expresses the existence of riskier projects, where achievements are more relevant, but also are not necessarily associated with positive market outcomes. This leads us to classify this cluster as *Risky Innovators*. Nevertheless, we take into account that such results are highly dependent on firms' perceptions, and do not represent essentially the existence of relevant market aspects.

If we confront these three clusters regarding some relevant variables for the evaluation of the hypotheses formulated in this research, some further insights can be found in addition to those provided by logistic regressions. A summary of such approaches is reported in table 34. Categorical variables were tested through Mann-Whitney non-parametric tests for independent samples, where continuous variables were assessed through ANOVA (Bonferroni and Tamhane's *post hoc* tests were assigned according to results of Levene's homogeneity of variance tests). Also, descriptive statistics are provided for each variable within each cluster.

The variable RATIO_RD, a measure of firms' innovative intensity and a proxy of absorptive capacity, does not result in an efficient indicator of differences between clusters. This can be gathered from an evaluation of means, medians, and standard deviations. The Mann-Whitney test for non-parametric differences between samples confirms this perception, where cluster comparisons are not significant in any pairwise contrast. A similar outcome is achieved for COUNTRY, indicating that clustering procedures according to firms' outcomes (TECHACHIEV, COMMACHIEV, and EXP_IMPACT) do not produce *internally* homogeneous groups in terms of these two variables.

Means (Medians in parentheses; Std. Dev. in brackets)			
	Cluster 1	**Cluster 2**	**Cluster 3**
RATIO_RD	2.12 (2) [.677]	2.05 (2) [.631]	2.05 (2) [.714]
FUNCTIONING	1.97 (2) [.407]	1.96 (2) [.631]	1.29 (1) [.502]
COUNTRY	1.93 (2) [.805]	1.84 (2) [.759]	1.94 (2) [.826]

Non-Parametric Tests for Independent Samples
Mann-Whitney Tests for Pairwise Comparison

	Cluster I	Cluster J	Sig.
RATIO_RD	1	2	.532
		3	.570
	2	1	.532
		3	.992
	3	1	.570
		2	.992
FUNCTIONING	1	2	.799
		3	.000
	2	1	.799
		3	.000
	3	1	.000
		2	.000
COUNTRY	1	2	.525
		3	.991
	2	1	.525
		3	.585
	3	1	.991
		2	.585

Means (Std. Dev. in parentheses)			
	Cluster 1	**Cluster 2**	**Cluster 3**
TOT_COST	7.362 (15.709)	3.383 (3.396)	2.853 (3.731)
DURATION	44.97 (22.716)	41.48 (16.591)	39.10 (21.256)

One-Way Anova Results
Tamhane and Bonferroni's Post Hoc Tests

	Cluster (I)	Cluster (J)	Mean Difference I-J	Sig
TOT_COST*	1	2	3.978	.032
		3	4.508	.012
	2	1	-3.978	.032
		3	.530	.845
	3	1	-4.508	.012
		2	-.530	.845
DURATION**	1	2	3.487	1.000
		3	5.869	.296
	2	1	-3.487	1.000
		3	2.382	1.000
	3	1	-5.869	.296
		2	-2.382	1.000

*Tamhane´s post hoc tests. Levene´s sig. .001
**Bonferroni´s post hoc tests. Levene´s sig. .293

Table 34. 2000-2005 Clusters' ANOVA and Mann-Whitney tests

However, while the variable FUNCTIONING has a comparable structure between clusters 1 (Consistent Innovators) and 2 (Inventors), cluster 3 (Risky Innovators) is composed by better rates of project functioning (lower ratings represent better results; refer to table 9 for variables' descriptions). We find statistical support for this indication in non-parametric tests, where cluster 3 is relevantly different from clusters 1 and 2. This is an indication that better results (technological, and economic) are again significantly related to projects that excel in managing networks properly. Even though cluster 3 has a stronger variance in terms of market achievements than cluster 1, firms from the former also achieve more relevant economic outcomes, thus excelling in innovative attainments.

In the case of the continuous variables, TOT_COST and DURATION, we remind that neither had expressive results in the regressions previously analyzed. On the other hand, differences between groups show that costlier projects are associated with cluster 1 (*Consistent Innovators*), which shows satisfactory, but not outstanding, results for firms. This particular variable complements, as pointed out before, the innovative intensity of projects (whereas RATIO_RD represents innovative intensity of *firms*).

The conclusion that can be drawn from this analysis is that projects with a *safer* return involve larger amounts of investment, even if such investment shall not provide *excellent* effects. Under a different perspective, firms might be more critical when evaluating the results of these projects. Under this perspective, cluster 3 would not necessarily outperform cluster 1, since opinions about achievements can be biased by the size of investment made, while firms from cluster 3 could be more sensitive to results in face of smaller R&D expenditures. This brings us to a discussion on the *productivity* of projects, and self-reports do not allow for a robust conclusion in this case. Nonetheless, such aspect is relevant for comprehending weaknesses of such method when gathering data.

In the case of DURATION, no difference between groups could be statistically identified, even though means and standard deviations give some support to the possibilities outlined above, where cluster 3 is associated with projects of shorter duration, while cluster 1 presents those projects with longer periods of development (cluster 2 stands in the middle).

8.6.2 2006-2008 Clusters (All Countries)

The analysis of clusters for the period 2006-2008 results in clusters of similar sizes in comparison to those found for projects finished within 2000-2005. Nonetheless, their internal structure differs significantly in terms of achieved results. We cannot exclude the chance of interference from different scales in the measurement of COMMACHIEV and EXP_IMPACT (please refer to table 10 for description of variables).

The variable TECHACHIEV does not perform well in the process of cluster construction, as it can be seen by its lack of statistical significance (chi-square) for the three groups. The largest group in this case is cluster 3, which has worse outcomes in all of the levels under scrutiny. While its profile in technical terms is not properly bad, commercial achievements and expected impacts are fragile (and both are statistically significant regarding features of this cluster). This lack of marketability in face of relatively satisfactory technological leads us to classify this cluster under the *Inventors* category.

Cluster 2 is significantly defined only by its rate of commercial achievements. While TECHACHIEV suggests a very good profile in the technical dimension (similar to that of cluster 1 and above that of cluster 3), market results are poor, resulting in outcomes that are basically the same size of investments made. Expected impacts, though, are more optimistic, outperforming those observed in cluster 3, but not as positive as those in cluster 1. Such features, mainly the excellent capacity of achieving technological benefits, while “failing” in capturing economic benefits from them in the present should lead us to classify this cluster also as *Inventors*. Nonetheless, future expectations indicate the possibility of satisfactory results in the market. Hence, we define this cluster as *Risky Innovators*, even if its correspondence with Fischer and Molero's (2012) classification is imperfect.

Cluster Distribution			***Correspondence to Fischer and Molero's (2011) Classification***
	Cluster 1	25 (21.7%)	Consistent Innovators
	Cluster 2	30 (26.1%)	Risky Innovators
	Cluster 3	60 (52.2%)	Inventors
	Missing	-	

Cluster Profiles and Main Trends

	Cluster 1	**Cluster 2**	**Cluster 3**
TECHACHIEV	Excellent (44%) and Good (52%) Technological Achievements	Excellent (40%) and Good (53.3%) Technological Achievements	Excellent (23.3%) and Good (58.3%) Technological Achievements. Also, 18.3% of Weak/Bad Attainments
COMMACHIEV	Commercial Achievements of 2-5 times RTD investment (76%) and +-10 times RTD investment (20%)*	Commercial Achievements < or = RTD investment (100%)*	Very Low (100%) Commercial Achievements*
EXP_IMPACT	Expected Impacts of 2-5 times RTD investment (32%) and +-10 times RTD investment (56%)*	Expected Impacts of 2-5 times RTD investment (56.7%) and +-10 times RTD investment (26.7%)	Very low Expected Impacts (28.3%), < or = RTD investment (26.7%), and 2-5 times RTD investment (31.7%)*

*Clusterwise Importance (chi-square at 95% confid.)
Percentages correspond to within cluster data.

Table 35. 2006-2008 Clusters

Cluster 1 in 2006-2008 projects is the one which shows consistently better performances in the three dimensions used for cluster distribution (significantly represented by COMMACHIEV and EXP_IMPACT). We classify this cluster as *Consistent Innovators.* However, this classification does not represent perfectly the taxonomy proposed by Fischer and Molero (2012), since these companies outperform those from the other clusters in all of the aspects involved. An alternative would be to name such cluster as *Successful Projects*, where cluster 2 would be in an intermediate relative position, and cluster 3 would not represent projects that necessarily failed, but those with the worst performance out of the three groups.

