serie ec

WP-EC 2011-06

Making sense of innovation by R&D and non-R&D innovators in low technology contexts: a forgotten lesson for policymakers

José L. Hervas-Oliver and José Albors-Garrigos

Ivie

Working papers

Working papers

Working papers

Edita / Published by: Instituto Valenciano de Investigaciones Económicas, S.A.

Depósito Legal / Legal Deposit no.: V-2809-2011

Impreso en España (agosto 2011) / Printed in Spain (August 2011)

WP-EC 2011-06

Making sense of innovation by R&D and non-R&D innovators in low technology contexts: a forgotten lesson for policymakers[*]

José L. Hervas-Oliver and José Albors-Garrigos[**]

Abstract

This paper attempts to use an integrated theory based on a firm's internal and external sources of knowledge framework to analyze how different are R&D from non-R&D activities to innovate, specially in a context of low and medium low tech (LMT) sectors where most of the firms are SMEs. Simultaneously, the paper also explores the key differences between R&D and non-R&D innovators. The empirical analysis is based on a representative panel of 2023 Spanish manufacturing firms for 2005 and 2006 from the Spanish Ministry of Industry. Innovation in product and process is explained using non-R&D variables such as in Marketing, Design or hiring tertiary degree employees. Only innovation in product is explained by R&D expenditures. Addressing innovation in process, R&D variables work in few cases and neither R&D expenditures but occasionally R&D employees and are specially relevant the non-R&D variables. The interaction (moderating) effect is specially negative and significant, addressing the substitution effect with different implications regarding product or process innovation. Therefore, innovation can be explained using non-R&D variables such as investments in Marketing, Design, and other routines linked to human resources, technology monitoring committees or the existence of a formal plan to innovate. The firms with more internal resources, those which conduct R&D activities present a better AC and it leads to engage in cooperation agreements and access to external flows of knowledge. The paper has important implications for policymakers due to the fact that most of policies for R&D are based on R&D programmes, while there are other realities: non-R&D factors which also explain innovation, specially when considering low tech sector contexts

Keywords: innovation sources, technology cooperation, absorptive capacity, search strategies.

Resumen

El presente artículo usa la teoría de recursos y capacidades para, a través de los recursos internos y externos de las empresas, analizar las actividades de R&D y las actividades de no-R&D en su impacto sobre la performance de innovación de la empresa, en un contexto sectorial de baja y media tecnología. Asimismo, el artículo explora el rol innovador de las empresas que hacen R&D y las que no lo hacen. Con una muestra de 2023 empresas manufactureras españolas, obtenemos un comportamiento innovador para la innovación en producto y en proceso y, sobre todo, observando que las actividades de R&D tienen muy poco peso explicativo sobre el resultado de innovación. El artículo presenta implicaciones para la Academia y los policymakers, sobre todo por el hecho de que la mayoría de las políticas de innovación se basan en actividades de R&D.

Palabras clave: fuentes de innovación, estrategias de búsqueda de conocimiento externo, cooperación tecnológica, capacidad de absorción.

---

[*] We are thankful to the financial support from the Spanish Ministry of Science and Innovation (MICINN), Proyecto Nacional de I+D+i ECO-2010:17318, "Analisis de la Innovación a través de la Absorción Tecnologica y la interacción empresas-clusters". We also acknowledge the great financial support by IVIE-Valencia (Spain)

[**] Polytechnic University of Valencia. Correpondencia: Jose.hervas@omp.upv.es.

1. Introduction

Arundel et al. (2008) pointed out that "neglected" (non-R&D performers) innovators are not properly policy supported, even when the change in the growth of annual revenues between R&D and non-R&D ("neglected) innovators is similar and there is no reason for policy bias. In fact, when comparing R&D and non-R&D performers, *half of all innovative firms do not perform R&D and there is no difference in performance, measured by a change in revenues* (pp.32). Following this line of study, some unanswered questions arise: is the process of analyzing a firm's innovative performance well measured when most of the companies are neglected innovators? Put differently, to what extent can innovative performance be measured using non-R&D variables? Which differences between R&D and non-R&D innovators are relevant? These research gaps highlight the excessive focus on R&D affirmed in past years by a growing number of scholars who criticized the technological approach through only R&D (e.g. von Tunzelmann and Acha, 2005; Mendonça, 2009). In fact, R&D expenditures present rather weak evidence (Raymond and St. Pierre, 2009; Brouwer and Kleinkecht, 1996; Roper and Love, 2002) for explaining innovation. Much of the empirical evidence on innovation is focused on large firms and on R&D intensive sectors (Cockburn and Henderson, 1998; Lane and Lubatkin, 1998; Narula, 2001; Rosenkopf and Almeida, 2003) and mostly using R&D indicators (e.g. Vega-Jurado et al, 2008; Escribano et al., 2009), albeit in the last few years, the problem has been recognized, especially in the topic of the SMEs (e.g. Ortega-Argilés et al., 2009). This study deepens our knowledge of critical success factors in the innovation process of low and medium tech industries, using R&D and non-R&D variables (inputs).

Empirical findings in the topic have been ambiguous and fragmented. Ambiguous regarding the magnitude of the R&D activities, especially when most of the samples are based just on R&D innovators. Fragmented because some empirical studies focus on a very narrow set of constructs and causal relationships, to the extent that some of them lack of certain interactions or moderating effects. Overall, the linear R&D-based innovation paradigm has been challenged from different perspectives. Raymond and St-Pierre (2010) claimed that the link between R&D and innovation in SMEs still requires clarification and further understanding. Following Raymond and St-Pierre (2010) it is pointed out the relationship between R&D and innovation is less than 10% of the variance, which is a weak evidence for a direct casual relationship between the two constructs (e.g. Roper and Love, 2002). It is especially recognized that non-technological forms of innovation also contribute to upgrading a firm's performance (Piva and Vivarelli, 2002; OECD, 2005; Arundel et al., 2008) and thus innovation can be observed as a phenomenon occurring in low and medium tech sectors (e.g. Kirner et al., 2009). In this vein of thought, Jensen et al. (2007) distinguish between "Science, Technology and Innovation" and "Doing, Using, Interacting" modes of innovation and consider the latter to rely on processes and experience-based know-how which refer mainly to low-medium tech sectors. Similarly, following Muscio (2007), there is little evidence on innovation in low-tech industries. Continuing this line of inquiry, the Oslo Manual (OECD, 2005: Oslo Manual pp:65-66) stated that dividing R&D activities from downstream activities (marketing, design, etc.) can, in some industries, be a fine and useful process. In this context, the process of innovation is well described in Albaladejo and Romijn (2000) who posit that: "*A substantial part of the learning may not take the form of well-defined R&D programmes* *and other formalized technological effort. Informal and incremental problem solving and experimentation take place on the shop floor and are closely associated with production. This is* a fortiori *the case in small companies that do not have the resources and organization to mount large R&D and human resource development programmes (pp:4-5).* This non-R&D view on innovation is supported by the fact that economy in real terms is more than 90% based on the low and medium tech sectors (see Robertson et al., 2003)[1]. Therefore, the goal of this paper is to explore three main issues. First, the paper attempts to understand what role non-R&D input activities play to explain a firm's innovative performance, exploring which key differences can be observed when R&D activities are undertaken in order to innovate. Second, the study tackles the role of the non-R&D innovators and their strategies combining internal and external resources to innovate. And third, the paper explores the process of innovation disentangling the ambiguous results of the literature about the effects of absorptive capacity to access to external sources of knowledge and the interaction (complementary versus substitution) effect of combining internal and external sources of knowledge. In our opinion, the three stated gaps are inconclusive and deserve more attention from scholars and policymakers. The paper explores the process of innovation in the context of low and medium tech sectors.

The low-medium tech sector context is precisely noticeable in Spain. The sample issued annually by the Spanish Ministry of Industry evidences the importance the low-medium tech sectors have. The R&D expenditures present an average of 0.81%, which can be broken down into the following percentages: 0.36% in the case of low tech sectors, 1.7% for medium-tech and 1.9% for high-tech. When figures are restricted to only innovators, the results are 0.78%, 1.7% and 2.6% for low, medium and high tech sectors respectively, following the OECD classification. Innovative firms present an average of 1.56%, which is similar to the official data from the INE (National Statistics Institute, the official body which supplies information to EUROSTAT, 1.35% on average of R&D/GDP in 2008.) Following this chain of thought, the question is if non-R&D innovation activities are accounted for properly? Can policymakers and academics establish common policies for the same industry across countries? Our study is set in Spain, a technology-follower country. As such, Spain's productive sector is characterized by a concentration of traditional low-technology sectors and medium and small enterprises with low R&D expenditure (Vega-Jurado et al., 2009). Moreover, according to official statistics from CIS by EUROSTAT in 2006, the turnover from innovation was 13.4 for the EU-27 (countries) of which Spain accounts for 15.9%, well above the average. Nevertheless, in 2007 the R&D/GDP ratio was 1.27% and the EU (27) 1.85%, well below the average. Taking Spain as an example of hidden (neglected) innovators, could firms present a different way of performing innovation? Are innovation policies focusing on this fact?

This paper explores these questions by analyzing, through R&D and non-R&D activities, the strategies of firms when combining in-house activities or internal resources with external flows of knowledge to better understand a firm's innovative performance in both process and product.

[1] For shares of low-medium tech employment in total employment in the EU in 1995 and 2006 see Heidenreich (2009). As such, the industrial low and medium tech. of a large number of industrialized OECD countries has a high employment share of more than 60 per cent. Moreover, as claimed by several scholars, the crucial importance of low-medium tech sectors is based on the innovation ability of many of these enterprises with regard, for instance, to continuous product development (e.g. Hirsch-Kreinsen, 2008).

The study is based on a technology-follower country, Spain, and mainly based on low-medium tech sectors. High tech sectors have less presence in the Spanish economy while the SMEs' performance could vary drastically from traditional SMEs, especially those which are new tech-based firms (NTBFs) or gazelles (e.g. Stam and Wennberg, 2009; Hölzl, 2009). In fact, following Edwards et al. (2005), understanding innovation in SMEs requires assessing innovation in the context of strategic conduct within institutional processes and structures. SMEs face adverse conditions such as access to finance (e.g. Freel, 2007), limited capabilities (e.g. van Stel et al., 2007), and lack of knowledge about how and where to acquire the necessary competence, i.e. absorptive capacity (e.g. Ortega-Argiles et al., 2009; Czarnitzki, 2006). Nevertheless, it is also true that the informal R&D carried out by the SMEs underestimates the innovation capability when only formal R&D is taken into account (e.g. Kleinknecht, 1987; 1989). In addition, there is a lack of proper policies attributed to the SMEs due to the: (1) high degree of heterogeneity within the SMEs (e.g. Audretsch, 2001; 2002), from highly innovative *new tech-based firms* (NTBFs; e.g., Stam and Wennberg, 2009) to traditional SMEs; (2) the crucial role found in the environment, such as the tech intensity of the country in which the SMEs are based (e.g. Hölzl et al., 2009); (3) most of the literature is biased on specific samples which makes it difficult to provide a comprehensive picture of the innovative capabilities in the SMEs (e.g. Ortega-Argiles et al., 2009; Edwards et al., 2005). This paper covers the problem of innovation in the SMEs.

The study tackles the aforementioned gaps which refer to combining a firm's internal and external flows of knowledge to innovate. In the internal resources analysis, a firm's absorptive capacity (AC, hereinafter; Cohen and Levinthal, 1990) is also explored. In this paper the absorptive capacity concept is referred to the realized one and not the potential one, regarding the Zahra and George's (2002) distinction. Thus, potential capacity comprises knowledge acquisition and assimilation capabilities, and realized capacity focus on knowledge transformation and exploitation. In addition, the paper also explores the interaction (moderation) effect between internal and external resources. This specific effect seems to be a two-way street in the sense that there is a positive relationship between internal and external variables in innovation (e.g. Mowery, 1983; Cohen and Levinthal, 1989, 1990; Cassiman and Veugelers, 2006; Nieto and Quevedo, 2005; Huergo, 2006; Escribano et al., 2009) and also a negative one (Laursen and Salter, 2006; Vega-Jurado, 2008). The study offers valuable insight on this core topic of the innovation management studies.

The study uses a sample of 2,023 Spanish firms from a panel database published annually by the SEPI, a body of the Spanish Ministry of Industry. This sample is portioned into several groups (all firms, innovative ones, different sectors, SMEs, etc.) to obtain all possible explanations about innovation decision. This exercise checks results and offers a more comprehensive view of the innovation phenomenon without restricting results to biased samples. The main contributions highlighted in the paper are based on the fact that R&D variables, and especially R&D expenditures, work only in a few cases, explaining occasionally innovation in product rather than innovation in process. On the contrary, non-R&D innovative efforts better explain innovation in process, activities and competences based on design, marketing, formal planning of innovation or the highly-qualified human resources hired. Complementarily, the external flows of knowledge such as suppliers, customers or external consulting staff for technology purposes also contribute to the explanation of innovative output. In addition, interesting results are provided which distinguish R&D and non-R&D innovators. R&D innovators account for the majority of the external resources and the non-R&D innovators present very low percentages of external cooperation, although this is much more active than that of the non-innovative firms. This result is also consistent with the fact that firms with R&D activities, and thus better AC, can easily engage in cooperation agreements and access external flows of knowledge. The study has implications for both *Academia* and policymakers. The results are of great interest to governments and regional planning agencies in the sense that the policies formulated to promote innovation are mainly based on R&D activities and, in the aforementioned context of low-medium tech and SMEs, these policies may not be adequate to develop innovation (Ortega-Argilés et al 2009).

The study has been organized as follows. First, in Section Two, the theory and the hypothesis are presented. Then, in Section Three, the sample and the empirical design are described. The fourth section presents results, and the fifth specifically addresses the distinction between R&D and non-R&D innovators. The sixth and seventh sections discuss results and summarize the conclusions. Finally, an appendix complements the evidence.

2. Theory

The organizational perspective based on Resource-based View (RBV) [e.g. Barney 1991, Peteraf 1993] stressed that a firm's unique internal resources at least partially determine a firm's performance. RBV establishes a correspondence between a firm's unique set of resources and capabilities and its level of performance. From this internal perspective, innovation stems from better organizational routines and other core functions. Barney (1991) referred to RBV with a broad definition of resources as all types of assets, organizational processes, knowledge capabilities and other potential sources of advantage. What are these internal competences? Tidd (2000) classified the internal competences in three categories: (a) organisational competences (managerial systems, skills, etc.), (b) market competences, and (c) technological competences, mainly derived from in-house R&D activities. The AC construct points out that internal capabilities are central for a firm's technological capacity and enhance the firm's ability to assimilate and exploit external knowledge. Therefore, a firm's internal resources determines the possibility to use and exploit external knowledge, and thus improve innovation in firms (e.g. Cohen and Levintal 1989, 1990; Klevorick et al., 1995). As a result, the AC concept is linked to innovation through access to external knowledge. Similarly, Lundvall and Nielsen (1999) emphasized that higher levels of training also reinforce the creation and exploitation of external knowledge, although there is no empirical evidence in the mentioned work.

