The R&D funding scenario: Can capabilities foster product innovation of firms? El escenario de financiación de I + D: ¿pueden las capacidades fomentar la innovación de productos de las empresas?

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El escenario de financiación de I + D: ¿pueden las capacidades fomentar la innovación de productos de las empresas?

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Abstract
Product innovation is a widespread scheme of organizational innovation recognized by OECD (2005), hence the concept of innovation itself has driven much attention of many agendas as the Strategic European Research one (European Commission, 2013). In this article we develop an analytical model of the technological impact of public funding for private R&D activities in terms of product innovations achieved, to study if its differential effects among firms depend to some extent on firm’s resources and capabilities. This analysis is based on firm level data from the manufactory industry under the ESSE (Spanish survey for Firms Strategy), for the period 2000-2012. We identify the technological activities of 3350 Spanish firms, characterize their resources and capabilities and identify the most relevant ones regarding its influence on product innovation. We detect that both: public R&D funds and private investment help in the new product generation; but also, that the innovation capabilities and inter-firm cooperation positively affect the technological outcome.

Keywords: Capabilities; innovation; public funding; resources.

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Abstract

Product innovation is a widespread scheme of organizational innovation recognized by Oslo Manual, hence the concept of innovation itself has driven much attention of many agendas as the Strategic European Research one (European Commision, 2013). In this article we develop an analytical model of the technological impact of public funding for private R&D activities in terms of product innovations achieved, to study if its differential effects among firms depend to some extent on firm’s resources and capabilities. This analysis is based on firm level data from the manufactory industry under the ESSE (Spanish survey for Firms Strategy), for the period 2000-2012. We identify the technological activities of 3350 Spanish firms, characterize their resources and capabilities and identify the most relevant ones regarding its influence on product innovation. We detect that both: public R&D funds and private investment help in the new product generation; but also, that the innovation capabilities and inter-firm cooperation positively affect the technological outcome.

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Resumen

La innovación de productos es un esquema generalizado de innovación organizacional reconocido por el Manual de Oslo, de ahí que el concepto de innovación ha atraído la atención
de muchas agendas como Strategic European Research (European Commision, 2013). En este artículo se desarrolla un modelo analítico del impacto tecnológico del financiamiento público para actividades privadas de I + D en términos de innovaciones de producto logradas, para estudiar si sus efectos diferenciales entre empresas dependen en cierta medida de los recursos y capacidades de la empresa. Este análisis se basa en los datos a nivel de empresa de la industria de la manufactura bajo ESSE (encuesta española para estrategia de las empresas), para el período 2000-2012. Se identificaron las actividades tecnológicas de 3350 empresas españolas, se caracterizaron sus recursos y capacidades e identificaron las más relevantes en cuanto a su influencia en la innovación de productos. Se encontró que tanto los fondos públicos de I + D como la inversión privada ayudan en la generación de nuevos productos; pero también, que las capacidades de innovación y la cooperación inter-empresarial afectan positivamente el resultado tecnológico.

**Palabras clave:** Capacidad; innovación; financiamiento público; recursos.

1. **INTRODUCTION**

The financing of R&D activities is being increasingly examined as public bodies continuously demand measures of impact obtained from the public funding of private R&D activities (Giebe, Grebe, & Wolfsteller, 2006; Heijs, 2003). To quantify such an impact, a set of economic, academic and technological measures have been proposed. From the technological perspective, the product innovation it’s been one of these measures.

Product innovations encompasses the implementation phase (Damanpour, 1991; Wolfe, 1994) and refers to the development and launching of products which are unique or distinctive from existing ones (Higgins, 1996; OECD, 2005). In competitive conditions, they are often considered a crucial resource since the business environment is characterized by rapid technological change, shortened product life cycles and globalization, forcing firms to be more innovative in their product introduction if they want to gain competitive advantages (Argüello, 2015; Chen, Wang, Nevo, Benitez-Amado, & Kou, 2015; Muralla, 2015; Song & Parry, 1997; Torres-Barreto & Antolinez, 2017). Their importance is consequently based on the possibilities of entering new markets and take advantages of new opportunities in order to make greater profits.

The link between R&D investments and product innovations has been explored in the literature so far. R&D projects have been identified as precursors of new products (Balachandra & Friar, 1997), while public subsidies are considered to influence decisions of companies in order to improve their innovation processes (Afcha & López, 2014). Public funding fostering private R&D activities has been identified to positively affect firm innovations through the complementarity effect (Griliches, 1987); until the point that it can be perceived as a signal of quality for a certain project (Beaudry & Allaoui, 2012).