The analysis of differences between groups regarding a set of variables is presented below (table 36). As it can be noticed, none of such variables return significant results in terms of innovative intensity (RATIO_RD and TOT_COST), macroeconomic aspects (COUNTRY), and projects' duration (DURATION). As occurred in previous assessments, comparisons between datasets (2000-2005 and 2006-2008) do not perform well as a robustness evaluation.

Besides differences in methods of data collection (Final Reports' structure), such finding indicates that results must be regarded carefully, as statistical findings are not consistent over time. Therefore, implications arising from this present research must be regarded with strong support from additional theoretical and empirical sources, since sample sizes and variability of results provide a rather blurry map for interventions. This lack of time consistence can be attributed to the quality of available information (clustering variables) regarding their representativeness of the sample in terms of cooperative dynamics.

Means (Medians in parentheses; Std. Dev. in brackets)			
	Cluster 1	**Cluster 2**	**Cluster 3**
RATIO_RD	2.16	2.28	2.19
	(2)	(2)	(2)
	[.688]	[.702]	[.754]
COUNTRY	2.12	1.96	2.23
	(2)	(2)	(2)
	[.881]	[.889]	[.851]

Means (Std. Dev. in parentheses)			
	Cluster 1	**Cluster 2**	**Cluster 3**
TOT_COST	2.47	2.84	2.23
	(3.941)	(5.388)	(.851)
DURATION	30.44	33.63	36.23
	(15.798)	(15.294)	(12.795)

Non-Parametric Tests for Independent Samples
Mann-Whitney Tests for Pairwise Comparison

	Cluster I	Cluster J	Sig.
RATIO_RD	1	2	.519
		3	.829
	2	1	.519
		3	.628
	3	1	.829
		2	.628
COUNTRY	1	2	.521
		3	.580
	2	1	.521
		3	.173
	3	1	.580
		2	.173

One-Way Anova Results
Bonferroni's Post Hoc Tests

	Cluster (I)	Cluster (J)	Mean Difference I-J	Sig
TOT_COST*	1	2	-.367	1.000
		3	-.086	1.000
	2	1	.367	1.000
		3	.280	1.000
	3	1	.086	1.000
		2	-.280	1.000
DURATION**	1	2	-3.193	1.000
		3	-5.793	.265
	2	1	3.193	1.000
		3	-2.600	1.000
	3	1	5.793	.265
		2	2.600	1.000

*Levene´s sig. .954
**Levene´s sig. .591

Table 36. 2006-2008 Clusters' ANOVA and Mann-Whitney tests

8.6.3 2000-2005 Clusters (Spain only)

This third part of cluster analysis takes into account Spanish companies from projects finished within the period 2000-2005 for which we could collect corporate level information (namely Return on Total Assets – ROTA), thus allowing a comparison between firms in a more objective manner. In the division of these firms (77 Spanish companies), TECHACHIEV and EXP_IMPACT resulted as significant separators for the three clusters, while COMMACHIEV is significant only in the composition of cluster 3.

Cluster Distribution			***Correspondence to Fischer and Molero's (2011) Classification***
	Cluster 1	37 (48.1%)	Inventors
	Cluster 2	21 (27.3%)	Consistent Innovators
	Cluster 3	19 (24.7%)	Risky Innovators
	Missing		

Cluster Profiles and Main Trends

	Cluster 1	**Cluster 2**	**Cluster 3**
TECHACHIEV	Good (81.1%) and Weak (16.2%) Technological Achievements*	Good Technological Achievements (100%)*	Excellent Technological Achievements (94.7%)*
COMMACHIEV	Good (29.7%), Weak (27%), and Nil (32.4%) Commercial Results	Good (71.4%), Weak (14.3%), and Nil (14.3%) Commercial Results	Excellent (36.8%), Good (31.6%), and Nil (21.1%) Commercial Achievements*
EXP_IMPACT	Large (32.4%), Small (51.4%), and Nil (16.2%) Expected Impacts*	Medium Expected Impacts (100%)*	Very Large (21.1%), Large (36.8%), and Medium (42.1%) Expected Impacts*

*Clusterwise Importance (chi-square at 95% confid.)
Percentages correspond to within cluster data.

Table 37. 2000-2005 Clusters (Spain only)

First of all, we would like to remind that this dataset corresponds to that used by Fischer and Molero (2012) for the construction of a taxonomy proposal for firms engaged in international R&D cooperation. However, that assessment was exploratory in nature, where 8 variables were simultaneously used in the definition of clusters. Such procedure resulted in the proposition of groups which we have analyzed the present results against (Risky Innovators, Consistent Innovators, and Inventors).

But this course of action creates undesirable instabilities in the generation of reliable structures for clusters, since as not all variables have a strong association with each other, some of them result as non-significant for all groups. In order to deal with these issues, the clusters in this research are oriented towards firms' outcomes, providing a contributive element for policy evaluation regarding such activities[60].

Cluster 1 represents the group with the worst level of attainments throughout the Spanish sample. Firstly, it gathers all of the *Weak/Bad* results in technological terms (16.2% within cluster 1; 7.8% of total observations). For the case of the variable COMMACHIEV (which is not a significant dimension for this particular cluster) it shows a high level of variability in results (which explains the lack of statistical significance). Nonetheless, there is a slight predominance of *Nil* commercial achievements over *Good* and *Weak* results. Expected results are also mainly *Small* and *Nil* (cumulative percentage of 67.6% within cluster 1, more than twice the presence of *Good* expected impacts). In face of a relatively high rate of technological satisfaction in comparison to the lack of positive market exploitation from these firms, we classify this cluster under the *Inventors* category.

Cluster 2 consists entirely of companies with positive technological achievements (but not *excellent*). Its commercial outcomes vary, but are predominantly *Good* (unlike cluster 1), while expectations regarding results unfolding in the future are conservative, and rate such prospects as *Medium* (100%

[60] The creation of clusters follows a principle of segmentation of the population into (more) homogeneous groups of firms, thus making it possible to address policy intervention and adaptation according to participants' necessities. A lack of adequacy because of the existence of significant deviations within the population is then avoided.

of cases). This linearity within cluster 2 regarding firms' results leads us to put it under the *Consistent Innovators* category, where variability in results is hardly noticed, and outcomes are fairly positive, though far from outstanding.

In the case of cluster 3, for the TECHACHIEV dimension, firms are represented by *only* positive results, with an emphasis on *Excellent* results (94.7%, while the remaining 5.3% regards *Good* technological achievements). In this first item, cluster 3 performs consistently better than clusters 1 and 2. However, for the variable COMMACHIEV, the situation is blurrier (but statistically significant): *Excellent* results occur more frequently than for any other cluster, but there is a higher perception of *Nil* market results in comparison to characteristics found for cluster 2, which totalizes more *positive* results – 71.4% (accumulation of *Excellent* and *Good* outcomes) – than cluster 3 (68.4%).

Nonetheless, for the third variable under scrutiny (EXP_IMPACT), results point towards consistent expectations of better performance arising as a result of firms' participation in Eureka projects in cluster 3 when comparing its features to cluster 1 and 2. The higher relative technological capacity achieved by these firms, the combination of *Excellent* and poor market achievements, as well as the positive expectations that they have regarding future impacts of international R&D projects drives us to define cluster 3 as *Risky Innovators*, i.e., those firms that incur in higher variability regarding market achievements, but are also capable of attaining the most relevant benefits within the population.

Turning to statistical analysis of differences *between* groups (table 38), it can be noticed that the relevance of FUNCTIONING is present, and again (as in the case for the analysis of all countries, 2000-2005) related to those firms which are associated with the best set of outcomes (*Risky Innovators*). It is interesting to see, though, that *Consistent Innovators* once more do not differ from *Inventors* in this regard. *Excellence* in projects' capacity of network management seems to determine outstanding results, whereas fair functioning can lead to satisfactory market results, as well as to technological success without proper market success.

However (though without statistical significance), TOT_COST and DURATION behave similarly to results previously found for the complete 2000-2005 population. *Risky Innovators* are related to *shorter* and *cheaper* projects, which might lead to a higher level of satisfaction in these firms even when results are not as relevant, since *projects' productivity* may be considered as optimal. *Consistent Innovators*, on the other hand, once again are represented by companies with longer and costlier projects. Such features must be thoroughly regarded in the examination of these companies' outcomes. In face of quantitative methods' shortcomings, qualitative appraisal of results might be considered in the process of policy intervention.