Without taking into consideration firms in SMEs, another set of studies offered a different but complementary pattern of work. As a result, it has also been emphasized that higher levels of R&D efforts improve a firm's ability to exploit sources of knowledge outside its boundaries (e.g. Caloghirou et al., 2004; Gambardella, 1992; Mowery et al., 1996; Huergo, 2006; Vega-Jurado et al., 2008). However, the results offered by Caloghirou et al. (2004) showed that R&D intensity measured as personnel in R&D is statistically significant and related to innovation, instead of only the amount of R&D expenditures, and that the variable is statistically significant over innovation.

On the other hand, regarding R&D expenditures as a proxy for AC, higher levels of R&D efforts improve a firm's ability to exploit sources of knowledge outside its boundaries (e.g. Caloghirou et al., 2004; Gambardella, 1992; Mowery et al., 1996; Huergo, 2006; Vega-Jurado et al., 2008). Some contributions assimilate AC to a firm's other internal variables such as the existence of a design office (Bougrain and Haudeville, 2002) or the educational and training policy which gives people within organizations the basis to introduce innovation (Lundvall and Nielsen, 1999). As showed, different contexts and focuses have provided a variety of types of firms and variables analyzed and thus, results are heterogeneous.

Integrating the different ways of measuring AC, one very important idea from Nieto and Quevedo, (2005) and also Szulanski (1996) and Mangematin and Nesta (1999), is the fact that absorptive capacity could be measured by a set of factors instead of a single indicator such as R&D expenditures on sales, patents, or the formally established R&D department in a company. Nieto and Quevedo (2005) offered a great revision of the variables and ways of measuring the internal factors or absorptive capacity. Hervas-Oliver and Albors-Garrigos (2009) utilized the skills in the production and design department. Absorptive capacities provide firms with a richer set of diverse knowledge, facilitating more available knowledge to problem-solving and preparing firms to cope with environmental changes (e.g. March, 1991; Grimpe and Sofka, 2009). Therefore, the first two hypotheses are stated as follows:

Hypothesis 1: A firm's unique stock of internal resources is positively associated with a firm's innovative performance.

Hypothesis 2: A firm's AC (internal resources) moderates the acquisition of external resources.

Nevertheless, as mentioned above, the RBV cannot explain how clustered firms improve performance in environments in which firms maintain frequent and multiple relationships. This drawback could be attenuated by the relational view (Dyer and Singh, 1998; Lee et al., 2001; Capaldo, 2007) which argues that a firm's critical resources go beyond a firm's boundaries and inter-firm collaborative linkages generate further relational returns (Dyer and Singh, 1998).These *strategic assets* (Gulati, Nohria and Zaheer, 2000), embedded in their surrounding social context (Gulati, 1998), are claimed to generate impact on innovation by facilitating knowledge-sharing and an interactive learning process (Powell et al., 1996; McEvily and Zaheer, 1999; Rowley et al., 2000; Lee et al., 2001), although the debate on *relational capabilities* is still in its infancy (Capaldo, 2007). External knowledge as a technological opportunity improves innovation capacity and can be found in sources such as firm-university linkages (e.g. Hervas-Oliver et al., 2011) or relationships with suppliers or customers (e.g. Klevorick et al., 1995; Lee et al., 2001).

The literature on innovation reflects a dramatic increase in the systematic use of external networks by firms (Hagedoorn, 2000; Zeng et al., 2009). Interactions and networks are key to innovation (Doloreux, 2004;). The external sources of innovation search aims at identifying valuable impulses from customers, suppliers, competitors or universities and other public research organisations in order to orient innovation efforts (von Hippel, 1988; Katila and Ahuja 2002; Laursen and Salter 2006).

In fact, there are empirical findings which suggest that the relationships of firms with local institutions through research linkages improve the firms' capabilities (e.g. Decarolis and Deeds, 1999; McEvily and Zaheer, 1999; Lee et al., 2001), especially in those in clusters and areas of agglomeration. Following this chain of thought, linkages with local institutions have constituted a key element in the development of new knowledge for firms with innovative strategies (e.g. Von Hippel, 1998). These local entities and/or universities are claimed to be sources of new knowledge (Rosenberg and Nelson, 1994). In addition, empirical evidence shows that proximity between local universities and firms promotes the exchange of ideas (Lindelöf and Löftsen, 2004) and also improves the performance of innovative firms (Hanel and St-Pierre, 2006; Caloghirou et al., 2004; Caloghirou et al., 2001; Hervas and Albors, 2009 or Vega-Jurado et al., 2008) and the capability of firms to introduce more advanced innovations (Tödtling et al. 2009). McEvily and Zaheer (1999), Lee et al. (2001) and Capaldo (2007) found that diversity and number of linkages within a firm's network, and its participation in regional institutions, expose the firm to new ideas, information and opportunities leading to acquisition of capabilities. Besides universities or R&D institutions, other sources of external knowledge such as suppliers or client relationships can also be exploited by firms. As a matter of fact, Massa & Testa (2008) found that SMEs prefer linkages with suppliers and customers because universities have concepts and purposes different from the ones sought by the SMEs in innovation activities. Consequently, the higher the number of suppliers, institutions or other agents potentially accessible to firms, the higher the potential gains to be obtained from new ideas, information or knowledge. The third hypothesis referring to technological opportunities is therefore stated as follows:

H3: A firm's interactions with other firms/institutions are sources of external knowledge which are positively associated with a firm's innovative performance

Cohen and Levinthal (1990:139) referred to technological opportunities as the quantity of knowledge to be assimilated and exploited: the more there is, the greater the incentive to invest in AC. In other words, the concept of technological opportunities is related to the probability that the resources dedicated to foster innovation will generate technological advances (e.g. Dosi, 1988; Nelson and Winter, 1982). Indeed, this idea is based on the differences in a firm's innovation across different sectors. This external driver from the original concept has been corroborated in later re-conceptualizations (e.g. Todorova & Durisin, 2007). To date, following Nieto and Quevedo (2005:3), most of the work carried out on the stimulus given for undertaking innovative activities arising from the presence of technological opportunities highlights the existence of a positive linkage between the level of technological opportunity available to a firm and the efforts the firm makes to innovate (Scherer, 1965; Levin et al., 1985; Jaffe, 1986, 1988, 1989; Geroski, 1990; Klevorick et al., 1995; Nieto and Quevedo, 2005). In order to analyse the industry variations related to the effect of external and internal factors on firm's innovative performance, the firms are classified in broad sectoral categories (Arundel et al., 1995; Cesaretto and Mangano, 1992; Souitaris 2002). These categories are based on the taxonomy of patterns of technological change proposed by Pavitt (1984), who distinguishes four types of firms: (a) supplier-dominated firms; (b) large-scale producers; (c) specialised suppliers; and (d) science-based firms. The paper also uses the OECD classification. Technological opportunities and appropriability conditions (e.g. patents, lead effect or the learning curve) are considered relevant factors affecting the dynamics of market structure and innovation (Winter 1984; Levin et al. 1985; Lin and Huang 2008). As such, these effects are captured in this hypothesis addressing the type of industry to which the firms belong to. Thus, the fourth hypothesis is stated as follows:

> **H4: The level of technological opportunities and appropriability conditions embedded in a firm's industry is related positively to the firm's innovative performance**.

The previous hypothesis suggests that internal and relational capabilities influence performance independently. The internal resources mentioned in the second hypothesis refer to the skills for maximizing inputs into outputs (Burt, 1992) and the relational aspect (third hypothesis) allows accessibility to channels for securing inputs, deploying outputs and developing more opportunities (Burt, 1992; Lee et al., 2001:622). Lee et al. (2001) connect the two ideas above and establish that internal capabilities help a firm to develop its relational aspects. Similarly, the opposite is also true. As such, the relational capability permits access to information, technology and other assets which upgrade the (internal) technological capabilities (e.g. Teece, 1987; Lee et al., 2001), a fact especially developed in cluster literature (e.g. Foss, 1996). Hence, the literature reviewed tacitly suggests a synergic or interaction effect[2] obtained from a combination of both the internal and relational capabilities of a firm to perform. This is also confirmed in Nieto and Quevedo (2005), Veugelers (1999), Cassiman and Veugelers (2006) and Hervas and Albors (2009). Nevertheless, this moderating effect seems to be a two-way street in the sense that there are also negative effects (Laursen and Salter, 2006; Vega-Jurado, et al. 2008; Vega-Jurado et al., 2009), suggesting the existence of a substitution effect (negative relationship) between openness to external search activities and internal R&D, instead of a complementary (positive) one. Likewise, there is a lack of consensus on the complementary or the substitution effect of internal resources and external technology, and the impact on a firm's innovative performance. Thus, no sign is predicted. Therefore, the fifth hypothesis is stated as follows:

> **H5: The interaction from firm's combination of internal and external sources of knowledge generates an impact on a firm's innovative performance**

3. Empirical design:

3.1. Sample, data and variables

The database for the empirical analysis is the *Spanish Business Strategies Survey* (*SBSS*) from the years 2005 and 2006. This is an annual firm-level panel of data compiled by SEPI, a body of the Spanish Ministry of Industry. The *SBSS* contains variables on Spanish companies in manufacturing industries following the NACE-Rev.1. classification. This database has been exploited by some scholars (e.g. Huergo, 2006; Santamaria et al., 2009). The *SBSS* has the advantage that it is designed to consider other variables in order to understand innovation in a Spanish context in which the R&D intensity activities are lower. This is especially relevant for capturing a firm's

[2] Following Nieto and Quevedo (2005) when the interaction effect is introduced in the model specification then the term obtained by multiplying two variables have the effect of a moderating variable. Thus, the beta coefficient of the interaction factor indicates a unit change in the effect of one of the independent variables on the criterion variable when the value of the moderating variable changes by one unit. When the moderating variable takes effect the moderated variable itself ceases to be significant.

level of innovative performance when it is not restricted to only R&D activities, a fact frequently observed in low-medium tech, and specifically in LOW-TECH, industries. In the years 2005 and 2006, there were 2,023 firms available, alow-techhough only 1,990 had all the variables selected below. It is important to note that the sample, as detailed below, contained both innovative and non-innovative firms.

Table 1. Variables and their explanation

Variable	Definition	Values
NewSkills	The company has incorporated in the last year graduates from tertiary studies	1 = yes; 0 = otherwise
Skills	% of tertiary degrees (engineers, economists, lawyers and so) over FTEs (total full time employees)	%
Skills_med	% of technicians over FTEs	%
DCT	The firm has a technology monitor committee	1 = yes; 0 = otherwise
Design	The firm has conducted adding value design activities	
Marketing	The firm has conducted or hired market research and marketing activities and studies to evaluate the market trends and alternatives	1 = yes; 0 = otherwise
PAI	The firm has a innovation plan and thus the innovation process is formalized and standardized.	1 = yes; 0 = otherwise
R&D employees	% of R&D FTEs over FTEs	%
R&D expenditures	R&D expenditures over sales	%
UIAT	The firm has used external consulting staff for technology purposes	1 = yes; 0 = otherwise
Customers	The firm has technological linkages, with clients	1 = yes; 0 = otherwise
competitors	The firm has technological linkages with competitors	1 = yes; 0 = otherwise
Suppliers	The firm has technological linkages with suppliers	1 = yes; 0 = otherwise
University and PROs	The firm has technological linkages, with universities and public research organizations (PROs)	1 = yes; 0 = otherwise
IP	Innovation in product	1 = yes; 0 = otherwise
IPR	Innovation in process	1 = yes; 0 = otherwise
Ln_employees	logarithm for FTEs	
GB	The firms in integrated in an industrial group	1 = yes; 0 =otherwise
Pavitt	Pavitt' industry classification Supplier dominated 1 Textile ; Clothing and Textil; Leather and footwear ;Wood industry ; Paper ; Rubber and plastics ; Furniture; Other manufacturing Scale intensive 2 Meat industry, Beverages, Food products and tobacco, Printing and publishing, Non-metallic mineral products, Iron metallurgic products ;Non-iron metallurgic products Metallic products (except machinery and equipment) ; Motor vehicles ; Other transport material Specialised suppliers 3 Industrial and agricultural Machinery ; Office machines and computers Science based 4 Chemistry; Electrical material and machinery	Categorical variable taking 1, 2, 3, 4

Table 1. Variables and their explanation *(cont.)*

Variable	Definition	Values
OECD	OECD's industry classification Low-tech =1 Meat industry; Food products, tobacco; Beverages; Textils; Footwear; Wood industry; Paper Printing and publishing; Non-metallic mineral products; Iron and non-iron metallic products Metallic products; Furniture; Other manufacturing Med-tech =2 Rubber and plastics; Industrial and agricultural Machinery Motor vehicles; Other transport material High-tech =3 Chemestry; Office machines and computers; Electrical material and machinery	Categorical variable taking 1, 2, 3

Source: own from SEPI, Ministry of Industry, Spain

Table 1 shows the variables depicting internal and external sources of resources for innovation. The firm-distinctive competences**,** or main internal resources addressing the absorptive capacity construct, are based on human resources (the incorporation of tertiary degree employees, percentage of employees with tertiary degrees, percentage of technicians over employees), value-adding non-R&D activities (design, marketing effort), and technology, with both non-R&D activities (the existence of a formal plan for innovation, PAI; the existence of a technology monitor committee, DCT) and R&D activities (R&D expenditures and percentage of R&D employees) .

Although R&D is a core activity of innovation (e.g. Vega-Jurado et al., 2008), it is also recognized that carrying out R&D is associated with high costs and risk, especially for those firms which are SME. SMEs face problems because R&D is subject to minimum project sizes due to technical indivisibilities (see Galbraith 1952:92) in order to generate useful results; R&D is associated with high entry costs, i.e. specific investment in laboratory equipment and human capital (see Cohen and Klepper 1996), in addition to the possible problems of external funding (Freel, 2003). Overall, all of these factors result in a lower propensity of the SMEs to invest in R&D (Rammer et al., 2009). According to theory, investment in R&D by SMEs is limited due to the fact that small firms face problems of restricted cash flow (Cohen and Klepper, 1996; Galbraith, 1952). In fact, these, among other factors, result in a lower propensity of the SMEs to conduct R&D, relying instead more on innovation management tools to innovate (e.g. Rammer, Czarnitzki and Spielkamp, 2009). In order to control all these problems related to R&D activities, our specifications include the variables and their controls.