However, succeed in innovating is a complex and difficult task, and it is not easy to explain why few R&D projects come up with innovations that reach the market, while the rest of them fail. Since the task seems to be of a certain difficulty level (Eisenhardt & Martin, 2000),
we draw on the literature to examine the causes that may lead to some firms to succeed in product innovations and found that capabilities of firms (Barney, 1991), in some extent, may contribute to foster the generation of product innovations. Previous results show a positive influence of: cooperation among partners (Antolín-López, Céspedes-Lorente, García-de-Frutos, Martínez-del-Río, & Pérez-Valls, 2015; Un, Cuervo-Cazurra, & Asakawa, 2010), the capability to implement management control systems (Bisbe & Otley, 2004), capabilities of firms to generate organizational innovations (Ballot, Fakhfakh, Galia, & Salter, 2015) and firm’s IT capabilities (Bharadwaj, 2000; Chen et al., 2015). Consequently, this research attempts to identify the relationship between public funding for R&D activities and the obtention of product innovations, as well as identify capabilities leading to successful product innovations when funding is given to firms.

Using data from the Spanish Survey of Business Strategy (years: 1998-2013), we explore the effects on product innovation in the presence of different combinations of capabilities: innovation planning, updating the R&D knowledge base, R&D cooperation and absorptive capability.

With this research, we aim to contribute to theory and practice in several ways. Since empirical studies of the effects of public funding policies on firm competitiveness and innovative output remains limited (Chen et al. 2015; Afcha & Leon Lopez 2014), and the validity of patents when measuring public R&D funding is still a gap in the literature (Zvi Griliches, 1990; Torres-Barreto, Mendez-Duron, & Hernandez-Perlines, 2016), we study certain firm characteristics that could make R&D funding profitable, discuss them as possible drivers in the obtention of innovations that reach the market, and provide a framework for future research. By examining these relationships, we support manager’s performance since they need to know whether R&D funding may function as an antecedent for product innovation and if so, under which conditions, so that they can ensure those conditions exist when the funding is received. Moreover, policy makers would be able to design programs that maximize R&D public budget for private research. Is therefore important to explore how this variable interact and what factors may influence this relationship.

### 2. THEORETICAL FRAMEWORK AND HYPOTHESIS

#### 2.1. PRODUCT INNOVATIONS AND R&D EFFORT

The importance of studying the impact of public R&D funding relies not only on the amount of public money spent but also on the intended effects in both: firms and the society, as product innovation can enhance firms' competitive advantage; the offspring of products changes the technological ecosystem, and, new product introduction redefines patterns, habits and behaviors in society in general (Ahlstrom, 2010).

Moreover, product innovations as a technological indicator of R&D activity are also appropriate if the objective is to measure the effect of SMEs’s R&D effort. The process innovation behavior of big incumbent firms contrasts with that of small and medium enterprises who attempt to differentiate via new products (Malerba & Orsenigo, 1996).
to this heterogeneity in the innovative activities of firms, big companies are still dominant on post-innovation markets, while smaller ones are likely to be pioneers on the new-product markets (Yin & Zuscovitch, 1998). Furthermore, product innovation can eventually stimulate private R&D investment, which would contribute to minimize the market failure common in the appropriation of R&D (Callejón & García-Quevedo, 2005).

In the quest for measuring the technological impact of public R&D investment, researchers can rely on outcomes as the function of new or improved skills, by a technological gap closed, by the use of a newly developed technology, or by the subsequent technological progress achieved (Sohn, Gyu Joo, & Kyu Han, 2007). Under these circumstances, firms developing new technological skills may harvest the returns in new processes or new products, which lead to a competitive advantage (Buisseret, Cameron, & Georghiou, 1995; Link, Paton, & Siegel, 2005).