The next step of this analysis considers the inclusion of a corporate indicator of firm performance: Return on Total Assets (ROTA). The procedure is simple and analogous to those undertaken for differences between groups regarding variables of choice. We applied ANOVA tests for ROTA regarding firms' corporate behavior three years prior to project completion, in the year of project completion, and results that unfolded three years after the project was finished. The timeframe varies according to the date of project completion for each firm, so the periods of analysis are stable across firms, but it does not comprehend a fixed period of time. The idea is to approximate the impacts that Eureka projects might have had on these firms, and if cluster classifications are accurate in capturing firms' overall achievements[61]. Results are presented in table 39.

[61] We would like to acknowledge the contribution of Prof. Phillip Shapira concerning this approach. Unfortunately, such procedure could not be applied for the whole set of firms for two reasons: the first one refers to the non-identification of German, French, Italian, and British firms in the database that was provided; secondly, access to firm-level financial data for cases located outside Spain represented an additional cost to this research that could not be covered by available funds.

Means (Medians in parentheses; Std. Dev. in brackets)	Cluster 1	Cluster 2	Cluster 3
RATIO_RD	1.93 (2) [.740]	1.67 (2) [.617]	1.62 (2) [.650]
FUNCTIONING	2.00 (2) [.632]	2.10 (2) [.447]	1.32 (1) [.478]

Non-Parametric Tests for Independent Samples

Mann-Whitney Tests for Pairwise Comparison

	Cluster I	Cluster J	Sig.
RATIO_RD	1	2	.253
		3	.192
	2	1	.253
		3	.796
	3	1	.192
		2	.796
FUNCTIONING	1	2	.692
		3	.000
	2	1	.692
		3	.000
	3	1	.000
		2	.000

Means (Std. Dev. in parentheses)	Cluster 1	Cluster 2	Cluster 3
TOT_COST	3.68 (6.607)	4.69 (7.750)	2.20 (1.251)
DURATION	39.84 (19.739)	47.00 (26.987)	37.37 (13.655)

One-Way Anova Results

Bonferroni's Post Hoc Tests

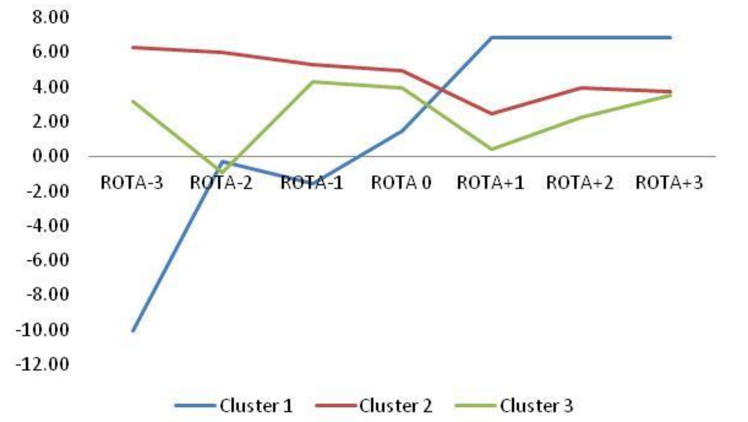
	Cluster (I)	Cluster (J)	Mean Difference I-J	Sig
TOT_COST*	1	2	-1.007	1.000
		3	1.487	1.000
	2	1	1.007	1.000
		3	2.494	.613
	3	1	-1.487	1.000
		2	-2.494	.613
DURATION**	1	2	-7.162	.633
		3	2.469	1.000
	2	1	7.162	.633
		3	9.632	.442
	3	1	-2.469	1.000
		2	-9.632	.442

*Levene´s sig. .184

**Levene´s sig. .114

Table 38. 2000-2005 (Spain only) Clusters' ANOVA and Mann-Whitney tests

Means (Std. Dev. in parentheses)	Cluster 1	Cluster 2	Cluster 3
ROTA-3	-10.07 (80.133)	6.29 (4.284)	3.20 (13.700)
ROTA-2	-.31 (35.358)	6.03 (5.027)	-.90 (12.367)
ROTA-1	-1.57 (28.294)	5.27 (5.509)	4.29 (29.119)
ROTA 0	1.49 (21.690)	4.93 (5.892)	3.95 (14.898)
ROTA+1	6.82 (14.593)	2.50 (9.487)	.44 (19.078)
ROTA+2	6.82 (9.132)	3.96 (7.108)	2.23 (17.883)
ROTA+3	6.82 (13.470)	3.71 (7.747)	3.55 (17.006)



One-Way Anova Results
Bonferroni's Post Hoc Tests*

	Cluster (I)	Cluster (J)	Mean Difference I-J	Sig
ROTA-3	1	2	-16.366	.956
		3	-13.274	1.000
	2	1	16.366	.956
		3	3.092	1.000
	3	1	13.274	1.000
		2	-3.092	1.000
ROTA-2	1	2	-6.343	1.000
		3	.588	1.000
	2	1	6.343	1.000
		3	6.931	1.000
	3	1	-.588	1.000
		2	-6.931	1.000
ROTA-1	1	2	-6.857	.968
		3	-5.869	1.000
	2	1	6.857	.968
		3	.987	1.000
	3	1	5.869	1.000
		2	-.987	1.000
ROTA 0	1	2	-3.442	1.000
		3	-2.465	1.000
	2	1	3.442	1.000
		3	.977	1.000
	3	1	2.465	1.000
		2	-.977	1.000

	Cluster (I)	Cluster (J)	Mean Difference I-J	Sig
ROTA+1	1	2	4.312	.935
		3	6.372	.430
	2	1	-4.312	.935
		3	2.060	1.000
	3	1	-6.372	.430
		2	-2.060	1.000
ROTA+2	1	2	2.865	1.000
		3	4.595	.532
	2	1	-2.865	1.000
		3	1.729	1.000
	3	1	-4.595	.532
		2	-1.729	1.000
ROTA+3	1	2	3.113	1.000
		3	3.273	1.000
	2	1	-3.113	1.000
		3	.159	1.000
	3	1	-3.273	1.000
		2	-.159	1.000

*All variables show homogeneity of variance (Levene´s sig. >.05)

Table 39. 2000-2005 (Spain only) Clusters' ANOVA tests for ROTA (Return on Total Assets) and its evolution over time

It is important to notice that standard deviations within clusters' are high for all periods of ROTA analysis, leading to the conclusion that firms with somewhat similar outcomes from Eureka projects are inherently different in terms of corporate finance, i.e., there is a marked heterogeneity between firms in each cluster when it comes to financial returns. This aspect indicates that means are not a good measure for cluster profiles regarding ROTA.

Nonetheless, if we analyze clusters' evolution over time, cluster 1 (*Inventors*) outperforms clusters 2 (*Consistent Innovators*) and 3 (*Risky Innovators*) after projects' completion (considering averages), which is precisely the opposite of what one would expect. On the other hand, statistical measures do not give much reason to develop conjectures regarding such outcomes. This is reflected by the abovementioned standard deviations, and by ANOVA results: differences between clusters in terms of ROTA are largely non-significant. This confirms the existence of strong heterogeneity within groups concerning this indicator, thus not allowing confirmation of the existence of differences between them.

This result, however, is rich in analytical terms. They can be interpreted as the result of the overall impact of Eureka projects on firms' overall situation. Even though such projects may not be *peripheral* to firms (Eureka, 2006) it would not be reasonable to assert that their outcomes are consistent determinants of the general corporate situation. The economic size of impacts shall vary from company to company, but to state that participation in a Eureka project *defines* the trajectory of a whole organization (even a SME) is to underestimate the capacity of firms' strategists and managers in designing tools for organizational competitiveness.

It is more likely (and more logical) to say that firms with stronger market presence, as well as a stronger capacity of internationalizing R&D activities through networking, are more prone to engage in pan-European projects and submit them to Eureka. Their overall corporate performance should then represent the *cause* of their relationship with Eureka, not its *effect*.

9. Policy and Managerial Implications

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 research characterizes an exercise of constructive criticism with the ultimate goal of providing information and feedback in order to allow continuous improvement of any kind of initiative geared towards promoting international R&D cooperation – private, governmental or even supranational.

The methodology used in our analysis had a quantitative character aiming at taking the step beyond purely descriptive assessments. It could be noticed that the overall rate of technological achievements is abnormally 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. It could also mean that the questionnaires are failing in capturing the real complexity involved in the process (Georghiou, 1997) or are influenced by too optimistic respondents (Huggins, 2001).

Overall results highlight the relevance of *H2* which states that "*The management quality of a given cooperative R&D project undertaken at the international level will influence the ultimate corporative outcomes of such project, both at the technological and economic (commercial) levels*". The relevance of the variable FUNCTIONING regarding its role as a determinant of TECHACHIEV, COMMACHIEV, and EXP_IMPACT may be related to an optimistic view of the managing process in the face of positive outcomes, i.e., the respondent of Eureka's Final Report may be biased in evaluating the quality of a given project's functioning in face of successful outcomes, thus minimizing issues that may have happened during collaboration's development.