The core elements of a firm's search strategy are also innovation inputs from external sources such as suppliers, clients, competitors, universities and technology centres (Katila and Ahuja, 2002; Laursen and Salter, 2006; Grimpe and Sofka, 2009). The relational resources for innovation or linkages are measured by whether or not a firm engages in cooperation agreements to access external flows of knowledge. In addition, group-belonging (depicting whether the firms are privately owned or belong to an industrial group) and industry were all included as control variables, the latter in the form of the Pavitt's (1984) classification and the OECD classification. Size (average number of full-time employees, measured by logarithm) is also controlled, in agreement with several studies which reveal its relationship with cooperation (e.g. Negassi, 2004; Lopez, 2006) and innovation as previous research has found that innovation performance is benefited by economies of scale and scope (Cockburn and Henderson, 1994; Damanpour, 1992).

3.2. Descriptive statistics

The study included 2,023 available firms (size 203.1 full-time employees on average) from the SEPI, a body of the Spanish Ministry of Industry, with data from the years 2005 and 2006. The sample included innovative and non-innovative firms in order to shed light on all nuances explaining innovative performance. There are 596 firms in the *supplier-dominated* category (29.5% of the sample), 1020 in the *scale-intensive* (50.4%), 173 firms in the *specialized suppliers* (8.6%) and 234 in the *science-based* (11.6%) industrial category. Similar figures which stress the low-medium tech character of the sample are shown in the OECD classification, which accounts for 1378 firms in low-tech (68.1%), 378 in medium (18.7%) and 267 in high-tech (13.2%). Nevertheless, as presented in Section 1, even the high-tech firms presented lower R&D expenditures compared to the figures of other countries.

A total of 414 firms (20.5%) carried out product innovation and 562 (27.8%) conducted process innovation; 1280 (63.3%) carried out no innovation activities and 233 firms (13.5%) conducted simultaneously both product and process innovation in 2006. At the same time, an analysis of low-tech firms found that only 14.8% of the firms declared innovation in product while 25.5% declared innovation in process. Regarding low-medium tech, 26.7% declared innovation in process and 18.5% in product. Therefore, the type of industry influences a firm's innovative performance, as seen below. The highest sector of innovative product firms is *specialized suppliers* (36.4% of the group), followed by *science-based* (32.9%), *supplier-dominated* (20.6%) and *scale-intensive* (14.8%). Thus, the group with the lowest product innovation was the *scale-intensive* group, (85.2%) followed by *supplier-dominated* (79.4%). Overall, these results are significant (Chi-S.69.38, $p<0.01$). In table 2 it is showed the type of industries and their importance in the sample. As observed, the food industry (9.1%), metallic products (13.0%) non-metallic mineral products (8.2%) or textiles (7.6%) are roughly more than 40% of the sample. This is a clear example of the type of industry composition which represents the manufacturing sector in Spain.

The low tech and smaller size of the firms which are represented in the paper have effects on the study's results. In fact, Table 3 shows how the SME firms present lower values in most of the key input activities for innovation. The comparison in the indicator, or R&D expenditures (0.0081 for all firms versus 0.004814 for SMEs), and the R&D employees (0.0135 for SMEs versus 0.049 for all firms), and also in other non-R&D variables such as skills (4.1% for SMEs versus 5.89% for all firms) or design activities (0.22 for SMEs versus 0.44 for all firms), among others, is especially notable. In fact, the aforementioned constraints and lack of resources in the SMEs are very evident in Table 3.

Table 2. Industries and number of firms in the sample

Industry	Number of firms	% of the sample
Beverages	45	2,2
Non-metallic mineral products	166	8,2
Chemestry	131	6,5
Electrical material and machinery	103	5,1
Food products	184	9,1
Leather and footwear	54	2,7
furniture	106	5,2
Iron and non-iron metallurgic products	62	3,1
Machinery	140	6,9
Meat industry	55	2,7
Metallic products	263	13,0
Motor vehicles	95	4,7
Office machines and computers	33	1,6
Other transport material	41	2,0
Other manufacturing	40	2,0
Paper	64	3,2
Printing and publishing	109	5,4
Rubber and plastics	102	5,0
Textils	153	7,6
Wood	77	3,8
Total	**2023**	**100,0**

Table 3. Descriptive statistics in differing type of firms

All firms sample = 2023					**SMEs = 1408**			
	Min.	**Max.**	**S.d.**	**Mean**	**Min.**	**Max.**	**Mean**	**S.d.**
1-NewSkills	0	1	0.429	0.24	0	1	.13	.337
2-skills	0	80	9.13	5.89	0.000	69.40000	4.1066826	6.4600
3-Design	0	1	0.441	0.26	0	1	.22	0.416
4-Skills_med	0	95.5	10.32	6.94	0	95.5	5.44	9.03456
5-DCT	0	1	0.402	0.20	0	1	0.10	0.297
6-Marketing	0	1	0.369	0.16	0	1	0.09	0.293
7-PAI	0	1	0.414	0.22	0	1	0.11	0.313
8-R&D	0	0.55	0.0496	0.0184	0.00	0.55556	0.0135528	0.04535
9-R&D	0	27.3	2.29367	0.0081	0.00	24.00	0.004814579	1.6998
1-IP	0	1	0.404	0.20	0	1	0.14	0.350
12-IPR	0	1	0.448	0.28	0	1	0.22	0.415
13-customers	0	1	0.380	0.17	0	1	0.10	0.294
14-competitors	0	1	0.144	0.02	0	1	0.01	0.095
15-suppliers	0	1	0.406	0.21	0	1	0.12	0.325
16-university	0	1	0.413	0.22	0	1	0.12	0.319
17-UIAT	0	1	0.401	0.20	0	1	0.14	0.345
18-GB	0	1	0.4757	0.654	0	1	0.2687	0.548
19-Ln_employees	1	13892	733.044	230.10	1	250	60.68	64.959
20-Pavitt	1	4	0.918	2.02	1	3	1.72	0.607
21-OECD	1	3	0.715	1.45	1	2	1.20	0.396
22-ROA	-208.2	69.3	7.742	14.836	-208.20	69.300	7.3635785	15.3826
23-Productivity	0.2	808	46.9941	45.225	.20000	808.00	41.3870028	39.973

There are 1760 low-medium tech firms which, on average, declare 220 full-time employees per year (S.d = 754.57) while this drops to 60.68 full-time employees (S.d. 64.9) in the SMEs in low-medium tech sectors (1404 firms). In the case of the SMEs in low-tech sectors, the average recorded is 56.3 full-time employees (S.d. 61.8) for the mentioned 1139 firms.

3.3. Multivariate study

A *logit* model was run to gain an understanding of the contribution of each independent variable representing a firm's internal, and some external, flows of knowledge to explain the probability of conducting innovation in either product or process. The independent variables refer to 2005 and the dependent variable (innovation) to 2006, i.e. independent variables were lagged one period. The model takes the following form:

$$\text{Innovation i}, _{2006} = \textit{Const} + \textit{Absorptive capacity}_{2005} \textit{ (through R\&D and non-R\&D activities)} + \textit{external sources of innovation}_{2005} + \textit{industry} + \textit{control variables} + \varepsilon i.$$

The specification of the model including the aforementioned variables is represented as follows:

$$\textit{Innovation t,i} = \textit{Const} + \beta 1 \textit{ Absorptive Capacity}_{t-1} \textit{ [NewSkills + Skills +Skills\_med + PAI + Marketing+ Design + DCT]i} + \beta 2 \textit{ Absorptive Capacity R\&D}_{t-1} \textit{ [R\&D skills +R\&D expenditures] i} + \beta 3 \textit{ External linkages}_{t-1} \textit{ [UIAT + customers}_{t-1} + \textit{suppliers}_{t-1} + \textit{competitors}_{t-1} + \textit{universities] i} + \beta 4 \textit{ Control}_{t-1} \textit{ (ln\_employees +GB] i} + \beta 5 \textit{ industry}_{t-1} \textit{ [Pavitt + OECD]} + \varepsilon i.$$

Absorptive capacity was measured by a set of factors instead of a single indicator such as R&D expenditures on sales, patents, or the formally established R&D department in a company (Nieto and Quevedo, 2005; Szulanski, 1996, and Mangematin and Nesta, 1999). Nieto and Quevedo (2005) offered a revision of the variables and ways of measuring the internal factors or absorptive capacity. In the same line of Escribano et al. (2009:99) and Arbussa and Coenders (2007), we established two factor-analysis models (e.g. Bollen, 1989) for the principal dimensions (Principal Components Analysis, PCA) used to proxy the AC construct. First, the PCA for all firms in the sample referring to a firm's internal resources resulted in two factors (AC_1, addressing the R&D variable of the percentage of R&D employees over the full-time employees and R&D expenditures with 0.85 and 0.84 load factor, respectively; and, AC_2 formed by marketing, design, new employees with tertiary degrees, formal plan for innovation and technology forecast committee), explaining 78% of the total variance. Afterwards, the second PCA is applied on just the innovative firms (734) obtaining exactly the same factors, although resulting in a poorer explanation of 59.8% of the total variance. In fact, the second PCA is less reliable than the first one in terms of explained variance.

4. Results for the sample and for the innovative firms

Tables 4 and 5 present the 8 different logistic regression specifications in reference to the presented model to explain a firm's innovative performance, including the first four specifications (Table 4) with the original variables, and the next four specifications, 5 to 8, (Table 5) using the PCA factors obtained for all firms, and for the innovative ones. The models reflect the effects of AC and some external resources, as well as the control and sector variables on the probability of conducting product or process innovation. The specifications were tested using *stepwise logistic regression*. This procedure estimated a specification using the minimum number of non-superfluous and, at the same time, significant variables (e.g. Guillen, 1992). The Chi-squared test in each model suggested that the models, through explanatory variables, were significant for explaining the propensity for innovation at $p<0.01$. Furthermore, the coefficient for the overall percentage of correct predictions indicated that the models gave correct predictions within the range of values from 70.2% (minimum, specification 7) to 83.2% (maximum, specification 1). Only specification 8 presented a low value in the *Nagelerkerke* indicator (0.046), compared to the rest of the models. The variables OECD and Pavitt were used indistinctly to check differences.

Table 4 shows that, in the sample formed by all firms (2,023) in specifications 1 and 2, the variable R&D expenditures is statistically significant (11.297 $p<0.01$) explaining innovation in product, not in process. In fact, in both types of innovative performance, R&D variables do not influence the rest of specifications, neither do R&D expenditures in innovation in product or process (specifications 3 and 4 for the sample of innovative firms, 734), nor R&D employees in any model. On the contrary, except for specification 1, the rest of the models can be explained without R&D variables by using only alternative input activities for innovation, represented by the percentage of new high-qualified human resources hiring (NewSkills), the performance of a technology monitor committee (DCT), marketing, design and formal planning to innovate (PAI), all of them significant at $p<0.01$. The latter variable (PAI) is interesting because it confirms what Prakash and Gupta (2008) pointed out about a positive and significant relationship between formalization and the implementation of innovation in SMEs. Complementarily, cooperation with external technology consultants (UAIT) and with suppliers (Suppliers) is vital for explaining innovation in process (specification 2), while suppliers are also important for nurturing knowledge for innovation in product (specification 1, 3). The size variable is not significant in any model, confirming previous literature that the relationship between innovation and size is inconsistent (Camison-Zornoza et al., 2004). Regarding industry classification, there is evidence that medium and high tech intensive sectors outperform the low tech in terms of innovative performance, although the variable reflecting the high tech group is not always significant (only in specification 3, $p<0.01$). These results confirmed hypothesis 1, 3 and 4.

Table 4. Results of the logit model to explain innovation in product and process

Specifications	1	2	3	4
Type of innovative ouptut	**IP**	**IPR**	**IP**	**IPR**
Sample and Variables		**All firms**		**Innovative firms**
NewSkills	.344**	.790***		0.691***
DCT	.506**	.525***	1.202***	0.807***
Marketing	.502***	.436***		
Design	.692***		0.708***	0.472***
PAI	.841***	.792***		
R&D employees				
R&D expenditures	11.297***			
UIAT		.536***		0.524**
Suppliers	.819***	.643***	0.499**	
OECD med	.439***		.897***	0.589***
OECD high	.160		.396**	.393
Interception	-2.681	-1.631	-.933	1.467
Nagelkerke	,350	,182	0.249	0.088
-2 log-lik.	1519,514	2092,693	857.125	768.6841
% correct predicted	83.2%	74.7%	70.7%	77%

***significant at 1% **significant at 5%
Model is run using step wise regression, which means that only significant variables remain in the final equation.
NewSkills : The company has incorporated in the last year graduates from tertiary studies; DCT: The firm has a technology monitor committee
Design: The firms has activities through CAD-CAM; Marketing: The firm has conducted or hired market research and marketing activities and studies to evaluate the market trends and alternatives; PAI: The firm has an innovation plan and thus the innovation process is formalized
R&D employees: % of R&D FTEs over FTEs; R&D expenditures: R&D expenditures over sales
UIAT: The firm has used external consulting staff for technology purposes;
Customers: The firm has technological linkages with clients; Competitors: The firm has technological linkages with competitors
Suppliers: The firm has technological linkages with suppliers; University and PROs: The firm has technological linkages with universities and public research organizations (PROs); Size: logarithm for FTEs (size)
OECD: OECD's sectorial classification (low tech is the reference group)
(Dependent) ; IP: Innovation in product; IPR: Innovation in process

In Table 5, the PCA factors are employed as independent variables representing a firm's internal resources, at the same time as also employing the rest of the constructs. The PAC 1 factors obtained for the sample of all firms (AC_1 for R&D variables and AC_2 for non-R&D ones) are significant at $p<0.01$ explaining both innovation in product and process (specifications 5 and 6). Supplier flows of knowledge are important for innovation in product, and supplier and customer for innovation in process. Product innovation is non-dependent on a firm's size, but process innovation shows a positive relationship. Again, the medium and high tech intensive sectors outperform the low tech for both innovation in product and process, although the high tech group is not statistically significant. Overall, the factor AC_2 (non-R&D variables) explains more than the factor regarding R&D variables, according to the size of the coefficient in both specifications (5 and 6); this result is also extended to specification 7 regarding innovation in product by innovative firms. Nevertheless, model 8, regarding innovation in process for only innovative firms showed negative coefficients in the PAC 2 factors obtained. This model is the least consistent when observing the aforementioned low *Nagelerkerke* indicator. Table 5 confirms the 1, 3 and 4 hypothesis.