Studies on the effect of R&D funding analyze the originality and profitability of the resulting innovations (Ebersberger, 2005; Guellec & Van Pottelsberghe De La Potterie, 2003; Moore, Arent, & Norland, 2007); the differential effects when using diverse innovation outcomes (Mairesse & Mohnen, 2004); and the mediating impact of industry and cooperation (Ebersberger, 2005). These previous studies have as common finding the positive relationship between the R&D grants and the technological effect experienced by firms. Nonetheless, most of these studies focus their attention on the number of patents as an extended and consistent protection regime over countries, disregarding their potential shortcomings as R&D output measure. Firstly, patents serve as protection mechanisms that prevent imitation from competitors. Notwithstanding, they have a preemptive scope by reinforcing the first mover advantage, although many of these patents may never become actual products. Secondly, usually complex products require more than one patent, which makes them overestimate the innovation performance of the firm. Thirdly, patents grant protection to inventions lying on a limited definition of innovation according to the Oslo Manual; which leaves products and technologies of lesser inventive activity unprotected. Finally, patenting decisions usually entail strategic decisions, thus, firms may opt out from patents and retain their technology as trade secrecy. On the contrary, product innovations are the most tangible expressions of the techniques and inventive capacity of the firm. They reveal whether the company knows or dominates the technology, so as they embody the firms' knowledge in actual outcomes. They represent the creation of new or significantly improved ready-to-market products, with new or improved technical characteristics or materials, or with improved functional characteristics, as well as products that encompass a simplified way of use (OECD, 2005). At last, firms leery of revealing their knowledge through patents, are not that modest when disclosing their new products. For these reasons and the pervasiveness of product innovations in SMEs in opposition to patents we claim that:

\textbf{H.1:} R&D grants beneficiary firms obtain more product innovations than that not receiving grant support.

2.2. CAPABILITIES AS INNOVATION DRIVERS
Public intervention supporting firm’s innovation may encourage the development of new resources and capabilities within firms (Buisseret et al., 1995; Link et al., 2005; Torres-Barreto, 2013), and our study also digs on them as firm characteristics that may influence the relationship between R&D funding and product innovations. Substantial bodies of literature claim that they must be unique to the firm to turn into the source of competitive advantage (Jay Barney, Wright, & Ketchen, 2001; Helfat & Peteraf, 2003; Wernerfelt, 1984). Therefore, what the firm knows, possess, does and integrates become critical elements in innovation. Mostly, resources and capabilities facilitate firms exploiting their inputs varyingly and more efficiently than its competitors, and transforming their knowledge into valuable products (Alvarez-Melgarejo & Torres-Barreto, 2018a, 2018c). Thus, resources and capabilities represent desirable static and dynamic skills when firms want to pursue new ventures with the auspice of public funds.

In particular, planning capabilities may provide firms with an explicit innovation strategy (Hunter, Cassidy, & Ligon, 2012; Petrick & Echols, 2004; Phaal, Farrukh, Mills, & Probert, 2003), and constitutes decision analysis resources of firms. On the risky road of innovation, to follow a determined innovation plan may turn out into a necessary guide to help firms to gather the benefits of R&D investments by minimizing risks (Tomala & Sénéchal, 2004); by motivating firms to move into yet unknown fields (Clark & Wheelwright, 1995), driving opportunities of successful innovations. Also, previous research on key factors of invention’s success point out the necessity of a high level discipline of innovation planning (Damanpour, & Gopalakrishnan, 2001), since rigorous tools and structured methods of planning innovation, together with the intervention of several areas within the company (marketing, engineering, design), are considered pillars of successful R&D outcomes, and competitive advantage producers (Hunter et al., 2012). Therefore, we posit that:

**H.2:** R&D grant beneficiary firms obtain more product innovations if they follow an innovation plan.

Capabilities linked to human resources within firms have been considered to be a complementary asset to product innovation. From the resource based view perspective, an experienced human resource system creates and develops organizational capabilities that become the source of competitive advantages (De Saa-Perez & Garcia-Falcon, 2002). Also, high experienced individuals are linked to creative success (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Hershey, Walsh, Read, & Chulef, 1990), and leadership and experience it’s been proved to be linked to the number of ideas generated and the development of plans to implement them (Vincent, Decker, & Mumford, 2002).

But, although capabilities and experience of personnel are relevant in terms of obtaining innovation outcomes, the crux of the issue is the capability of firms to maintain a skilled and qualified human resource system that supports the innovation processes through an organizational culture focused on innovation (Lado & Wilson, 1994; McMahan, Virick, & Wright, 1999; Muffatto, 1998). The capability of hiring and assuring the persistence of an R&D team attain competitive advantages for firms, whose organizational culture is focused.
on innovation, and have human resource systems with a higher propensity to create and develop new ideas (Hunter et al., 2012; Lau & Ngo, 2004). Therefore, we propose that:

**H.3:** R&D grant beneficiary firms obtain more product innovations if they are capable of maintaining an updated R&D knowledge base.