Nonetheless, innovation is a manageable process, not a result of chaotic forces acting by chance. Many authors have recognized through case studies and econometric analyses the central role played by organizational structure in fostering innovation. In this regard, the chain-linked model of innovation (Kline & Rosenberg, 1986) is an important framework of analysis, where proper coordination among different departments is of utmost importance in defining firms' innovative capacities.

This situation is not likely to change through outsourcing or open innovation settings, where the boundaries of firms are redefined. The formation of networks of innovation implies that good coordination must be present within and between agents involved in such activities. It is not surprising then that the rate of functioning works as a strong determinant factor in terms of both technology and market outcomes by firms. In an international context, such dimension is even more critical, provided that companies share distinct institutional environments, cultures, languages, and are geographically apart from each other (Bottazzi & Peri, 2007). This particular result provides striking evidence in favor of a transaction cost perspective of R&D networks, where network management faces a wide array of constraints (outlined in our literature review) that largely shape innovative activity (with impacts comparable to those caused by purely technical developments). A direct implication of this finding regards the role played by alliance managers in setting the stage for effective interactions among firms. Ireland, Hitt and Vaidyanath (2002) refer to this viewpoint as the *managerial imperative*, which states that transaction costs represent core aspects in the definition of alliances' dynamics. They also put emphasis on the importance of the Resource-Based View, but as we discuss below, our perceptions are somewhat different in this regard.

A policy implication related to this finding is one of efficiency of allocated resources. Much is argued about the need for improvement in the amount of financing for innovative activities. Nonetheless, the dynamics of these resources are bound to be affected not only by the institutional environment, but, as we have shown, they are also a function of companies' managerial capabilities. Therefore, establishing behavioral patterns for the economic transaction that take place within these networks can be desirable in order to provide the dedicated funds with increased probabilities of generating optimal returns for firms and, consequently, for the economic system as whole. Hence, Eureka is likely to have an important role to play in monitoring the activities undertaken by its networks. In summary, investing *more* in innovation cannot be as beneficial for society as investing *better*. As the management of innovative activities lies at the core of the definition of "*better*", improving the quality of coordination in R&D networks is of utmost importance.

Hence, in a cooperative context, it is not surprising that inter-firm management plays a leading role in defining effectiveness of processes and outcomes. What is more important, however, is that the required managerial competences most likely differ from standard intra-firm administrative tasks, as hierarchical and departmental structures take more complex forms (often interdisciplinary when it comes to innovation), redefining the landscape for efficient coordination.

Furthermore, it is important to notice the relatively low level of importance of variables included in what we defined as *Microeconomic* and *Macroeconomic Dimensions*. If we resort to the foundations of economic thought, Adam Smith (1776) in *an Inquiry into the Nature and Causes of the Wealth of Nations* pinpoints the widely acknowledge philosophy of the *invisible hand*, an idea which explains rather simply that the search for individual profit would lead to society's overall gains. With this idea in mind, organizations are similar in pursuing individual benefits (*through innovation* for a good contextualization in the terms of this research), but their strategies and tactics to achieve firm-specific goals are highly

idiosyncratic. This might represent a whole deal of subjectivity in the terms of what represents success or failure, but it also copes better with reality than to build investigations upon models that face such phenomena as irrelevant. This leads us to a perspective in which the *Contextual Dimension* rises as the logical determinant of outcomes (technological and economic) that are also *context-specific*.

Firms are not equal, they do not behave equally, and they measure achievements *differently*[62]. Using inherently subjective analysis (e.g. using perception-oriented questionnaires) might not be optimal in terms of adequate consistence for what it is *expected* for firms. To rely on subjective observations is to believe that individual perception is related to also individual benefits or characteristics. Through the use of data gathered via projects' questionnaires we were able to estimate and associate a rich set of variables, which would be otherwise impossible to verify[63]. It is not our intention to argue against the feasibility of evaluation assessments of RTD initiatives and policymaking given the subjectivity of firms. The use of instruments that collect information which is bound to face subjectivity "issues" (questionnaires, interviews, etc) can be extremely valuable when estimating quantitative and qualitative relationships between variables.

Interestingly, the proxies for absorptive capacity did not correspond to prior expectations. Even considering that results are evaluated taking into consideration individual goals, one would argue that firms that are better capable of capturing results from networks would be better positioned to find their strategic goals satisfied. Our results suggest, on the other hand, that this situation does not hold for the samples under scrutiny. A possible explanation for such finding lies in the

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[62] In an assessment of Framework Programme's impacts, Georghiou (1994) points out that firms are strongly heterogeneous not only in their inherent characteristics (such as sector, size, etc.), but also in the strategies they seek. While this might sound somewhat obvious, it is an important remark for microeconomic approaches which often consider firms' interests as given. Pinsonneault and Rivard (1998), studying the "productivity paradox" of IT, propose a very similar conclusion, though in a different context.

[63] Bergek and Bruzelius (2010) suggest that surveys are likely to provide more in-depth knowledge on the analysis of R&D networks when compared to more objective indicators such as patents.

imperfectness of the variables used for such estimations, where organizational capabilities might not be well represented by R&D investment, firm size, or amount of funds dedicated to a given project, but rather on the quality of human resources, organizational culture, etc. This can be especially relevant when we consider market-oriented outcomes, provided that other abilities can be referred as more pertinent than the usual instruments of absorptive capacity. Nonetheless, our results offer scant evidence in favor of the relevance of the Resource-Based View as a useful approach regarding the determinants of success in international R&D networks. Further research in this regard, especially considering additional variables, is needed in order to verify this proposition.

A similar conclusion can be directed towards the National Innovation System approach, since the country to which a given firm belongs seems to affect its results only marginally. Again, this outcome is based upon a very limited view of the NIS framework and a larger set of variables should be taken into account when considering the vast viewpoint that the macroeconomic context may carry with it.

This unambiguously represents that the quality of international R&D cooperation projects is the core determinant of its results, regardless of firms' characteristics or the broad environment in which they are located (Innovation Systems), considering that such outcomes are not *static* or *exogenously defined*, but rather depend on agents' strategies and objectives[64]. In the policymaking realm, this means that the selection of projects must be based on the merits of propositions, not on *who* is proposing or to *where* they shall be located. Therefore, more emphasis should be given to the managerial structure of alliances when projects are analyzed *ex ante*, since purely technical aspects omit relevant aspects of projects' development. Companies are then expected to dedicate full attention to international R&D networks' excellence of management in order to develop consistent and successful initiatives. Such outcomes of this research provide

[64] This is especially true for the case of Eureka's individual projects, since they are developed under a "bottom-up" structure.

strong support to criticisms made towards *quasi-experimental methods* as a robust source of innovation policy evaluation (section 7.2 Methodological Discussion).

Another aspect to be pointed out regards the *ad hoc* variables, i.e., those that refer basically to the particular sort of achievements undertaken by firms (Product Innovation, Process Innovation, Service Innovation, and Strategic Alliances). Product innovation (PROD_INNO) presents a stronger relationship with *achieved* successful results (but not those that are expected to take place in the future), whereas the relevance of service and process innovations is inconstant across estimations. This outcome, however, should be carefully analyzed before it becomes a line of suggestion for projects' appraisal. Innovation in products is more likely to provide tangible and immediate results both at the technological development and market environment, which leads to a better evaluation of the results arising from such activity.

In its turn, Process Innovations are also tangible, and they are indeed associated with better technological outcomes. Nonetheless, such kind of innovative activity presents a non-significant level of association with market achievements. A plausible explanation for this situation is the inherent *internal* character of process innovation, improving productive activities, while not necessarily resulting in observable market success in the short term. For the case of service innovations, results do not indicate reliable associations between such kind of activity and positive outcomes, which is likely to be related to the technological orientation (*hard innovation*) of Eureka individual projects (table 15).

For the case of the creation of strategic alliances (STRAT_ALL), estimations point towards the importance of the existence of competitors within the network (2000-2005) and positive technological and market achievements (2006-2008). Regarding cooperation involving rivals, these results are an indication of the necessity of more structured agreements in order to face potential risks among partners in terms of knowledge and capability sharing, thus leading to networks with longer duration than those that are exclusively project-specific. Transaction costs seem to play yet another important role in this regard. The attainment of positive outcomes functions as catalyst of inter-firm connections, where successful developments guide firms towards more stable relationships.