Table 5. Results of the logit model to explain innovation in product and process using PCA Factor's punctuations to represent a firm's internal resources

Specifications	5	6	7	8
Type of innovative ouptut	IP	IPR	IP	IPR
Sample		**All firms**		**Innovative firms**
PCA 1 (all firms) Ac_1 (R&D variables)	0.521***	0.163***		
PCA 1 Ac_2(Non-R&D variables)	0.762***	0.398***		
PCA 2 (innovative firms) Ac_1 (R&D variables)			0.396***	-0.313***
PCA 2 Ac_2(Non-R&D variables)			0.662***	-0.289***
UIAT				.510**
Customers		.392**		
Suppliers	.855***	.621***	.428**	
Lnemployees		0.138***		.143**
OECD med	.429***		.770***	
OECD high	.119		.307	
Interception	-1.993	-1.767	-.105	.327
Nagelkerke	0.346	0.161	0.247	0.046
-2 log-lik.	1525.759	2128.998	859.006	790.079
% correct predicted	82.2%	74%	70.2	75.6%

***significant at 1% **significant at 5%
Pavitt 1 (supplier-dominatd) is the criteria dummy for the variable Pavitt
Factors 1 and 2 PCA **AC1** (%R&D employees over FTEs and R&D expenditures) and **AC2** (Marketing, Design, new employees with tertiary degree, formal plan for innovation and technology forecast committee)
Model is run using step wise regression, which means that only significant variables remain in the final equation.
UIAT: The firm has used external consulting staff for technology purposes; Customers: The firm has technological linkages with clients; Competitors: The firm has technological linkages with competitors
Suppliers: The firm has technological linkages with suppliers; University and PROs: The firm has technological linkages with universities and public research organizations (PROs); Size: logarithm for FTEs (size)
OECD: OECD's sector classification (low tech is the reference group)
(Dependent); IP: Innovation in product; IPR: Innovation in process

Table 6 provides additional analysis in which the models control the use of R&D variables in order to obtain a sensitivity analysis of results. The specifications are tested using *stepwise logistic regression*. All specifications from 9 to 14 in Table 6 fit significantly at $p<0.01$ and the pseudo-R_2 varies from 74.2% (specification 14) to 83.4% (specification 9). From specifications 9 to 12, original independent variables are used, while in specifications 13 and 14, the obtained PCA 1 factors were employed. R&D expenditures is an important variable (10.94 at p<0.0.05) only for explaining innovation in product in specification 9, not in process (specifications 11, 12). Therefore, R&D variables are not significant for innovation in process as they are for innovation in product. On the contrary, the R&D employees variable is not significant in any specification. Then, NewSkills, DCT, marketing, design and PAI are non-R&D variables which also contribute significantly ($p<0.01$) to the explanation of a firm's innovative performance in product (specification 10) and process (specification 11 and 12). In addition, size also has a positive and statistically significant ($p<0.01$) coefficient only for innovation in product, not in process. Regarding industry effect, statistically the scale intensive sector and the science-based sectors significantly outperform the supplier-dominated sector (reference category) in terms of innovation in product, and the specialized-suppliers sector is not significant. As shown in Table 6, the PCA 1 factors, including non-R&D variables (Ac_2), explain more (higher significant coefficient) than the factor addressing R&D variables (Ac_1), for all types of innovative outcomes (see specifications 13 and 14). This analysis of sensitivity confirms previous results. The R&D variables are very limited in explaining innovation in process, and especially, the R&D expenditures variable works occasionally in innovation in product. Nevertheless, other non-R&D variables are key predictors explaining both innovation in product and especially, in process. Table 6 again confirms hypothesis 1, 3 and 4.

Table 6. Results of the logit model innovation in product and process controlling for R&D efforts

Specifications	9	10	11	12	13	14
Variables	IP	IP (non-R&D)	IPR (non-R&D)	IPR	IP	IPR
			Original variables		PCA 1 Factors	
Industries involved	All firms	All firms	All firms	All firms	All firms	All firms
Ac_1 (R&D)					0.477***	0.136**
Ac_2(Non-R&D)					0.744***	0.354***
NewSkills		0.374**	0.805***	0.791***		
DCT	0.412**	0.487**	0.495***	0.546***		
Marketing	0.515***	0.517****	0.405***	0.414***		
Design	0.661***	0.681***				
PAI	0.754***	0.910***	0.834****	0.787***		
R&D expenditures	10.947**					
UIAT			0.523***	0.516***		0.511***
Customers				0.357**		
Suppliers	0.798***	0.813***	0.654***	0.504***	0.825***	0.553***
Lnemployees	0.146***	0.129**				0.124***
Pavitt (scale-intensive)	0.492**	0.451**	-0.024	-0.008	0.583**	
Pavitt (specialized su.)	-0.273	-0.384	-0.010	0.019	-0.202	
Pavitt (science-b.)	0.567**	0.566**	-0.593**	-0.610**	0.539**	
Interception	-3.370	-3.126	-1.585	-1.611	-2.294	-1.795
Nagelkerke	0.367	0.360	0.188	0.190	0.364	0.170
-2 log-lik.	1487.338	1500.238	2084.577	2073.632	1490.910	1279,295
% correct predicted	83.6%	83.4%	74.5%	74.3%	83.5%	74.2%

***significant at 1% **significant at 5%

Factors 1 and 2 PCA **AC1** (%R&D employees over FTEs and R&D expenditures) and **AC2** (Marketing, Design, new employees with tertiary degree, formal plan for innovation and technology forecast committee)

Model is run using step wise regression, which means that only significant variables remain in the final equation.

NewSkills : The company has incorporated in the last year graduates from tertiary studies; DCT: The firm has a technology monitor committee

Design: The firms has activities through CAD-CAM; Marketing: The firm has conducted or hired market research and marketing activities and studies to evaluate the market trends and alternatives; PAI: The firm has an innovation plan and thus the innovation process is formalized

R&D employees: % of R&D FTEs over FTEs; R&D expenditures: R&D expenditures over sales

UIAT: The firm has used external consulting staff for technology purposes; Customers: The firm has technological linkages with clients; Competitors: The firm has technological linkages with competitors

Suppliers: The firm has technological linkages with suppliers; University and PROs: The firm has technological linkages with universities and public research organizations (PROs); Size: logarithm for FTEs (size)

Pavitt: Pavitt's sectorial classification; Pavitt 1 (supplier-dominated) is the criteria dummy for the variable Pavitt (Dependent) ; IP: Innovation in product; IPR: Innovation in process

Table 7. Explanation of the innovative performance with interactions

Type of industry	All firms		low-tech firms		LTM firms	
Models	15	16	17	18	19	20
Variables	IP	IPR	IP	IPR	IP	IPR
AC_1	0.696*		0.428*	0.431*	0.623*	0.263*
AC_2	1.093*	0.484*	1.002*	0.629*	1.037*	0.613*
UIAT		0.515*				0.505*
Suppliers	1.537*	0.907*	1.345*	0.972	1.395*	0.863*
Lnemployees		0.126*	0.18*	0.123*	0.160*	0.111*
Pavitt (2)	0.521*					
Pavitt (3)	-0.277					
Pavitt (4)	0.439					
AC_1 x Suppliers	-0.462*				-.318*	
AC_1 x University			0.499*			
AC_2 x Suppliers	-0.681*	-0.338*	-0.564*	-0.399*	-0.687*	-.455*
AC_2 xCuestomers						0.357*
AC_2 x University						-0.417*
Interception	-2.014	-1.88	-3.26	-1.608	-2.228	-2.0310
Nagelkerke	0.377	0.120	0.346	0.190	0.365	0.198
Chi-Squared	549.28	255.33	296.94	188	442.015	253.89
% correct predicted	83.4	74.3	88%	78%	84.9	76.3
N	1999	1999	1378	1378	1756	1753

*significant at 1% **significant at 5% Innovation in product (IP); innovation in process (IPR);
%R&D employees over FTEs and R&D expenditures Factors 1PCA **AC1** (%R&D employees over FTEs and R&D expenditures) and **AC2** (Marketing, Design, new employees with tertiary degree, formal plan for innovation and technology forecast committee)
Model is run using step wise regression, which means that only Significant variables remain in the final equation.
UIAT: The firm has used external consulting staff for technology purposes; Suppliers: The firm has technological linkages with suppliers
Size: logarithm for FTEs (size); (Dependent) IP: Innovation in product; IPR: Innovation in process
Pavitt: Pavitt's sectorial classification; Pavitt 1 (supplier-dominated) is the criteria dummy for the variable Pavitt

In Table 7, the fifth hypothesis is tested and the results show that the interaction (moderating effects) presents negative and significant coefficients, especially with suppliers (both, AC_1 x Suppliers and AC_2 x Suppliers, models 15 to 20). These results indicate, confirming Vega-Jurado et al. (2008), Vega-Jurado et al. (2009) and Laursen and Salter (2006) a clear substitution effect, instead of the complementary effect claimed by Cassiman and Veugelers (2006). These results also have two different interpretations in this study. First, for innovation in product in both cases, i.e. all firms (model 15) and low-medium tech firms (model 17), AC_1 x Suppliers is negative and statistically significant (-0.462 and -0.318, respectively). This means that a substituting effect exists between AC_1 (R&D variables) and suppliers external knowledge. In other words, firms which undertake innovation through R&D variables in-house do not need external knowledge from suppliers because it is substituted by internal knowledge. This does not occur with low-tech firms. In model 20 the variable *customers* interacts positively with innovation in process. Second, this substituting effect is exactly the same as the one observed for innovation in process (models 16, 18, 20) with non-R&D variables in all type of firms. Finally, according to the results, it is evidenced a substitution effect, instead of the synergistic effect. Thus, hypothesis 5 (with no predicted sign) is confirmed and the results show a clear substitution effect.

Following recommendations stated in previous studies (e.g. Becheikh et al., 2006), differentiating variable categories such as SMEs versus large firms, traditional industries or Pavitt sectors, would be useful toward developing configurations of innovation determinants which can be helpful to managers, policymakers and scholars. This complementary exercise is shown in **APPENDIX A**. In this complementary section, a distinction is offered between low-medium tech and low-tech sectors, which are the predominant sectors in the sample and a special reference is made to the SMEs, in order to obtain evidence about differing innovation patterns. Restricting the sample to solely low-medium tech sectors gives evidence that R&D expenditures work significantly for innovation in product, while R&D expenditures do not work in any model of innovation in process. The rest of variables addressing a firm's internal resources, human resources, and value-adding non-R&D activities are important and significant in most of the specifications. It is also interesting to observe the importance R&D employees have in innovation in process which, jointly with NewSkills, reflect the core importance of human resources to explain innovation in process. On the contrary, in innovation in product, the R&D expenditures variable captures all innovation, and the NewSkills or R&D employees variables do not have any effect. Size is also important in innovation in product, although it is not for innovation in process. Therefore, when restricting the studies to SMEs exclusively (SMEs-low-medium tech, 1402 and SEMs-low-tech, 1130), the results hold, and the most remarkable difference is the fact that the SMEs in low-tech sectors can not be explained by any R&D activity, not even by the R&D employees variation. This variance is not significant in the type of limited and classic SMEs from the sample. Therefore, the explanation of the innovative process in the vast majority of SMEs (in low-tech, they represent one half of the total sample) can be done without the R&D variables, and thus the innovative pattern can be captured. Finally, Table A3 shows that the PCA factors referring to non-R&D variables (AC_2) explain more than the ones referring to R&D variables (AC_1).

Finally, an exercise of analyzing the performance was conducted in both financial (ROA, Return on Assets) and productive (Productivity, value-added on employees) among the low-medium tech sectors. Regarding innovation in product (ROA: 8.15; Productivity: 54.08) versus the non-innovative (ROA:7.64; Productivity: 45.39), both differences were statistically significant at $p<0.01$ ($F = 8.137$, $F=19.734$, respectively). For innovative in process, the results indicated the same outcome (ROA: 9.41 vs 7.13; Productivity: 54.91 vs 44.10), significant at $p<0.01$. Results for all firms indicate similar conclusions. Summarizing, the firms which declared innovation in product or process outperform the non-innovative ones in financial and productivity terms.

5. An analysis of the neglected innovators

All previous results suggested that the innovators should be separated into R&D innovators and non-R&Ds to check the robustness of results. This exercise is justified by Arundel et al. (2008:3):

"R&D is not the only method of innovating. Other methods include technology adoption, incremental changes, imitation, and combining existing knowledge in new ways. With the possible exception of technology adoption, all these methods require creative efforts on the part of the firm's employees and consequently will develop the firm's in-house innovative capabilities. These capabilities are likely to lead to productivity improvements, improved competitiveness, and to new

or improved products and processes that could be adopted by other firms. For these reasons, the activities of firms that innovate without performing R&D are of interest of policy".

This different type of input innovation activity has always been less valued by scholars (see all literature in the introductory section). They are the firms which declared innovative performance in form of process or product while not performing R&D activities and have also declared innovative output without conducting R&D expenditures in 2005 and 2006.

Table 8. Main descriptive statistics on innovators: R&D and non-R&D ones.

Variables	Type of innovator	N	Mean	S.deviation	F
Skills	Non-R&D innovators	337	4.329	6.62979	41.627***
	R&D Innovators	402	7.7474	7.60365	
	Total	739	6.1883	7.37494	
R&D expenditures	Non-R&D innovators	337	0.0000	0.00000	150.001***
	R&D Innovators	403	0.01716	0.0256	
	Total	740	0.00934	0.0208	
R&D employees	Non-R&D innovators	337	0.002	0.0133	212.689***
	R&D Innovators	401	0.061	0.0743	
	Total	738	0.034	0.0630	
Employees	Non-R&D innovators	337	181.88	523.818	19.647***
	R&D Innovators	403	512.48	1282.579	
	Total	740	361.92	1023.107	
Productivity	Non-R&D innovators	337	45.9890	36.53111	26.184***
	R&D Innovators	403	63.3039	52.36194	
	Total	740	55.4188	46.61184	
Sales	Non-R&D innovators	337	60,262,925.82	353,900,000	9.59***
	R&D Innovators	403	181,000,000	637,700,000	
	Total	740	126,000,000	530,800,000	

*** p<0.01

The existence of 337 non-R&D innovators and 403 R&D performers is observed in Table 8. It is clearly stated that R&D innovators outperform non-R&D innovators (significant at p<0.01) in terms of highly-skilled personnel (Skills, 7.74 vs 4.32), R&D expenditures (1.71%), R&D employees (6.1% vs 0.2%), size (Employees 512 vs 181), Productivity (63.3 vs 45.9) or Sales (60 millions vs 181 millions). These results feature both types of innovators. In addition, statistical differences were calculated based on contingency tables between R&D and non-R&D innovators and the main innovation activities. The variables NewSkills, DCT, marketing, design, PAI, innovation in product, innovation in process and the different types of networks accessed showed remarkable differences for the two groups. Overall, the R&D performers hire more new high-degree employees (55.6% vs 24.6%), frequently employ tech committee monitoring (66.7% vs 4.7%), perform design (53% vs 26%) and marketing activities (39.6% vs 16.2%), mostly conduct innovation in a formal plan (PAI, 74.9% vs 6.98%); outperform in terms of product innovation

(72.5% vs 35.6%), and extensively access networks with customers (55.3% vs 7.4%), suppliers (68.7% vs 8.9%), universities (57.3% vs 13.9%), technology consultants (47.6% vs 19%) and competitors (7.7% vs 0.9%). The non-R&D performers only outperform the R&Ds in conducting innovation in process (80.7% vs 71.5%). In addition, the R&D performers are more intense in high-tech activities following the OECD classification (the non-R&D performers are 73.9% low-tech, 16.6% MT and 9.5% HT; the R&Ds are 47.6% low-tech, 27.3% MT and 25.1% HT). All these descriptive statistics offer the features of each group of innovators and all are statistically significant at $p<0.01$.