Another key element considered in this research is the cooperation capability as mediator in the relationship between R&D funding and technological success. From the literature search, we found that a technological cooperation relationship may have positive as well as negative effects on firm’s innovation results. From the Organizational Learning Theory, cooperation among partners is understood as a mechanism that generates technological knowledge complementarities among partners; deriving into incremental and radical innovations. This is because a firm only possess some of the resources and capabilities needed in order to achieve technological success since those resources and capabilities are mostly tacit and complex and not easily obtained over time (Pitelis, 2009), hence, making evident the importance of designing a proper R&D alliance portfolio (Belderbos, Carree, & Lokshin, 2004; Quintana & Benavides, 2010). Cooperation may allow firm: to access supplementary technologies and assets, and also facilitates scale economies (Baum, Calabrese, & Silverman, 2000; Miotti & Sachwald, 2003; Mohnen & Hoareau, 2003; Teece, 1982), to access to the partner’s knowledge (Belderbos et al., 2004; Fritsch & Franke, 2004), to expand their knowledge capabilities (Becker & Dietz, 2004; Kleinknecht & Reijnen, 1992), to generate more tangible innovations when combining it with internal R&D efforts (Cassiman & Veugelers, 2002) and to increase the probability of getting new products as the number of cooperating partners raise (Becker & Dietz, 2004).

On the other hand, there is a number of authors postulating that competitive advantages linked to R&D cooperation have also disadvantages and risks associated. The empirical evidence in this sense is reduced and more studies in this field are believed to be necessary (Ahuja, 2000; Powell, Koput, & Smith-Doerr, 1996; Stuart, 2000). Opportunistic behaviors (Das & Teng, 1998), competition instead of cooperation (Hamel, 1991), extra costs of cooperation (Doz, 1996) and interdependence among cooperating partners (Kale, Singh, & Perlmutter, 2000) have been pointed out in the literature as main negative consequences of cooperation.

With different lines of thinking, we consider that studying the effects of cooperation on the relationship between R&D funding and innovative results of firms may be of a high interest, therefore we propose that:

**H.4:** R&D grant beneficiary firms obtain more product innovations if they cooperate with partners for R&D activities.

Another capability considered in this research is the absorptive capability. This is the ability firms have to identify, assimilate and use knowledge from the environment (Alvarez-Melgarejo & Torres-Barreto, 2018b; Cohen & Levinthal, 1989). This includes not only the capability some firms have to copy and imitate innovations, but also the capability to identify
basic research from third parties and turn it out into applied research by means of product innovations, utility models, or other forms of innovations that reach the market.

According to Cohen & Levinthal (1989), the absorptive capability represents an important part of firm’s skills needed to create new knowledge. Indeed, this capability is recognized to be a byproduct of previous investments firms have done regarding R&D, as the quantity of knowledge a firm accumulates through R&D processes, and the variety of this knowledge may influence the development of an absorptive capability by the side of firms. The more R&D investments a firm perform, the higher its capability to appreciate and value the external knowledge which is part of the absorptive capability, so, R&D investments definitely play an important role in the development of absorptive capability within firms by means of preparing them to assimilate technological knowledge, enabling firms to see different ways of perform activities or processes and finally, opening the door for the obtention of new innovations (Cohen & Levinthal, 1989).

The importance of absorptive capability has been explained by some authors in terms of the ability firms have to effectively transform the knowledge obtained from outside, and convert it on ideas, inventions, innovative services or products that could represent revenues for firms (Zahra & George, 2002), making evident the significance of the acquired capability. Some other researchers have stated that acquisition and use of external information is closely related to the development of new products that overtake its competitors (Cassiman & Veugelers, 2006). In spite of these statements, the relationship between absorptive capability and the development of new inventions have scarcely been explored (Atuahene-Gima, 1992; Kumar & Nti, 1998). For this reason, we dig deeply on the precise ways a firm has to generate absorptive capability and found that a firm internally performing R&D activities is more prone to develop such a capability (Mowery, Oxley, & Silverman, 1996; Tilton, 1971). Also technological training activities contributes to boost the absorptive capability (Cohen & Levinthal, 1990) and, performing manufacturing activities play an important role as well, since such operations prepares companies to recognize and take advantage of new product’s market information (Abernathy & Utterback, 1978). To empirically test this relationship, we propose that:

**H.5:** R&D grant beneficiary firms obtain more product innovations if they have developed an absorptive capability.

After this argumentation, we expect that the impact of public support policies follows a different pattern on the production of product innovations, depending on the capabilities firms may develop. Figure 1 shows the complete model of this research.
3. METHODOLOGY

The empirical strategy consists of 1) testing whether these resources and capabilities, in combination with the aids, can lead to new products 2) testing whether these resources and capabilities alone lead a company to obtain product innovations, or increases the chances of getting them, but that they do not take to him to obtain helps. That is to say: it is not because of having those resources and capabilities that companies obtain aid.

Our study relies on a sample of 3,350 firms included in the Spanish Survey of Business Strategies (ESEE). We analyze manufacturing companies with more than ten employees through a panel data analysis including years 1998–2008. Since our dependent variable is discrete we chose a negative binomial (NB) model, as it has been suggested in previous studies (Hilbe, 2011; McKenzie, 1985). We test both the fixed and random effects variants of NB specification. Finally, and consistently with previous studies suggesting that there might be differences between regional and national R&D policies (Afcha Chávez, 2011b, 2011a), we estimate different equations depending on the origin of the funding. Secondly, we address endogeneity by choosing a two-stage least squares specification, identifying those resources and capabilities which can lead to obtaining national or regional R&D funding, but that do not explain new product development. We compare both results.

4. MAIN FINDINGS

We study the influence of public R&D funds on product innovations, and we separately analyze the funds' origin on their effect. Moreover, we explore the role of resources and capabilities in obtaining product innovations through public R&D funds. In particular, we study the resources of own R&D spending and the industrialization level of the firm. Alternatively, we review the capabilities of innovation planning, the constant update of their knowledge base, the technological cooperation, and the absorptive capacity.

Our results indicate that public R&D funding from regional entities has a positive and direct effect on product innovations, but it is not the case for the national R&D programs. On the
side of resources, the private investment in R&D leads to greater number of products. However, the industrialization level of the firm is not significant. On the side of capabilities, the innovation planning, the constant update of the knowledge base, and cooperation agreements with customers and suppliers positively influence the number of product innovations obtained. Nevertheless, we could not find a moderating effect of capabilities on the relationship between R&D funding, and product innovations, except for the case of national grants, highlighting a potential switch to more science oriented partners.

5. IMPLICATIONS FOR MANAGERS, PRACTITIONERS AND POLICY MAKERS

This research shed light on the effectiveness of R&D public funding and points out the necessity of reinforcing resources and capabilities that boost their economic and technologic position. The main findings regarding technologic impact give a hint to identify the technological impact derived from the public investments in private R&D activities; as well as to characterize the role that resources and capabilities of firms play in product innovation. From our analysis, we can assert that public funding for R&D activities has an impact on the technological output of Spanish firms, and that resources and capabilities of firms do play a role in obtaining a higher technologic production (Torres-Barreto, 2017). Our findings contribute to the Resource-Based View of the firm in the sense that resources and capabilities do matter to explain heterogeneity in innovation. Moreover, the heterogeneity in outcomes is the result of strategically diverse set of resources and capabilities (Torres-Barreto, Martínez, Meza-Ariza, & Molina, 2016).

Our findings have an application from a regulatory perspective because they may contribute to the design of technology policy, and reducing market failure. Since the design of the particular funding programs, has a significant effect on the private expenditure on R&D, by complementing or substituting the private R&D expenditure. On the other hand, practitioners would also extract relevant conclusions from these results as our study highlights the necessary resources and capabilities needed for both apply to public grants and introducing new products.

Our results shed light on the literature about the effectiveness of R&D public funding by measuring the tangible outputs of the firm. However, we also call to the necessity of developing and reinforcing resources and capabilities to potentiate the effect of R&D grants on the number of product innovations. Therefore, our conclusions depict scenarios where policymakers can ascertain the spillovers of public R&D funding, as well as to anticipate the potential funding results depending on the resources and capabilities of the grantees. Moreover, managers can identify the relevant resources and capabilities to receive a grant, but also to extract its full potential.

Nevertheless, it raises another question, are these resources and capabilities ex-ante characteristics to R&D grant application, or are the funds that help to develop these resources and capabilities?

6. REFERENCES


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