Oddly, the quality of projects' functioning and results that are expected to unfold in the future do not represent significant factors affecting such behavior. An explanation for this can be found in the specialized literature. Fernández-Ribas and Shapira (2009) indicate that industries with a high dynamic of technological change are not prone to engage in what they call *harder* forms of cooperative agreements (alliances, joint ventures, and other forms of contractual agreements). Therefore, such aspects that were unobservable in the sample (to preserve firms' identities) can be present in this interaction, thus making relationships with other variables blurry.

Moreover, we can consider the generation of strategic alliances as an indicator of *behavioral additionality*, a desirable feature in an initiative with the characteristics of Eureka (perhaps the *most* desirable). Considering the relative values of STRAT_ALL over the two datasets (2000-2005 and 2006-2008), we can notice a significant increase of this dimension, with special impact on the Spanish case. However, such observations are not able to provide an examination of robust trends over time.

Concerning the use of clustering techniques for the evaluation of firms' results according to relatively homogenous groups, this procedure is based on an analogous approach to that used for market segmentation. The underlying rationale is that policy intervention is more likely to succeed if it fits adequately groups with similar characteristics, instead of approaching heterogeneous groups of firms in a similar manner. In this research, this fragmentation of Eureka participants follows a *post hoc* structure, where the occurrence of relatively stable (and similar) groups of firms according to technological and market-related results seems to be more efficient than the use of firm-level information or macroeconomic conditions for formulation and adaptation of international R&D cooperation initiatives.

This particular methodology can function as a valuable instrument for policymakers in terms of international R&D networks monitoring and *ex post* intervention. The basic structure tested in this case is that of Fischer and Molero (2012), which divides companies in three different categories. Robustness of this framework was relevant across datasets.

Each group presents strengths and weaknesses that can be supported through technical and managerial support. *Risky Innovators* lack steadiness in their ability to market results. *Consistent Innovators* represent companies with projects that could be addressed in terms of their incapacity to exceed fair results (and achieve excellence). *Inventors* are those companies that could not meet their market goals, even in face of positive technological outcomes. As a control instrument, the cluster analyses facilitate evaluations, as well as further capacity to deal with such constraints in a combined manner (instead of a case-to-case approach). This tool also serves the purpose of identifying complementary agents that could be matched for future projects (according to their particular strengths).

Furthermore, this approach allowed a closer examination of influential variables in the determination of outcomes arising from Eureka's individual projects. Instead of the sole use of regression statistics, we could complement this approach with a verification of differences between relatively homogeneous groups of firms regarding their inherent differences in a set of aspects. Once again, quality of projects' management (FUNCTIONING) was significantly associated with higher rates of combined outcomes. This situation allowed a confirmation of the *Contextual Dimension*'s importance in terms of results achieved by firms.

Focusing on the properties of overall results from the perspective of Spanish companies, relevant aspects arise. Even though the *Macroeconomic Dimension*'s hypothesis was *partially* accepted, some level of consistency existed for the case of *expected outcomes*. Drawing from the structure of results, we develop some implications and useful insights for integrants of this specific Innovation System regarding their interaction with international R&D networks.

The sample of Spanish firms seem to be in a better situation in terms of appropriation of results coming from international R&D networks than its peers located in more developed Innovation Systems, which is gathered from descriptive statistics (table 15). Inferential statistics provide significant support for such expectation in the cases of technological outcomes (2006-2008) and expected impacts (2000-2005). As previously outlined, other relationships do not provide conclusive considerations. Nonetheless, we found fair indications that Spanish agents included in our analysis are bound to increase their competitiveness when resorting to *open innovation* strategies, even lagging behind its peers in terms of measurable *absorptive capacity* (R&D intensity).

As literature suggests that R&D networks function, among other things, as a way for companies to achieve a higher capacity of R&D spending, the Spanish economic structure (mainly based on traditional sectors' SMEs with lack of innovation investment capacity) can find in European partners the source for their evolution, thus bringing benefits to those individual actors that are prone to (and capable of) establishing international connections with the aim of generating innovations, even though our results cannot be regarded as representative of the whole Spanish context.

Nonetheless, considering the usual constraints of the Spanish economy regarding its Innovation System (amplified by the current socioeconomic situation), promoting this behavior is an advantageous form of building long-term innovation strategies while increasing the productivity of RTD resources. Taking into account that this country finds itself in a relatively laggard position in most innovation-related indicators, more concern on the ways of closing technological gaps through absorption of external knowledge that (and especially within Europe) is likely to provide better results than independent, internal, initiatives (as suggested by

Herstad *et al*, 2010)[65]. Nonetheless, this does not mean that policies oriented towards domestic cooperation are not relevant, but that a combination of both is likely to be more effective than if they happen in isolation. This perspective is reinforced by the damages caused by the economic turmoil faced by Spain. Further access to foreign markets is of utmost importance for innovative companies to achieve sustainable growth in this moment. If our results hold true for the population of Spanish enterprises, then international cooperation can provide these firms with sufficient structure for that to happen.

The creation of networks' support system in Spain is an interesting aspect to be considered. This suggestion comes from endemic problems that this country faces, such as the low level of foreign languages' skills (Heijs, 2009) and the higher relative levels of instability that Spanish agents face in international relationships (Segarra, 2011). A dedicated infrastructure in this case shall be cost-efficient and fruitful in strengthening the cooperation abilities of Spanish organizations as a whole. Such sort of innovation policy actions would not render this economy less dependent on foreign sources of technology in the short term, but would create the environment for future *competitive* and long term-oriented development of companies located within this National Innovation System. Once again, however, we must be cautious in appropriating results from a limited sample of companies participating in Eureka and drawing broader conclusions for the remaining of Spanish firms.

Some additional limitations exist regarding the appropriation of outcomes of this research, as outlined throughout most of our empirical assessment and methodological definitions. Analytical variables offer meager conclusions regarding their overall explanatory power. In-depth case studies may be recommended in order to design other aspects regarding Eureka's Final Reports so they can gather more contributive information, especially regarding detailed aspects of managerial activities that take place in networks, since our results streamline the relative

[65] Even though the necessary scale for this to happen would have to be much larger than Eureka-based cooperation.

importance of coordination in shaping ultimate results. Identifying the existence of previous ties among agents, kind of cooperative agreement (governance modes), evaluation of specific cases of transaction costs are examples of dimensions that can be usefully included in these questionnaires. Moreover, other limitations of our assessment regard barriers regularly faced by R&D cooperation researchers (for an example, see Gallié & Roux, 2010): selection bias, lack of partners' information, and single data cross section, which does not allow the control of firms' evolution over time, thus somewhat limiting the validity of our findings to the sample under scrutiny.

10. Concluding Remarks

As Carlsson (2003) puts it, "*the European Union appears to be the only major supranational scientific and technological block now emerging*". In fact, and in many aspects, the international approximation between EU's member states represents a search for closer interaction, coordination, and, consequently, appropriation of benefits that are expected to arise from large markets (at least from the economic perspective).

Initiatives such as the European Research Area, the Innovation Union, Joint Technological Initiatives, and Eureka/Eurostars represent efforts in this direction. All of them propose support for creating stronger innovative capabilities within Europe *through* the generation of collaboration in innovative activities across the continent, i.e., involving agents belonging to different national settings (National Innovation Systems).

The durability of Eureka shows that this initiative can be considered as a relevant RTD program. However, evaluating its effectiveness via an input-output approaches is not likely to provide the evaluator with a good perspective of the whole context (Georghiou, 1999a). Multiple dimensions influence the overview of outcomes' quality (Dyer & Powell, 2002). Aspects like these highlight the need for further efforts in assessing systemic impacts of international R&D cooperation, where Social Network Analysis is bound to provide interesting findings. Therefore, approaches that consider the structure of Eureka's networks as a whole shall contribute to understand the generation of behavioral additionality in agents (possibly the core goal in the promotion of R&D cooperative settings).

In this case, economic and technological results *are not* the sole objective. Such strategies must be regarded according to an *efficiency* perspective, together with its *efficacy*. The *efficacy* of such programs is related to innovative results that are or are not achieved, thus corresponding to a linear and result-oriented evaluation of RTD policies. On the other hand, the *efficiency* of these initiatives should be understood not only as the measures of proper allocation of resources (additionality), but also as the construction of a more integrated business/research environment in terms of innovation.

Nonetheless, few countries consider the focus on international integration of innovation systems as a policy tool (Edler, 2008), where usual initiatives are directed towards enhancing R&D support through availability of funds and promotion of stronger linkages between firms, universities and research institutions *within national boundaries*. Even though these policies are beneficial for Innovation Systems, they shall not *by themselves* create an optimal framework for development if they do not consider the productivity that may arise from interactions with foreign organizations. As classical economic theory predicts, overall benefits arise from specialization and trade, thus some form of R&D internationalization can analogously result in an increased outcome for economies.