As observed in Table 9, the variables of marketing, design and PAI are main factors which explain innovative performance. In fact, a remarkable difference is seen based on the fact that PAI (formal innovation plan) is only significant in innovation in product, nor in process.

Table 9. Neglected innovators (Firms which innovate with non R&D expenditures)

	All firms		SME firms	
Specification	21	22	23	24
Variables	IP	IPR	IP	IPR
Marketing	0.786**	0.630	0.774**	
Design	0.635**	0.741		0.863***
PAI	1.135**		2.451**	
OECD(2)			0.827***	
OECD(3)			-.206	
Interception	-1.028	1.087	-0.995	1.664
Nagelkerke	0.107	0.063	0.094	0.040
-2 log-lik.	354.602	310.22	324.873	264
% correct predicted	70.5	81.1	70.2	78.8
N	291	338	272	272

*significant at 1% **significant at 5% (Dependent variable) Innovation in product (IP); innovation in process (IPR);
Model is run using step wise regression, which means that only Significant variables remain in the final equation.
Design: The firms has activities through CAD-CAM
Marketing: The firm has conducted or hired market research and marketing activities and studies to evaluate the market trends and alternatives
PAI: The firm has an innovation plan and thus the innovation process is formalized
OECD: OECD's sector classification (low tech is the reference group)

In Table 9, models 21 and 22 present an average of 185 full-time employees, indicating that the firms analyzed are mainly SME, although only at a proportion of 82%. Next, in models 23 and 24, the average representing SME firms drops to 59.19 (S.d. 60.56). In this table, the analysis is restricted to only "neglected" innovators, firms which innovate without performing R&D expenditures. As observed, the key internal variables explaining innovation are marketing, design and PAI, i.e., the formalization of innovation activities, especially for innovation in product (models 21, 22). It is to be noted that no external sources of knowledge, such as suppliers or customers, are obtained. These neglected innovators concentrate solely on internal sources of resources. The explanation is based on the fact that they may lack absorptive capacity to access certain external resources. Nevertheless, a more accurate and thorough analysis is needed to answer these questions properly. What is the reason why external sources of knowledge are not required? Are neglected innovators better or worse than R&D innovators in terms of performance?

The figures indicated that, among the 338 neglected innovators, 121 declared innovation in product and 273 in process. On the other hand, of the R&D innovators (405), 293 declared innovation in product and 289 in process.

The following tables point out how the percentage of firms of the total sample (2,023 firms) that have cooperation agreements with customers (17.4%), competitors (2.21%), suppliers (20.86%), university (21.8%) are, by far, less cooperative in terms of technology agreements in accessing external knowledge than the innovative firms (743 firms). In this case, it can be observed that innovative firms have more open innovation processes and engage more with different partners to access external flows of knowledge. In particular, the firms which simultaneously combine innovation in product and process are comparatively those which are more active in conducting interactions with external partners (see Table 10). Following the analysis, Table 10 demonstrates that innovators account for much more engagements in cooperation agreements with customers, competitors, suppliers and universities-PROs. In addition, innovators presented far more external agreements than the non-R&D innovators (55.1%, 7.7%, 68.6% and 57%, respectively), differences significant at p<0.01. Summarizing, R&D innovators accounted for the majority of external resources, and the non-R&D innovators present very low percentages of external cooperation. This is consistent with results observed in Table 9, in which only internal factors explain innovation, in the case of non-R&D innovators, and it is also in line with the fact that the firms with more internal resources can easily absorb or access external ones. Put differently, firms with R&D activities and thus, better AC, can easily engage in cooperation agreements and access external flows of knowledge. This result confirms hypothesis 2. In addition, this effect is also confirmed with the positive and significant correlation between internal (R&D) and external resources (hypothesis 2, absorptive effect). Nevertheless, when their interaction effect

Table 10. All firms in the sample and their technology cooperation agreements. Distinction between innovators (both R&D and non-R&D performers) and non-innovators.

Sources of external knowlede	Type of interactions	Chi-S.	Non-innovators	Innovators in product or process	Innovators in both types simultaneously	Total
Customers	No interactions	277,1 p<0.01	1175	380	115	1670
	Cooperations		**105(8.2%)**	**130(25.49%)**	**118(50.6%)**	**353 (17,4%)**
	Total		1280	510	233	2023
Competitors	No interactions	54.78 p<0.01	1271	495	214	1980
	Cooperations		**9 (0.70%)**	**15 (2.9%)**	**19(8.15%)**	**43 (2.21%)**
	Total		1280	510	233	2023
Suppliers	No interactions	383 p<0.01	1166	345	90	1601
	Cooperations		**114 (8.9%)**	**165(32.35%)**	**143(61.37%)**	**422 (20.86%)**
	Total		1280	510	233	2023
University-PROs	No interactions	229.1 p<0.01	1117	360	105	1582
	Cooperations		**163 (12.73%)**	**150(29.41%)**	**128(54.93%)**	**441(21.8%)**
	Total		1280	510	233	2023

table 11 illustrates that the R&D innovators, compared to the non-R&D (neglected) on innovation is evaluated they function as substitutes rather than complementarities[3]. Lastly, the R&D innovators presented a higher productivity ratio (p<0.01) than the non-R&D innovators. On the other hand, the ROA is higher for non-R&D performers, but this result is not significant (see Table 12). As a result, the existence of R&D variables, combined with a more active network formation to access external knowledge, are key drivers of a firm's performance, as evidenced in the productivity results.

Table 11. Different patterns of tech agreements by R&D innovators and non-R&D innovators

Partner for technology agreements	**Chi-S.**	Existence of cooperation	Non-R&D innovators	R&D innovators	Total
Customers	188.2***	No agreements	313	182	495
		Cooperation	25 **(7.4%)**	223 **(55%)**	**248 (33.3%)**
		Total	338	405	743
Competitors	19.31***	No agreements	335	374	709
		Cooperation	3 **(0.9%)**	31 **(7.65%)**	**34 (4.5%)**
		Total	338	405	743
Suppliers	271***	No agreements	308	127	435
		Cooperation	30 **(8.9%)**	278 **(68.6%)**	**308 (41.45%)**
		Total	338	405	743
University	146***	No agreements	291	174	465
		Cooperation	47 **(13.9%)**	231 **(57%)**	**278 (37.4%)**
		Total	**338**	**405**	**743**

******* p<0.01

Table 12. Performance differences between R&D and non-R&D innovators

Innovative firms		N	Mean	S.d.
Productivity F = 26.184***	Neglected	337	45.980	36.5311
	R&D performers	403	63.3039	52.3614
	Total	740	55.4188	46.6114
ROA (no significant) 0.161	Neglected	338	9.280	11.7345
	R&D performers	405	8.927	12.1093
	Total	743	9.087	11.9336

******* p<0.01

[3] Adding the binaries variables UAIT, customers, competitors, suppliers and universities and thus obtaining a variable from 0-to-5 reflecting cooperation agreements. The correlation (Pearson Coefficient 0,296) is positive and significant at p<0.01

6. Discussion of results

The results, summarized in table 13, clearly show that the innovation patterns addressing product and process innovation differ in terms of their drivers or determinants. Therefore, this study contributes to highlighting the clear distinction between product and process innovations pointed out in previous studies (e.g. Freel, 2003; Michie and Sheehan, 2003; Lager and Hörte, 2002; Sternberg and Arndt, 2001; Gopalakrishnan et al., 1999; Papadakis and Bourantas, 1998) which claimed that these two types of innovations follow different paths and do not necessarily have the same determinants, as stated in Becheikh et al. (2006). In addition, the results strongly support the view that non-R&D activities are crucial to understanding the innovation process of any firm, at least in this low-medium tech context, and thus confirming Santamaria's et al. (2009) results.

Overall, the empirical results show that low-technology manufacturing firms lag behind their medium- and high-tech counterparts regarding their product innovation performance, although they seem to perform similarly at process innovation and confirming the results pointed out by Kirner et al. (2009). The main reason is that R&D activities are not so important in this innovation type. In fact, the process innovation is not affected by the type of industry (e.g. see table 7). In addition, low and medium tech industries are characterised by process, organisational and marketing innovations, by weak internal innovation capabilities (even to the extent that most of them lack of R&D facilities) and by strong dependencies on the external provision of inputs (such as machines and so forth). Suppliers are the most important source for their information and knowledge, (see table 6 and 7). These results confirmed those of Heidenreich (2009).

Overall, R&D variables are very limited in explaining innovation in process. Specifically, R&D expenditures work in some cases of innovation in product. In contrast, the role of R&D employees in innovation in process for low-medium tech and low-tech is remarkable. Similarly, non-R&D variables are key predictors in explaining both innovation in product and, remarkably, in process. These results highlight the key importance of human resources in firms in regards to internal resources (e.g. Cohen and Levinthal, 1990), especially in SMEs (e.g. Muscio, 2007). Overall, innovation in process can be measured using non-R&D variables, and especially the key importance of human resources to explain innovation in process, rather than R&D expenditures. The variables on which the study was based are beyond those of intramural R&D, and the results have shown that "doing, using and interacting" (Jensen et al., 2007) is a way in which firms rely on processes and experience-based know-how also found in downstream activities (marketing, design, etc.) (OECD, 2005). This mainly refers to the low and medium-tech sectors that use "*…incremental problem solving and experimentation [which]take[s] place on the shop floor and are closely associated with production beyond well-defined R&D programmes…*" (Albaladejo and Romijn, 2000:4-5). Put differently, innovation is not an exclusive technological effort, but a strategic and market-driven perspective instead (e.g. Bessant and Tidd, 2007; Terziovski, 2010). Size is also important in innovation in product, although it is not significant for innovation in process. This is in line with Rammer et al. (2009) who pointed out that there are few, if any, size-related barriers to applying innovation management techniques successfully, and innovation performance is not clearly linked to size (Camison-Zornoza et al., 2004).

Table 13. Summary of the paper's objectives and main results.

Objectives:	Results
• First, the paper attempts to understand what the role of non-R&D input activities is to explain a firm's innovative performance, exploring key differences when addressing R&D activities undertaken to innovate. In addition, this objective is focused on disentangling the differing role of the R&D and non-R&D activities effects on both product and process innovative output. • Second, the paper explores the role of non-R&D innovators and their strategies of combining internal and external resources to innovate. • Third, the paper explores the process of innovation in order to disentangle and shed light on the ambiguous and fragmented results on the effects of absorptive capacity to access to external sources of knowledge and the interaction (complementary versus substitution) effect.	• R&D activities are limited, especially for explaining the process innovation output, case in which R&D expenditures does not work. They neither work on small firms, nor in low tech sectors. On the contrary, R&D expenditures basically work on product innovation in large firms and high tech sectors. • Regarding innovation in product, the size is positively related to the innovation output and the university and the suppliers are core sources of external knowledge. • Regarding innovation in process, the non-R&D activities are important as drivers to explain the innovation outcome. In this case Human Resources (internally) and suppliers, as external sources of knowledge, are both critical. In addition, consultants and customers are also important. Nevertheless, size is not a determinant, nor the access to university knowledge sources. • Neglected innovators show a poor search strategies to access to external knowledge, thus reinforcing the AC (hypothesis 2) proposition; and, the key non-R&D variables to explain innovative output are basically based on internal sources of resources, mainly marketing, design and the development of a formal innovation plan. Neglected innovators are mainly based on innovation in process. • R&D innovators take over the majority of external sources of knowledge, meaning that their higher level of AC, then the more intensive the use of all available sources of external knowledge. In fact, the R&D innovators' innovative outcome is mostly explained by the combination of internal and external sources of knowledge. The R&D innovators are more productive, and access to more resources (open innovation perspective), compared to the non-R&D innovators. • In general, cooperation for innovation (open innovation), is positively related with R&D intensive firms and also with those firms which achieve simultaneously process and product innovation. • The results strongly support the view that non-R&D activities are crucial to understanding the innovation process of any firm, at least in this low-medium tech context. • The empirical results show that low-technology manufacturing firms lag behind their medium- and high-tech counterparts regarding their product innovation performance, although they seem to perform similarly at process innovation. • Low and medium tech industries are characterised by process, organisational and marketing innovations, by weak internal innovation capabilities (even to the extent that most lack of R&D facilities) and by strong dependencies on the external provision of inputs, i.e. suppliers.

Source: own

Regarding SMEs, it can be seen that the R&D activities are less important to the extent that, in low-tech industries, even R&D employees are not significant. These results in SMEs showed that innovation in these firms is not captured by using only R&D variables, and that other non-technological and informal activities are also important, confirming previous studies (Rammer et al., 2009; Hall et al., 2009). Therefore, the explanation of the innovative process in the vast majority of SMEs (in low-tech, they represent one half of the total sample) can be made without R&D variables and thus, the innovative pattern can be captured.

Nevertheless, R&D variables have also showed strength. Some authors claim that firms need to improve their organizational capabilities by formalizing their structures and systems in order to become more efficient (Bessant and Tidd, 2007; Prakash and Gupta, 2008), especially regarding the functional specialization showed in R&D expenditures, or the formal plan to innovate (PAI). In fact, Terziovski's (2010) findings reveal that formalization is a main driver of the SMEs innovative performance, even beyond the traditional R&D expenditures variable. However, and following Terziovski (2010), these results contradict the traditional view that formalization varies inversely with innovation (Acs *et al.*, 1997; Damanpour, 1992).

Lastly, the R&D innovators presented a higher productivity ratio than that of the non-R&D innovators. As a result, the existence of R&D variables, combined with a more active network formation to access external knowledge, are key drivers of a firm's performance as evidenced in the productivity results. Confirming Arundel et al. (2008) it can be noted that, in comparison with R&D innovators, non-R&D innovators (1) present a lower access to external flows of knowledge, i.e. networking. These results contradict some scholars' conclusions that certain types of SMEs have a greater ability to rely on external networks (Nooteboom 1994; Rothwell and Dodgson 1994) and to create innovative alliances (van Dijk et al. 1997); (2) the non-R&D innovators present lower innovation capabilities, i.e. AC; (3) the non-R&D innovators are more likely to focus on process innovation. Nevertheless, one key distinction should be noted: the non-R&D performers are basically performers of innovation in process and, in this aspect, outperform the R&Ds (80.7% conducted innovation in process and 35.6% in product, while the R&D innovators carried out 71.5% in process and 72.5% in product; $p<0.01$).

7. Conclusions

This paper attempts to use an integrated framework based on a firm's internal and external resources to innovate and contributes to the innovation literature in three different ways. First, the paper attempts to understand what the role of non-R&D input activities is to explain a firm's innovative performance, exploring which key differences can be detected when R&D activities are undertaken for innovation. In addition, the paper analyzes the main effects of the R&D and the non-R&D activities on measuring process and product innovation. Second, the study tackles the role of the non-R&D innovators and their strategies of combining internal and external resources to innovate comparing them with the traditional R&D innovators. And third, the paper explores the process of innovation disentangling the ambiguous results of the literature about the effects of absorptive capacity to access to external sources of knowledge and the interaction (complementary versus substitution) effect of combining internal and external sources of knowledge. The paper fills all these gaps by obtaining empirical evidence on 2,023 Spanish firms. The summary of the conclusions, effects and the accomplishment of the hypothesis are showed in table 14.

Table 14. Hypothesis, results and related conclusions.

Hypothesis	Effect	Expected result	Result	Table and method	Hypothesis	Results	Literature confirming results	Conclusions
H1 A firm's unique stocks of internal resources is positively associated with a firm's innovative performance	Internal knowledge and innovative output	Positive	Positive, significant	Table 4, 5, 6 and 7 (Logit test)	Accepted	The firms' internal resources, both R&D and non-R&D influence positively innovation	Vega-Jurado et al. (2008); Escribano et al., (2009)	A firm's internal resources affects positively its innovative output. Thus, the drivers to explain IP and IPR are different. IP is mainly explained by R&D activities and IPR by non-R&D activities
H2 A firm's AC moderates the access to external resources	Absorptive capacity or the potential capability to access to external knowledge	Positive	Positive and significant	Table 9 and 11 (Anova test)	Accepted	The firms' internal resources (AC) allow the access to external sources of knowledge. Thus, the higher the AC, the higher the access to external sources of knowledge.	Escribano et al. (2009); Hervas-Oliver and Albors-Garrigos (2009);	The firm's AC, i.e. the firm's internal resources, moderate the access to external sources of knowledge. Thus, the higher the level of AC, the more intensive the access and variety of external sources of knowledge. Especially, this is noticed comparing R&D and non-R&D innovators.
H3 A firm's linkages with other firms/institutions are sources of external knowledge which are positively associated with a firm's innovative performance	External sources of knowledge and innovative output	Positive	Positive and significant	Table 4, 5, 6 and 7 (Logit test)	Accepted	The external sources of knowledge impacts positively the firms' innovative output	Escribano et al. (2009); Hervas-Oliver and Albors-Garrigos (2009); Vega-Jurado et al., 2009; Gambardella, 1992; Huergo, 2006;	The sources of external knowledge are positively related with the firms' innovative output. In addition, the sources employed to achieve innovation in product (suppliers and university) differs from those related to process innovation (customers and also suppliers).
H4 The level of technological opportunities and appropriability conditions embedded in a firm's industry is related positively to the firm's innovative performance	Tech opportunities and appropriability (Industry)effects on innovative output	Positive	Positive, significant	Table 4, 5, 6 and 7 (Logit test)	Accepted	The tech opportunities and the appropriability conditions affect the firms' innovative output. Thus, the more knowledge intensive industries affect positively the innovation outcome	Escribano et al. (2009); Vega-Jurado et al., (2009); Nieto and Quevedo, 2005; Klevorick et al., 1995; Geroski, 1990)	The level of tech opportunities and appropriability in each group of industries (low, medium and high tech) influence the innovative output. The more knowledge-intensive industries present higher innovation output that the lower ones.
H5 The interaction of a firm's internal and external sources of knowledge generates an impact on a firm's innovative performance	Interaction effect of combining internal and external sources of knowledge on innovative output. Positive (complementary) and negative (substitution)	Positive or negative	Negative, significant	Table 7 (Logit test)	Accepted	Substitution effect. Firms with higher internal resources need less the use of external sources of knowledge to innovate*	Especially confirming Vega-Jurado et al. (2008) results in a different sample of Spanish firms. Vega-Jurado et al. (2009); Laursen and Salter, (2006)	The substitution effect shows a decrease in the effect exercised by the externals sources of knowledge on innovation when the variables for internal resources are increased **

*****Do not confuse with hypothesis 2. H2 is just access to external resources and H5 is the use of the resources in combination with the internal ones to innovate. ****** This is not a OLS and therefore there is no linear (by unit of change) explanation. IP Innovation in product; IPR innovation in process, AC Absorptive capacity

For this purpose, our study goes beyond intramural R&D, consistent with the fact that, in low-tech intensive countries, firms do not perform high levels of intramural R&D expenditures. Spain is chosen because it is a technology-follower country predominantly articulated by traditional low-technology sectors, and SMEs with low R&D expenditure (Vega-Jurado et al., 2009). The paper articulates the innovation performance measurement while combining literature on internal and external sources of knowledge, offering a comprehensive theoretical framework based on five hypotheses which disentangle the role of internal and external flows of knowledge to explain a firm's innovative output in a comprehensive and integrative manner. The paper analyzes the non-innovators and the innovators, differentiating in the latter, the R&D and the non-R&D innovators. All these sub-samples offer an in-depth analysis for checking the behaviour of all the different firms to innovate. The results confirmed the stated hypotheses.

While R&D expenditures are a key driver of a firm's innovative product performance, innovation in process should be measured differently, using non-R&D variables, especially when addressing low-tech and low-medium tech sectors extensively. It is also interesting to note the importance R&D employees have in innovation in process. This, jointly with other indicators of qualified employees, reflects the core importance of human resources to explain innovation in process, rather than solely R&D expenditures which do not work in this type of innovation. This results confirmed the claims made by Raymond and St-Pierre (2010) about the fact that firms in low tech and medium-low tech sectors surpass the medium to high tech firms adopting advanced manufacturing technologies, although the medium to high dominate in terms of R&D. In addition, it is pointed out that firms in low-tech sectors are more active in process innovation. Following the outcomes form the innovators from the sample, the results also disentangle the true role of R&D expenditures from other innovation activities in low-medium tech-low-tech contexts. In this case, it can be seen that the R&D variables do not work in both innovation in product and process, but that the non-R&D variables do, and are key predictors. SMEs conduct innovation activities with no permanent in-house R&D performing. This result implies alternative ways, other than solely R&D, to exploit internal innovation potentials and access external sources of knowledge to innovate.

Therefore, the innovation performance in product and process can also be explained using non-R&D variables such as investments in marketing, design, DCT (technology monitoring committee existence), PAI (formal innovation planning established) and NewSkills (process of hiring new high-qualified academic workers). In fact, different scholars have worked without taking into consideration R&D intensity, addressing only technological competences (Bougrain and Haudeville, 2002; Freel, 2003, 2007; Muscio, 2007) when working on SMEs. Using PCA factors, it is notable that the non-R&D variables factor obtained explains more (higher coefficient) than the R&D variables factor obtained, albeit in some cases, R&D expenditure occasionally works with the highest coefficient, especially for innovation in product. As for the tech intensity in the sectors analyzed, it can be seen that the lower the tech-intensity of the industry, and thus the lower the tech opportunities and the appropriability conditions, the less relevant are the R&D variables.

By explaining the differing types of innovation performance, i.e. product and process, the paper reached the following conclusions. First, when explaining innovation in product, the R&D

variables are representative of the innovation activities for all types of firms in all types of sectors (low-medium tech and low-tech), and even for SMEs. Nevertheless, the non-R&D variables become much more important especially for low-tech sectors and the SMEs, where R&D variables have less importance. In the case of innovation in product, the university is an important source of external knowledge, even for the SMEs, complementing the source of knowledge from suppliers, which is the core external source of external capabilities. Overall, size has a positive and significant effect for innovation in product. Second, addressing innovation in process, it is evidenced that R&D variables work in a few specific cases. Additionally, the R&D expenditures variable never works and the R&D employees variable works only occasionally. In this type of innovation, the non-R&D variables are crucial for explaining innovation in process, being more important than the R&D variables. Here, size is not important statistically, i.e. all types of firms, even the SMEs, can conduct innovation in process and the university is not necessary, but suppliers and, especially, qualified human resources in-house are

Regarding external sources of knowledge, it is stressed that while innovation in process requires external resources such as interaction with UAIT, customers and suppliers, innovation in product mainly needs suppliers, and occasionally universities. This is in line with some studies (e.g. Nieto and Santamaria 2007) which indicated that the specific characteristics and objectives of different partners would bring different results. This is in line partially with some scholars (e.g. Grimpe and Sofka, 2009 focus on Germany) who pointed out that, in low-medium tech industries, the search pattern is mainly aimed towards customers and competitors, and the high-tech industries are more related to linkages with suppliers and institutions. Suppliers are the external sources most employed by firms in their search strategies. Nevertheless, our evidence reveals that the low-tech sectors (following Pavitt or OECD) are more engaged with suppliers, rather than with customers or competitors. This can also be linked to the fact that our sample of firms presented very low levels of R&D expenditures compared to other studies referring to other countries, such as Germany, which presented higher figures for R&D expenditures. This conclusion opens new research avenues about the European Union’s differences and requires more in-depth analysis.

When restricting the sample to only “neglected” innovators, then according to the results, the key internal variables explaining innovation are marketing, design and PAI. The latter variable (PAI, the formal plan of innovation activities) is important, especially in innovation in product for the non-R&D innovators, meaning that the formalization of innovation activities, through R&D or PAI activities, for the non-R&D innovators, improves and upgrades a firm’s innovation output in product. This confirms previous literature about manufacturing firms which claimed that formalization through functional specializations, which is linked to formal structure, improves a firm’s innovative performance (Benner and Tushman, 2003; Camison-Zornoza *et al.*, 2004; Terziovski, 2010). In addition, no external sources of knowledge, such as suppliers or customers, are utilized for innovation, meaning that the neglected innovators concentrate mainly on internal sources of resources. The explanation is based on the fact that they may lack absorptive capacity to access certain external resources, a fact that is reinforced below when comparing them with the R&D performers. In fact, R&D innovators accounted for the majority of the external resources of knowledge, and the non-R&D innovators present very low percentages of external cooperation, although they are much more active than the non-innovative firms. This is consistent with the results observed in the econometric specifications in which only internal factors explain innovation for non-R&D innovators, and it is also in line with the fact that the firms with more internal resources can easily absorb or access external ones, according to the hypothesis presented in regard to absorptive capacity. This result is also consistent with the fact that firms with R&D activities and thus, better AC can easily engage in cooperation agreements and access external flows of knowledge. Our results contradict those of Barge (2010) which state that small firms and less intensive R&D ones are more active about cooperation. Nevertheless, the non-R&D performers are basically performers of innovation in process. Lastly, the R&D innovators presented a higher productivity ratio ($p<0.01$) than the non-R&D innovators, which are predominantly innovators in process.

The interaction effect is especially negative and significant, addressing the substitution effect found in the other studies mentioned. The point made that firms conducting R&D efforts through R&D variables (AC_1 factor) substitute the supplier source of knowledge for in-house knowledge only for performing innovation in product is really interesting. In the case of non-R&D variables, the substitution effect through AC_2 factor occurs in all types of innovation activities, both for product and process. Therefore, and addressing the discussion about the complementing or substituting role of external sources of knowledge (e.g. Laursen and Salter, 2006), it is evidenced that the observed "informal way" of conducting innovation in process, represented mainly by non-R&D variables (*NewSkills, Design, Marketing* activities, and so on) carried out in-house, substitutes the incorporation of external knowledge from suppliers. These results reinforce those pointed out by Laursen and Salter (2006) and especially by Vega-Jurado (2008, 2009) who works using a sample of Spanish firms.

The paper has important implications for policymakers. The non-consideration of the non-R&D performers and variables, especially in innovation in process, left uncovered an important issue in the traditional policymakers' view. In addition, innovation in product needs R&D activities and the support of the university, while innovation in process requires a different input of innovation activities. Therefore, instead of trying to develop only R&D activities, policymakers should pay attention to the fact that innovative performance can be achieved without R&D activities, especially by reinforcing a firm's internal resources which determine, at least partially, the amount of external knowledge accessed from cooperation agreements.

Overall, the paper has two main issues which require further discussion. First, R&D activities are very important. The presence of formal R&D activities within SMEs is crucial in order to explain innovation, as confirmed in other studies (e.g. Hall et al., 2009; Rammer et al., 2009; Hölzl, 2009; Stam and Wennberg, 2009). Nevertheless, it has also been mentioned that innovation in SMEs presents peculiarities which traditional R&D indicators do not capture, also evidenced in previous works (e.g. Hall et al., 2009; Rammer et al., 2009; Arundel et al., 2008). R&D performers achieved better performance, in terms of productivity or innovation, and also presented a better AC to absorb external flows of knowledge in connected networks, a task which is poorly performed by non-R&D innovators. Second, considering the results (especially those outlining the key role of *R&D employees* and *NewSkills*), the promotion of a solid repository of human resources and the hiring of qualified personnel as a driver to build a firm's own resources (e.g. Lundvall, 2002; Muscio, 2007; Vinding, 2006) is also crucial. This policy can foster the building-up of core in-house resources for conducting non-R&D activities to achieve innovative output and, simultaneously, could provide firms with a more consistent AC platform to access external knowledge, especially in the case of the SMEs in low-tech and low-medium tech sector contexts. Therefore, this step is necessary to finally construct sufficient capabilities for engaging in R&D activities. Nevertheless, most of the policies try to promote just the opposite, fostering the formalization of R&D activities through R&D expenditures, when the lack of proper human resources can be a deterrence in SMEs and low-tech sectors, discouraging them from accessing external knowledge and consequently from achieving the aforementioned virtuous circle. Put differently, R&D policy should be targeted at particular categories of SMEs, instead of a general-policy purpose, confirming other studies (e.g. Ortega-Argiles et al., 2009; Stam and Wennberg, 2009). Following this chain of thought, policymakers should ensure that SMEs have access to other innovative inputs different from R&D activities, such as hiring academically-skilled personnel and incorporating high-value activities such as marketing and design. These efforts will upgrade a firm's AC to conduct the straight development of new product/process and the indirect mechanism of upgrading the firm's AC to access innovative networking. Nevertheless, a firm's AC is not only R&D (e.g. Cohen and Levinthal, 1990; Lane et al., 2006) but also human resources.