The promotion of an integrated European Innovation System works as a way to achieve stronger integration among different regions, amplifying economic development throughout the continent. This would in its turn promote an environment of further incentives to investment in innovative activities in economic agents. In a context of economic crisis, structural demands are usually maintained unattended to the benefit of more “urgent” policy initiatives. The current public debate has been around Keynesian (economic stimuli) and neoclassical (austerity) approaches, where the Schumpeterian view would focus on innovation and entrepreneurship as a form of confronting such period of recession/depression (Audretsch & Link, 2011). Many reasons why this *innovation oriented* perspective is desirable are made explicit in this research, even though it must be acknowledged that our empirical assessment only marginally tackles the much wider perspective regarding the ERA. Therefore, our results can shed some light on this issue, but do not warrant a broader level of analysis.

Under a macroeconomic perspective, innovation is a desirable and relevant event because of its inherent capacity of generating economic growth. Literature acknowledges the complexity involved in this context, where investment, monetary policy, institutions, geography, education, etc. represent influential variables. Unfortunately, little consensus exist on to how to promote economic growth, as well as on how to develop stronger Innovation Systems.

We hope that this research has contributed in this direction. For such, we have approached the international R&D cooperation phenomena in a way to offer insights on what factors determine firms' performance, as well as establishing behavioral patterns in these agents. Achieved results put emphasis on the internal developments of networks as main influential dimensions in terms of technological and economic attainments. This perspective highlights the importance of managerial capabilities for the success of collaborative arrangements, highlighting the importance of transaction costs involved in the process. Identified patterns suggest that Eureka's participants highly succeed in the technological arena, but actual innovation is limited to fewer firms: RTD cooperation might reduce risks that are inherent to the innovative process, but not eliminate them.

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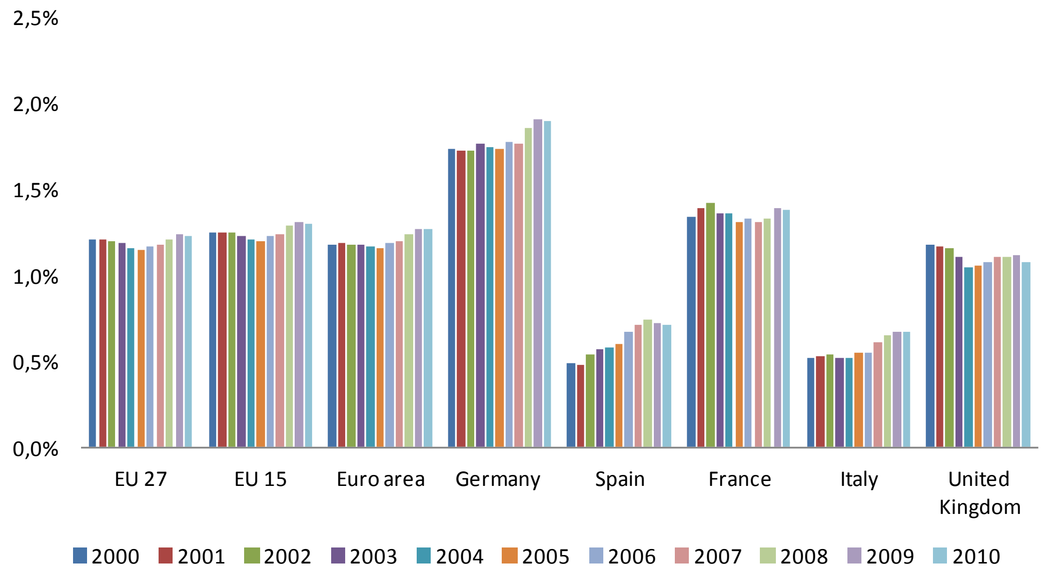
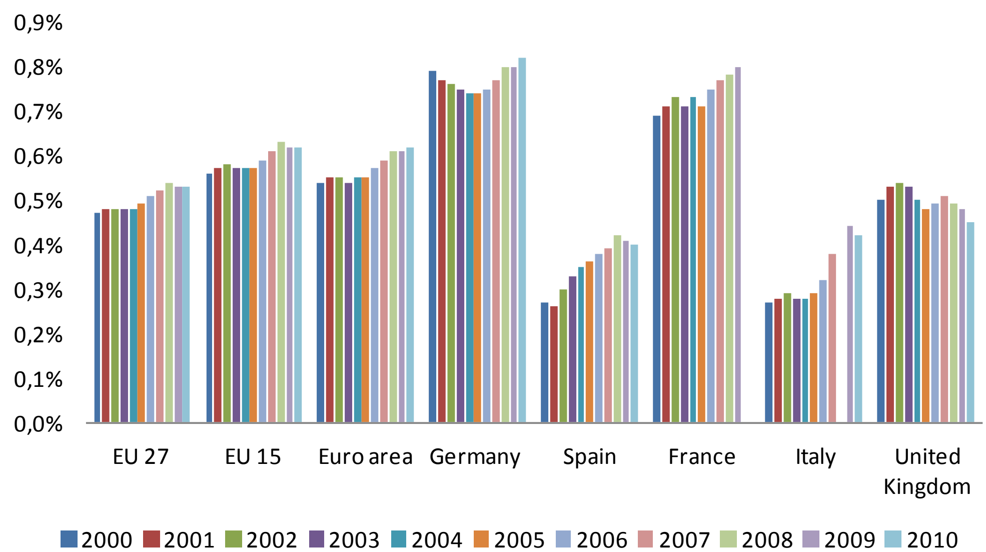
APPENDIX I – Supplementary Graphs on the Relative Position of the Spanish Innovation System

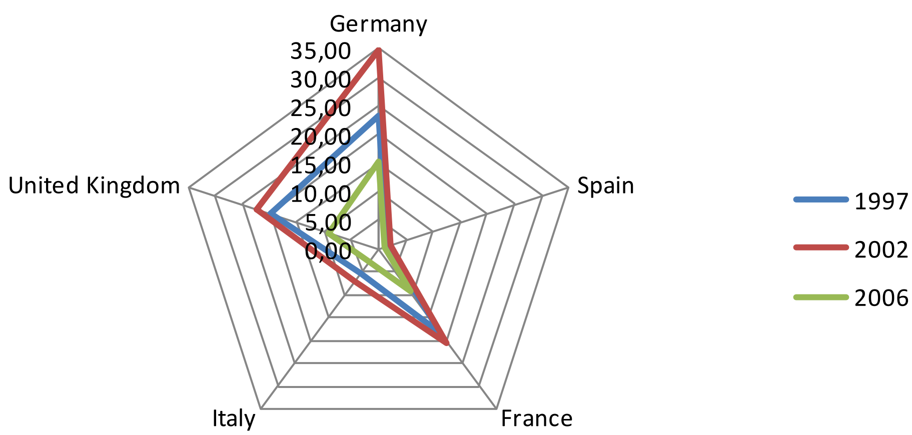
Total intramural R&D expenditure (GERD) – Business Enterprise Sector (% of GDP). Source: Eurostat, 2012.



Total R&D personnel (FTE – Business Enterprise Sector (% of Active Population). Source: Eurostat, 2012.

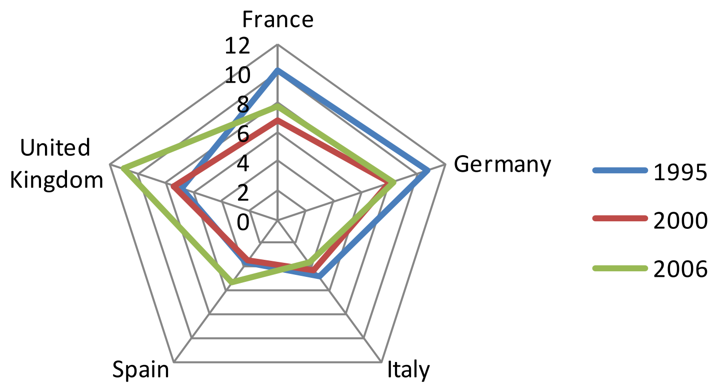


High-Tech patents granted by the USPTO per million inhabitants. Source: Eurostat, 2012.