The paper has some limitations. As Qian and Li (2003) pointed out, causality is impossible to determine at a single point in time, although this study makes the assumption that the independent variables have a causal relationship with the firm's innovative performance, due to the lag period considered between independent and dependent variables. In addition, the results are limited to technology followers countries, and some conclusions may not be observed in other tech advance countries. For future studies, the role of non-R&D innovators should be analyzed deeper, especially comparing the European Union countries.

Appendix A

In table A1 the analysis is restricted to low-medium tech (1735) firms (specifications 25 to 28) and low-tech (1365) (29 to 32) firms. R&D expenditures work significantly (18.339 and 24.37 at p<0.01, specifications 15 and 19) for innovation in product, nor in any innovation in process outcome. Only innovation in process in low-tech firms is explained by R&D employees (specification 22, 5.9 at p<0.01 and specification 18, 3.15 at p<0.05) while R&D expenditures does not work in any model of innovation in process. Overall, the external flows of knowledge (suppliers, universities and customers) work statistically significant. Size is also important (specification 25, 26, 29, 30 at p<0.01) in innovation in product, although it does not work for innovation in process. UAIT is significant (specification 27 and 28, p<0.01; and specification 31 and 32, p<0.05) in innovation in process for both low-medium tech and low-tech firms. Therefore, the role of R&D employees in innovation in process for low-medium tech and low-tech is remarkable. And the role of external resources is always important in a firm's strategic combination of external flows of knowledge. Nevertheless, focusing on the rest of variables addressing a firm's internal resources, it is pointed out how the variables addressing human resources (NewSkills) and value-adding non-R&D activities (Design, Marketing effort,) and technology (the existence of a formal plan for innovation, PAI; the existence of a technology

Table A1. Results of the logit model explaining the probability of innovation in product and process

Type of industry	low-medium tech firms				low-tech firms			
Specification	25	26	27	28	29	30	31	32
Variables	IP (R&D variables)	IP (non-R&D)	IPR	IPR (R&D variables)	IP (R&D variables)	IP (non-R&D variables)	IPR (non-R&D)	IPR(R&D variables)
NewSkills			0.745***	0.787***			0.853***	0.746***
DCT					0.958***	1.137***		
Marketing	0.746***	0.723***	0.440***	0.472***	0.640***	0.640***		
Design	0.588***	0.667***			0.767***	0.779***	0.405***	0.418***
PAI	0.690***	0.895***	0.392**				0.616***	
R&D employees				3.150**				5.988***
R&D expenditures	18.339***				24.379***			
UIAT			0.517***	0.551***			0.398**	0.422**
Customers			0.416**	0.429**			0.540**	
competitors					-1.668**	-1.686**		
Suppliers	0.994***	0.985***	0.579***	0.697***	1.062***	1.077***	0.538**	0.940***
University		0.403**			0.505**	0.521**		
Lnemployees	0.212***	0.205***			0.209***	0.197***		0.138**
Interception	-3.083	-2.762	-2.272	-2.378	-4.035	-3.973	-1.701	-2.221
Nagelkerke	0.355	0.343	0.188	0.191	0.333	0.324	0.189	0.173
-2 log-lik.								
% correct predicted	84.7%	84.5%	76.3%	76.3%	87.7%	87.9%	77.7%	77.1%
	1735	1735	1735	1735	1365	1365	1365	1365

***significant at 1% **significant at 5% Model is run using step wise regression, which means that only significant variables remain in the final equation.

monitor committee, DCT) are important and significant in most of the specifications (see table A1). Again, it is remarkable the fact that R&D expenditures variable is important and present the larger coefficient (18.3 and 24.3) only for innovation in product. As a result, at least innovation in process should be measured differently, using non-R&D. It is also interesting to observe how important can be R&D employees in innovation in process (specifications 28 and 32), which jointly with NewSiklls reflect the core importance of human resources to explain innovation in process, rather than R&D expenditures. This key importance is much more reflected when firms are in low-tech sectors (specification 32 for low-tech context the coefficient takes de value 5.9 vs 3.1 in specification 28 for the low-medium tech case).

In table A2 it is showed the specific results when the low-medium tech and low-tech industries are restricted to SMEs (1402 and 1130, respectively). As such, when the analysis is restricted to just SMEs in low-medium tech sectors the size average drops to from 220 (all the sample) 60.68 (S.d. 64.9); similarly the SMEs in low-tech sectors presented a size average of 56.3 (S.d. 61.8). In this context of low-medium tech-low-tech and SMEs, it is observed how R&D expenditures have a principal effect on innovation in product (specification 33 and 37), with a coefficient of 30.178 and 22.4, respectively ($p<0.05$). In the rest of specifications, without R&D variables and specially for measuring innovation in process this variable does not work. Again R&D employees and NewSkills only work for innovation in process (2.88, $p<0.01$, specification 36) and the rest of models the non-R&D variables are statistically significant. No R&D variables is significant in low-tech sectors

Table A2. SMEs in low-medium tech and low-tech industries with original variables

Type of industry	**low-medium tech_SME**				**low-tech_SME**			
Specification	33	34	35	36	37	38	39	40
Variables	IP (R&D variables)	IP (non-R&D)	IPR	IPR (R&D variables)	IP (R&D variables)	IP (non-R&D variables)	IPR (non-R&D)	IPR(R&D variables)
NewSkills			0.543***	0.559***			0.783***	0.811***
DCT					0.901***	1.082***		
Marketing			0.441***	0.517***		0.656**		
Design	0.794***	0.821***	0.317***		0.911***	0.807***	0.501***	0.511***
PAI		0.908***					0.929***	0.893***
R&D employees				2.886***				
R&D expenditures	30.178**				22.432**			
UIAT			0.626	0.623***				
Suppliers	1.518***	1.403***	1.046***	0.983***	1.504***	1.586***		1.066***
University	0.59***	0.653***			0.796***	0.941***		
Lnemployees	0.29300***	0.262***			0.249			
Interception	-3.928	-3.628	-0.747	-0.642	-3.825	-2.951	-1.714	-1.716
Nagelkerke	0.309	0.234	0.125	0.127	90.2	0.272	0.126	0.128
-2 log-lik.	882.6	907.6	1366	1402	624.61	631.6	1130	1081
% correct predicted	87.9%	86.9%	78.6%	78.8%	90.2%	90.3	79.6%	79.6%
N	1402	1402	1402	1402	1130	1130	1130	1130

***significant at 1% **significant at 5% Model is run using step wise regression, which means that only significant variables remain in the final equation.

In table A3, regarding specifically low-medium tech and low-tech sectors (specifications 41 to 48) and using the PCA factors to check results it is evidenced that AC_2 (non-R&D variables) explain more than AC_1 (R&D variables) due to its larger coefficients, although both are significant ($p<0.01$). The rest of results are similar to the ones explained above.

Table A3. Results of the logit model of the probability innovation in product and process for low-medium tech and low-tech industries including SMEs.

Type of industry and firms	**low-tech firms**		**low-medium tech**		**low-medium tech_SME**		**low-tech_SME**	
	41	42	43	44	45	46	47	48
Variables	IP	IPR	IP	IPR	IP	IPR	IP	IPR
AC_1	0.617***	0.421***	0.522***	0.214***	0.519***	0.222***	0.442***	0.482***
AC_2	0.804***	0.460***	0.697***	0.340***	0.671***	0.379***	0.724***	0.532***
UIAT		0.362**		0.518***		0.593***		
Suppliers	0.945***	0.648***	0.856***	0.668***	1.288***	0.797***	1.522***	0.784***
University							0.816***	
Lnemployees		0.115**	0.125**	0.121*	0.297***			0.188***
Interception	-2.031	-1.655	-2.920	-1.804	-2.104	-1.398	-2.304	-1.844
Nagelkerke	0.289	0.187	0.330	0.176	0.291	0.122	0.270	0.136
-2 log-lik.	893.687	1364.042	1262.241	1789.218	900.14	1364.66	632	1074.83
% correct predicted	86.4%	77.5%	81.6%	76.4%	87.2%	78.6%	90.2%	80.2%
N	1378	1378	1756	1756	1402	1402	1139	1139

***significant at 1% **significant at 5% Model is run using step wise regression, which means that only significant variables remain in the final equation.

References

Acs Z.J., Morck R., Shaver J.M., Yeung, B., 1997. The internationalization of small and medium sized enterprises: a policy perspective. Small Business Economics. 9(1), 7–20.

Albaladejo, M., Romijn, H., 2000. Determinants of innovation capability in small UK firms: an empirical analysis, WP 00. 13. ECIS, Technische Universiteit Eindhoven, Eindhoven.

Arbussa, A., Coenders, G., 2007. Innovation activities, use of appropriation instruments and absorptive capacity: Evidence from Spanish firms. Research Policy. 36 (10), 1545-1558.

Arundel A., Bordoy, C., Kanerva, M., 2008. Neglected innovators: How do innovative firms that do not perform R&D innovate? Results of an analysis of the Innobarometer 2007 survey No. 215, INNO Metrics Thematic Paper, The Hague.

Arundel, A., Van de Paal, G., Soete, L., 1995. Innovation strategies of Europe's largest industrial firms, PACE Report. MERIT, University of Limbourg, Maastricht.

Audretsch, D. B., 2001. Research issues relating to structure, competition and performance of small technology-based firms. Small Business Economics. 16, 37–51.

Audretsch, D. B., 2002. The dynamic role of small firms: evidence from the US. Small Business Economics. 18, 1–3.

Barge-Gil, A. (2010). Cooperation-based innovators and peripheral cooperators. An empirical analysis of their characteristics and behaviour. *Technovation*. 30 (3), 185-206

Barney, J. 1991. Firm resources and sustained competitive advantage. Journal of Management. 17(1), 99-120.

Becheikh, N., Landry, R., Amara, N., 2006. Lessons from innovation empirical studies in the manufacturing sector: a systematic review of the literature from 1993-2003. Technovation. 26, 644-664.

Benner M.J., Tushman M.L., 2003. Exploitation, exploration, and process management: the productivity dilemma revisited. Academy of Management Review, 28(2), 238–256.

Bessant, J., and Tidd, J., 2007. Innovation and entrepreneurship. Wiley: Chichester, UK.

Bollen, K.A., 1989. Structural equations with latent variable. J. Wiley & Sons, New York.

Bougrain, F., Haudeville, B., 2002. Innovation, collaboration and SMEs internal research capacities. Research Policy. 31, 735–747.

Brouwer, E., Kleinknecht, A., 1996. Location, agglomeration and innovation: Towards regional innovation systems in Norway. European Planning Studies. 5, 299–330.

Burt, R. S., 1992. Structural Holes: The social structure of competition. Harvard University Press.

Caloghirou,Y.,Tsakanikas, A., V. Nicholas S., Y Vonortas, N. S., 2001. University-industry cooperation in the context of the European framework programmes. Journal of Technology Transfer. 26, 153-161.

Caloghirou, Y., Kastelli, I., Tsakanikas, A., 2004. Internal capabilities and external knowledge sources: complements or substitutes for innovative performance? Technovation. 24, 29–39.

Camison-Zornoza, C., Lapiedra-Alcami, R., Segarra-Cipres, M., Boronat-Navarro, M., 2004. A meta-analysis of innovation and organizational size. Organization Studies. 25(3), 331–361.

Capaldo, A., 2007. Network structure and innovation. The leveraging of a dual network as a distinctive relational capability. Strategic Management Journal. 28, 585-608.

Cassiman, B., Veugelers, R., 2002. R&D Cooperation and spillovers: some empirical evidence from Belgium. American Economic Review. 92, 1169–1184.

Cassiman, B., Veugelers, R., 2006. In search of complementarity in innovation strategy: internal RD and external knowledge acquisition. Management Science. 52, 68-82.

Cesaretto, S., and Mangano, S., 1992. Technological profiles and economic performance in the Italian manufacturing sector. Economics of Innovation and New Technology. 2, 237–256.

Cockburn, I., Henderson, R., 1998. Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. The Journal of Industrial Economics. 46 (2), 157–183.

Cockburn, I., Henderson, R., 1994. Measuring competence? Exploring firm effects in pharmaceutical research. Strategic Management Journal. 15, 63–84.

Cohen, W.M., Klepper, S., 1996. Firm size and the nature of innovation within industries: the case of process and product R&D. The Review of Economics & Statistics. 78, 232-43.

Cohen, W., Levinthal, D., 1989. Innovation and learning: The Two Faces Of R&D. Economic Journal. 99, 569–596.

Cohen, W., Levinthal, D., 1990. Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly. 35, 128–152.

Czarnitzki, D., 2006. Research and development in small and medium-sized enterprises: The role of financial constraints and public funding. Scottish Journal of Political Economy. 53, 335–357.

Damanpour, F., 1992. Organizational size and innovation. Organization Studies. 13(3), 375–402.

Decarolis, D.M., Deeds, D.L., 1999. The impact of stocks and flows of organizational knowledge on firm performance: an empirical investigation of the biotechnology industry. Strategic Management Journal. 20, 953-968.

Doloreux, D., 2004. Regional networks of small and medium sized enterprises: Evidence from the metropolitan area of Ottawa in Canada. European Planning Studies. 12, 173-189.

Dosi, G., 1988. The nature of the innovation process, in: Dosi, G. et al. (eds.), Technical Change and Economic Theory., London: Pinter.

Dyer, J., Singh, H., 1998. The relational view: cooperative strategy and sources of inter-organizational competitive advantage, Academy of Management Review, vol. 23, 4, 660-79

Edwards, T., Delbridge, R., Munday, M. 2005. Understanding innovation in small and medium-sized enterprises: a process manifest. Technovation. 25, 1119-1127.

Escribano, A., Fosfuri, A., Tribó, J., 2009. Management external knowledge flows: the moderating role of absorptive capacity. Research Policy. 38, 96-105.

Foss, Nicolai J., 1996. Knowledge-based approaches to the theory of the firm: some critical comments. Organization Science. 7, 470-476.

Freel, M. S., 2007. Are small innovators credit rationed? Small Business Economics. 28, 23–35.

Freel, M.S., 2003. Sectoral patterns of small firm innovation, networking and proximity. Research Policy. 32, 751–770.

Galbraith, J.K., 1952. American capitalism, the concept of countervailing power, 2nd edition, Oxford (UK) and Cambridge (USA): Blackwell (use is made of the reprinted version from 1980).

Gambardella, A., 1992. Competitive advantages from in-house scientific research: the US pharmaceutical industry in the 1980s. Research Policy. 21, 391-407.

Geroski, P.A., 1990. Innovation, technological opportunity and market structure". Oxford Economic Papers. 42, 586–602.

Gopalakrishnan, S., Bierly, P., Kessler, E.H., 1999. A re-examination of product and process innovations using a knowledge-based view. Journal of High Technology Management Research. 10 (1), 147–166.

Grimpe, C., Sofka,W., 2009. Search patterns and absorptive capacity: low- and high-technology sectors in European Countries. Research Policy. 38 (3), 495-506.

Guillén, M.F. 1992. Análisis de regresión múltiple, Centro de Investigaciones Sociológicas, Madrid.

Gulati, R., 1998. Alliances and Networks. Strategic Management Journal. 19(4), 293-317.

Gulati, R., Nitin N., Akbar, Z., 2000. Strategic networks. Strategic Management Journal. 21(3), 203-215.

Hagedoorn, J., Link, A., Vonortas, N., 2000. Research partnerships. Research Policy. 29(4-5), 567-586.

Hall, B., Lotti, F., Mairesse, J., 2009. Innovation and productivity in SMEs: empirical evidence for Italy. Small Business Economics. 33, 13-33.

Hanel, P., St-Pierre, M., 2006. Industry-university collaboration by Canadian manufacturing firms. Journal of Technology Transfer. 31, 485-499.

Heidenreich, M., 2009. Innovation patterns and location of European low- and medium-technology industries. Research Policy. 38(3), 483-494.

Hervas-Oliver, J.L., Albors-Garrigós, J. 2009. The role of a firm's internal and relational capabilities in clusters: when distance and embeddedness are not enough to explain innovation. Journal of Economic Geography. 9 (2), 263-283.

Hervas-Oliver, J.L., Albors-Garrigos, J. and Baixauli, J.J. (2011) Beyond R&D activities: the determinants of firms' absorptive capacity explaining the access to scientific institutes in low–medium-tech contexts, *Economics of Innovation and New Technology*, 1–27, iFirst DOI: 10.1080/10438599.2011.555113

Hirsch-Kreinsen, H., 2008. Low-technology: A forgotten sector in innovation policy. Journal of Technology Management & Innovation. 3, 11-20.

Hölzl, W., 2009. Is the R&D behaviour of fast-growing SMEs different? Evidence from CIS III data for 16 countries. Small Business Economics. 33, 59-75

Huergo, E., 2006. The role of technological management as a source of innovation: Evidence from Spanish manufacturing firms. Research Policy. 35(9), 1377-1388.

Jaffe, A.B., 1989. Real effects of academic research. American Economic Review. 79(5), 957–970.

Jaffe, A.B., 1988. Demand and supply influences in R&D intensity and productivity growth. The Review of Economics and Statistics. 70, 431–437.

Jaffe, A.B., 1986. Technological opportunity and spillover of R&D: evidence from firms, patents, profits and market value. The American Economic Review. 76(15), 984–1001.

Jensen, M.B., Johnson, B., Lorenz, E., Lundvall, B.A., 2007. Forms of knowledge and modes of innovation. Research Policy, in press.

Katila, R., Ahuja, G., 2002. Something old, something new: a longitudinal study of search behavior and new product introduction. Academy of Management Journal. 45(6), 1183–1194.

Kirner, E., Kinkel, S., Jaeger, A., 2009. Innovation paths and the innovation performance of low-technology-firms – an empirical analysis of German industry. Research Policy. 38, 447-458.

Kleinknecht, A., 1987. Measuring R&D in small firms: how much we are missing? The Journal of Industrial Economics. 36, 253–256.

Kleinknecht, A., 1989. Market structure, firm characteristics and innovative activity. Journal of Industrial Economics. 37, 327–336.

Klevorick, A., Levin. R., Nelson, R., Winter, S., 1995. On the sources of significance of inter-industry differences in technological opportunities. Research Policy. 24, 185-205.

Lager, T., Hörte, S.A., 2002. Success factors for improvement and innovation of process technology in process industry. Integrated Manufacturing Systems. 13(3), 158–164.

Lane, P., Koka, P., Pathak S., 2006. The reification of absorptive capacity: a critical review and rejuvenation of the construct. Academy of Management Review. 31(4), 833–863.

Lane, P.J., Lubatkin, M., 1998. Relative absorptive capacity and interorganizational learning. Strategic Management Journal. 19, 461- 77.

Laursen, K., Salter A., 2006. Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. Strategic Management Journal. 27(2), 131-150.

Lee, Ch., Lee, K., Pennings, J., 2001. Internal capabilities, external networks, and performance: a study on technology-based Ventures. Strategic Management Journal. 22, 615–640.

Levin, R. C., Cohen, W. M., and Mowery, D. C., 1985. R&D appropriability, opportunity, and market structure: New evidence on some Schumpeterian hypotheses. The American Economic Review. 75, 20–24.

Lin, P., Deng-Shing H., 2008. *Technological regimes and firm survival: evidence across sectors and over time. Small Business Economics*. 30(2), 175-186

Lindelöf, P., Löftsen, H., 2004. Proximity as a resource base for competitive advantage: university-industry links for technology transfer. Journal of Technology Transfer. 29, 311–326.

López, A., 2006. Determinants of R&D cooperation: evidence from Spanish manufacturing firms. International Journal of Industrial Organization. 26, 113–136.

Lundvall, B.A., 2002. The University in the learning economy. DRUID, Working Paper 02-06.

Lundvall, B.A., Nielsen, P., 1999. Competition and transformation in the learning economy, illustrated by the Danish case. Revue d'Economie Industrielle. 88, 67–89.

Mangematin, V., Nesta, L., 1999. What kind of knowledge can a firm absorb? International Journal of Technology Management. 8(3–4), 149–172.

March, J.G., 1991. Exploration and exploitation in organization learning. Organization Science. 2, 71–87.

Massa, S., Testa, S. 2008. Innovation and SMEs: Misaligned perspectives and goals among entrepreneurs, academics, and policy makers. Technovation. 28, 393-407.

McEvily, B., Zaheer, A., 1999. Bridging ties: a source of firm heterogeneity in competitive capabilities. Strategic Management Journal. 20, 1133-1156.

Mendona, S., 2009. *Brave old world: Accounting for 'high-tech' knowledge in 'low-tech' industries*. *Research Policy*. 38(3), 470-482

Michie, J., Sheehan, M., 2003. Labour market deregulation, 'flexibility' and innovation. Cambridge Journal of Economics. 27 (1), 123–143.

Mowery, D. C., 1983. The relationship between intra-firm and contractual forms of industrial research in American manufacturing, 1900-1940. Exploration in Economics History. 20, 351-374.

Muscio, A., 2007. The impact of absorptive capacity on SMES' collaboration. Econ. Innov. New Techn. 16(8), 653–668.

Narula, R., 2001. R&D collaboration by SMEs: new opportunities and Limitations in the Face of Globalization. MERIT-Infonomics Research Memorandum Series, 2001–2012.

Negassi, S., 2004. R&D co-operation and innovation: a microeconometric study on French firms. Research Policy. 33, 365–384.

Nelson, R., Winter, S., 1982. An evolutionary theory of economic change. Belknap Press.

Nieto, M., Quevedo, P., 2005. Absorptive capacity, technological opportunity, knowledge spillovers, and innovative effort. Technovation. 25, 1141-1157.

Nieto, M., Santamaria, M.J., 2007. The importance of diverse collaborative networks for the novelty of product innovation. Technovation. 27, 367-377.

Nooteboom, B., 1994. Innovation and diffusion in small firms: theory and evidence. Small Business Economics. 6, 327– 347.

OECD., 2005. Oslo manual: guidelines for collecting and interpreting innovation, 3rd ed. OECD Publications, Paris.

Ortega-Argiles, R., Vivarelli, M., Voigt, P., 2009. R&D in SMEs: a paradox? Small Business Economics. 33, 3-11

Papadakis, V., Bourantas, D., 1998. The chief executive officer as corporate champion of technological innovation: an empirical investigation. Technology Analysis and Strategic Management. 10 (1), 89–98.

Pavitt, K., 1984. Sectorial patterns of technical change: towards a taxonomy and a theory. Research Policy. 13, 343-373.

Peteraf, M., 1993. The cornerstones of competitive advantage: a resource-based view. Strategic Management Journal. 14, 179-91

Powell, W. W., Koput, Kpo. W., Smith-Doerr, L., 1996. Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. Administrative Science Quarterly. 41 (1), 116-141.

Prakash, Y., Gupta, M., 2008. Exploring the relationship between organisation structure and perceived innovation in the manufacturing sector of India. Singapore Management Review. 30(1), 55–76.

Qian, G., Li L., 2003. Profitability of small- and medium sized enterprises in high-tech industries: the case of the biotechnology industry. Strategic Management Journal. 24(9), 881–887.

Rammer, C., Czarnitizki, D., Spielkamp, A., 2009. Innovation success of non-R&D-performers: substituting technology by management in SMEs. Small Business Economics. 33, 35-58

Raymond, L., St-Pierre, J., 2010. R&D as a determinant of innovation in manufacturing SMEs: An attempt at empirical clarification. Technovation. 30, 48-56

Robertson, P.; Pol, E.; Carroll, P., 2003. Receptive capacity of established industries as a limiting factor in the economy's rate of innovation. Paper presented at the PILOT Workshop on Concepts, Theory, Taxonomies and Data. Dept. of Industrial Economics and Management, Royal Institute of Technology in Stockholm, 26-27 September 2003

Roper, S., Love, J.H., 2002. Product innovation and small business growth: a comparison of the strategies of German, UK and Irish companies. Research Policy. 31, 1087–1102.

Rosenberg, N., Nelson, R.R., 1994. American Universities and Technical Advance in Industry. Research Policy. 23, 325–348.

Rosenkopf, L., Almeida, P., 2003. Overcoming Local Search through Alliances and Mobility. Management Science. 49, 751–766.

Rothwell, R., Dodgson, M., 1994. Innovation and size of firm, in: Dodgson, M., Rothwell, R. (Eds.), The handbook of industrial innovation. Edward Elgar Publishing Limited, Aldershot, pp. 310–324.

Rothwell, R., Dodgson, M., 1991. External linkages and innovationn in small and medium-sized enterprises. R&D Management. 21(2), 125-136.

Rowley, T.; Behrens, D. Y Krackhardt, D., 2000. Redundant governance structures: An analysis of structural and relational embeddedness in the steel and semiconductor industries. Strategic Management Journal. 21, 369-386

Santamaria, L., Nieto, M.J., Barge-Gil, A., 2009. Beyond formal R&D: Taking advantage of other source of innovation in low- and medium-technology industries. Research Policy. 38, 507-517.

Scherer, F.M., 1965. Firm, size, market structure, opportunity, and the output of patented inventions. American Economic Review. 55, 1097–1125

Souitaris V., 2002. Firm-specific competencies determining technological innovation. A survey in Greece. R&D Management. 32 (1), 61-77.

Stam, E., Wennberg, K., 2009. The roles of R&D in new firm growth. Small Business Economics. 33,77-89

Sternberg, R., Arndt, O., 2001. The firm or the region: what determines the innovation behaviour of European firms? Economic Geography. 77(4), 364–382.

Szulanski, G., 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. Strategic Management Journal. 17, 27-43.

Teece, D.J., 1987. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy, in: Teece, D.J. ed (1987): The competitive challenge. Strategies for industrial innovation and renewal, Harper & Row, Nueva York.

Terziovski, M., 2010. Innovation practice and its performance implications in small and medium enterprises (SMES) in the manufacturing sector: a resource-based view. Strategic Management Journal, forthcoming.

Tidd, J., 2000. Measuring strategic competencies: technological, market and organisational indicators of innovation. Imperial College Press: London.

Todorova, G., Durisin, B., 2007. Absorptive capacity: valuing a reconceptualization. Academy of Management Review. 32(3), 774-786.

Tödtling F., Lehner P., Kaufmann A., 2009. Do different types of innovation rely on specific kinds of knowledge interactions? Technovation. 29, 59–71.

Van Dijk, B., Hertog, R. D., Menkveld, B., & Thurik, R. (1997). Some new evidence on the determinants of large and small-firm innovation. Small Business Economics, 9, 335–343.

Van Stel, A., D. Storey, R. Thurik., 2007. The effect of business regulations on nascent and young business entrepreneurship. Small Business Economics 28, 171–186

Vega-Jurado, J., Gutierrez-Gracia, A., Fernández-de-Lucio, I., Manjarrés-Henríquez, L., 2008. The effect of external and internal factors on firms product innovation. Research policy. 37, 616-632.

Vega-Jurado, J., Gutierrez-Gracia, A., Fernández-de-Lucio, I., Manjarrés-Henríquez, L., 2009. La relación entre las estrategias de innovación: coexistencia o complementariedad. Journal of Technology Management & Innovation 4.3.

Veugelers, R., Cassiman, B., 1999. Make and buy in innovation strategies: evidence from Belgian manufacturing firms. Research policy. 28, 63-80.

Vinding, A.L., 2006. Absorptive capacity and innovative performance: a human capital approach. Econ. Innov. New. Techn. 15(4-5), 507-517

Von Hippel, E., 1998. Economics of product development by users: the impact of sticky local information. Management Science. 44 (5), 629-649.

Von Tunzelmann, N., Acha, V., 2005. Innovation in ‘low-tech’ industries, in: Fagerberg, J., Mowery, D., Nelson, R. (eds.), The Oxford Handbook of Innovation. Oxford University Press, Oxford, pp. 407–432.

Winter, S.G., 1984. Schumpeterian competition in alternative technological regimes. Journal of Economic Behavior and Organization. 5, 287-320

Zahra, S. A., & George, G. 2002. Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, 27: 185–203.

Zeng, S. X., Xie, X. M., Tam, C. M., Sun, P. M., 2009. Identifying cultural difference in R&D project for performance improvement: a field study. Journal of Business Economics and Management. 10(1), 67–76.

Ivie

Guardia Civil, 22 - Esc. 2, 1º
46020 Valencia - Spain
Phone: +34 963 190 050
Fax: +34 963 190 055

Website: http://www.ivie.es
E-mail: publicaciones@ivie.es