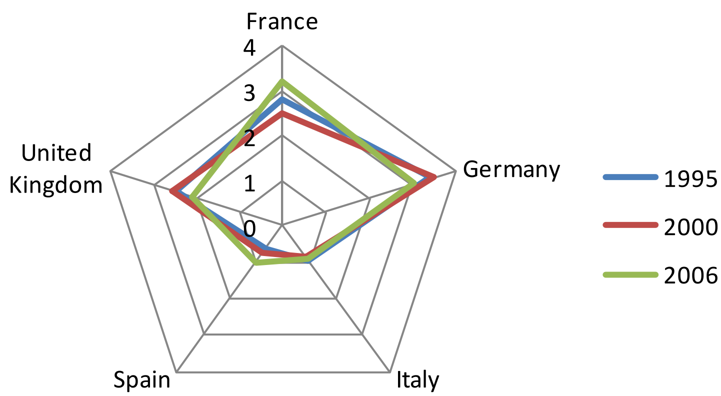
R&D intensity of High-Tech Manufactures (using production data). Source: STAN Indicators/OECD Stat, 2012.

Note: R&D intensities expresses R&D expenditures as a percentage of production. This indicator is calculated as follows: 100 * (ANBERD_i / PROD_i) where ANBERD: Analytical Business Enterprise Research and Development



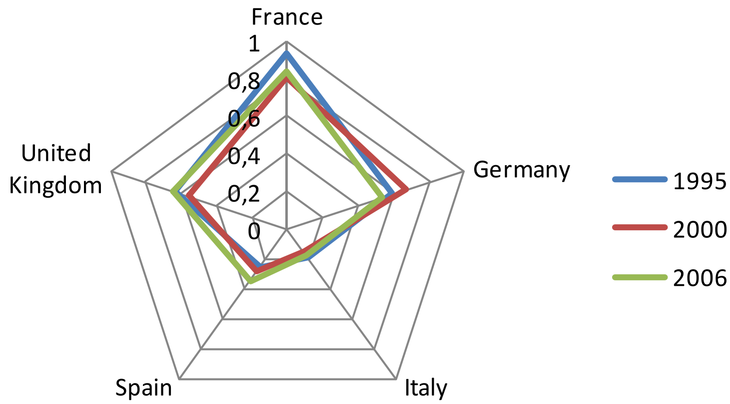
R&D intensity of Medium High-Tech Manufactures (using production data). Source: STAN Indicators/OECD Stat, 2012.

Note: R&D intensities expresses R&D expenditures as a percentage of production. This indicator is calculated as follows: 100 * (ANBERD_i / PROD_i) where ANBERD: Analytical Business Enterprise Research and Development



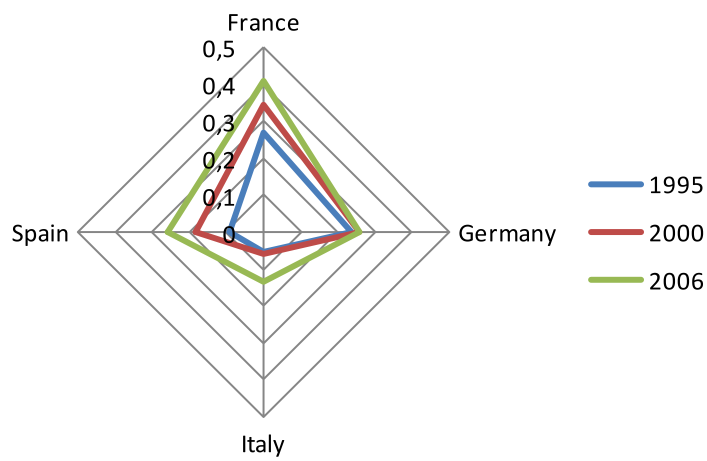
R&D intensity of Medium Low-Tech Manufactures (using production data). Source: STAN Indicators/OECD Stat, 2012.

Note: R&D intensities expresses R&D expenditures as a percentage of production. This indicator is calculated as follows: 100 * (ANBERD_i / PROD_i) where ANBERD: Analytical Business Enterprise Research and Development



R&D intensity of Low-Tech Manufactures (using production data). Source: STAN Indicators/OECD Stat, 2012.

Note: R&D intensities expresses R&D expenditures as a percentage of production. This indicator is calculated as follows: 100 * (ANBERD_i / PROD_i) where ANBERD: Analytical Business Enterprise Research and Development



R&D Cooperation Profiles of selected countries disaggregated by firm size – Manufacturing and Services. Source: Eurostat, 2012 (Community Innovation Survey, waves 4, 5, and 6).

MANUFACTURING

		Total			SMEs (10 to 49 employees)			SMEs (50 to 249 employees)			Large Firms (250 employees or more)		
Total Cooperation in Innovation (% of Innovative Firms)		**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**
	Germany	19,2%	21,3%	22,9%	13,8%	16,2%	17,7%	18,6%	20,7%	27,1%	47,5%	47,8%	55,0%
	Spain	***18,6%***	***18,1%***	***18,8%***	***14,2%***	***13,2%***	***14,2%***	***28,4%***	***27,6%***	***26,3%***	***50,6%***	***47,2%***	***45,5%***
	France	38,8%	48,3%	43,9%	32,6%	na	39,7%	42,9%	43,6%	46,3%	63,0%	60,6%	64,6%
	Italy	11,0%	11,3%	13,6%	8,7%	8,6%	10,5%	16,4%	18,3%	22,8%	34,2%	35,9%	44,2%
	UK	28,9%	30,8%	na	25,9%	27,3%	Na	31,2%	35,1%	na	45,3%	47,5%	na

SERVICES

		Total			SMEs (10 to 49 employees)			SMEs (50 to 249 employees)			Large Firms (250 employees or more)		
Total Cooperation in Innovation (% of Innovative Firms)		**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**
	Germany	na	na	na	na	na	Na	na	na	na	na	na	na
	Spain	***12,7%***	***11,6%***	***15,5%***	***10,7%***	***8,5%***	***13,0%***	***20,2%***	***22,5%***	***22,8%***	***38,3%***	***35,0%***	***32,8%***
	France	37,7%	na	38,1%	35,6%	na	34,9%	42,0%	na	45,3%	50,2%	na	59,1%
	Italy	15,9%	13,3%	18,9%	15,2%	11,5%	16,5%	16,6%	20,1%	29,5%	29,6%	25,1%	44,2%
	UK	na	na	na	na	na	Na	na	na	na	na	na	na

MANUFACTURING

		Total			SMEs (10 to 49 employees)			SMEs (50 to 249 employees)			Large Firms (250 employees or more)		
Cooperation in Innovation at the National Level (% of Innovative Firms)		**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**	**CIS4**	**CIS5**	**CIS6**
	Germany	18,1%	na	22,1%	13,3%	na	17,3%	17,0%	na	25,5%	45,3%	na	52,6%
	Spain	***17,5%***	***16,8%***	***17,7%***	***13,7%***	***12,2%***	***13,4%***	***25,5%***	***25,5%***	***24,6%***	***46,1%***	***42,6%***	***41,0%***
	France	36,2%	43,8%	40,5%	31,0%	na	37,4%	39,2%	39,8%	40,5%	57,7%	54,3%	60,8%
	Italy	10,5%	na	12,4%	8,3%	na	9,6%	16,0%	na	20,2%	31,2%	na	40,8%
	UK	na	na	na	na	na	Na	na	na	na	na	na	na

SERVICES

Cooperation in Innovation at the National Level (% of Innovative Firms)		Total			SMEs (10 to 49 employees)			SMEs (50 to 249 employees)			Large Firms (250 employees or more)		
		CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6
	Germany	na	na	na	na	na	Na	na	na	na	na	na	na
	Spain	***12,1%***	***11,0%***	***15,0%***	***10,2%***	***7,9%***	***12,7%***	***19,3%***	***21,6%***	***21,7%***	***37,0%***	***33,8%***	***30,9%***
	France	35,8%	na	36,0%	33,8%	na	32,8%	39,7%	na	42,8%	47,9%	na	57,3%
	Italy	15,6%	na	17,6%	15,0%	na	15,6%	15,8%	na	26,1%	29,3%	na	38,9%
	UK	na	na	na	na	na	Na	na	na	na	na	na	na

MANUFACTURING

Cooperation in Innovation at the European Level (% of Innovative Firms) - excluding National cooperation		Total			SMEs (10 to 49 employees)			SMEs (50 to 249 employees)			Large Firms (250 employees or more)		
		CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6
	Germany	6,6%	na	7,3%	3,0%	na	3,7%	5,8%	na	8,7%	26,6%	na	35,6%
	Spain	***4,6%***	***4,7%***	***4,8%***	***2,0%***	***2,1%***	***2,3%***	***9,5%***	***7,8%***	***7,1%***	***27,6%***	***27,5%***	***26,3%***
	France	17,5%	25,2%	17,9%	9,8%	na	10,3%	22,2%	18,1%	24,9%	48,7%	43,8%	46,8%
	Italy	2,3%	na	3,5%	1,5%	na	2,1%	3,3%	na	5,7%	14,1%	na	26,5%
	UK	na	na	na	na	na	Na	na	na	na	na	na	na

SERVICES

Cooperation in Innovation at the European Level (% of Innovative Firms) - excluding National cooperation		Total			SMEs (10 to 49 employees)			SMEs (50 to 249 employees)			Large Firms (250 employees or more)		
		CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6
	Germany	na	na	na	na	na	Na	na	na	na	na	na	na
	Spain	***2,9%***	***2,3%***	***3,1%***	***2,1%***	***1,5%***	***2,0%***	***5,6%***	***4,8%***	***6,5%***	***12,1%***	***9,6%***	***10,9%***
	France	11,2%	na	11,0%	9,6%	na	8,7%	13,5%	na	16,4%	23,9%	na	26,4%
	Italy	2,4%	na	5,3%	1,9%	na	4,0%	4,1%	na	11,7%	7,7%	na	15,9%
	UK	na	na	na	na	na	Na	na	na	na	na	na	na

MANUFACTURING

Cooperation in Innovation with Countries outside the European Region (% of Innovative Firms)		Total			SMEs (10 to 49 employees)			SMEs (50 to 249 employees)			Large Firms (250 employees or more)		
		CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6
	Germany	3,8%	na	4,9%	0,6%	na	2,5%	3,9%	na	4,8%	19,3%	na	27,4%
	Spain	***1,5%***	***1,7%***	***2,0%***	***0,5%***	***0,9%***	***0,7%***	***3,2%***	***2,2%***	***3,0%***	***11,4%***	***11,9%***	***14,4%***
	France	10,0%	13,5%	10,2%	6,1%	na	5,2%	10,5%	7,9%	10,7%	31,0%	27,9%	40,5%
	Italy	0,9%	na	1,8%	0,4%	na	0,7%	1,7%	na	4,5%	10,1%	na	15,5%
	UK	na	na	na	na	na	Na	na	na	na	na	na	na

SERVICES

Cooperation in Innovation with Countries outside the European Region (% of Innovative Firms)		Total			SMEs (10 to 49 employees)			SMEs (50 to 249 employees)			Large Firms (250 employees or more)		
		CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6	CIS4	CIS5	CIS6
	Germany	na	na	na	na	na	Na	na	na	na	na	na	na
	Spain	***0,6%***	***1,3%***	***1,6%***	***0,3%***	***1,0%***	***1,0%***	***1,9%***	***1,9%***	***3,0%***	***5,6%***	***5,4%***	***6,3%***
	France	7,6%	na	8,5%	6,6%	na	6,5%	9,2%	na	13,3%	15,3%	na	20,1%
	Italy	1,1%	na	2,5%	0,8%	na	1,8%	1,6%	na	7,1%	4,2%	na	5,9%
	UK	na	na	na	na	na	Na	na	na	na	na	na	na

APPENDIX II – SPSS TwoStep Cluster's Operational details
(Source: SPSS 16.0.0)

Notation

K^A	Total number of continuous variables used in the procedure.
K^B	Total number of categorical variables used in the procedure.
L_k	Number of categories for the *k*th categorical variable.
R_k	The range of the *k*th continuous variable.
N	Number of data records in total.
N_k	Number of data records in cluster *k*.
$\hat{\mu}_k$	The estimated mean of the *k*th continuous variable across the entire dataset.
$\hat{\sigma}^2_k$	The estimated variance of the *k*th continuous variable across the entire dataset.
$\hat{\mu}_{jk}$	The estimated mean of the *k*th continuous variable in cluster *j*.
$\hat{\sigma}^2_{jk}$	The estimated variance of the *k*th continuous variable in cluster *j*.
N_{jkl}	Number of data records in cluster *j* whose *k*th categorical variable takes the *l*th category.
N_{kl}	Number of data records in the *k*th categorical variable that take the *l*th category.
d(j, s)	Distance between clusters *j* and *s*.
$<j, s>$	Index that represents the cluster formed by combining clusters *j* and *s*.

Log-Likelihood distance – Clustering Algorithms

The log-likelihood distance measure can handle both continuous and categorical variables. It is a probability based distance. The distance between two clusters is related to the decrease in log-likelihood as they are combined into one cluster. In calculating log-likelihood, normal distributions for continuous variables and multinomial distributions for categorical variables are assumed. It is also assumed that the variables are independent of each other, and so are the cases. The distance between clusters *j* and *s* is defined as:

$$d(i,j) = \xi_i + \xi_j - \xi_{<i,j>}$$

where

$$\xi_v = -N_v \left(\sum_{k=1}^{K^A} \frac{1}{2} \log\left(\hat{\sigma}_k^2 + \hat{\sigma}_{vk}^2 \right) + \sum_{k=1}^{K^B} \hat{E}_{vk} \right)$$

and

$$\hat{E}_{vk} = -\sum_{l=1}^{L_k} \frac{N_{vkl}}{N_v} \log \frac{N_{vkl}}{N_v}$$

If $\hat{\sigma}_k^2$ is ignored in the expression for ξ_v, the distance between clusters *i* and *j* would be exactly the decrease in log-likelihood when the two clusters are combined. The $\hat{\sigma}_k^2$ term is added to solve the problem caused by $\hat{\sigma}_{vk}^2 = 0$, which would result in the natural logarithm being undefined. (This would occur, for example, when a cluster has only one case.)

When the variable is continuous, the importance measure is based on:

$$t = \frac{\hat{\mu}_k - \hat{\mu}_{jk}}{\hat{\sigma}_{jk} / \sqrt{N_k}}$$

which, under the null hypothesis, is distributed as a *t* with $N_k - 1$ degrees of freedom. The significance level is two-tailed. Either the *t* statistic or its significance level can be reported as the importance measure.

When the variable is categorical, the importance measure is based on:

$$\chi^2 = \sum_{l=1}^{L_k} \left(\frac{N_{jkl} - N_{kl}}{N_{kl}} \right)^2$$

which, under the null hypothesis, is distributed as a χ^2 with L_k degrees of freedom. Either the χ^2 statistic or its significance level can be reported as the importance measure.

TwoStep can use the hierarchical clustering method in the second step to assess multiple cluster solutions and automatically determine the optimal number of clusters for the input data. A characteristic of hierarchical clustering is that it produces a sequence of partitions in one run: 1, 2, 3, … clusters. In contrast, a *k*-means algorithm would need to run multiple times (one for each specified number of clusters) in order to generate the sequence. To determine the number of clusters automatically, TwoStep uses a two-stage procedure that works well with the hierarchical clustering method. In the first stage, the BIC for each number of clusters within a specified range is calculated and used to find the initial estimate for the number of clusters. The BIC is computed as

$$\mathrm{BIC}(J) = -2\sum_{j=1}^{J} \xi_j + m_J \log(N)$$

where

$$m_J = J\left\{2K^A + \sum_{k=1}^{K^B}(L_K - 1)\right\}$$

and other terms defined as in Distance Measure (TwoStep clustering algorithms). The ratio of change in BIC at each successive merging relative to the first merging determines the initial estimate. Let $\mathrm{dBIC}(J)$ be the difference in BIC between the model with J clusters and that with (J + 1) clusters, $\mathrm{dBIC}(J) = \mathrm{BIC}(J) - \mathrm{BIC}(J+1)$. Then the change ratio for model J is

$$R_1(J) = \frac{\mathrm{dBIC}(J)}{\mathrm{dBIC}(1)}$$

If $\mathrm{dBIC}(1) < 0$, then the number of clusters is set to 1 (and the second stage is omitted). Otherwise, the initial estimate for number of clusters*k* is the smallest number for which $R_1(J) < 0.04$

In the second stage, the initial estimate is refined by finding the largest relative increase in distance between the two closest clusters in each hierarchical clustering stage. This is done as follows:

- Starting with the model C_k indicated by the BIC criterion, take the ratio of minimum inter-cluster distance for that model and the next larger model C_{k+1}, that is, the previous model in the hierarchical clustering procedure,

$$R_2(k) = \frac{d_{\min}(C_k)}{d_{\min}(C_{k+1})}$$

where C_k is the cluster model containing *k* clusters and $d_{min}(C)$ is the minimum inter-cluster distance for cluster model *C*.

- Now from model C_{k-1}, compute the same ratio with the following model C_k, as above. Repeat for each subsequent model until you have the ratio $R_2(2)$.

- Compare the two largest R_2 ratios; if the largest is more that 1.15 times the second largest, then select the model with the largest R_2 ratio as the optimal number of clusters; otherwise, from those two models with the largest R_2 values, select the one with the larger number of clusters as the optimal model.